Dublin Bay Birds Project

2013-2016

Project Synthesis

BirdWatchIreland
protecting birds and biodiversity

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DUBLIN PORT COMPANY

Contents

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Executive Summary

Given the location of Dublin Bay, directly adjacent to the capital city of Ireland with a resident population of over half a million people, it is inherently obvious that Dublin Bay will be subject to a range of pressures and threats, many of which have the potential to adversely affect waterbirds.

Dublin Bay is internationally important for waterbirds, and it comprises two Special Protection Areas designated under the EU Birds Directive. It is especially important during the winter months, supporting tens of thousands of waterbirds that migrate from their arctic and boreal nesting areas. It is internationally important for Light-bellied Brent Goose, Knot, Black-tailed Godwit and Bar-tailed Godwit, and nationally important for a suite of other species. Half of the species that occur in nationally important numbers do so in six months of the year or more, and Oystercatchers occur in nationally important numbers in every month of the year, showing that Dublin Bay is not just important during the winter months, but particularly important as a staging site for birds on migration in spring and autumn.

The bay is also of importance for seabirds during the breeding season. The mooring dolphins and pontoons within Dublin Port support a breeding colony of Common Terns and Arctic Terns, and up to 80 individual Black Guillemots breed within the port. And the bay plays host to significant numbers of terns, from many colonies in Ireland and further afield, as a post-breeding staging area.

The primary aim of the project was to gather detailed and specific information about how waterbirds use the Dublin Port area and Dublin Bay overall, for roosting and foraging, by day and by night. This synthesis brings together the findings of three-years of survey work, which was conducted between February 2013 and June 2016, with support from the Dublin Port Company.

The work involved a comprehensive programme of bi-monthly low and rising tide surveys; specific surveys and observations targeted at particular species or species groups, including roosting gulls and breeding terns; and colour-ringing and radio-tagging a selection of key wader species, namely Oystercatcher, Bar-tailed Godwit and Redshank.

The series of successful catches have resulted in over 2,200 birds ringed from 13 species, and there have been some very interesting reports of birds seen at locations outside Ireland, including Iceland, the Faroe Islands, Norway, Scotland, Wales, Germany and The Netherlands. The re-sighting database now holds well over 2,000 records, more than half of which have been submitted by interested amateur ornithologists. The ringing of post-breeding terns on Sandymount Strand has proved particularly enlightening, and a good start has been made on determining the migratory origins of these important flocks.

The wintertime catching and colour-ringing has allowed the commencement of integrated population monitoring for waders, through the investigation of key life-history parameters. This, in conjunction with ongoing monitoring (counts) will help to ascertain the drivers of population change and also inform on the health of the benthic prey populations on which they depend.

Many of the pressures upon Dublin Bay have arisen from urbanisation and population increase, and these same pressures and threats, are likely to extend into the future, and in many cases increase. The combination of these pressures and threats upon waterbirds is concerning. While these are inherently difficult to quantify, a comprehensive and on-going baseline data collection regime are a prerequisite to any actions aimed at protecting and maintaining biodiversity.

1. Purpose

Given the location of Dublin Bay, directly adjacent to the capital city of Ireland with a resident population of over half a million people, it is inherently obvious that Dublin Bay is subject to a range of pressures and threats, many of which have the potential to adversely affect waterbirds[1].

In order to facilitate adequate assessment of potential impacts, up to date information on how birds use the bay and its surrounds is vital. Only with long-term monitoring of the bird populations, which are a key element in the Dublin Bay ecosystem, can developmental decisions relating to the bay be made in a way that is in harmony with nature. The purpose of the Dublin Bay Birds Project (2013-2016) was to compile a comprehensive dataset on the waterbirds in Dublin Bay and the extent of their usage of the area to serve as a baseline upon which future monitoring can be compared.

In the longer term, the Irish Wetland Bird Survey (I-WeBS), since 1994/95, has provided the evidence that shows that Dublin Bay is an internationally important site, regularly featuring within the top-10 most important sites in Ireland (Hutchinson 1979, Sheppard 1993, Crowe 2005, Boland and Crowe 2012). I-WeBS undertakes (mainly) rising-tide counts to establish the size of the waterbird populations at wetland sites throughout Ireland. However, these winter-time surveys can only provide part of the picture. The additional components employed during this project have filled in some of the gaps and provided valuable information needed to gauge the potential effects on waterbirds from a variety of human activities as well as indirect effects such as climate change. This additional information includes:

- how birds are distributed at low tide when feeding, and the relative importance of their feeding areas;
- extent of high-tide roost usage, location and relative importance;
- how selected waterbirds use Dublin Bay at night;
- how the bay is used by waterbird populations outside the mid-winter period.

This document provides an overview of all of the work components that were completed during this project, between 2013 and 2016. Further specific details can be found in the annual technical reports, and these are detailed in the Appendix. In addition, some aspects have been written up as peer-reviewed scientific papers and will feature in the ornithological literature, and some detailed survey results are freely available for viewing and download online (details presented in the Appendix).

1.1 Core work programme

A programme of bi-monthly waterbird surveys, took place in each month between July 2013 and June 2016. One low and one rising tide survey took place in each month, and covered all of Dublin Bay between Sutton and Dun Laoghaire (Fig. 1). The survey area encompassed the intertidal zone, some adjacent areas of grassland, the Liffey Channel and Dublin Port, and areas of open sea visible from land-based vantage points. These surveys recorded the distribution and abundance of waterbirds and

[1] Waterbirds are defined as *"birds that are ecologically dependent on wetlands"* (Ramsar Convention 1971).

seabirds at low tide, when intertidal flats are exposed and available for feeding, and at high tide, when most birds are roosting.

Annual Gull Roost surveys were carried out on three occasions - each February between 2014 and 2016 - to determine the number of gulls that use Dublin Bay for roosting at night. As gulls have a tendency to forage in inland areas during the day and roost on the coast at night, they are not adequately monitored by daytime coastal counts (I-WeBS), so dedicated dusk surveys were undertaken to determine the true extent of usage by gulls of Dublin Bay. A further four dusk gull roost surveys focused on the Tolka Estuary, as it is known to be important for roosting gulls.

Eighteen 'All-day' focused observations were carried out on the outer Tolka Estuary (the nearest part of the bay to Dublin Port) between October 2013 and April 2016. This involved surveying waterbirds and seabirds iteratively throughout daylight hours in order to record how waterbird and seabird species use the area throughout the tidal cycle.

Low tide surveys on spring tides were also carried out on the outer Tolka Estuary to measure waterbird and seabird occupancy during extreme low tide events, when areas of mud and sand that are not usually exposed become available for exploitation by foraging waterbirds and seabirds. Surveys took place during the winter months, on seven occasions between September 2013 and March 2016, during spring tides when low tides occurred during daylight hours.

Monitoring of the Common Tern *Sterna hirundo* and Arctic Tern *S. paradisaea* colonies in Dublin Port was undertaken each breeding season, by conducting an annual nest census and determining productivity (the number of chicks raised per egg-laying pair). In 2015 and 2016, an additional project element was added, namely the colour-marking of Common and Arctic Tern chicks that will facilitate future assessments of juvenile recruitment into the breeding population.

Dusk post-breeding tern surveys were carried out on the intertidal sandflats between Poolbeg and Dun Laoghaire on 26 evenings, in each August and September, between 2013 and 2016. Two surveys took place on Dollymount Strand in August and September 2016. Surveys involved counting the flocks of terns as they arrived to roost on the sandflats each evening.

A programme of wintertime wader ringing and post-breeding season tern ringing was carried out at several locations across Dublin Bay. Most of the waders were caught in cannon-nets in February 2013, January 2014 and November 2014. The remaining waders and the fledged terns were captured at night with mist nets on 20 occasions between October 2013 and September 2016. Oystercatcher *Haematopus ostralegus*, Bar-tailed Godwit *Limosa lapponica*, and Redshank *Tringa totanus*, were chosen as target species for in-depth research, which involved assessing local and long-distance movements of birds at an individual level, through radio-tracking and colour-ringing, respectively.

This project facilitated the initiation of a PhD, in collaboration with University College Cork, that is designed to examine the effects of human-related activities on waterbirds, specifically on their behaviour and distribution during the winter. This study is ongoing and is due for completion in 2021.

2. Dublin Bay

2.1 Site importance and protection

The high concentrations and assemblages of waterbirds in Dublin Bay make the site particularly important in its own right, and in the context of other Irish estuaries. Dublin Bay has remained among the top ten most important sites for wintering waterbirds in Ireland since national-scale monitoring began in the 1970s (Hutchinson 1979). Furthermore, it is located in close proximity to other important waterbird sites, namely Baldoyle Bay, Broadmeadow/Malahide Estuary and Rogerstown Estuary in Dublin, and the Murrough Wetland Complex in Wicklow.

Dublin Bay, together with the other sites listed above, is internationally important for waterbirds, based on criteria for assessing the international importance of wetlands agreed by the Contracting Parties to the Ramsar Convention on Wetlands of International Importance (Ramsar Convention Bureau 1988), as well as criteria set out to justify the designation of sites as Special Protection Areas under the European Birds Directive.

Dublin Bay qualifies under Criterion 5 of the Ramsar Convention, as it regularly supports greater than 20,000 waterbirds (Table 1), and under Criterion 6, as it regularly supports greater than 1% of the individuals in a population of a species or subspecies of waterbird. Dublin Bay regularly exceeds the threshold for international importance for Light-bellied Brent Goose *Branta bernicla hrota* (hereafter referred to as Brent Goose), Black-tailed Godwit *Limosa limosa* and Bar-tailed Godwit, and is nationally important numbers of a further 23 species (I-WeBS 2016).

In terms of European designations, there are two Special Protection Areas (SPAs) in Dublin Bay: The North Bull Island SPA (Site Code 4006) and the South Dublin Bay and River Tolka Estuary SPA (Site Code 4024). These sites have been designated based on the significant numbers of birds that they support each year. The North Bull Island SPA overlaps with the North Dublin Bay Special Area of Conservation (SAC) and Rockabill to Dalkey Island SAC. It adjoins the Howth Head SAC and the South Dublin Bay and River Tolka Estuary SPA. The South Dublin Bay and River Tolka Estuary SPA overlaps with the South Dublin Bay SAC and adjoins the North Dublin Bay SAC.

The conservation objectives for both SPAs are similar: to safeguard the long-term winter population trends for 17 (in the North Bull Island SPA) and nine waterbird species (in the South Dublin Bay and River Tolka Estuary SPA), to ensure that there is no significant decrease in the range, timing or intensity of use of areas by waterbirds, and to maintain the favourable conservation condition of the wetland as a resource for the regularly-occurring migratory waterbirds that use it (NPWS 2015a, 2015b). Furthermore, safeguarding the passage populations of three species: Roseate Tern *Sterna dougallii*, Common Tern and Arctic Tern, as well as the breeding population of Common Terns are listed as conservation objectives for the South Dublin Bay and River Tolka Estuary SPA (NPWS 2015b).

Figure 1. The area surveyed during low and rising tide surveys in Dublin Bay divided into four regions (North Bull Island and Dollymount Strand – orange; Tolka Estuary, Liffey Channel and Dublin Port – green; Sandymount Strand and Booterstown Marsh – yellow; Coastal grasslands – red).

Table 1. Peak numbers of waterbirds and species groupings recorded during low and rising tide surveys throughout Dublin Bay between July 2013 and June 2016. A full description of the species that make up the broad waterbird groupings described below is presented in Crowe (2005).

	Low tide	Rising tide
All waterbirds	35007	24882
Waders	18637	15584
Wildfowl and allies	6865	5608
Gulls	9506	3690

To generate the peak for each group and in each tidal state, the means for each species in each month and tidal state across the three years were first calculated. These means were then totalled for the respective species within each group in each month, and the peak monthly total is given in the table.

The overall general pattern of occurrence of waterbirds within Dublin Bay is for numbers to build from July onwards and to peak in December or January, followed by a steady monthly decline until May, when numbers stabilise (Fig. 2a).

For all species groups, the number of birds recorded during low tide surveys was greater than during rising tide surveys, and this was particularly notable for the gulls. Some waders and wildfowl tend to avail of foraging opportunities away from the coast during high tide, so they would therefore have been missed during surveys in the core area. Gulls have a particularly strong tendency to do this, particularly when the intertidal substrate is inundated. As a result, the low tide gull totals were, on average, 62% higher than the rising tide totals (Fig. 2d). Many Brent Geese tend to forage inland during the day and roost at night on Dublin Bay so they also be missed by daylight surveys.

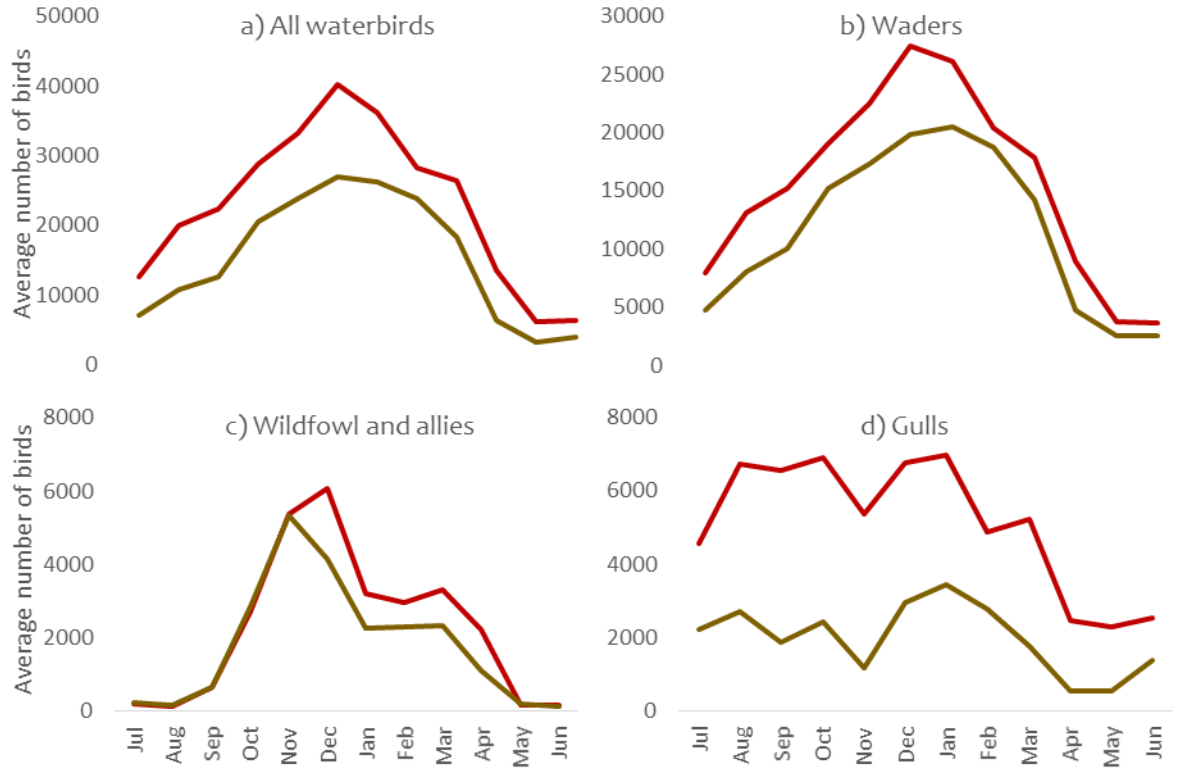


Figure 2. The average number of a) waterbirds, b) waders, c) wildfowl and allies and d) gulls recorded during monthly low and rising tide surveys across 23 count subsites in Dublin Bay between July 2013 and June 2016. Low tide counts are shown in red and high tide in green.

The three species that occur in internationally-important numbers exceeded the international threshold in several months of the year (Table 2). Brent Goose was present in such numbers for 7 months – from October through to April. The number Black-tailed Godwits exceeded the threshold between September and March (with the exception of December), showing the importance of the site for this species not only during the winter, but also during the passage periods in spring and autumn. Bar-tailed Godwits occurred in internationally important numbers during the mid-winter period, between November and January.

Ten of the twenty species that occurred in nationally important numbers did so in six months of the year or more (Table 2), and Oystercatchers occurred in nationally important numbers in every month of the year, showing that Dublin Bay is not just important during the winter months, but also during the passage periods and in the summer.

The numbers of several of these species occurring within Dublin Bay are particularly important in a national context (Crowe and Holt 2013), with peak counts of Great Crested Grebe *Podiceps cristatus*, Brent Goose, Shelduck *Tadorna tadorna*, and Sanderling *Calidris alba* occurring in Dublin Bay each making up 6% of the national population; Pintail *Anas acuta* and Black-tailed Godwit making up 8%; Bar-tailed Godwit 10%; Dunlin *C. alpina* 11% and Knot *C. canutus* 14%.

Table 2. Waterbird species that were recorded in nationally and internationally important numbers.

Species	*1% Nat.* [1]	*1% Int.* [2]	Peak count [3]	Number of months	
				Nat. important	Int. important
Great Crested Grebe	*50*	*980*	278	5	0
Light-bellied Brent Goose	*400*	*400*	**2560**	**7**	**7**
Shelduck	*120*	*3000*	698	7	0
Wigeon	*630*	*15000*	1007	2	0
Teal	*340*	*5000*	1254	6	0
Pintail	*20*	*600*	164	4	0
Shoveler	*30*	*400*	136	3	0
Red-breasted Merganser	*20*	*1700*	54	7	0
Red-throated Diver	*20*	*3000*	89	1	0
Little Egret	*20*	*1300*	55	6	0
Grey Heron	*25*	*2700*	47	4	0
Oystercatcher	*690*	*8200*	2653	12	0
Ringed Plover	*100*	*730*	142	2	0
Grey Plover	*30*	*2500*	127	7	0
Knot	*280*	*4500*	3872	5	0
Sanderling	*60*	*1200*	376	10	0
Dunlin	*570*	*13300*	6068	6	0
Black-tailed Godwit	*190*	*610*	**1455**	**10**	**7**
Bar-tailed Godwit	*150*	*1200*	**1533**	**9**	**3**
Curlew	*350*	*8400*	772	9	0
Greenshank	*20*	*2300*	36	5	0
Redshank	*300*	*3900*	1640	10	0
Turnstone	*95*	*1400*	177	3	0

Population thresholds listed for waterbirds only, according to the Ramsar Convention definition.

[1] 1% of the national population (Crowe & Holt, 2013). [2] 1% of the international population (Wetlands International, 2017). Figures in **underlined bold** font refer to low tide 3-year monthly means that exceeded the 1% international threshold. [3] Peak count refers to the highest low-tide monthly 3-year mean for each species.

2.2 Regional importance of Dublin Bay

Dublin Bay was divided into four regions to enable an assessment of broad-scale usage of the bay by waterbirds. These were North Bull Island and Dollymount Strand; The Tolka Estuary, Liffey Channel and Dublin Port; Sandymount Strand and Booterstown Marsh; and the coastal grasslands (Fig. 1).

Overall, the North Bull Island and Dollymount Strand region supported the greatest abundance of waterbirds, during both low and rising tide surveys (Table 3). Waders accounted for most of the birds in this region, followed by wildfowl and their allies, which occurred in numbers much greater than any of the other regions.

The Tolka Estuary, Liffey Channel and Dublin Port region supported more than 10,000 waterbirds during low tide, but only about 10% of this number at high tide. This region serves as a valuable foraging area at low tide, supporting over 6,000 waders, almost 1,000 wildfowl and 3,000 gulls.

Waders account for most of the birds occurring in the Sandymount Strand and Booterstown Marsh region, with numbers reaching almost 6,000 during low tides. At this time, greater than 3,000 gulls occur here, with less than half this number occurring here during high tides.

The small areas of coastal grassland surveyed supported several hundred birds, which were mostly wildfowl (Brent Geese) at high tide and gulls during low tides.

Table 3. Peak numbers of waterbirds and species groupings recorded during monthly low and rising tide surveys across four regions in Dublin Bay between July 2013 and June 2016.

	All waterbirds		**Waders**		**Wildfowl & allies**		**Gulls**	
	Low	*Rising*	*Low*	*Rising*	*Low*	*Rising*	*Low*	*Rising*
Bull Island and Dollymount Strand	14371	16132	6423	10217	5305	4394	2644	1521
Tolka Estuary, Liffey channel and Dublin Port	10403	1070	6283	139	919	233	3201	698
Sandymount Strand and Booterstown Marsh	9806	7453	5889	5166	556	829	3361	1458
Coastal grassland	427	227	42	62	85	152	300	13

Peak numbers were calculated by summing the 3-year monthly means for each species to give the total for each species group, and then the total for the month when the peak number of that species group was recorded is presented. Numbers refer to daytime surveys only. Seperate dedicated dusk surveys for gulls and terns have resulted in larger numbers of birds.

2.2.1 North Bull Island and Dollymount Strand

The North Bull Island (or Bull Island) sand spit is a relatively recent depositional feature, formed as a result of improvements to Dublin Port during the 18th and 19th centuries (Jeffrey 1977). It is almost 5 km long and 1 km wide and runs parallel to the coast between Clontarf and Sutton in a north easterly – south westerly orientation. Extensive salt marshes occur between the island and the mainland. These lagoons, known as the north and south lagoon, are separated by a causeway. The southern end of the island is accessible via a bridge, known as the Wooden Bridge. The seaward side of the island is a fine sandy beach. This, and an extensive area of shallow marine water, are included in the site. There

are two golf courses in the interior of the island. The proximity of the North Bull Island to Dublin City results in it being a very popular recreational area for walkers, dog-walkers and water sport enthusiasts.

General waterbird patterns of occurrence

At low tide, the waders and gulls are distributed throughout the region: on the mudflats and saltmarshes in the north and south lagoons and on the sandflats on Dollymount Strand. Some waders, notably Oystercatcher, Curlew *Numenius arquata* and Redshank, forage on the golf course fairways. Most of the wildfowl feed exclusively in the intertidal areas of both lagoons, with the exception of Brent Geese, which often feed on the golf courses too.

As the tide rises, the amount of intertidal foraging area is dramatically reduced, and birds remain relatively widely distributed on exposed areas up until the high tide, when most tend to congregate to roost in several discrete areas. The waders and wildfowl gather to roost in several dense flocks along the edge of, and within saltmarsh habitat in both lagoons. The location of these roosting assemblages is determined by the height of the tide, and while roosting birds occur along the eastward sides of both lagoons, there are high concentrations towards the tip of the island , just north of the causeway in the north lagoon, and at the southern end of the south lagoon. At this time, the number of gulls present in the region almost halves (compared to at low tide).

Dollymount Strand is one of two important areas within Dublin Bay for Sanderling (the other being Sandymount Strand). There can be extensive usage of Dollymount Strand by a variety of other waders at certain times. It remains uncertain what factors cause them to use the beach; perhaps their occurrence here is caused by disturbance and/ or weather. Extensive usage of Dollymount by waders has also been observed at night (BirdWatch Ireland, pers. obs.).

Table 4. The number of seabird, wader and wildfowl (and allies) species recorded at North Bull Island and Dollymount Strand throughout the year (July to June).

	Seabirds		**Waders**		**Wildfowl and allies**		**All waterbirds and seabirds**	
	Low	*Rising*	*Low*	*Rising*	*Low*	*Rising*	*Low*	*Rising*
July	8	7	9	10	4	5	21	22
August	5	6	14	13	7	7	26	26
September	8	6	14	14	11	12	33	32
October	5	7	13	14	13	16	31	37
November	6	5	13	14	14	14	33	33
December	5	5	16	13	13	14	34	32
January	5	5	13	13	14	16	32	34
February	6	7	13	14	13	12	32	33
March	5	6	12	13	11	11	28	30
April	7	6	12	13	12	11	31	30
May	6	7	6	9	5	7	17	23
June	6	6	8	7	7	5	21	18

The greatest diversity in the assemblage of species occurring within this region in any one month was in October, and more generally was highest between October and January (Table 4). For seabirds,

which, apart from terns and gulls, are generally recorded in low numbers, diversity was highest during the summer months and lowest in mid-winter, when most seabirds are wintering out at sea. The diversity of waders increased in August, reflecting birds returning from their breeding grounds, with greatest diversity during mid-winter months. Similarly, the number of wildfowl species (and their allies) was lowest between April and August, and highest during mid-winter.

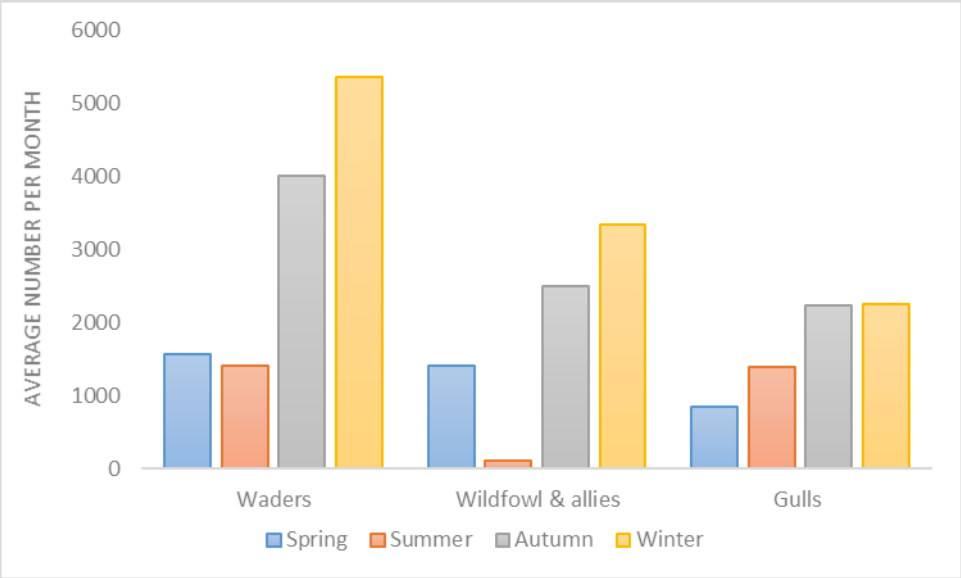


Figure 3. The average number of waders, gulls and wildfowl and allies present at North Bull Island and Dollymount Strand during monthly low tide surveys throughout the year. [1] Spring = Mar, Apr, May; Summer = Jun, Jul, Aug; Autumn = Sep, Oct, Nov; Winter = Dec, Jan, Feb.

In terms of numbers (Fig. 3), the total number of birds was lowest in spring and summer and highest in autumn and winter. For all groups, the average number of birds was highest in winter, and for waders and wildfowl and their allies was lowest in summer. Gull numbers were lowest in spring, and were shown to build in the summer, with the autumn peak maintained into the winter.

Wildfowl and their allies

Brent Geese were recorded in internationally important numbers on Bull Island in six months between October to April, with the exception being the month of January. It is recognised that the totals recorded during these counts are underestimates because of the tendency for Brent Goose to move to terrestrial grasslands to forage during the day. Totals recorded using this region represent the majority of the birds counted during low and rising tide surveys throughout Dublin Bay, accounting for 69% and 79% of the Dublin Bay total, respectively.

Some of the wildfowl in the Bull Island region appear to have limited distribution with Shelduck, Wigeon *Anas Penelope*, Teal *A. crecca*, Mallard *A. platyrhynchos*, Pintail and Shoveler *A. clypeata* being distributed across a relatively similar subset of subsites during both the low and rising tides. Each of these species, with the exception of Mallard, occurred in nationally important numbers on Bull Island. Shelduck were present in Dublin Bay throughout the year, with numbers varying from about ten birds in August to 600 during the mid-winter period. In all months, the vast majority (94 – 100%) of the

Shelduck that occurred in Dublin Bay were on Bull Island. During the months when Wigeon occur in nationally important numbers (October to December), 98-100% of them were recorded on Bull Island.

Teal were present on Bull Island from August to April, and in nationally important numbers from October to March. During this time, greater than 90% of the Teal in Dublin Bay were located in the Bull Island lagoons. All of the Mallard (less than 70 birds) that winter in Dublin Bay were recorded exclusively on Bull Island, and were most often found in the north lagoon.

Pintail arrive into Dublin Bay in September and leave in March. They were recorded in just three subsites during rising tide surveys and in two during low tide surveys, each of which are close to the Bull Island causeway. Shoveler are present in the Bull Island lagoons from September to February and did not occur in any other areas in Dublin Bay, and like Pintail, were only found in the three subsites closest to the causeway during high tides.

Bull Island supports the majority of Grey Herons *Ardea cinerea* and Little Egrets *Egretta garzetta* in Dublin Bay, when they are most abundant in Dublin Bay (April to December).

Waders

The majority of the over-wintering Oystercatchers in Dublin Bay are found on Bull Island. Between August and February, when present in largest and nationally-important numbers, the majority of Oystercatchers (55%) were on Bull Island during high tide. The area is less important at low tide, as the birds seem to have a more widespread distribution when foraging.

The number of Grey Plovers *Pluvialis squatarola* that use Bull Island exceeded the national threshold in each month between September and March. During this time, most of the Grey Plovers in Dublin Bay are on Bull Island, with 95% of the total numbers present at high tide, and 71% at low tides. Lapwing *Vanellus vanellus* occur in Dublin Bay in relatively small numbers; a small flock (20-50 birds) was present between July and February. These birds were found exclusively on Bull Island, mostly in the vicinity of the causeway.

During November to March, when Knot are present in Dublin Bay in nationally important numbers, they were most often at Bull Island. On average, 70% of the total number of Knot recorded were in this region, however in some months, a large proportion were found on Sandymount Strand. Sanderling occurred on Dollymount Strand in nationally important numbers between August and April, and during this period, the majority of the Dublin Bay flock were recorded here. However, the birds are known to move between Dollymount Strand and Sandymount Strand on a regular basis. During rising tide counts in the mid-winter period, 64% of the Dunlin in Dublin Bay were on Bull Island, but this proportion reduced to 30% at low tide, when the adjacent intertidal foraging areas in the Tolka Estuary are exposed.

Bull Island is particularly important for both Black- and Bar-tailed Godwits. Between September and March, during rising tides, over 80% of Black-tailed Godwits were recorded here. Meanwhile, the south lagoon was found to be nationally important for Bar-tailed Godwit between July and March; most of the birds were recorded roosting in the south lagoon, but during spring tides, they often relocated to roost on Sandymount Strand.

Whimbrel were recorded in each month between March and September, with the bulk of the birds being recorded during May and June as they move through the area en route to Iceland. During these months, the majority of Whimbrel (93%) in Dublin Bay were on Bull Island, with the northern end of Bull Island and Sutton Strand especially favoured locations (see also Cooney 2016). More than 90% of the Dublin Bay Curlew occurred on Bull Island, roosting in sparse groups along the length of both lagoons. While the birds were much more dispersed during the low tide period, the majority occurred on Bull Island, either in the lagoons or on Dollymount Strand, especially the most northerly part.

Redshank were present on Bull Island throughout the year, albeit in very low numbers during May and June. From August through to March, the total numbers recorded were in excess of 1,000 individuals, with the majority being located at Bull Island. During high tides, 73% of the birds in Dublin were located here, with a smaller proportion (54%) during low tides, when birds were more prevalent in other sections, especially in terrestrial areas and the Tolka Estuary which were used for foraging. While Turnstones *Arenaria interpres* have been recorded Dublin Bay in each month of the year, largest numbers were present from August through to April. Nationally important numbers were recorded during December and January, and Bull Island was found to support the majority of Dublin Bay's Turnstones during the winter period.

Gulls and terns

Most gull species have a tendency to forage in terrestrial areas during the day, so daytime coastal counts can greatly underestimate the number of gulls that Dublin Bay supports. Each February between 2014 and 2016, dedicated Gull Roost Surveys were carried out to determine the number of gulls using Dublin Bay at night. During these Gull Roost Surveys, all gulls were counted as they arrived at the coast from inland areas. Bull Island was found to be an important roosting area, supporting six species, namely: Black-headed Gull *Chroicocephalus ridibundus*, Common Gull *Larus canus*, Great Black-backed Gull *L. marinus*, Herring Gull *L. argentatus*, Lesser Black-backed Gull *L. fuscus* and Mediterranean Gull *Ichthyaetus melanocephalus*. The average number of gulls that was recorded during these surveys on Bull Island between 2013 and 2016 was 5,308 (SE = 924), which is considerably greater than the totals recorded during the daytime surveys (Fig. 3).

Several hundred terns roost on Dollymount Strand in August and September, and while the number of birds makes up only a small fraction of the numbers roosting on Sandymount Strand at this time, this area may be important as an alternate roost site at times when there is disturbance on Sandymount Strand.

Black-tailed Godwits in breeding plumage in spring

2.2.2 Tolka Estuary, Liffey Channel and Dublin Port

The Tolka Estuary is located close to Dublin City Centre and adjacent to the Liffey Channel. This region encompasses the intertidal and subtidal area between the Bull Wall and the Great South Wall, and the Alexandra Basin. The Tolka Estuary is bordered to the north by the Clontarf Road and to the south by the East Point Business Park and the Dublin Port North Bank. Up to the 18th Century the Tolka Estuary was considerably larger. All of its banks have been modified over time to allow for urban development, and are mostly rock-armoured embankments and sea walls. Sediments in the Tolka Estuary vary from soft muds with a high organic content in the inner estuary to exposed, well aerated sands in the outer estuary, particularly at the Bull Wall.

The Liffey Channel encompasses the area from east of the Poolbeg power station to the ends of the Bull Wall and the Great South Wall. The majority of this area is the shipping channel, but there is a small amount of intertidal mud exposed at the base of the Great South Wall at low tide. The Alexandra Basin lies on the north side of the Liffey, within Dublin Port. The quays surrounding the basin are used for the importation and exportation of a wide variety of cargo and for docking cruise ships. This area was included in the survey area due to the presence of foraging Brent Geese in the winter months. The geese are attracted to feed from spilled agricultural products on the quays.

This is a popular recreational area. The promenade that runs along the entire north and east sides of Tolka Estuary is very popular for walkers and dog-walkers and there is a yacht and boat club in Clontarf. A small portion of the intertidal substrate, on the outer estuary, is used by bait-diggers, dog-walkers and occasionally by swimmers. The Liffey Channel and Alexandra Basin are both industrial areas, and experience high levels of vessel and vehicular traffic and noise associated with port operations.

General waterbird patterns of occurrence

As it is totally covered with water at high tide, this region is mostly used for foraging during other tidal states. There are no significant high tide roosts although Grey Herons were recorded roosting in the trees on the southern bank of the inner Tolka Estuary, and Golden Plover *Pluvialis apricaria* occasionally roosted on the mudflats during low tide.

At low tide, waders and gulls are distributed throughout the Tolka Estuary: on the mudflats in the inner estuary and the sandflats in the outer estuary. Most of the wildfowl are distributed in the inner, muddier parts of the site. However, as the tide rises, the amount of intertidal foraging area is dramatically reduced, and ultimately disappears and the majority of waterbirds leave this part of the estuary. Those that remain during the high tide period include gulls, Black Guillemots *Cepphus grylle*, Red-breasted Mergansers *Mergus serrator*, Great Crested Grebes and Cormorants *Phalacrocorax carbo*.

The Liffey Channel is mainly used by gulls, Black Guillemots and Cormorants for feeding and roosting. The Alexandra Basin is used by foraging gulls and Brent Geese throughout the tidal cycle (Tierney *et al*. 2016a), and the use of this area by birds is likely to be governed by the availability of spilled agricultural produce.

As well as the wintering birds, Common Terns and Arctic Terns have been known to breed in the Dublin Port area since at least 1949 (Merne 2004). Each year since 1994, they have nested on two isolated mooring dolphins situated on the south side of the port, with Common Terns almost exclusively on the ESB dolphin and Arctic Terns on the CDL dolphin. In 2013 a pontoon was moored by Dublin Port Company in the outer Tolka Estuary and this has also been used for nesting by Common Terns each year since. They typically arrive in April and remain within the area up until their nesting period has ended, usually around late July.

The highest number of species in the region is supported between November and April. For seabirds, which, apart from terns and gulls, are generally recorded in low numbers, the total number of species recorded was found to vary little across the year, but was highest in summer and lowest during the winter. The number of wader species was highest between September and April, and lowest during the summer when birds are on their breeding grounds away from Dublin Bay. Similarly, the number of wildfowl species was highest in winter, between November and February, and lowest during the summer. Since the Tolka Estuary is fully covered by water at high tide, the number of wader species recorded during rising tide surveys is always considerably lower than during low tide counts.

Table 5. The number of seabird, wader and wildfowl (and allies) species recorded at the Tolka Estuary, Liffey Channel and Dublin Port throughout the year.

	Seabirds		Waders		Wildfowl & allies		All waterbirds and seabirds	
	Low	*Rising*	*Low*	*Rising*	*Low*	*Rising*	*Low*	*Rising*
July	9	9	8	1	4	4	21	14
August	7	8	9	3	6	2	22	13
September	7	10	11	5	6	5	24	20
October	7	7	12	2	9	4	28	13
November	8	8	12	3	10	8	30	19
December	8	7	11	5	13	6	32	18
January	7	6	12	2	11	8	30	16
February	7	8	12	6	14	12	33	26
March	7	9	12	6	12	10	31	25
April	11	9	12	3	9	5	32	17
May	9	10	5	2	8	5	22	17
June	8	12	5	1	9	3	22	16

In general, the number of birds overall was lowest in summer and highest in winter (Fig. 4). For waders, highest numbers occurred during winter. Wildfowl and their allies occurred in relatively low numbers in this region. The average number of gulls recorded during daytime low tide surveys was relatively consistent between seasons, but occasionally the number of birds recorded during winter dusk roost surveys was considerably higher.

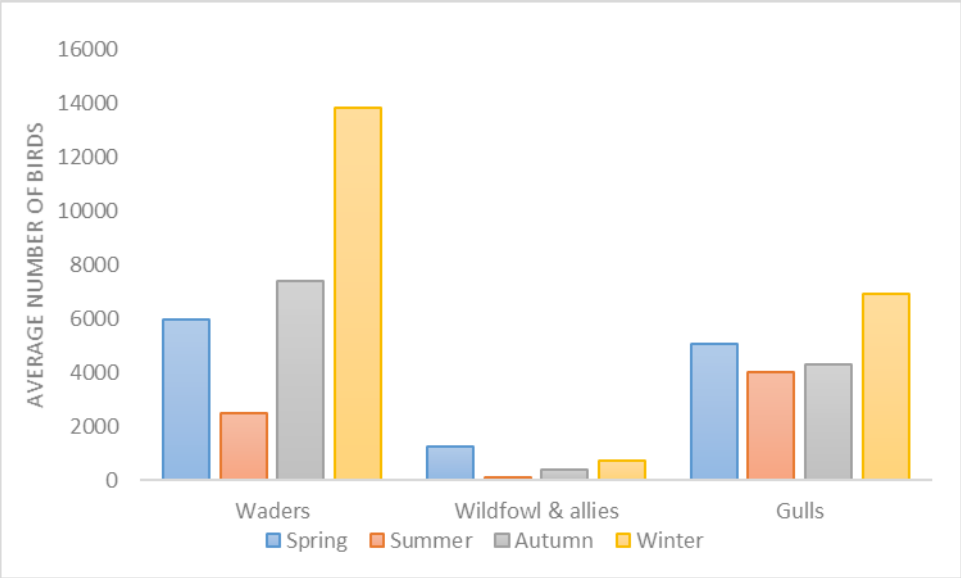


Figure 4. The average number of waders, wildfowl & allies and gulls present in the Tolka Estuary, Liffey Channel and Dublin Port during monthly low tide surveys throughout the year. [1] Spring = Mar, Apr, May; Summer = Jun, Jul, Aug; Autumn = Sep, Oct, Nov; Winter = Dec, Jan, Feb.

A total of 18 'All-day' observations took place between October 2013 and April 2016 to examine variation in numbers during the course of the tidal cycles. During these, an average of 24 (range: 19-32) wildfowl, wader and gull species was recorded. The number of waterbirds was found to vary greatly throughout the tidal cycle, with highest numbers occurring at low tide, when the greatest amount of the substrate is exposed. At this time, large numbers of birds, mainly waders and gulls, were found to congregate and feed. Notwithstanding the survey area's small size (*c*. 200 ha), seven

species, namely: Red-breasted Merganser, Golden Plover, Grey Plover, Knot, Sanderling, Dunlin and Bar-tailed Godwit, were recorded in nationally important numbers on at least one occasion (Table 6). Dunlin occurred in nationally important numbers in six of the 18 surveys, Knot in ten, and Bar-tailed Godwits in eleven, showing the importance of the area for foraging waders during winter.

While the area is important for species that occur in large numbers, other species occur in smaller numbers, but do so on a regular basis. Figure 5 shows the cumulative number of bird-records collected across all surveys, and demonstrates the relative importance of the area for the most numerous 20 species. Dunlin and Knot had the highest number of bird-records, being both recorded in large numbers and on many survey days, whereas Golden Plover were recorded in large numbers, but were only present sporadically, on 11 out of the 18 surveys. Conversely, other species, such as Bar-tailed Godwit, Black-headed Gull, Herring Gull, Oystercatcher, Common Gull, Curlew and Redshank occurred in smaller numbers, but were present on each of the survey days.

Table 6. Maximum count per day of species that occurred in nationally important numbers in the outer Tolka Estuary during 18 'All-day' observations between October 2013 and April 2016.

	Red-breasted Merganser	**Golden Plover**	**Grey Plover**	**Knot**	**Sanderling**	**Dunlin**	**Bar-tailed Godwit**
Nat Imp. [1]	*20*	*1200*	*30*	*280*	*60*	*570*	*150*
Oct-13		0	**150**	**485**	4	354	**525**
Nov-13	6	0	3	20	0	263	103
Dec-13	6	0	**33**	**310**	8	**700**	105
Jan-14	8	0	1	0	0	17	**181**
Mar-14	6	320	26	**500**	0	**1500**	**236**
Oct-14	7	330	0	**398**	17	136	**484**
Nov-14	2	**1740**	6	85	32	20	52
Nov-14	13	4	0	**1350**	6	360	**343**
Dec-14	7	540	10	**1650**	10	463	**390**
Jan-15	5	0	0	**1200**	32	**1180**	**183**
Feb-15	6	1090	1	**2000**	**66**	**3820**	**390**
Mar-15	5	0	1	61	**116**	16	81
Oct-15	0	5	0	53	0	6	**503**
Nov-15	2	**2930**	12	240	0	74	**293**
Jan-16	**46**	460	2	**3645**	42	**1670**	**165**
Mar-16	20	456	**91**	**920**	25	**1690**	**188**
Mar-16	9	492	22	0	**84**	3	63
Apr-16	4	0	0	0	0	0	86

1 Population thresholds listed for waterbirds only, according to the Ramsar Convention definition (Crowe & Holt, 2013). Figures are in **bold** font refer to survey days when the peak count exceed the 1% national threshold.

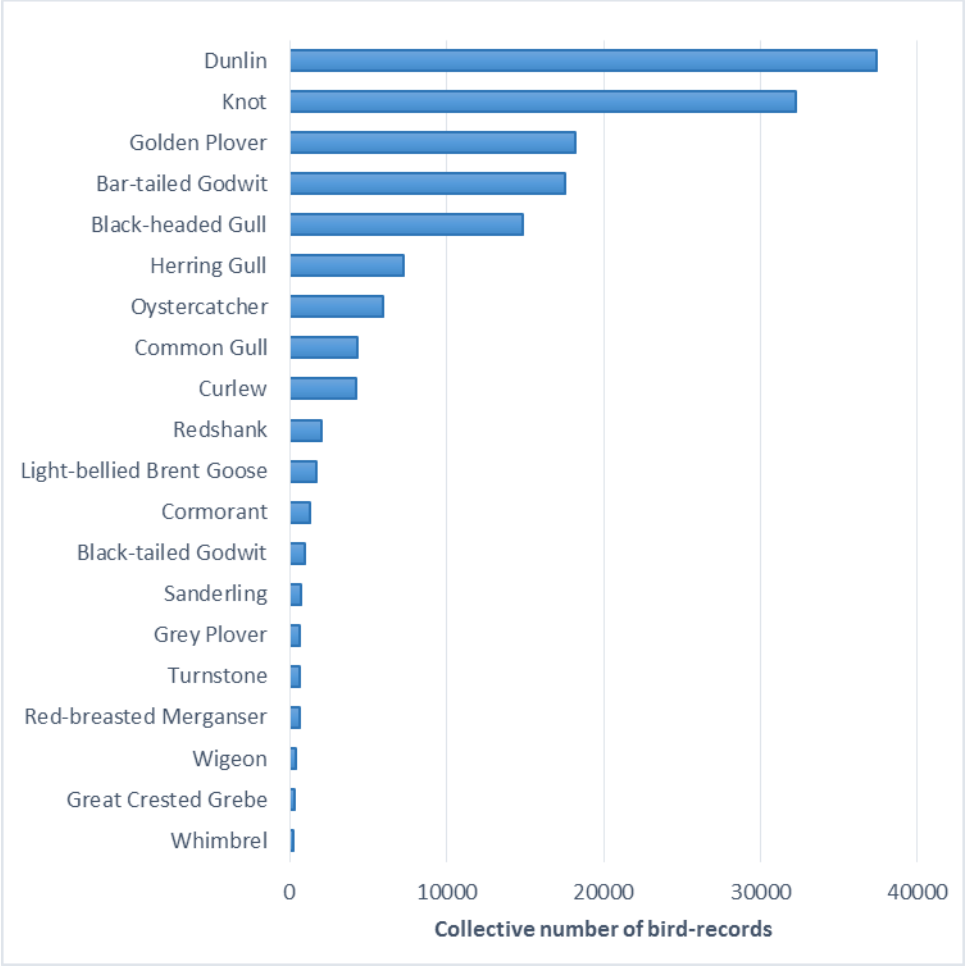


Figure 5. The total number of bird-records amassed on the outer Tolka Estuary during 18 'All-day' survey days between October 2013 and April 2016. Only the most numerous 20 species are shown.

Wildfowl and their allies

The outer Tolka Estuary is an important foraging area, but for most species their use of the area is determined by the height of the tide. Piscivorous birds, such as Red-breasted Mergansers, Great Crested Grebes and Cormorants use the Tolka for foraging when the tide is in, and when the tide drops, Grey Herons and Little Egrets forage in the shallows and on the exposed mud and sand.

Waders

The Tolka Estuary was shown to be an important foraging resource for several wader species. Nationally important numbers of Knot were recorded foraging on the mudflats between November and February. Dunlin were present in every month except May and June and occurred in nationally important numbers between December and March.

Black-tailed Godwits occurred in nationally important numbers during August and later on from January to April. The Tolka Estuary was shown to be an important foraging area for these birds each spring. Total numbers of Black-tailed Godwits within Dublin Bay increased each March and April, presumably reflecting passage birds moving through and mixing with wintering birds. During this period each year, the numbers foraging in the Tolka Estuary showed a corresponding increase. Bar-

tailed Godwits, which were present in every month except May, occurred in nationally important numbers between July and March.

Redshank occurred in nationally important numbers in March, April, September, October and November. Like Black-tailed Godwits, the spring influx of migrating Redshanks passing through Dublin Bay was mirrored by an increase in the number of foraging Redshank on the Tolka Estuary, verifying the importance of this staging area for migrating waders.

Cormorant

Gulls

As most gull species have a tendency to forage in inland areas during the day, daytime coastal counts were assumed to underestimate the total number of gulls that use this area. The region was found to be important for foraging gulls, particularly at low tide. Black-headed Gulls were present in the Tolka Estuary, Liffey Channel and Dublin Port throughout the year, but numbers were greatest between July and March. During low tides, most (60%) of the Black-headed Gulls in Dublin Bay occurred in this region. Common Gulls occurred in each month of the year and this region supported the majority (70%) of the Dublin Bay total during March, April and May.

Seven dedicated Gull Roost Surveys were carried out during winter (October to February) between October 2013 and February 2016 to determine the number of gulls using the Tolka Estuary and Liffey Channel for roosting at night. During these surveys, all gulls were counted as they arrived at the coast from inland areas. The Tolka Estuary and Liffey Channel region was found to be a highly important roosting area, supporting six species, namely: Black-headed, Common, Great Black-backed, Herring, Lesser Black-backed and Mediterranean Gull. A peak of 12,248 gulls was recorded in February 2014.

The average number of gulls that were recorded during these surveys in the Tolka Estuary and Liffey Channel between 2013 and 2016 was much lower, at 3,927 (SE = 1,482).

Waterbird occurrence during low spring tides

Waterbird use of the Tolka Estuary is strongly constrained by tidal conditions, and as mentioned above all non-swimming birds, or those that forage in shallow water, are typically forced to leave this part of the estuary as the tide rises. However, the area was found to be very important for foraging when the sand and mudflats were exposed at low tide. The area of intertidal mud available to waterbirds increases in size during low spring tides, when a larger portion of the sand and mudflats are exposed, and specific observations were undertaken on the outer Tolka Estuary to determine the importance of the area during such conditions, which are highly infrequent.

A total of 29 species was recorded during the spring low tide period (Table 7) and six species were present in nationally important numbers. Numbers of Bar-tailed Godwit exceeded the threshold on each of the seven surveys. Black-tailed Godwit, Dunlin, Knot and Redshank were present in nationally important numbers on two occasions and Red-breasted Mergansers on one occasion. The series of surveys shows that this area is particularly important for waders and gulls in certain conditions. While bird numbers were similar to the low tide surveys in most cases, there were two exceptional surveys when considerably larger numbers of birds, mainly waders and gulls, were present (Fig. 6).

Red-breasted Merganser

Table 7. The total number of birds recorded in the outer Tolka Estuary during seven low spring tide surveys between September 2013 and March 2016.

	Sep-13	Sep-14	Oct-14	Feb-15	Sep-15	Oct-15	Mar-16
Black Guillemot	0	0	1	0	0	6	3
Light-bellied Brent Goose	19	0	0	31	0	0	145
Wigeon	0	0	0	0	0	0	22
Goldeneye	0	0	0	0	0	0	7
Red-breasted Merganser	0	0	6	**28**	1	3	**24**
Great Northern Diver	0	0	0	0	0	0	1
Great Crested Grebe	0	0	8	5	0	39	2
Cormorant	0	17	50	6	14	10	12
Little Egret	0	1	3	0	3	0	0
Grey Heron	15	10	24	0	1	16	2
Oystercatcher	520	428	198	262	337	192	132
Golden Plover	0	32	490	1200	89	671	0
Grey Plover	4	3	12	14	2	25	26
Knot	0	113	200	**2950**	0	93	**542**
Sanderling	0	0	1	0	0	0	0
Dunlin	0	40	77	**2400**	13	82	**3074**
Black-tailed Godwit	3	**380**	**402**	120	0	0	75
Bar-tailed Godwit	**284**	**506**	**344**	**248**	**306**	**200**	**335**
Whimbrel	0	53	0	0	2	3	2
Curlew	81	172	119	249	162	122	298
Greenshank	0	0	0	0	1	0	0
Redshank	187	279	95	72	**345**	28	114
Turnstone	0	0	12	3	7	0	0
Black-headed Gull	590	799	815	3140	476	469	2816
Common Gull	120	162	178	304	97	90	1046
Lesser Black-backed Gull	1	30	12	5	3	0	1
Herring Gull	469	476	453	2130	1086	849	1173
Great Black-backed Gull	13	3	19	10	6	19	13
Common Tern	0	0	0	0	1	0	0

Figures in bold font refer to counts that exceeded the 1% national threshold (Crowe & Holt, 2013).

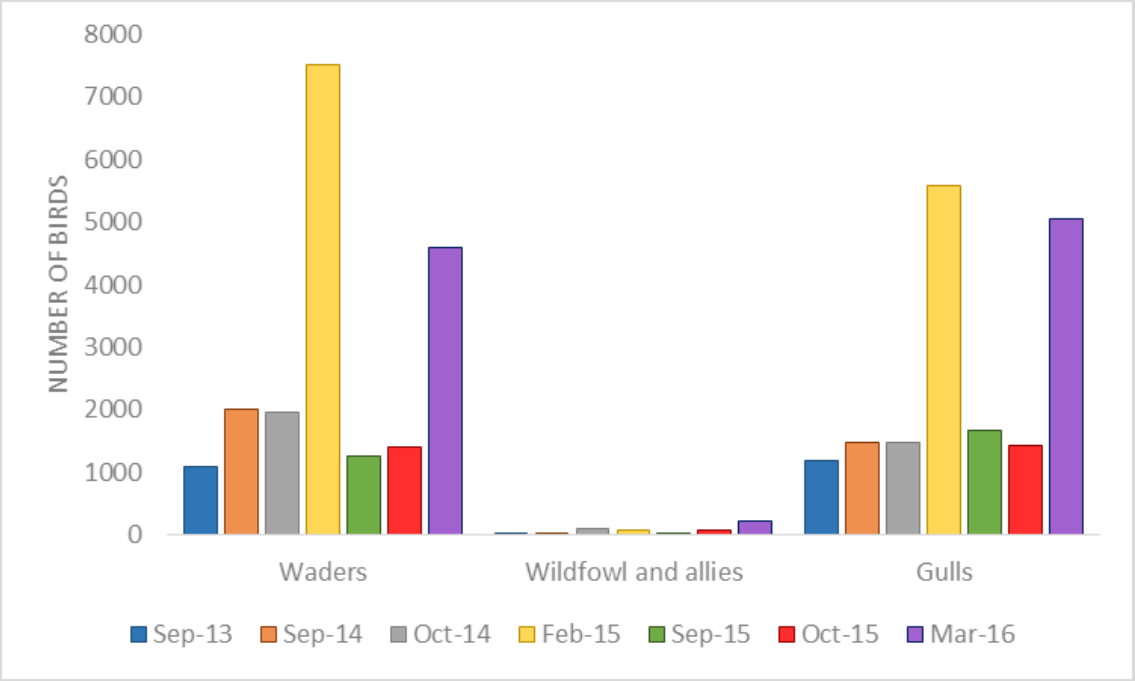


Figure 6. The number of waders, wildfowl (& allies) and gulls present in the outer Tolka Estuary, during seven low spring tide surveys between September 2013 and March 2016.

Breeding terns

Common and Arctic Terns arrive in Dublin Bay in May and egg-laying commences towards the end of the month. Most chicks fledge in July, but terns can remain in Dublin Bay in large numbers until the end of September. During this post-breeding period, they feed offshore and return to the coasts to roost on Sandymount Strand and Dollymount Strand at night.

Common Terns and Arctic Terns have been known to breed in the Dublin Port area since at least 1949 (Merne 2004), and their populations have been assessed a number of times between the 1950s and 1985. The first census of all coastal breeding seabirds in Britain and Ireland in 1969-70 (Cramp *et al*. 1974) reported 32 and 6 pairs of Common and Arctic Terns, respectively, in the Dublin Port area. In 1984, the All-Ireland Tern Survey recorded 61 pairs of Common Terns and 30 pairs of Arctic Terns at Dublin Port (Whilde 1985). During that survey, terns were recorded nesting at three locations: the oil terminal jetty at the North Wall, on reclaimed land on the East Wall and on a mooring dolphin at Poolbeg. There is little or no quantitative information on the terns between 1984 and when the National Parks and Wildlife Service commenced a conservation and research project in the Dublin Port area in 1994 (Merne 2004).

Each year since 1994, the breeding Common and Arctic Terns at Dublin Port have nested on two isolated mooring dolphins situated on the south side of the port (Merne 2004), with Common Terns almost exclusively on the ESB dolphin and Arctic Terns on the CDL dolphin. These dolphins are referred to here as the ESB (Electricity Supply Board) and CDL (Coal Distribution Ltd.) dolphins. The ESB dolphin comprises a wooden platform and a concrete one, which are connected by a gangway. This serves as the principal breeding site for Common Terns in Dublin Port and is included in the South Dublin Bay and River Tolka Estuary SPA. This dolphin has been managed to facilitate breeding terns since 1995,

when the nesting substrate was improved by adding a layer of gravel and chick shelters, and a wooden perimeter barrier was installed. Subsequent maintenance has been undertaken on several occasions, with the most recent modification occurring in spring 2014.

However, since 2014, there has been significant deterioration to the structural integrity of the dolphin. Due to this subsidence, it was deemed unsafe to alight on the wooden section of this dolphin in 2015 and 2016, and the wooden section was demolished on safety grounds after the 2016 breeding season. The CDL dolphin is regularly used for mooring ships, but in 2016 a wooden perimeter was affixed to the edge of the structure to prevent chicks from falling into the water when vessels were being secured. In 2013, a specially modified pontoon was floated in the Tolka Estuary and this structure (known as Pontoon No. 1) has been used by nesting terns in each year since deployment. Then, in 2015, a second, larger modified pontoon (Pontoon No. 2) was floated at the Great South Wall at Poolbeg. In spring 2016, it was relocated and was moored alongside the ESB dolphin for the duration of the breeding season. This means that there were four structures available for nesting terns within the port in 2016.

Monitoring of the Common and Arctic Tern colonies in Dublin Port has been undertaken each breeding season, by conducting an annual nest census (Table 8) and determining productivity (the number of chicks raised per egg-laying pair) (Fig. 7). In 2015, an additional project element was added; to individually identify Common and Arctic Tern chicks by colour-ringing, so that the movements of individual birds can be tracked from their natal structures to their breeding sites, when they recruit into the breeding population. Over several years, this will measure how the tern population responds to the deterioration and demolition (and restoration) of the ESB wooden platform and the presence of the new pontoons.

Table 8. The total number of Common and Arctic Tern nests at each of the breeding structures in the port in between 2013 and 2016.

	2013	**2014**	**2015**	**2016**
CDL	25	76	58	0
ESB concrete	39	60	59	78
ESB wooden	379	367	357	304
Pontoon No. 1	1	38	73	7
Pontoon No. 2	-	-	1	114
Total	444	541	548	503

Pontoon No. 1 has been located in the Tolka Estuary since its deployment in 2013. Pontoon No. 2 was deployed at the Great South Wall in 2015 and alongside the ESB Dolphin in 2016. Data for Pontoon No. 1 in 2013 and 2014 were provided by R. Nairn.

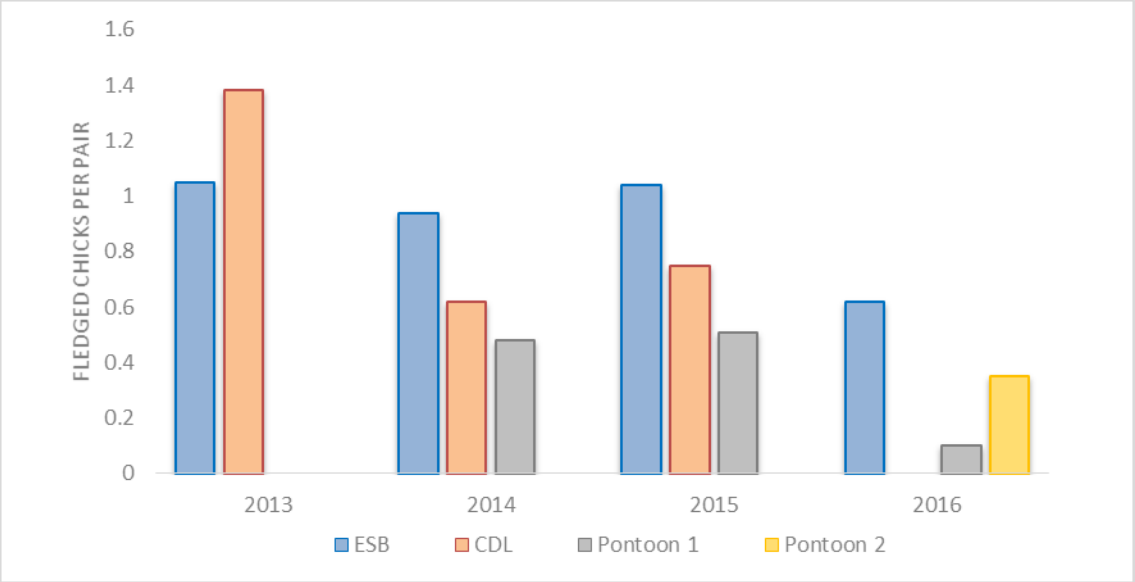


Figure 7. Estimated productivity at each of the breeding structures in Dublin Port and the Tolka Estuary between 2013 and 2016. Data for Pontoon 1 for 2013 and 2014 provided by R. Nairn. Data for the ESB Dolphin in 2016 refers only to the concrete platform. The 2016 estimate refers to the median point in the estimated range.

Productivity on the ESB dolphin had remained relatively stable since 2013, but decreased noticeably in 2016 (Fig. 7). Similarly, the productivity on Pontoon No. 1 was much lower in 2016 than in 2014 and 2015. Productivity on Pontoon No. 2 and the ESB dolphin in 2016 was consistent with the unusually low productivity recorded on Rockabill (Burke *et al*. 2016) and the Dalkey Islands (Butler *et al*. 2016), and seems to have been affected by the same factors as were active on those other colonies. However, it is not possible to ascertain the effects of the addition of the two new pontoons on the Dublin Port tern colony at this point. More work assessing nest numbers, productivity and the recruitment of colour-ringed birds is required over the coming years to determine whether these additions will serve to maintain the population at a suitable level until the installation and colonisation of the planned permanent nesting structure is built.

The very poor breeding performance on Pontoon No. 1, despite two positive seasons, underlines the fact that the long-term viability of these pontoons remains uncertain, and longer term monitoring is required to make an adequate assessment of their value to the colony. The productivity on the CDL dolphin was zero in 2015 and no eggs were laid in 2016, which means that no chicks were raised on that dolphin in either 2015 or 2016.

2.2.3 Sandymount Strand and Booterstown Marsh

This region comprises a substantial part of Dublin Bay. It includes all of the intertidal area in the south side of Dublin Bay and a portion of the adjacent shallow waters. The landward boundary is almost entirely artificially embanked. The Dublin/Wexford railway line runs along the southern half of the region and there is a promenade along most of the landward boundary. The northern boundary of this

region, the Poolbeg Peninsula and the Great South Wall comprises industrial land use and a promenade.

The intertidal flats on Sandymount Strand extend for almost 3 km at their widest. The sediments are predominantly well-aerated sands and are dissected by several permanent channels. Embryonic dune systems occur at Merrion Gates and Shellybanks Road, while some bedrock shore occurs near Dun Laoghaire.

Booterstown Marsh, an enclosed area of saltmarsh and muds with brackish water is also included. This area lies on the landward side of the Dublin/Wexford railway line, but is linked via Williamstown creek to the sea. The marsh contains two man-made islands, which serve as high tide roosting areas for waders.

The proximity of the region to Dublin city results in the strand and adjacent promenades being very popular for walkers, dog-walkers and water sport enthusiasts. While Booterstown Marsh is bounded on all sides (by a railway, a train station car park, a road and a footpath), the nature of the substrate means that the marsh itself is inaccessible to people.

General waterbird patterns of occurrence

At low tide, waders and gulls were widely distributed across Sandymount Strand. Some waders, notably Oystercatcher, Curlew and Redshank, were recorded foraging in nearby terrestrial areas. Most of the wildfowl that use this region were in Booterstown Marsh, but Brent Geese were regularly observed on the strand, especially in early winter. However, as the tide rises, the amount of intertidal foraging area is dramatically reduced and most of the birds were recorded roosting on the sand spit at Merrion Gates. Some species were recorded roosting on the islands in Booterstown Marsh. On spring high tides, or if the birds were disturbed at the Merrion Gates roost, some of the waders relocated to roost at the base of the sea wall in the vicinity of the Booterstown train station. The most notable difference in the bird numbers between low and rising tide surveys was found in the number in gulls. The two most numerous species, Herring Gull and Black-headed Gull, were twice as numerous during low tide counts compared to high tides.

This region supported the highest number of species, with more than 29 species recorded across all survey types in all months. The highest numbers of species were present between November and April (Table 9). For seabirds, the most species occurred during the breeding season, between April and September, when wader and wildfowl diversity was lowest. The diversity of waders and wildfowl increased when birds returned from their breeding grounds (most from September). The diversity of wader species was highest in November and wildfowl diversity was highest December and January.

Black-headed Gull

Table 9. The number of seabird, wader and wildfowl (and allies) species recorded at Sandymount Strand and Booterstown Marsh throughout the year.

	Seabirds		**Waders**		**Wildfowl & allies**		**All waterbirds and seabirds**	
	Low	*Rising*	*Low*	*Rising*	*Low*	*Rising*	*Low*	*Rising*
July	12	11	12	12	8	7	32	30
August	8	10	13	12	8	8	29	30
September	10	11	13	12	12	11	35	34
October	7	6	13	12	11	12	31	30
November	7	7	16	14	15	14	38	35
December	8	7	14	13	16	16	38	36
January	9	10	15	14	17	14	41	38
February	9	11	13	14	15	15	37	40
March	11	9	13	14	14	13	38	36
April	12	11	11	15	11	14	34	40
May	11	12	12	15	10	9	33	36
June	11	12	9	9	9	10	29	31

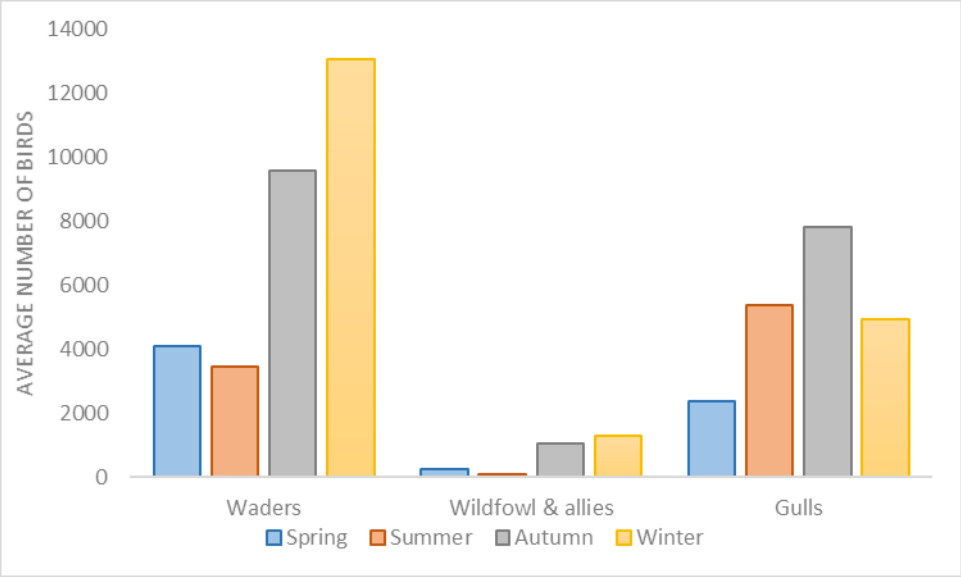


Figure 8. The average number of waders, wildfowl & allies and gulls present in Sandymount Strand and Booterstown during monthly low tide surveys throughout the year. [1] Spring = Mar, Apr, May; Summer = Jun, Jul, Aug; Autumn = Sep, Oct, Nov; Winter = Dec, Jan, Feb.

In general, the number of birds was lowest in spring and summer and highest in autumn and winter (Fig. 8). For waders, wildfowl and allies, the average number of birds was highest in winter, and lowest during spring and summer. Gull numbers were lowest in spring, built in the summer and peaked in the autumn.

Wildfowl and their allies

There is an important bed of Dwarf Eelgrass *Zostera noltii* near Merrion Gates upon which Brent Geese are known to forage, especially during the early winter period when this resource is plentiful (O Briain 1991). Offshore, nationally important numbers of Red-breasted Mergansers occurred in some mid-winter months, and Great Crested Grebes occurred in nationally important numbers throughout most of the autumn and winter, from September to February. At this time, this region supported almost 90% of the Dublin Bay total of this species.

Waders

This region was especially important for waders, both as a foraging and roosting area. Oystercatchers occurred in nationally important numbers from August through to February, and during this time 45% of the Dublin Bay total occurred on Sandymount Strand. Oystercatchers were present in this region throughout the year and an average of 445 (SE = 36) birds were present from March to July, when this region supports half of the summering Oystercatchers in Dublin Bay.

Sandymount Strand was particularly important for Ringed Plover *Charadrius hiaticula*, supporting almost 80% of the Dublin Bay total during the winter months. Ringed Plovers were recorded in nationally important numbers in August and October. Knot numbers on Sandymount Strand exceeded the threshold for national importance between November and March, and on these occasions, almost half (45%) of the Dublin Bay total were on Sandymount Strand. Sanderling occurred in nationally important numbers in six months between August and February, and Sandymount Strand was also important for the passage populations that spend time in Dublin Bay in May *en route* to their breeding grounds. The number of Dunlin in this region exceeded the threshold for national importance between

November and March. Black-tailed Godwits occurred in nationally important numbers in Booterstown Marsh in April, August, September and October (during the period when birds are moving to and from breeding grounds in Iceland). Bar-tailed Godwits occurred in nationally important numbers throughout the non-breeding season, from August to March, and Sandymount Strand supports about 40% of the Dublin Bay total during this period.

Gulls

Sandymount Strand was particularly important for gulls, for both daytime foraging and night time roosting. Mediterranean Gulls were found almost exclusively in this region of Dublin Bay and occurred on Sandymount Strand in each month of the year. Sandymount Strand was important for Lesser Black-backed Gulls, supporting greater than 50% of the Dublin Bay total in most months. Herrings Gull occurred on Sandymount Strand in all months of the year, with numbers much higher during low tides. There were between twice as many and fifteen times as many Herring Gulls on Sandymount Strand during low tides compared to high tides.

As most of the gull species in Dublin Bay have a tendency to forage in inland areas during the day and roost on the coast at night, dedicated dusk roost surveys are required to determine the number of gulls that use Dublin Bay. Each February between 2014 and 2016, dedicated *Gull Roost Surveys* were carried out to determine the number of gulls using Dublin Bay at night. During Gull Roost Surveys, all gulls were counted as they arrived at the coast from inland areas. Sandymont Strand was found to be the most important roosting area in Dublin Bay and supporteed six species, namely Black-headed, Common, Great Black-backed, Herring, Lesser Black-backed and Mediterranean Gull. The average number of gulls that was recorded during these surveys on Sandymount Strand between 2013 and 2016 is 13,237 (SE = 1,559), which is considerably greater than the totals from the daytime surveys (Fig. 8).

Post-breeding terns

The expansive sandflats on Sandymount Strand serve as a post-breeding staging site for Roseate, Common and Arctic Terns. This phenomenon was first noted in 1959 (Merne *et al*. 2008) and dedicated dusk counts have taken place sporadically since then. Merne (2010) reported an average of 2,845 terns in the 2010, Merne *et al*. (2008) reported averages of 3,868 and 2,344 terns in 2006 and 2007, and an average of 1,230 was recorded between 2002 and 2004. In 1998 and 1999, Newton & Crowe (1999) recorded total counts of 2,000 and 5,040 terns.

Typically, the number of terns using Sandymount Strand builds from late July onwards when birds disperse from the breeding colonies. There are roosting terns present on Sandymount Strand for up to two months each year, building reserves for migration and commencing their moult (Cabot and Nisbet 2013, Ginn and Melville 1983). Five species of tern, namely Black Tern *Chlidonias niger*, Sandwich Tern *Sterna sandvicensis*, Common Tern, Roseate Tern and Arctic Tern have been recorded regularly, and Little Terns *Sternula albifrons* have been reported occasionally. This staging site is especially important as there are only a small number of other such sites in the Irish Sea, in the southeast of Ireland close to the Lady's Island Lake Tern colony in Wexford, and on the west coast of England at Seaforth, near Liverpool.

During this project, peaks of 6,645 in 2013, 2,264 in 2014, 4,035 in 2015 and 17,440 terns in 2016 were recorded (Tierney *et al*. 2016b). The peak number of terns recorded in (August) 2016 is the second highest total ever recorded at the site. However, it is not known whether such large accumulations

occur annually but remain undetected. Perhaps the aggregation of this number of terns is a much rarer, short-lived event, like the estimated 20,000 to 30,000 terns that were reported on the 31st August, 1996 (Newton & Crowe, 1999).

This post-breeding roost is located within c.30km of three breeding colonies Rockabill (Common, Roseate and Arctic Terns), Dublin Port (Common and Arctic Terns) and the Dalkey Islands (Common, Roseate and Arctic Terns) and many of the terns that occur in the Sandymount roost are thought to originate from these breeding colonies. But there is evidence that some of the birds using the roost are coming from further afield than these Dublin colonies. Captures (for ringing) of ringed birds at the roost and re-sightings of colour-ringed birds that use the roost breed in Norway, Scotland, Wales and Northern Ireland (N. Tierney, unpublished data).

Common Terns

2.2.4 Coastal grasslands

Amenity grassland, in the form of parks, pitches and golf courses, are used by foraging gulls and waterbirds. While a comprehensive survey or the amenity grassland in the vicinity of Dublin Bay was beyond the scope of this project, two terrestrial areas, namely *Sean Moore Park* in Irishtown and the *Compensatory Grassland* in Ringsend, were included in low and rising tide surveys. Their immediate proximity to the coast meant that they could easily be incorporated into the regular surveys being undertaken.

The Compensatory Grassland is also referred to as *Goose Green* and the *Dublin City Council Brent Field Ringsend* (Benson 2009). This 2 ha area of grassland lies between the Ringsend Waste Water Treatment Plant and Irishtown Nature Park. It is included in the South Dublin Bay and River Tolka Estuary SPA. It is managed by Dublin City Council to accommodate foraging waterbirds.

Sean Moore Park is located at the northern end of Sandymount Strand at the base of the Poolbeg Peninsula. This 8 ha park comprises two football pitches with several tree-lined paths running alongside.

General waterbird patterns of occurrence

Both areas are popular for walkers and dog-walkers and the pitches in Sean Moore Park are regularly used. This 'survey region' is much smaller than the other regions in Dublin Bay. It supports the lowest number of species, with fewer than ten species being recorded across all survey types in all months (Table 10). For seabirds, which were mainly gulls, the highest number of species occurred during the winter months. The number of wader and wildfowl (and their allies) species using the parks was also highest in the winter months.

Table 10. The number of seabird, wader and wildfowl (and allies) species recorded at the coastal grasslands throughout the year.

	Seabirds		**Waders**		**Wildfowl & allies**		**All waterbirds and seabirds**	
	Low	*Rising*	*Low*	*Rising*	*Low*	*Rising*	*Low*	*Rising*
July	1	1	4	4	1	1	6	6
August	2	3	2	3	1	1	5	7
September	0	1	0	0	1	2	1	3
October	0	0	1	0	0	0	1	0
November	0	0	0	0	0	0	0	0
December	1	0	0	0	0	0	1	0
January	5	0	2	0	2	0	9	0
February	0	0	0	0	0	0	0	0
March	0	0	1	1	0	0	1	1
April	0	0	0	0	0	0	0	0
May	1	0	1	4	2	2	4	6
June	0	2	3	3	1	1	4	6

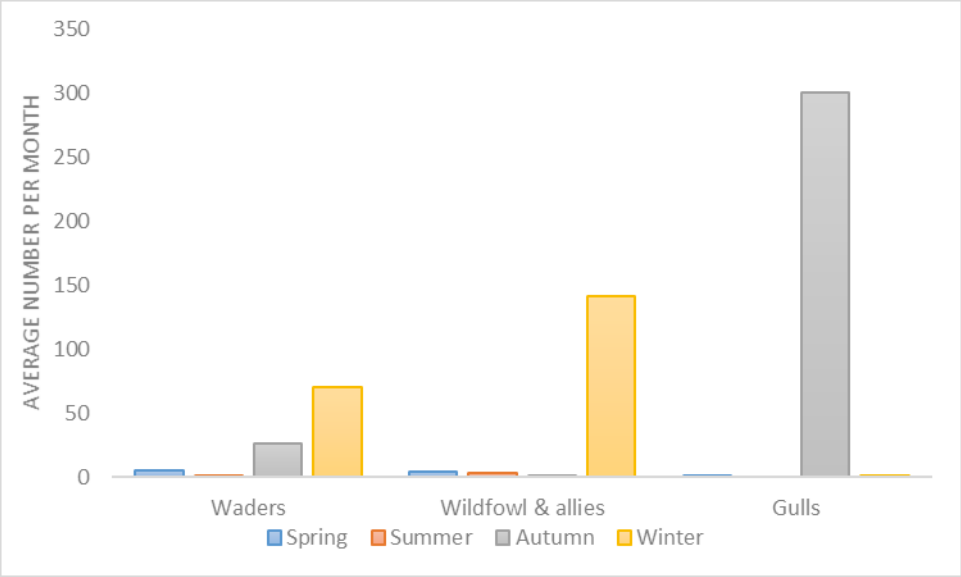


Figure 9. The average number of waders, wildfowl & allies and gulls present on the coastal grasslands surveyed during monthly low tide surveys throughout the year. [1] Spring = Mar, Apr, May; Summer = Jun, Jul, Aug; Autumn = Sep, Oct, Nov; Winter = Dec, Jan, Feb.

The number of birds using these grasslands was lowest in spring and summer and highest in autumn and winter (Fig. 9). For waders and wildfowl (and their allies), the average number of birds was highest in winter, and lowest during spring and summer. Gull numbers were highest in autumn. These grasslands were used by foraging Brent Geese from November to March. While the geese feed almost exclusively in intertidal areas on arrival in September and October, as winter progresses their diet comprises an increasing proportion of terrestrial grass (Inger *et al.* 2006).

The Brent Geese in Dublin have been exploiting man-made habitats in the form of amenity grasslands since the 1980s (O'Briain & Healy 1991). Benson (2009) listed 60 inland feeding sites in Dublin, noting that the number of these areas used by foraging geese increased by a factor of six in the ten years prior to the 2008/09 winter.

These grasslands were also used by foraging waders and gulls, with Oystercatchers and Redshanks, and Black-headed Gulls and Herring Gulls being the most numerous and frequent.

3. Selected species and species research

3.1 Species that occur in internationally important numbers

Three species, namely Brent Goose, Black-tailed Godwit and Bar-tailed Godwit occur in internationally important numbers and exceed their respective thresholds in several months of the year (Table 2), largely throughout the mid-winter period.

Brent Geese in Dublin

Brent Geese generally begin to arrive each winter during September, with numbers in single figures or tens of birds. During October, the numbers build considerably and exceed the threshold for international importance (Fig. 10). Numbers remain above this threshold until the geese leave Dublin Bay in April.

The numbers recorded during coastal low and rising tide surveys in late winter are likely to underestimate the true total, as there is a shift in their dietary preferences during the winter. On arrival, the geese feed almost exclusively on sea grass *Zostera* spp. in intertidal areas. During mid-winter, their diet contains green algae *Ulva spp.*, but terrestrial grass comprises an increasing proportion of the diet as the winter progresses, and by April, the birds are almost exclusively feeding on grass in areas of amenity grassland (Inger *et al*. 2006).

Brent Geese have been observed feeding on spilled agricultural products on the quay walls at Alexandra Basin within Dublin Port (Tierney *et al*. 2016a). The number of geese observed generally ranged from 2 to 40, but on 14 occasions there were greater than 100 geese present. A peak count of 465 geese was recorded in January 2014. It is not currently known whether this development is a result of a shortage of (more) natural foraging resources, or if capitalising on this processed food source, relatively close to the main roost (*c*. 5 km away at Bull Island), is a more efficient way of meeting calorific requirements.

The majority of Brent Geese occur in the Bull Island and Dollymount Strand region during autumn, winter and spring, but the Tolka Estuary is also important during spring (Fig. 11).

Black-tailed Godwits in Dublin

Black-tailed Godwits feed on a range of invertebrates, including bivalves and polychaete worms and prefer to feed in muddier regions. The earliest arrivals in Dublin Bay occur in June, but the majority of these waders arrive in August, and numbers then build until October (Fig. 10). By November, the numbers drop as the birds on passage migration have moved on to winter in Iberia and northwestern Africa. There is a slight rise and fall in numbers before and after the mid-winter period, which is followed by a distinct increase during March and April, which probably reflects passage birds moving northwards through Ireland on their way back to their breeding grounds in Iceland. This was particularly notable on the inner Tolka Estuary (Fig. 11), where March and April numbers are higher than at any other time of the year.

Bar-tailed Godwits in Dublin

Bar-tailed Godwits are entirely coastal on their wintering grounds and prefer sandy estuaries, where they feed along the tidal edge (del Hoyo *et al.* 1996). They occur throughout Dublin Bay on Bull Island and Dollymount Strand, on the outer Tolka Estuary and on Sandymount Strand. Their diet consists of polychaete worms, such as lugworms *Arenicola marina*, Catworms *Nephtys* spp., and bivalves (Diujns *et al.* 2003).

Bar-tailed Godwit numbers build steadily from July and peak in December. The numbers then drop in the early part of the year as birds move to staging grounds on the Wadden Sea coast before travelling onwards to their breeding grounds in high-arctic Scandinavia and Russia (Wernham *et al*. 2002).

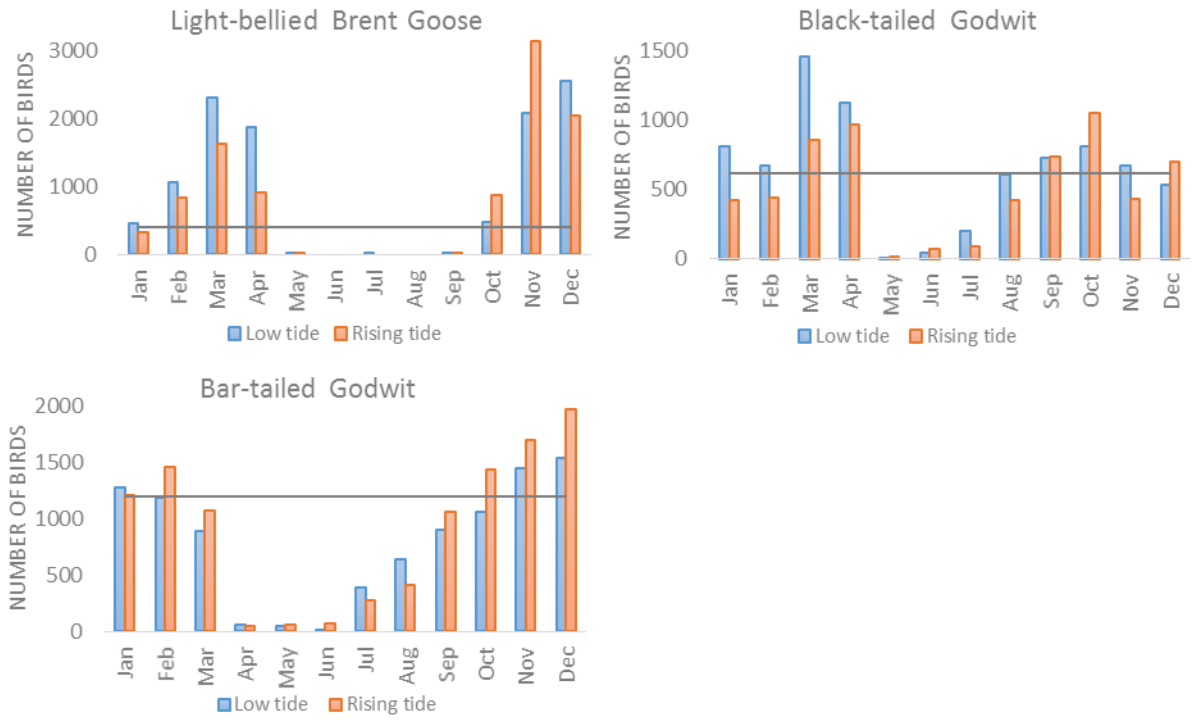


Figure 10. The number of Brent Geese, Black-tailed Godwits and Bar-tailed Godwits in Dublin Bay during monthly low and rising tide surveys between July 2013 and June 2016. The grey line represents the threshold for international importance (Wetlands International 2017).

3.2 Species that occur in nationally important numbers

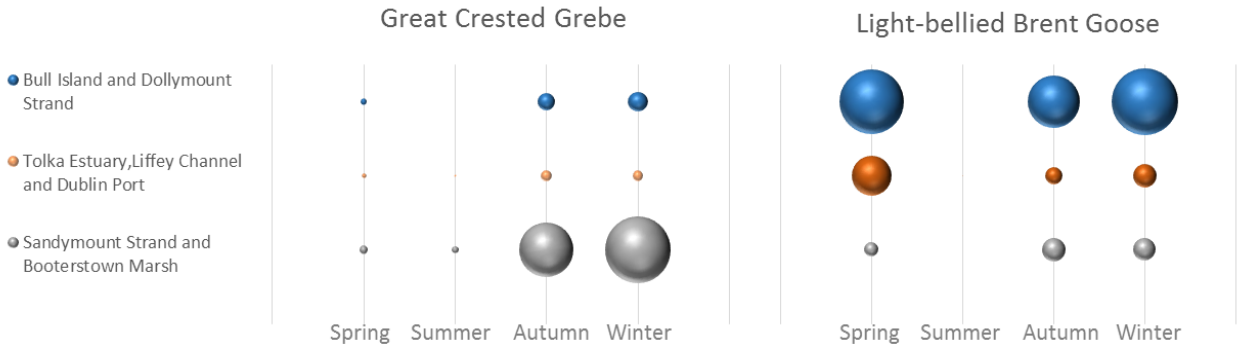
Twenty-three species occurred in nationally important numbers in Dublin Bay during this project. For each of these species, the changes in seasonal abundance and regional distribution (across three broad regions) throughout the year are presented in Figure 11. In these graphs, the size of the bubble represents the proportion of the Dublin Bay total. Comparing the bubble sizes horizontally shows how

the number of birds in each region changes throughout the year. Comparing the bubble sizes vertically shows how the total number of birds in Dublin Bay are distributed throughout the bay during each season.

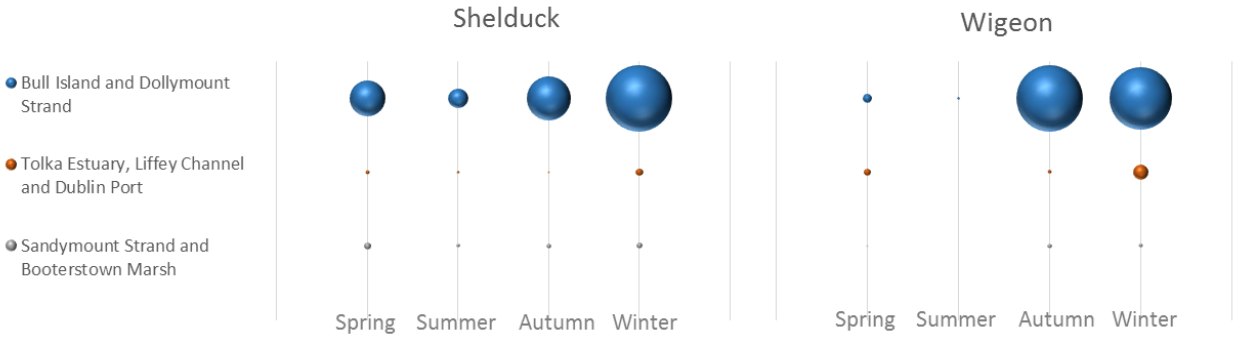
The abundance of these species various greatly according to the time of the year, and for some species, usage of the regions within Dublin Bay varies seasonally. Certain species occurred almost exclusively in a single region throughout the year. Distinct patterns are described as follows:

- Shelduck, Wigeon, Teal, Pintail and Shoveler occurred almost exclusively in the North Bull Island and Dollymount Strand region.
- Black-tailed Godwits showed a seasonal pattern in their usage of the three regions within Dublin Bay. During autumn, the majority of the birds forage in the Bull Island region. However, during the spring, the majority of the birds were recorded foraging in the Tolka Estuary.
- Bar-tailed Godwit distribution also changed as the season progressed. During the autumn, highest numbers were in the Tolka Estuary, but by winter the majority of the birds were on Sandymount Strand.
- For other species, such as Oystercatcher and Curlew, birds were present in each region throughout the year, and their numbers in each region changed in line with changes in the total number of birds in Dublin Bay.

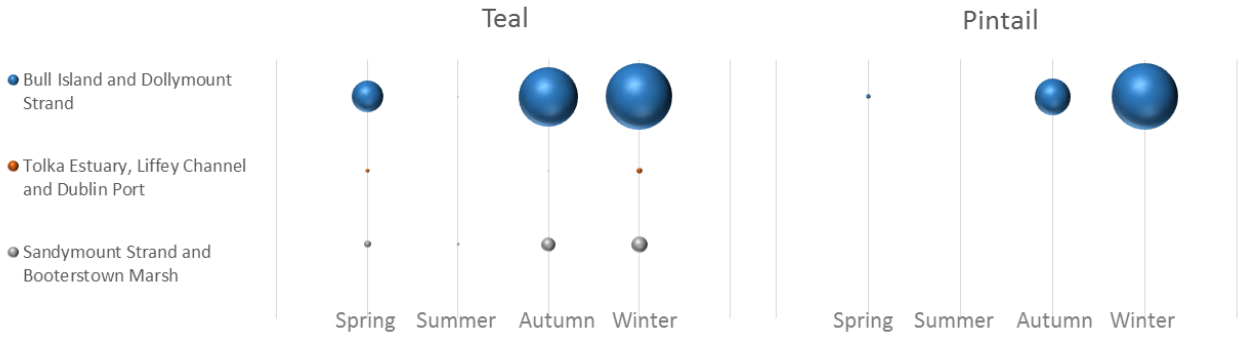
Sanderling


Great Crested Grebe
Bull Island and Dollymount Strand
Tolka Estuary,Liffey Channel and Dublin Port
Sandymount Strand and Booterstown Marsh
Spring
Summer
Autumn
Winter

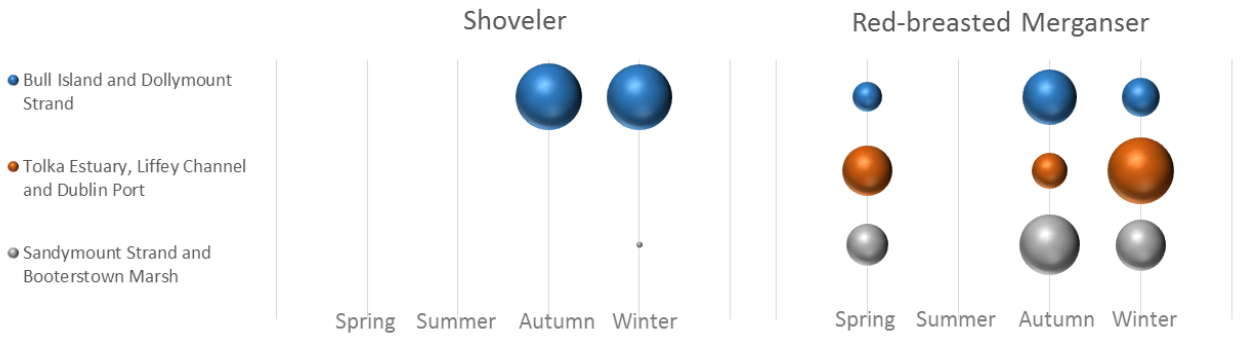
Light-bellied Brent Goose
Spring
Summer
Autumn
Winter


Shelduck
Bull Island and Dollymount Strand
Tolka Estuary, Liffey Channel and Dublin Port
Sandymount Strand and Booterstown Marsh
Spring
Summer
Autumn
Winter

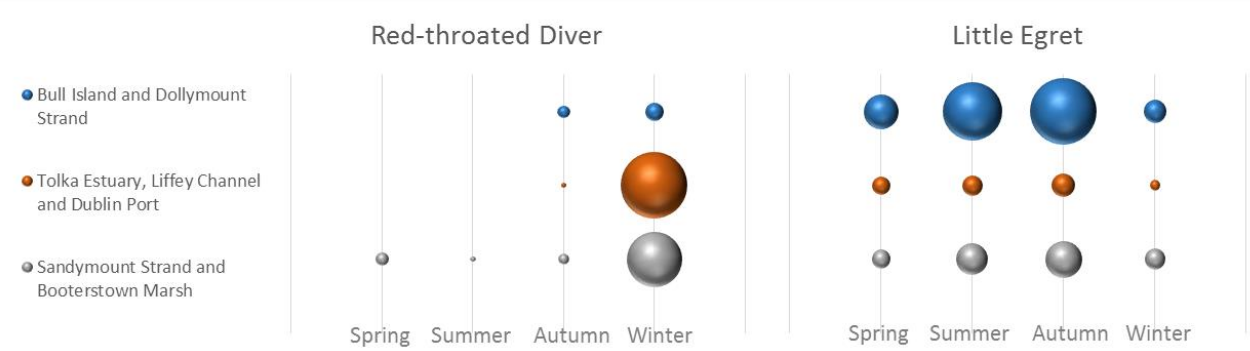
Wigeon
Spring
Summer
Autumn
Winter


Teal
Bull Island and Dollymount Strand
Tolka Estuary, Liffey Channel and Dublin Port
Sandymount Strand and Booterstown Marsh
Spring
Summer
Autumn
Winter

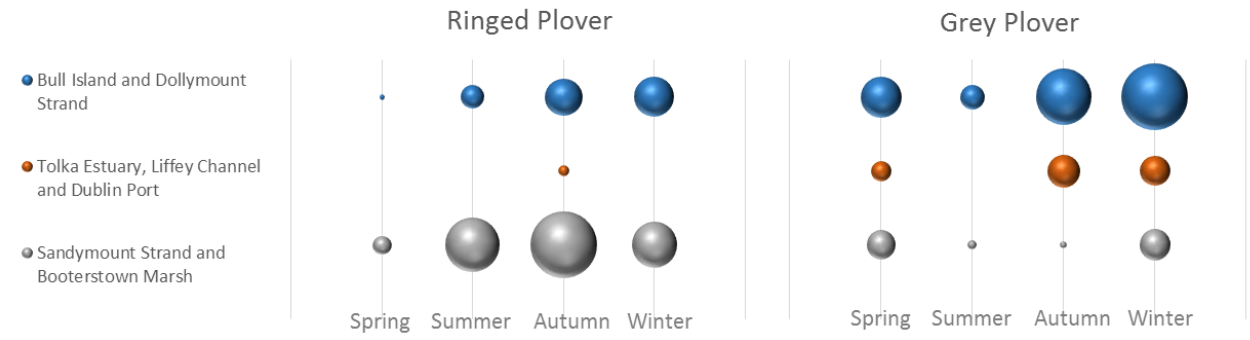
Pintail
Spring
Summer
Autumn
Winter


Shoveler
Bull Island and Dollymount Strand
Tolka Estuary, Liffey Channel and Dublin Port
Sandymount Strand and Booterstown Marsh
Spring
Summer
Autumn
Winter

Red-breasted Merganser
Spring
Summer
Autumn
Winter


Red-throated Diver
Little Egret
Bull Island and Dollymount Strand
Tolka Estuary, Liffey Channel and Dublin Port
Sandymount Strand and Booterstown Marsh
Spring
Summer
Autumn
Winter


Grey Heron
Oystercatcher
Bull Island and Dollymount Strand
Tolka Estuary, Liffey Channel and Dublin Port
Sandymount Strand and Booterstown Marsh
Spring
Summer
Autumn
Winter


Ringed Plover
Grey Plover
Bull Island and Dollymount Strand
Tolka Estuary, Liffey Channel and Dublin Port
Sandymount Strand and Booterstown Marsh
Spring
Summer
Autumn
Winter

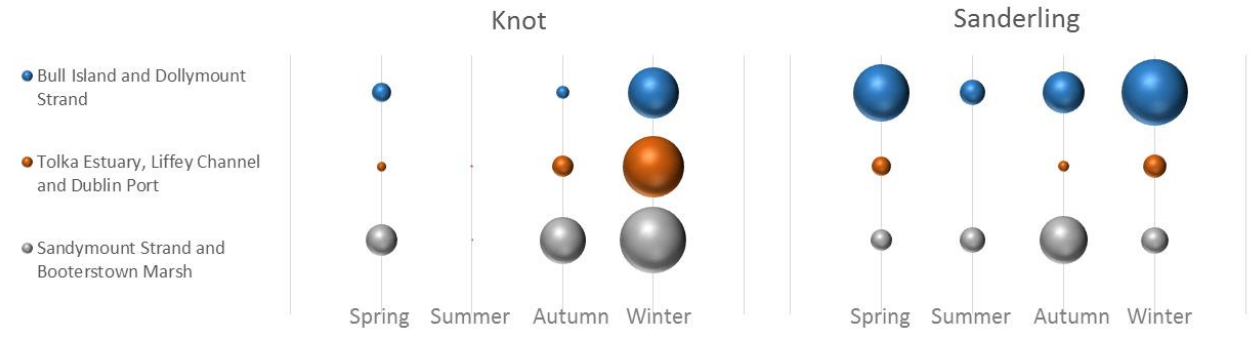

Knot
Sanderling
Bull Island and Dollymount Strand
Tolka Estuary, Liffey Channel and Dublin Port
Sandymount Strand and Booterstown Marsh
Spring
Summer
Autumn
Winter

Figure 11. Seasonal abundance and regional use of Dublin Bay for the 23 species that occur in nationally important numbers.

[1] Each bubble represents the proportion of the Dublin Bay total for that species in each region that season. The value for each season is the average of the low tide three-year monthly means for the three months of that season. Spring = Mar, Apr, May; Summer = Jun, Jul, Aug; Autumn = Sep, Oct, Nov; Winter = Dec, Jan, Feb. Comparing the bubble sizes horizontally shows how the number of birds in the region changes throughout the year. Comparing the bubble sizes vertically shows how the total number of birds in Dublin Bay are distributed throughout the Bay during each season. Bubble sizes cannot be compared between species.

3.3 Colour-ringing and radio-tracking

Oystercatcher, Bar-tailed Godwit and Redshank were chosen as target species for in-depth research during this project, which involved assessing local and long-distance movements of birds at the individual level. Further details about the ecology of these species is presented below. These species were selected for further detailed studies during this project on the basis of:

1. Their conservation status: they occur in numbers of national or international importance within Dublin Bay, are listed as Features of Interest in both of the SPAs, and they are Amber-listed on the Birds of Conservation Concern list for Ireland (Colhoun & Cummins 2013).
2. Their distribution and status: these species are numerous and widespread in the bay, meaning that sufficient sample sizes are available for capture and tracking.
3. All three species are known to use the intertidal habitats within the greater Tolka area, thereby allowing detailed studies of their movements within this especially busy region of Dublin Bay.

All three species were successfully captured in a number of catches, and a sample of individuals was fitted with colour rings to enable further follow up, in order to facilitate wider exploration of the life history traits of individual birds over time. Each individual was fitted with conspicuous, light-weight uniquely numbered ring that can be read in the field. This allows multiple observations of individual birds, with minimum disturbance to their behaviour. This approach facilitates the investigation of within and between season movements, the linking of wintering areas with breeding sites, and an assessment of longevity and annual survival rate.

However, with colour-ringing, the location of birds can only be determined when the bird is in a suitable location (i.e. not standing in water or with the rings obscured by vegetation), within telescope range, and when light conditions are optimal. Therefore, and in addition to the ringing, a sample of 21 birds, including some from each of the three target species, was radio-tracked to ascertain how these birds use the bay, by day and by night. This allowed the movements of individual birds to be tracked at various tidal stages and through the day and the night. But because radio-telemetry is limited to manual detection via receivers, the outputs are available at a relatively local (Dublin Bay) scale, and fixes are limited to periods when the observers were on site. The results below are based on the 11 individuals that were caught and tracked between January and April 2014.

Further and specific details about the catches are presented in the three annual technical reports. The overall results of detailed and dedicated ring-reading and tracking sessions undertaken across the three winters are summarised below.

3.3.1 Oystercatcher

Oystercatchers breed widely along coasts in northwestern Europe and winter on estuarine mudflats, saltmarshes and sandy and rocky shores. Irish-breeding birds are joined by immigrants from Iceland, Scotland, The Faroe Islands and Norway in winter (Wernham *et al*. 2002).

Oystercatchers are present in Dublin Bay in numbers of national importance in all months of the year, although numbers during the winter are much higher. They are widely distributed throughout Dublin Bay, occurring in each of three regions in each month of the year (Fig. 11). There is an influx of birds during August and September and these levels are sustained throughout the winter, before the birds return to their breeding areas during March.

Oystercatchers are known to reach sexual maturity at three years old, but most do not breed until much later, after their sixth year (Ens *et al*. 1996). Many immature birds spend their first three years away from their natal areas (Goss-Custard *et al*. 1982), so the summering birds in Dublin Bay are likely to be non-breeding, immature birds. Their diet includes bivalves, gastropods, polychaetes worms, crustaceans and molluscs (del Hoyo *et al.* 1996). Foraging is not confined to coastal habitats, and Oystercatchers prey on earthworms and insect larvae on terrestrial grasslands (del Hoyo *et al.* 1996), and during this project, several ringed individuals were reported in nearby grasslands.

The main threat to Oystercatcher is the overexploitation of the benthic shellfish on which they rely (Atkinson *et al.* 2003, Verhulst *et al.* 2004, Ens 2006, van de Pol *et al*. 2014). Bait digging has also been identified as a threat, through loss of prey species and disturbance to the benthic fauna (van de Pol *et al*. 2014). Other threats to Oystercatchers include land reclamation for industrial development (Melville *et al*. 2014), pollution, human disturbance (Burton *et al.* 2002b, Phalan & Nairn 2007, van de Pol *et al*. 2014) and coastal barrage construction (Burton 2006).

A total of 343 Oystercatchers were captured and ringed between February 2013 and November 2014, and a sub-sample of 263 were also colour-ringed. There have been over 2,000 re-sightings of these birds, with 1,972 coming from Dublin Bay, 18 from outside Dublin Bay and 65 from outside Ireland (Fig. 12). These re-sightings account for 254 individual birds, and 29 of these have been re-sighted outside Ireland on at least one occasion. Re-sightings were reported from Iceland (6 individuals), the Faroe Islands (2), Scotland (20) and Norway (1). As there is a sufficient number of re-sightings of the colour-ringed birds, annual survival rates for adult Oystercatchers can be calculated for Dublin Bay (Tierney *et al*. in prep). Survival (or conversely, mortality) is a key parameter in a bird's life-history. Estimates of annual survival rate for Oystercatchers wintering in Dublin Bay, in conjunction with ongoing monitoring (counts) will help to ascertain the drivers of population change and also inform on the health of the shellfish populations on which they depend.

The results of the radio-tracking (Fig. 13) revealed that of the four individuals that were caught in January 2014 and tracked during February and March 2014, three were highly faithful to Sandymount Strand at high tide and low tide, by day and at night. The sample of records from the remaining (fourth) individual was too low thereby preventing its inclusion in the analysis.

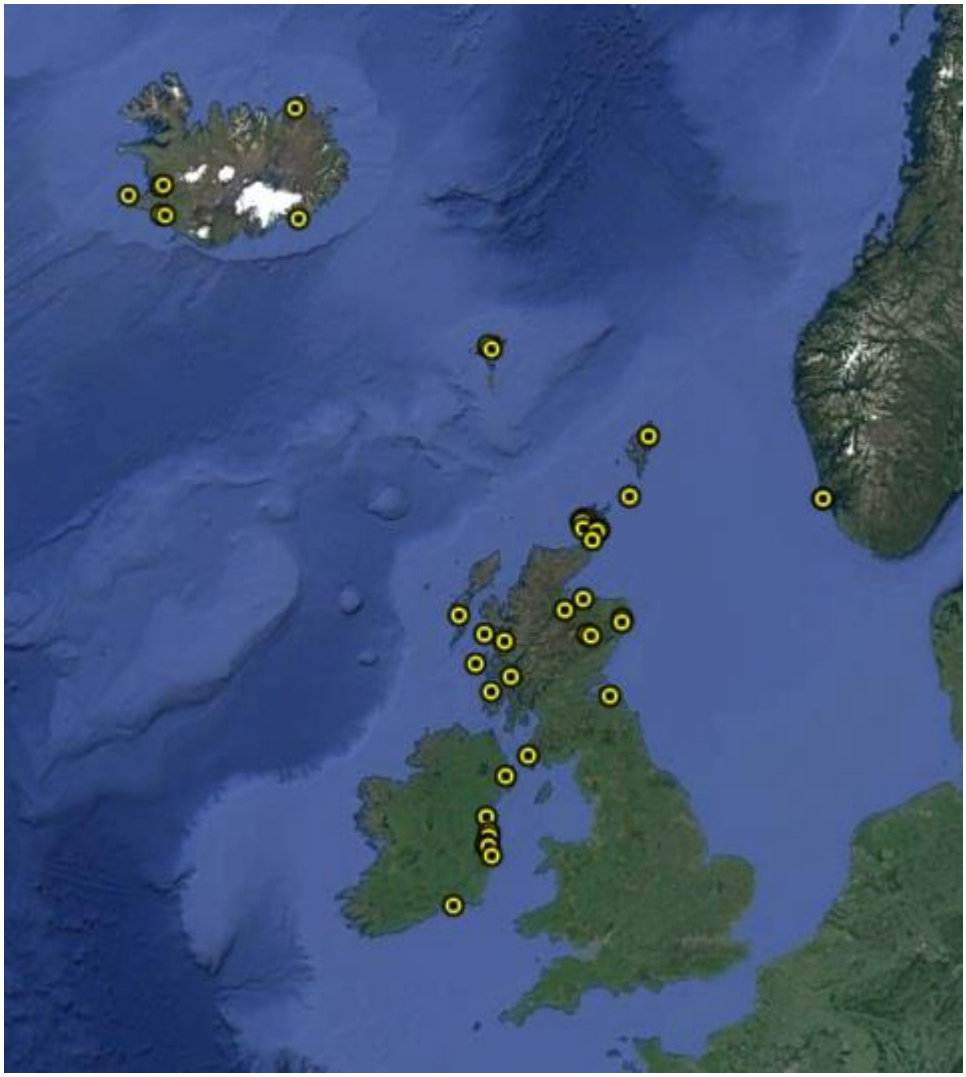


Figure 12. Re-sighting locations for Dublin-ringed Oystercatchers outside Dublin Bay between February 2013 and December 2016.

Oystercatcher

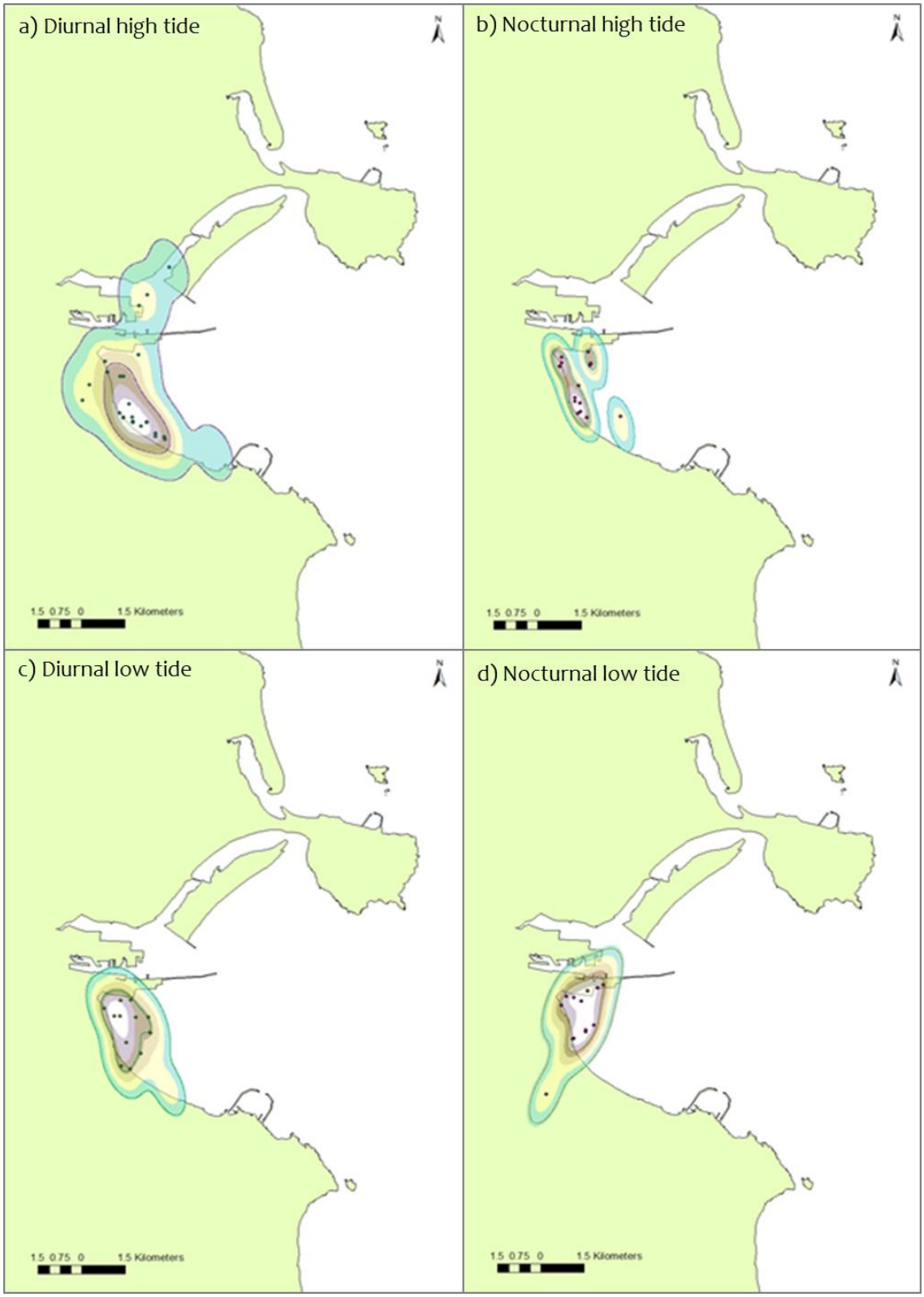


Figure 13. The radio-locations and estimated home ranges of three Oystercatchers (captured on the Merrion spit) between 29th January and 25th April, 2014 in four conditions: a) high tide by day, b)

high tide at night, c) low tide by day and d) low tide at night. The points represent the approximate location of individual birds. The inner line, the 50% volume contour, indicates the core area used by the birds and the outer line (95% volume contour), their home range (Worton 1989).

3.3.2 Bar-tailed Godwit

Bar-tailed Godwits do not breed in Ireland, but small numbers of immature birds spend the summer in Dublin Bay (< 50 birds on average). Those that spend the winter here breed in northern Fennoscandia, the Kola Peninsula to western Siberia and the Taimyr Peninsula (Wernham *et al*. 2002). Bar-tailed Godwits are entirely coastal on their wintering grounds, preferring the sandier parts of estuaries, where they feed along the tidal edge (del Hoyo *et al.* 1996). Their diet consists of polychaete worms, such as lugworms *Arenicola marina* and ragworms *Hediste diversicolor*, bivalves and crustaceans (Djuins *et al.* 2003).

They occur throughout Dublin Bay, where numbers build steadily from July and peak in December (Figure 10). They occur in internationally important numbers (>1,200) from October to February and in nationally important numbers (> 150) in all other months beginning in July and running up to March. Their numbers drop in the early part of the year as birds move to staging grounds on the Wadden Sea coast, before travelling onwards to their breeding grounds in high-arctic Scandinavia and Russia (Wernham *et al*. 2002).

The species is threatened by the degradation of foraging sites, pollution and human disturbance (del Hoyo *et al.* 1996, Kelin & Qiang 2006). Development, in the form of reclamation of intertidal areas, is considered a significant threat. Loss of intertidal stopover habitats due to reclamation activities in the Yellow Sea region of the East Asian-Australasian Flyway is thought to be driving declines in wader populations, including Bar-tailed Godwit (Amano *et al*. 2010, Yang *et al*. 2011, Leyrer *et al*. 2014).

A total of 470 Bar-tailed Godwits was captured and ringed in February 2014, and a sub-sample of 99 of these was also colour-ringed. There have been 239 re-sightings of these birds, with 226 coming from Dublin Bay, and 13 from outside Ireland (Fig. 14). These re-sightings account for 66 individual birds, and 5 of these have been re-sighted outside Ireland on at least one occasion. Four birds have been re-sighted in the Netherlands, and one bird was re-sighted in Denmark, and at two different locations in Norway (Figure 14).

Radio-tracking revealed that the four individuals tracked during February and March 2014 ranged widely within Dublin Bay. All of the tagged birds were captured while roosting at Merrion Gates on Sandymount Strand, but subsequently roosted on Sandymount Strand and in both of the Bull Island lagoons. The birds foraged at various locations in Dublin Bay (Figure 15). Two of the birds were located in the north lagoon of Bull Island at night, but were not recorded there during the day.

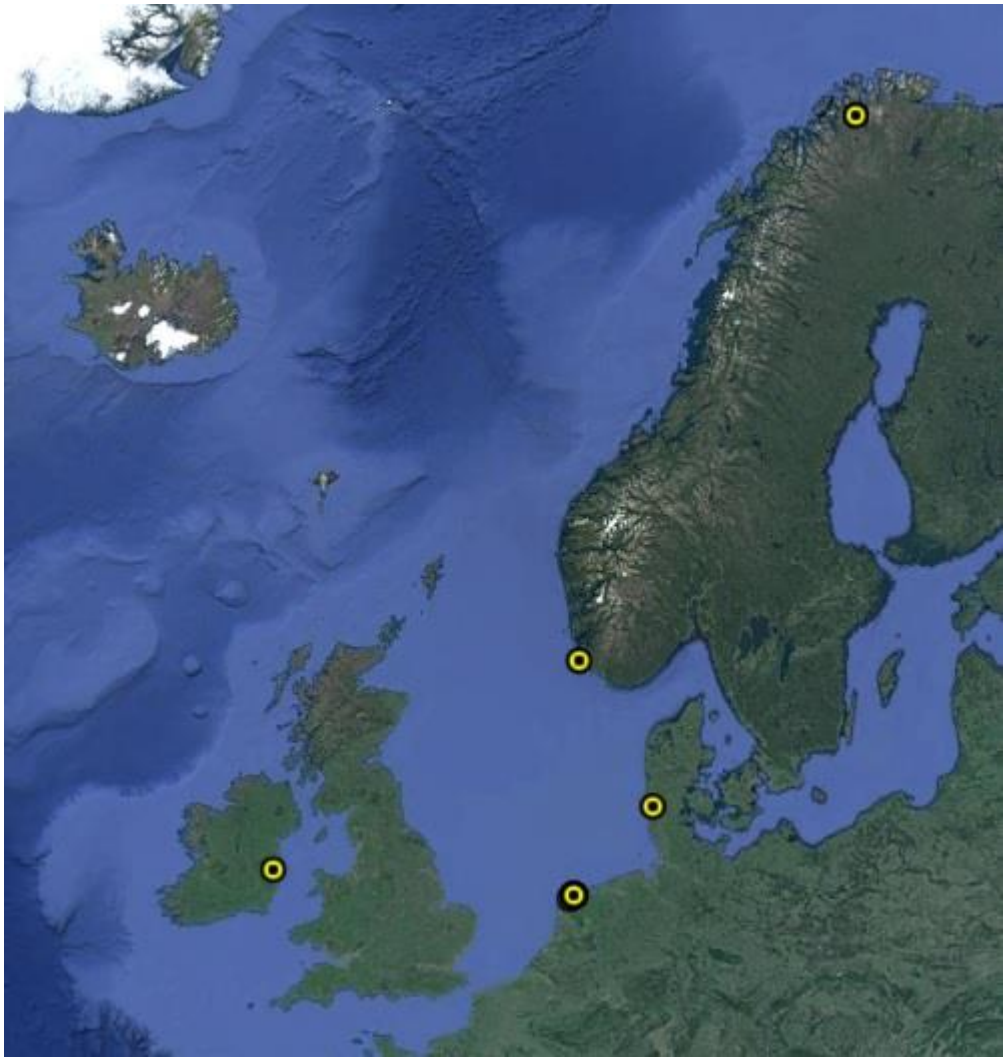


Figure 14. Re-sighting locations for Dublin-ringed Bar-tailed Godwits outside Dublin Bay between January 2014 and December 2016.

Bar-tailed Godwit

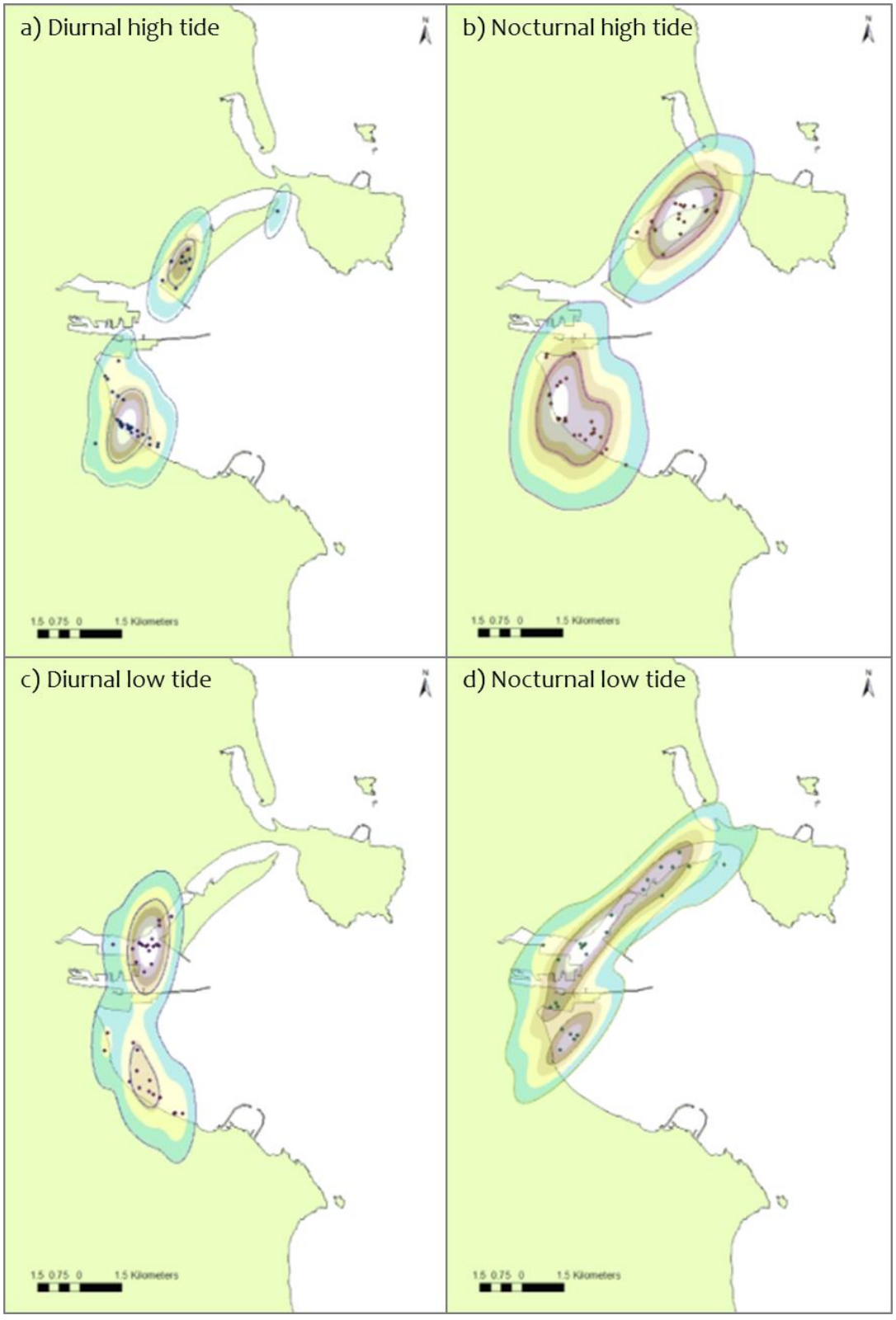


Figure 15. The radio-locations and estimated home ranges of four Bar-tailed Godwits (captured on the Merrion spit) between 29th January and 25th April, 2014 in four conditions: a) high tide by day, b)

high tide at night, c) low tide by day and d) low tide at night. The points represent the approximate location of individual birds. The inner line, the 50% volume contour, indicates the core area used by the birds and the outer line (95% volume contour), their home range (Worton 1989).

3.3.3 Redshank

Redshanks breed on saltmarshes and in inland wet grasslands, but are largely coastal in winter (Prater 1981). Wintering areas include rocky, muddy and sandy beaches, saltmarshes, tidal mudflats, coastal lagoons and estuaries (del Hoyo *et al.* 1996). It is thought that many of the Irish-breeding population remain in Ireland during the winter, and the numbers are swelled by an influx from Iceland (Wernham 2002). The number of Redshank in Dublin Bay increases from July onwards with numbers peaking in October as Redshank stage in Dublin Bay on the way to other wintering grounds. The number of birds increases again during February and March as Dublin Bay hosts staging birds *en route* northwards to breeding grounds in Iceland. Single numbers or tens of birds occur in Dublin Bay during May and June. During the winter, Redshank diet consists of insects, spiders and annelid worms as well as molluscs, crustaceans and occasionally small fish (del Hoyo *et al.* 1996).

Threats to Redshank include loss of habitat associated, industrial development and land reclamation (del Hoyo *et al.* 1996), encroachment of Cordgrass *Spartina* spp on mudflats (Evans 1986), coastal barrage construction (Burton 2006), disturbance on intertidal mudflats from construction work (Burton *et al.* 2002a) and amenity-related disturbance (Burton *et al.* 2002b).

A total of 39 Redshank were captured and colour-ringed between February 2013 and September 2016. There have been 63 re-sightings of 19 individuals. One of these re-sightings was from outside Ireland, in Iceland (Fig. 16). In winter, Redshank are very site faithful (Wernham *et al*. 2002) and have small home ranges (Furness & Galbraith 1980, Burton 2000, Rehfisch *et al*. 2003).

Radio-tracking revealed that during high tides, the three individuals tracked during February and March 2014 were very loyal to the southern end of the Bull Island south lagoon, where they had been captured (Fig. 17). At low tide, the birds foraged in the south lagoon and in the adjacent Tolka Estuary, by day and at night.

Redshanks

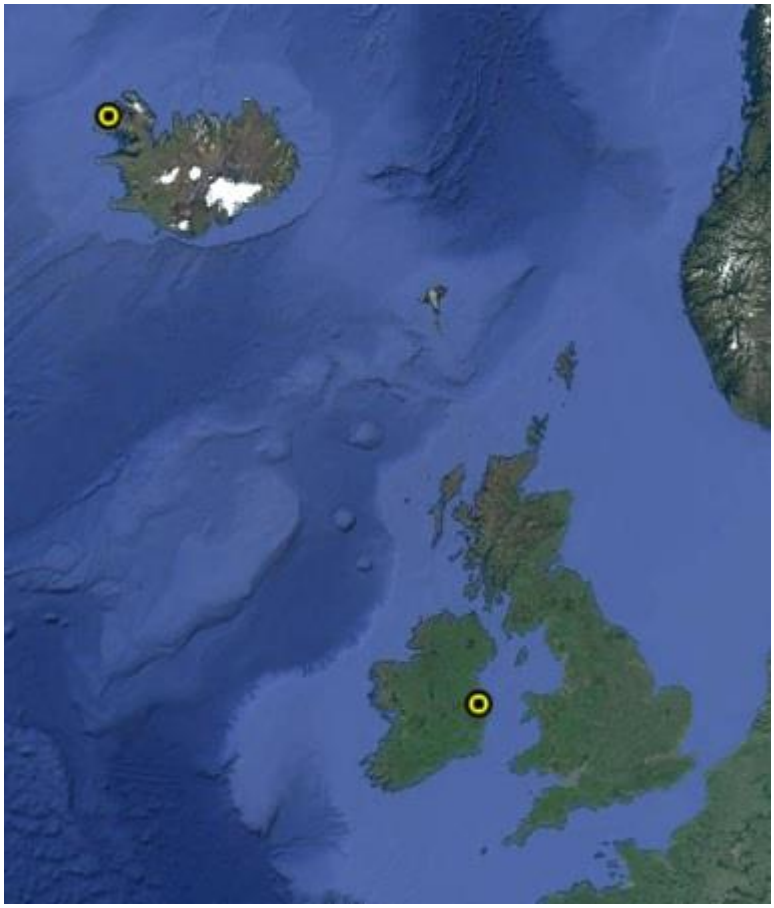


Figure 16. Re-sighting location for the Dublin-ringed Redshank that was re-sighted outside Dublin Bay between February 2013 and December 2016.

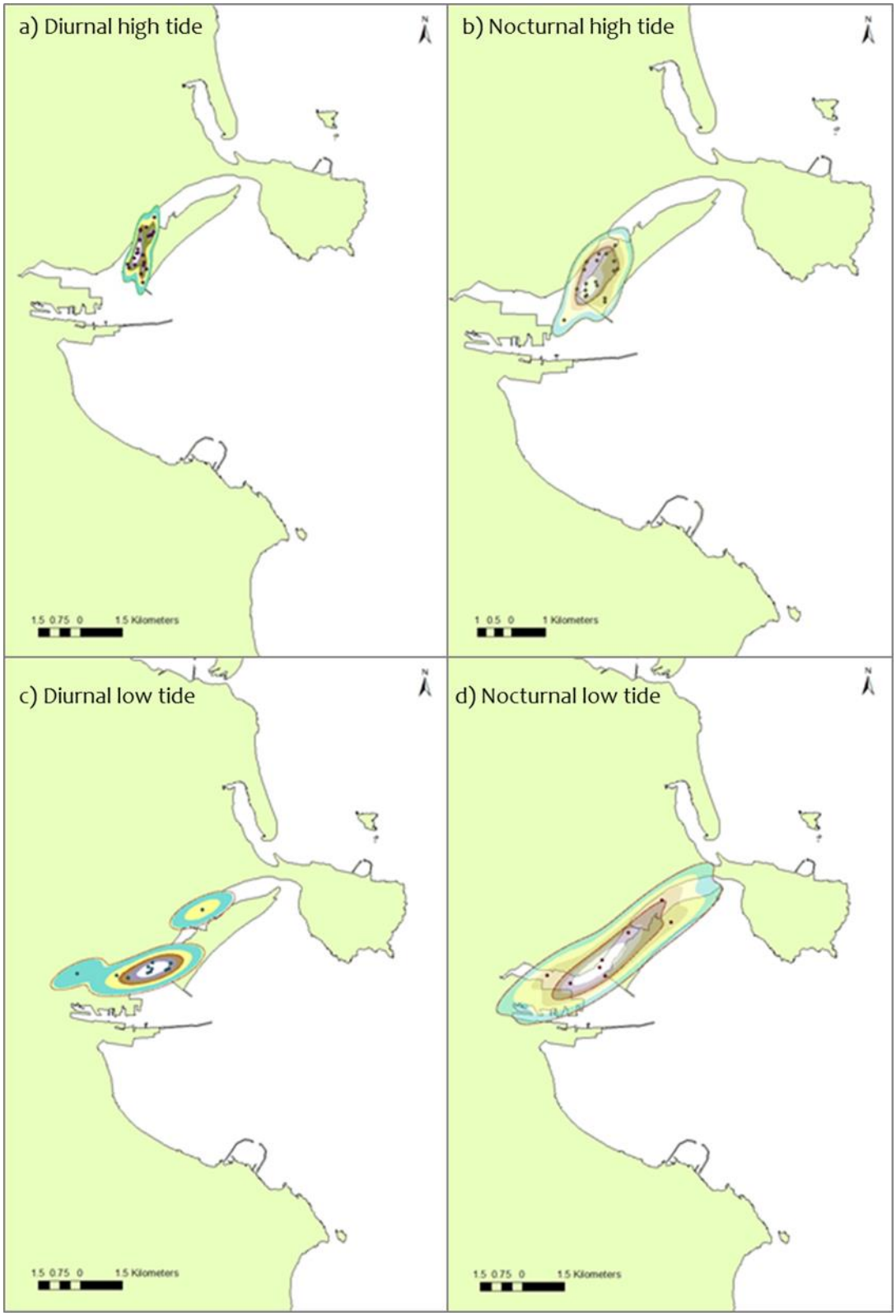


Figure 17. The radio-locations and estimated home ranges of three Redshanks (captured in the Bull Island south lagoon) between 29th January and 25th April, 2014 in four conditions: a) high tide by day, b) high tide at night, c) low tide by day and d) low tide at night. The points represent the approximate location of individual birds. The inner line, the 50% volume contour, indicates the core area used by the birds and the outer line (95% volume contour), their home range (Worton 1989).

4. Factors affecting waterbirds

Given the location of Dublin Bay, directly adjacent to the capital city of Ireland with a resident population of over half a million people, it is inherently obvious that Dublin Bay will be subject to a range of pressures and threats, many of which have the potential to adversely affect waterbirds.

Although growing at a slower pace than the state, the human population of the Dublin region has increased by 24% between 1991 and 2011 (from 1.025 to 1.270 million) (Redmond *et al*. 2012). During this time, the population trends of the majority of waterbird species listed as 'Special Conservation Interests' for North Bull Island SPA and South Dublin Bay and River Tolka Estuary SPA, were stable or increasing; notable exceptions being for Shoveler, Pintail, Golden Plover and Grey Plover (NPWS, 2015c). Waterbirds have therefore co-existed largely successfully, amongst a backdrop of continued growth and expansion of the city, its population, industry and development.

The protection of waterbirds has been the product of decades of conservation action, public involvement and legal designations including Special Protection Area status under the EU Birds Directive and more recently the designation of the entire Dublin Bay as a UNESCO Biosphere in 2015[2]. However, it cannot be assumed that these designations are sufficient to prevent threats to waterbirds into the future. On-going protection, management, monitoring and at times intervention, will all be required to ensure that Dublin Bay continues to provide sufficient feeding and roosting habitats to sustain its important concentrations of waterbirds. The most fundamental challenge will be to balance public use of Dublin Bay with an adequate protection policy for waterbirds, which is not an easy challenge given a range of often unpredictable natural threats such as climate change and sea-level rise. These, together with other main pressures and threats facing the waterbirds of Dublin Bay currently are detailed below.

4.1 Recreational disturbance to birds

Recreational use of Dublin Bay provides the most visually obvious form of disturbance to waterbirds, as birds generally move, often taking flight, in response to the presence of the activity. The impacts of these activities on migratory birds is potentially wide-ranging. The loss of roosting and feeding habitat, whether temporary or over a longer period, not only affects their direct survivorship, but may also impact on their breeding success in subsequent breeding seasons (e.g. Madsen 1995).

Dublin Bay is one of the most heavily used stretches of coastline in Ireland (Brooks *et al.* 2016), and boasts a large area of good quality sandy beaches that are easily accessed. Swimming has long been a popular activity at Dublin Bay. Visitors within Dublin Bay also enjoy boat trips, guided tours, kayaking, kite surfing, windsurfing, paddle boarding, and bird-watching tours. Dublin Bay has the largest single concentration of leisure sailors in Ireland (Brooks *et al.* 2016) with Dublin Sailing Club over 130 years old, while rowing is a popular pastime and competitive sport within the bay.

[2] http://www.dublinbaybiosphere.ie/about

Dollymount Strand on North Bull Island is an important amenity area and is managed as a public park and Nature Reserve by Dublin City Council. The island supports two golf courses (St Anne's Golf Course and Royal Dublin Golf Course). The management of the island is guided by a Management Plan (McCorry & Ryle 2009) that provides a framework to manage such pressures as dune erosion, vehicle management on Dollymount Strand, and kite-surfing.

Walking is a popular form of physical exercise and in addition to walkers, dog-walkers and joggers use the beaches of Dublin Bay, predominantly Dollymount and Sandymount Strands. Areas adjacent to intertidal habitat are used heavily such as the piers at Dun Laoghaire, the Great South Wall and the Bull Wall. As most of the shoreline of Dublin Bay is zoned as public space, there is almost a continuous walking route along the entire site (Brooks *et al.* 2016).

Waterbirds generally move away from the source of a disturbance, with the response varying between species. Loose dogs running on beaches, especially if chasing birds, appear to result in the greatest responses from waterbirds, while people simply walking by often elicits a much less severe response, presumably as the waterbirds have become habituated and do not perceive the activity as a threat (Phalan and Nairn 2007). But movements in response to disturbance, especially if frequent, can exert pressures upon a waterbirds' foraging success as well as exerting an energetic cost due to flying to an alternative foraging or roosting area. If disturbance is frequent and widespread, then it is easy to understand how this can exert pressure upon waterbirds, and this pressure is most significant at challenging times such as post- or prior to migration, or during cold weather spells when birds are under pressure to meet their required energy intake. The significance of in-combination effects (cumulative impacts) should not be underestimated, especially for a site like Dublin Bay where there exists the potential for a combination of pressures from various sources.

4.2 Development and industry

The two Special Protection Areas encompassed by Dublin Bay (NPWS 2015c) and their waterbird populations are adjacent to the most developed region of Ireland. In addition to extensive reclamation, both historical and more recent, that has modified and reduced the amount of natural wetland habitat, the shoreline is modified along nearly all of its length with linear defences (rock-armoured embankments and sea walls). The Great South Wall built in 1715, and the North Bull Wall built in the early 1800s, remain among the longest of the seawalls in Europe, and have marked the beginnings of the development of the modern Port of Dublin (Brooks *et al.* 2016). However, the building of these walls caused the redistribution of sand which became Bull Island, and which has been a positive effect in terms of wildlife and biodiversity within the bay.

Over time, the development of the area immediately adjacent to the intertidal areas has included complete urbanisation, an extensive road network, and a railway line that borders more than half of South Dublin Bay. A causeway to Bull Island was built in 1964-65. The vast majority of riverbank, shoreline and channels of the Tolka Estuary, as well as the Liffey and Dodder rivers have been modified over time (e.g. channelisation of the river, building of retaining walls and flood defences, and maintenance dredging). Further south, a second port is located at Dun Laoghaire.

The main concentration of industry in Dublin Bay is on the Poolbeg Peninsula, a narrow spit of land projecting into the bay on either side of the River Liffey, and which also forms the southern arm of Dublin Port (Brooks *et al.* 2016). Poolbeg Power station (ESB) is located at Ringsend and discharges cooling water to the Liffey Estuary (under IPCC licence). The Dublin Waste to Energy Facility[3] will open during 2017 and will generate energy from municipal waste, while the Ringsend Waste Water Treatment works are also located at Ringsend.

Dublin Port is mainly centred on the north side of the River Liffey, which flows out through the Great South Wall and the North Bull Wall into Dublin Bay. The port facilities span both sides of the Liffey and form the southern boundary of the Tolka Estuary. Dublin Port is Ireland's biggest sea port and handles almost 50% of the Republic's trade[4]. The total throughput in 2016 was 26 million tonnes, while nearly half a million freight vehicles passed through the ferry terminals. Growth and expansion of the port are seen as critical to the national and regional economies, and plans to develop Dublin Port are guided by a Masterplan (2012-2040)[5].

From the perspective of waterbirds, the wetland habitats of Dublin Bay have been modified greatly over time, both in terms of actual habitat loss, and development and change in the surrounding lands. Globally, habitat loss and modification have been and still are, two of the largest threats facing waterbirds. For example, in the United States, it is estimated that more than 50% of the wetlands that existed in the 1700s are now gone (Harrington 2003).

In Ireland, while current and future development are now preceded by ecological impact assessment and, in particular, the Appropriate Assessment process arising from Article 6 of the EU Habitats Directive (92/43/EEC), it is essential that impacts upon waterbird populations are assessed adequately. However, the responses of waterbird populations to environmental change are not easy to predict. Future impact assessments for internationally-important sites such as Dublin Bay are likely to require sophisticated methods such as behaviour-based models (e.g. Stillman 2003) that depend on good quality baseline data; further highlighting the need for regular and on-going surveying and ringing of Dublin Bay's waterbirds.

4.3 Fisheries and aquaculture

There are no designated shellfish waters or classified areas for bivalve production within Dublin Bay, so no commercial harvesting of shellfish takes place and there are no commercial aquaculture activities. However, Dublin Bay was historically important and famous for its shellfish stocks. Cockles *Cerstoderma edule* were collected by hand and West *et al.* (1979) report figures of 80-104 tonnes that were landed annually in Dublin between 1893 and 1901. In the subsequent decade the fishery declined to collapse linked to pollution and disease (West *et al.* 1979). While Cockles still occur within the intertidal habitat today, digging and consumption for personal use is advised against, without

[3] www.dublinwastetoenergy.ie
[4] www.dublinport.ie
[5] http://www.dublinport.ie/wp-content/uploads/2016/09/Dublin_Port_Masterplan.pdf

testing and treatment. However, the Cockle is most important as a food source for waterbirds, especially for Oystercatcher and Knot.

Within the open subtidal waters of Dublin Bay, relatively little fishery activity occurs apart from potting for crabs and lobster (Byrne 2009), likely due to considerations of navigational safety given the presence of a major shipping channel (Brooks *et al.* 2016). The main fishery in and around the Kish and Bray banks is for whelks *Buccinum undatum* which are landed largely at Dun Laoghaire and Howth harbours by small boats.

Bait digging is recorded widely across Dublin Bay. On a small-scale, the effects of the presence of bait-diggers upon waterbirds are thought to be negligible, but unregulated and widespread bait digging could lead to impacts in the form of (1) disturbance; (2) removal of prey species and (3) habitat modification/damage (e.g. Townsend & O'Connor 1993; Fearnley *et al.* 2013).

4.4 Water quality and pollution

Dublin Bay has a history (and recent issues) of nutrient enrichment and eutrophication. Studies of the pathways (chiefly riverine and sewage discharges) and subsequent impacts of nutrient inputs to the bay (e.g. ERU 1992a-d; Jeffrey *et al.* 1991, Wilson & Parks 1998) indicated that organic enrichment occurred in the sediments of the lower Liffey Estuary, the Tolka Estuary and in inner Dublin Bay (e.g. Wilson *et al*. 1986; Wilson & Jeffrey 1987). The Lower Liffey and Tolka Estuaries were first designated as 'sensitive' areas under the Urban Waste Water Treatment Directive in 2001, thus requiring nutrient removal during treatment. Water quality of Dublin Bay improved following the opening of a new waste water treatment works at Ringsend in 2003.

One consequence of nutrient enrichment is the proliferation of ephemeral species of algae and the formation of green macroalgal mats (filamentous *Ulva* sp.), which have occurred in abundance in both north and south Bull Island lagoons, near to the Wooden Bridge and in the Tolka Estuary. The presence of macroalgal mats can have both negative and positive effects upon waterbird foraging ecology with some species avoiding them or being negatively affected by lowered invertebrate abundances beneath them (Lewis & Kelly 2001, Lewis *et al.* 2014), while herbivores such as Brent Geese and Wigeon benefit from the algae being a source of food.

As well as historic problems with nutrient enrichment, Dublin Bay has a history of pollution from contaminants. Despite decades of scientific study, technical development, regulation and environmental monitoring that has resulted in a reduction in some of the most adverse forms of contamination (Brooks *et al.* 2016) resulting from the large human population and industrialisation of the surrounding area, the estuary and the bay remain subject to chemical pollution from a variety of sources (Murphy 2014). A recent study across three categories, namely contaminants, exposure and effects (Marine Institute 2014), revealed that levels of polycyclic aromatic hydrocarbons (PAHs), metals and a range of pesticides are still relatively high in parts of the bay (e.g. Tolka Estuary and parts of the Liffey Estuary), while Murphy (2014) reported substantial levels of PAHs in sediment of the bay with ten sampling stations exceeding the recommended levels. Some heavy metals associated with

run-off, shipping and industry found in both sediment and water remain relatively high and above recommended quality threshold levels (Marine Institute 2014).

4.5 Sea-level rise and storms

Increasing global air and ocean temperatures, widespread melting of snow and ice and rising sea levels all indicate an increasingly warmer planet (IPCC 2007) and that climate change is happening. However, the human responses to climate change, such as increased flood defences, and the consequences of these responses upon waterbirds, wildlife and biodiversity are likely to become enhanced into the future.

Sea-level rise and increasing frequency of storm surges pose a particularly serious threat, both economically and to coastal wildlife. Waterbirds as a group are associated with a habitat that is very vulnerable to changes in rainfall, evaporation and human-demand, and will therefore be most adversely affected by sea level rise and increased frequency of storm events (Crowe *et al*. 2013).

In Dublin Bay, sea level rise will bring an increased risk of coastal flooding to low-lying areas. Increasing frequency of significant storms will exacerbate the problem through storm surges (IPCC 2007). There are several regions within Dublin Bay that have been identified where the probability of flooding is relatively high (1 in 100 chance of flooding in a given year), mainly the low-lying regions along the shoreline of the northern end of Sandymount Strand as well as the eastern side of North Bull Island (Crowe *et al.* 2013). All of these regions support important concentrations of waterbird species that specifically require intertidal habitats.

Flood defences will be needed to protect the coastal infrastructure of industry and ports. The use of 'hard' flood protection embankments will constrain the ability of the coastal system to respond naturally, leading to the loss of intertidal habitats, a process known as 'coastal squeeze'. For example, in the Humber Estuary (UK), it is estimated that over 700 ha of intertidal habitat will be lost due to coastal squeeze and rising sea levels over the next 50 years (Mander *et al*. 2007). In Dublin Bay, it is expected that the area of intertidal habitat will be reduced, and in north Dublin Bay, the areas of saltmarsh, so important to roosting waterbirds, will become progressively narrower. Overall it is expected that natural habitats will be substantially changed and/or lost.

In addition, and no less serious than the aforementioned threats, are the indirect effects of climate change such as land-use change, alterations in prey availability, changes in the condition of wetlands, changes in matching of the timing of (migratory bird) arrival dates and prey dynamics, altered predation effects, disease and parasitism, amongst others (references in Sutherland *et al*. 2014).

4.6 Key future threats and challenges

Protecting and maintaining biodiversity requires targeted responses to major threats (Sutherland *et al*. 2012) so the identification of future threats upon waterbirds in Dublin Bay is of paramount

importance. Many of the pressures upon Dublin Bay have arisen from urbanisation and from an increase in the human population (Brooks *et al*. 2016), and these same pressures and threats, as identified in the sections above, are likely to continue into the future.

Tourism, leisure and recreational activities, and hence pressures upon the wildlife of Dublin Bay are likely to increase over the next decade and beyond. Increasing human population size of Dublin City in the future is likely to result in increased recreational pressure upon the bay as people seek to exercise and relax outdoors. For example, the Sutton to Sandycove cycle and walking route (S2S) is a 22 km route from Sutton in the north to Sandycove in the south (DCC 2014) and will further open up a large part of the coastline to recreational use, with a potential for increased disturbance to waterbirds.

Of key concern also is the effect of a combination of pressures and threats upon waterbirds. These are inherently difficult to quantify but need to be adequately addressed in all future impact assessments. In order to identify current and future threats, as well as to understand the significance of potential impacts, it is important to have a good baseline knowledge of the wildlife and biodiversity of Dublin Bay.

Waterbirds represent the most well-studied wildlife of the bay with waterbird monitoring (Irish Wetland Bird Survey) having commenced in the winter of 1994/95. Recent work under the Dublin Bay Birds Project has provided additional and important data not available previously. However, some data gaps remain, in particular:

1. The year-round waterbird counts have been a valuable addition to the current monitoring programme, most notably an understanding of the origins and interactions of the waterbird populations within Dublin Bay. However, it remains unknown how the age profiles vary throughout the year (for example it is thought that many of the summering wader populations comprise mostly juvenile non-breeding birds that do not start to migrate to breeding grounds until they mature). A program of multi-annual ringing would give information on the age-structure of flocks (from catches) and both adult and juvenile survival rates (from colour-ringing), could shed light on causes of population change.
2. Other valuable information not currently available include data on energetics (e.g. prey biomass available), commuting distances from roosts to feeding areas (use of GPS tagging), and the nocturnal usage of the bay (GPS tagging).

4.7. PhD research project on the effects on waterbirds of human-related activities

The research undertaken as part of this project is divided into two main project areas:

i. An investigation into what extent the foraging behaviour and foraging distribution of waders in a sandy bay is affected by human-related activities.
ii. An examination of long-term changes in trends and distribution of wintering waterbirds in Dublin Bay, using both long-term data gathered through the Irish Wetland Bird Survey, and the year-round data gathered through the Dublin Port-funded Dublin Bay Birds Project, will be carried out.

The first part aims to examine the foraging distribution and behaviour of waders on the intertidal sandflats of south Dublin Bay in relation to benthic prey distribution and human-related activities, and

is based on extensive benthic sampling and field observations that have already been carried out. Measuring potential sources of disturbance along with foraging behaviour, while also investigating the invertebrate density and biomass across the site, and the temporal variation of these across the season, will facilitate an assessment of what may be influencing the way in which waders use the bay for foraging. We are exploring whether birds are avoiding areas of high invertebrate density due to human disturbance, and using less profitable areas instead, or if they are continuing to exploit heavily disturbed areas despite the risk this may pose. The analyses and results will inform on practical considerations that are needed to address the ecological requirements of these migratory birds in the wider context of recreational disturbance, and will be detailed in a scientific paper. The data in this chapter relate specifically to the intertidal area between Poolbeg and Blackrock on Sandymount Strand.

The second component of this study aims to review the excellent datasets that are available for Dublin Bay. Further exploration of these datasets will allow an assessment of how waterbird populations have changed over time, and whether the species trends exhibited in Dublin Bay reflect those at flyway level, and those at adjacent estuaries, and if patterns exist that are consistent with climate change effects observed elsewhere. The datasets will also allow an examination of wintering waterbird trends at Dublin Bay in relation to other estuaries that are located close to conurbations with similar human-related activities.

5. Conclusions

Coastal habitats are in a constant natural state of flux and Dublin Bay is located adjacent to a capital city that inherently will grow, expand and change over time. The potential impacts caused by increasing human populations, and associated demand of Dublin Bay for recreation, as well as other impacting factors above, will undoubtedly be exacerbated by future sea-level rise and storms. Proactive and innovative approaches to mitigating these impacts present significant challenges ahead, and require consideration in planning and management proposals.

It is difficult to predict all future threats to the waterbirds and biodiversity of Dublin Bay but international designations (e.g. Natura 2000 sites; Dublin Bay Biosphere) and associated policies and management plans mean that Dublin Bay has a higher level of protection than at any time in its past. However true sustainable development of Dublin Bay will only be achieved when decision-makers facilitate the development and implementation of an integrated management strategy for the bay, with a broad perspective and a multi-sectoral approach (Brooks *et al*. 2015); something yet to be achieved.

This decision-making process is greatly facilitated and informed by a suite of long-term monitoring projects that have been in place for several decades. Certainly, there is a long history of monitoring at Dublin Bay of wintering waterbirds and of the tern colony that stems back to the mid 1990s through I-WeBS and the Dublin Port Tern Colony monitoring project respectively. These details provide the broader context from which important decisions can be made in relation to future developments, informing on the status of these birds populations and broad-scale usage of the bay.

The designation of Dublin Bay as a Biosphere in 2015, an expansion of the existing North Bull Island Biosphere Reserve designated in 1981, has been a welcome and positive initiative, with an aim of '*connecting people and nature'* while actively managing the site to '*promote a balanced relationship between people and nature*'[6]. By encouraging sustainable development and planning in the outer (transition) zone of the Biosphere, there will be greater integration at regional level in policy and implementation for the protection of Dublin Bay while promoting economic development.

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Teal

8. Appendix

7.1 Project outputs

Annual technical reports

Breeding tern reports

Newton, S.F., Tierney, N. & Valentín, A. 2013. *Dublin Port Tern Conservation Project 2013*. BirdWatch Ireland report to Dublin Port Company.

Tierney, N., Whelan, R. & Newton, S.F. 2014. *Dublin Port Tern Conservation Project 2014*. BirdWatch Ireland report to Dublin Port Company.

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Waterbird reports

Tierney, N., Whelan, R., Boland, H., Valentín, A., & Crowe, O. 2014. *Dublin Bay Birds Project Technical Report 2013/14*. BirdWatch Ireland report to Dublin Port Company. Kilcoole, Co. Wicklow.

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Publications

Tierney, N. 2014. Importance of Sandymount Strand in Dublin Bay as a post-breeding tern roost. *Irish Birds* 10, 124.

Lewis, L.J., Tierney, N., Boland, H. & Tierney, D. 2016. Tidal variation in the use of Dublin Bay by wintering waterbirds. *Irish Birds* 10, 373-382.

Tierney, N., Whelan, R. & Nairn, R. 2016. An arctic-breeding goose capitalising on man-made foraging opportunities within a busy port in winter. *Irish Birds* 10, 437.

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.

Online resources

Online platforms have been prepared and launched for ongoing collation of data from members of the public and for the dissemination of information and of summarised data gathered through this project. They include:

- Dublin Bay Birds Project blog, since 2013: www.dublinbaybirds.blogspot.com
- Summarised project results, waterbirds: http://bit.ly/2m1BeC2
- Online capture of wader ring resightings: http://arcg.is/2mN7d7k
- Online capture of tern ring resightings: http://arcg.is/2m1R9QA

Little Egret