An assessment of the effects of recreational and other activities on the waterbirds using the Bull Island saltmarsh - Final Report

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Front Cover Photograph: Brian Burke.

1. Introduction

North Bull Island Special Protection Area (SPA 4006) covers all of the inner part of north Dublin Bay, with the seaward boundary extending from the Bull Wall lighthouse across to Drumleck Point at Howth Head. A total of 17 waterbird species are listed as Special Conservation Interests (SCIs) for the site, including three that occur in numbers of international importance, and a further 14 species that occur in numbers of all-Ireland importance (NPWS 2014).

In addition to its importance for waterbirds, North Bull Island is one of the most 'designated' sites in Ireland in recognition of its nature conservation importance, particularly for the presence of several rare and threatened habitats and species listed in Annexes I and II of the EU Habitats Directive, and the presence of several rare and threatened plants listed on the Flora Protection Order (S.I. No. 94 of 1999) and in the Red Data Book by Curtis & McGough (1988) (McCorry & Ryle 2009). The site was designated as an official bird sanctuary under the Wild Bird Protection Act, 1931, the first bird sanctuary in Ireland (McCorry & Ryle 2009), and was established as a National Nature Reserve in 1988 (two parts covered by S.I. 231 and S. I. 232 of 1988). The site has been designated as part of a Special Area of Conservation (North Dublin Bay SAC - NPWS site code 000206). North Bull Island is also a Biogenetic Reserve (Council of Europe) and a UNESCO World Biosphere Reserve.

Given its location close to Ireland's capital city, Bull Island is also a location of a large and diverse amount of activities, and management of the site is key to prevent negative impacts upon key flora and fauna, while enabling the sustainable use of the site by all. To this end a management plan was prepared in 2009 (McCorry & Ryle 2009). One issue raised by the management plan was the potential for recreational disturbance, including un-restrained dogs, to impact upon wildlife. During May 2018, BirdWatch Ireland was commissioned to study the interactions between waterbirds using the saltmarsh habitat and recreational activities during the summer and autumn months (June to September). This study was subsequently extended through the winter season (November 2018 to February 2019). This report presents the results of the full study across all seasons, for the period June 2018 to February 2019.

2. Methods

2.1 Survey area, vantage points and count subsites

The study area extended *c.* 500m either side of the Bull Island causeway road. Survey areas were determined at the start of the study and encompassed the saltmarsh extending both sides of the causeway as shown in Figure 1a. These count areas (subsites) were labelled Area 1 (north of road) and Area 2 (south of road) and the area counted is shown in Figure 1b.

Figure 1a. Survey areas designed to encompass the saltmarsh extending both sides of the causeway as shown.

Figure 1b. Count areas; Area 1 north of road and Area 2 south of road.

2.2 Survey schedule

The summer/autumn study was carried out during the months June to September inclusive and a total of 16 survey days were completed with four days in each of the four months June, July, August and September 2018. The winter survey was carried out during the months of November 2018 to February 2019 inclusive and a total of 16 survey days were completed with four days in each of the four months November, December, January and February.

Waterbirds are most often distributed within the Bull Island saltmarsh habitat at high tide. The flooding tide pushes the birds up the shore and into the saltmarsh to roost at high tide. Because of this, the survey was designed to conduct counts across periods of rising high, and falling tides. On each survey day, the field surveyor commenced the survey at three hours before high water, and made repeated waterbird counts until three hours after high water, totalling six hours of survey (Table 1).

Survey dates were chosen each month based on suitable tidal stage and weather; with surveys occurring ideally on dry, bright days with no more than a moderate breeze.

Table 1. Breakdown of daily count sessions

Survey Hour	Start	End	Tidal Stage
Hour 1	3 hours before high tide	2 hours before high tide	HT-3
Hour 2	2 hours before high tide	1 hour before high tide	HT-2
Hour 3	1 hour before high tide	On high tide	HT-1
Hour 4	On high tide	1 hour after high tide	HT+1
Hour 5	1 hour after high tide	2 hours after high tide	HT+2
Hour 6	2 hours after high tide	3 hours after high tide	HT+3

2.3 Field Survey methods

Bird counts

Following the standard methods of the Irish Wetland Bird Survey (I-WeBS), the following waterbirds as defined by the Ramsar Convention (1971) were included in the survey: Gaviidae (divers), Podicipedidae (grebes), Anatidae (swans, geese and ducks), Rallidae (Water Rail, Moorhen & Coot), Haematopodidae (oystercatchers), Charadriidae (plovers and lapwings), Scolopacidae (sandpipers and allies) and Laridae (gulls and terns). In line with methods of the Irish Wetland Bird Survey (I-WeBS), Cormorant (*Phalacrocorax carbo*), Shag (*Phalacrocorax aristotelis*), Little Egret (*Egretta garzetta*), Grey Heron (*Ardea cinerea*) and Kingfisher (*Alcedo atthis*) were also included.

The survey was completed by a single fieldworker on each survey day. In each hourly count session, the peak number of waterbirds occurring in the two study areas was ascertained. The fieldworker made alternate and repeated counts of the two survey areas to obtain the maximum number of waterbirds per study area per hour.

Waterbirds were counted using the standard 'look-see' basis (Bibby *et al.* 2000) whereby the fieldworker scanned the survey area and recorded all waterbirds observed. In addition to counts, waterbird behaviour was recorded as either (a) foraging or (b) roosting/other, and waterbird location was recorded in one of three categories (intertidal, upper saltmarsh, lower saltmarsh). Significant flocks of birds were mapped using field maps ('flock maps').

Activity counts

During each hourly bird count, the fieldworker recorded the number of activities within each of the two study areas within three replicate ten-minute time blocks. The fieldworker stood at a suitable vantage point and scanned east and west across both study areas, recording the number of activities in each of the study areas at the same time. This resulted in three replicate counts of activities per hourly count session in each of the two study areas. Activities were categorized as shown in Table 2.

Table 2. Activity categories

Walker	Bait diggers
Runner	Vehicle
Dog walking on lead	Other (activity to be recorded)
Dog walking off lead	
Dog running on lead	
Dog running off lead	

Each of these activities were recorded with their location as to whether they occurred (1) on footpath/trail, or (2) off footpath/trail. This detail aimed to ascertain whether more disturbance is caused by people/dogs going off the trail/footpath into the saltmarsh habitat, as opposed to those people who use the well-worn tracks along the upper saltmarsh.

Disturbance recording

During each hourly count session, the fieldworker recorded the responses of waterbirds to disturbance events. Each time waterbirds were observed to be disturbed by an activity this was recorded as a separate 'disturbance event'. Each event was referenced separately (e.g. D1, D2, D3, and so on) and for each event the following was recorded:

- Start and end time of activity causing disturbance (if the activity was already in place when the count started then this was noted; likewise if an activity continued after a count session had ended then this was recorded);
- Direction of activity;
- Estimated distance between source of disturbance (activity) and the waterbirds that reacted;
- The zone that the waterbirds were in when they reacted to the disturbance event (lower, middle, and upper saltmarsh);
- The zone and location of the activity (e.g. persons/ dogs) when the waterbirds reacted to disturbance event;
- The length of time that the disturbance lasted;
- The number and species of waterbirds affected.

When an activity was observed to cause a disturbance to waterbirds, a record was made as to the species affected and a letter code system was used to indicate the bird's response to the activity as follows:-

W - Weak response, waterbirds move slightly away from the source of the disturbance.
M - Moderate response, waterbirds move away from the source of the disturbance to another part of your subsite; they may return to their original position once the activity ceases.
H - High response, waterbirds fly away to areas outside of your subsite and do not return during the current count session
(after Lewis & Tierney 2014).

2.4 Data compilation and analysis

After each field survey day, data were taken from field note books and entered into Microsoft Excel data sheets. At the end of the survey period, all data were compiled and validated and entered into a MS Access database from where data summaries were produced. Count data were assigned to the tidal stages as shown in Table 1.

Various data analyses were undertaken as appropriate for the resulting dataset. Data analysis included calculation of peak and mean numbers of waterbirds and simple measures of species diversity. To test the effects of disturbance, we calculated the percentage change in waterbird numbers between the count that was carried out in the hour that the disturbance event took place, and the count that was made in the hour following the disturbance event.

Throughout the text, species common names are used. The Latin names of all waterbird species recorded during the surveys are given in Table 5. Where other species are mentioned in the text, their Latin names are given at first mention.

3. Background to the waterbirds of Bull Island

Waterbirds, defined as ''*birds that are ecologically dependent on wetlands*'' (Ramsar Convention 1971), are a diverse group that includes divers, grebes, swans, geese and ducks, gulls, terns and wading birds. In Ireland, monitoring of waterbirds is primarily carried out during the non-breeding season (September –March inclusive) by the Irish Wetland Bird Survey (I-WeBS). These data have underpinned the SPA designation process and have enabled estimates and trends of Ireland's wintering waterbirds to be produced (e.g. Crowe & Holt 2013).

The importance of North Bull Island for waterbirds is well known and documented. An integral part of the wider wetland site of Dublin Bay, North Bull Island itself is designated as a Special Protection Area (Site Code 4006). A total of 17 waterbird species were listed as Special Conservation Interests (SCIs) for the site, including three that occurred in numbers of international importance, and a further 14 species that occurred in numbers of all-Ireland importance during the baseline period (NPWS 2014) (Table 3). Note that the thresholds used for determination of international (Wetlands International 2002) and all-Ireland (Crowe et al. 2018) importance during the baseline period differ from the international (AEWA 2018) and all-Ireland (Burke et al. 2018) thresholds used currently.

Table 3. Waterbird special conservation interests listed for North Bull Island SPA

Special Conservation Interests	Annex I species	Baseline Population 95/96 – 99/00	Population status at baseline	5-Year Mean 11/12 – 15/16 (I-WeBS Data)
Light-bellied Brent Goose *Branta bernicla hrota*		1,548	International importance	3,763**
Shelduck *Tadorna tadorna*		1,259	All-Ireland Importance	1,187*
Teal *Anas crecca*		953	All-Ireland Importance	1,086*
Pintail *Anas acuta*		233	All-Ireland Importance	169*
Shoveler *Anas clypeata*		141	All-Ireland Importance	104*
Oystercatcher *Haematopus ostralegus*		1,784	All-Ireland Importance	2,291*
Golden Plover *Pluvialis apricaria*	Y	2,033	All-Ireland Importance	683
Grey Plover *Pluvialis squatarola*		517	All-Ireland Importance	260*
Knot *Calidris canutus*		2,837	All-Ireland Importance	2,353*
Sanderling *Calidris alba*		141	All-Ireland Importance	332*
Dunlin *Calidris alpina*		4,146	All-Ireland Importance	2,563*
Black-tailed Godwit *Limosa limosa*		367	International importance	1,237**
Bar-tailed Godwit *Limosa lapponica*	Y	1,529	International importance	1,185*
Curlew *Numenius arquata*		937	All-Ireland Importance	940*
Redshank *Tringa totanus*		1,431	All-Ireland Importance	1,841*
Turnstone *Arenaria interpres*		157	All-Ireland Importance	295*
Black-headed Gull *Chroicocephalus ridibundus*		2,196	All-Ireland Importance	1,028

*denotes numbers of international importance and **denotes numbers of all-Ireland importance, using the current thresholds as published in 2018 (Burke et al. 2018)

4. Survey Results

4.1 Survey schedule and conditions

Between June and September 2018, weather conditions and visibility were good throughout the survey days and there were no survey constraints (Table 4). Survey conditions were generally favourable throughout the winter surveys although rain on two days (23rd December and 7th February) hampered visibility somewhat. In addition, one of the survey days in January could not go ahead due to unforeseen bad weather and hence only three survey days were completed that month.

Table 4. Summary of completed survey dates

Month	Survey dates	Cloud %	Rain	Wind	Survey Constraints
June 2018	24th, 25th, 26th, 28th	0-33	None	Calm	None, Good visibility throughout
July 2018	6th, 10th, 11th, 25th	Varied 0 – 100	None	Varied from calm to strong breeze	None, Good visibility throughout
Aug 2018	9th, 10th, 18th, 23rd	Varied 0 – 100	Varied from none to light showers	Light to moderate breezes	None, Good visibility throughout
Sep 2018	7th, 14th, 22nd, 25th	Varied 0 – 100	Varied from none to light showers	Light to moderate breezes	None, Good visibility throughout
Nov 2018	23rd, 24th, 25th, 26th	Varied 34 - 100	Varied from none to light showers	Light to moderate breezes	None, Good to moderate visibility throughout
Dec 2018	9th, 10th, 23rd, 24th	Varied 34 – 100	Generally none or light drizzle. One day (23.12.18) suffered from more persistent rain	Calm to moderate breezes	None, Good to moderate visibility throughout
Jan 2019	23rd, 24th 25th	Varied 34 – 100	Generally none or light drizzle	Calm to moderate breezes	Good to moderate visibility throughout
Feb 2019	6th, 7th, 19th, 21st	Varied 0-33	Generally none. . One day (07.02.19) suffered from more persistent rain	Calm to moderate breezes	Good to moderate visibility except 07.02.19 (poor due to rain)

4.2 Overview of species diversity and species of conservation interest

A total of 36 waterbird species were recorded within the entire survey area between June 2018 and February 2019 (Table 5) with a total of 32 species recorded between June and September (hereafter classified as summer/autumn season) and 29 species recorded between November and February (hereafter classified as winter season).

The total species list includes six species listed on Annex I of the EU Bird's Directive, and 28 species that are on the *Birds of Conservation Concern in Ireland* lists (Colhoun & Cummins 2013), including seven that are Red-listed and are of highest concern, and a further 21 species that are Amber-listed. The species list also includes 16 out of the total 17 waterbird species listed as Special Conservation Interests (SCIs) for North Bull Island SPA.

Seven species were recorded exclusively during the summer/autumn count period. Ruddy Shelduck is considered a non-native species in Ireland likely originating from escapes from domestic collections (Balmer *et al.* 2013) and was recorded on one summer survey date only (25th June 2018). Ringed Plover and Bar-tailed Godwit were recorded only during July, August and September. Mediterranean Gull (Plate 1) was recorded

during July, while Whimbrel (Plate 2) only occurred during the autumn passage season. Common Tern, a summer visitor, was recorded during July only, and Kingfisher was a once off record during September.

Plate 1. Mediterranean Gull (*Larus melanocephalus*) (Photo: Brian Burke).

Plate 2. *Whimbrel* (*Numenius phaeopus*) (Photo: Dick Coombes).

Monthly species richness (across the total study area) steadily increased from June 2018 to a peak during September (28 species). Thereafter December 2018 and February 2019 saw the greatest number of waterbirds (25) (Figure 2).

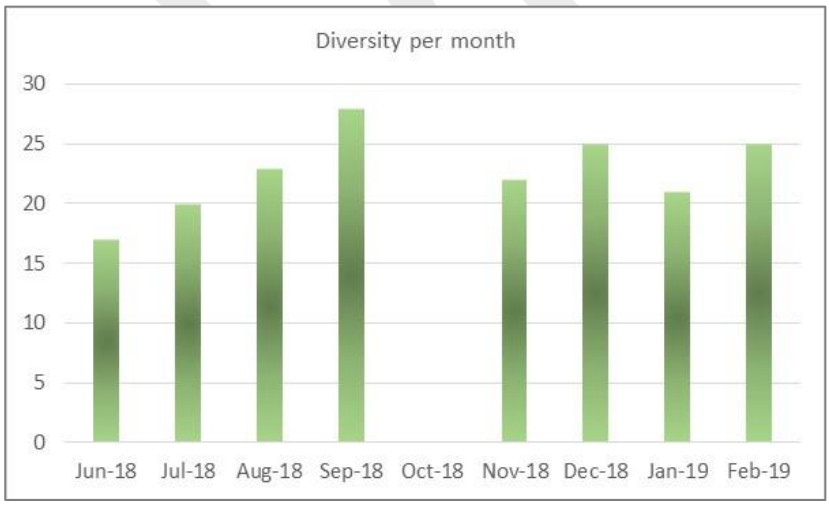


Figure 2. Species diversity per survey month

Table 5. Species recorded during the Bull Island saltmarsh study, June 2018 – February 2019 divided into summer/autumn season and winter season. Highlighted cell means that a species was recorded. The table also highlights Annex I species (EU Bird's Directive) and Red and Amber-listed species under 'Birds of Conservation Concern' (Colhoun & Cummins 2013).

Code	Common Name	Latin Name	BoCCI	Annex I	Summer /Autumn	Winter
MS	Mute Swan	*Cygnus olor*	A			
PB	Light-bellied Brent Goose	*Branta bernicla hrota*	A			
UD	Ruddy Shelduck	*Tadorna ferruginea*				
SU	Shelduck	*Tadorna tadorna*	A			
WN	Wigeon	*Anas penelope*	A			
T.	Teal	*Anas crecca*	A			
MA	Mallard	*Anas platyrhynchos*				
PT	Pintail	*Anas acuta*	R			
SV	Shoveler	*Anas clypeata*	R			
RM	Red-breasted Merganser	*Mergus serrator*				
LG	Little Grebe	*Tachybaptus ruficollis*	A			
ET	Little Egret	*Egretta garzetta*		Y		
H.	Grey Heron	*Ardea cinerea*				
OC	Oystercatcher	*Haematopus ostralegus*	A			
RP	Ringed Plover	*Charadrius hiaticula*	A			
GP	Golden Plover	*Pluvialis apricaria*	A	Y		
GV	Grey Plover	*Pluvialis squatarola*	A			
L.	Lapwing	*Vanellus vanellus*				
KN	Knot	*Calidris canutus*	R			
DN	Dunlin	*Calidris alpina*	A			
SN	Snipe	*Gallinago gallinago*	A			
BW	Black-tailed Godwit	*Limosa limosa*	A			
BA	Bar-tailed Godwit	*Limosa lapponica*	A	Y		
WM	Whimbrel	*Numenius phaeopus*				
CU	Curlew	*Numenius arquata*	R			
GK	Greenshank	*Tringa nebularia*	A			
RK	Redshank	*Tringa totanus*	R			
TT	Turnstone	*Arenaria interpres*				
MU	Mediterranean Gull	*Larus melanocephalus*	A	Y		
BH	Black-headed Gull	*Chroicocephalus ridibundus*	R			
CM	Common Gull	*Larus canus*	A			
LB	Lesser Black-backed Gull	*Larus fuscus*	A			
HG	Herring Gull	*Larus argentatus*	R			
GB	Great Black-backed Gull	*Larus marinus*	A			
CN	Common Tern	*Sterna hirundo*	A	Y		
KF	Kingfisher	*Alcedo atthis*	A	Y		

4.3 Species diversity and frequency of occurrence per count area

Across the entire study a total of 33 waterbird species was recorded in Area 1, with 32 species recorded in Area 2. During summer/autumn, species diversity was relatively similar across the two survey areas with 27 species recorded in Area 1 and 30 species recorded in Area 2 (Table 6). The winter surveys yielded slightly lower numbers of species in both areas with a total of 28 species in Area 1 and 25 species in Area 2 (Table 6).

Given that six hourly counts were undertaken on each survey date, a total of 96 hourly counts was carried out during summer/autumn, and 90 hourly counts were completed during winter.

During summer/autumn, the most frequently occurring species in Area 1, occurring in over 70% of counts, were Black-headed Gull, Curlew, Lapwing and Shelduck. Thereafter Black-tailed Godwit, Great Black-backed Gull, Herring Gull, Little Egret and Redshank were the most frequently occurring species. In Area 2, Black-headed Gull and Oystercatcher were the most frequently occurring species, recorded on all survey dates and in over 70% of hourly counts. During summer/autumn, Pintail and Ruddy Shelduck occurred exclusively in Area 1, while five species occurred exclusively in Area 2 – Bar-tailed Godwit, Greenshank, Kingfisher, Mute Swan and Mediterranean Gull.

During winter a total of eight species occurred with most frequency in Area 1 (over 70% of hourly counts): Black-tailed Godwit, Curlew, Light-bellied Brent Goose, Redshank, Shelduck, Shoveler, Teal and Wigeon. A similar suite of species were the most frequently occurring in Area 2 namely Black-tailed Godwit, Curlew, Light-bellied Brent Goose, Pintail, Redshank, Shelduck, Teal and Wigeon. During winter, Little Grebe, Red-breasted Merganser, Snipe and Turnstone occurred exclusively in Area 1, while Lesser Black-backed Gull occurred only in Area 2.

Table 6. Species diversity per count area during summer/autumn and winter seasons.
'*n*' refers to the total number of hourly counts that a species was recorded in.

Species Name	Season	Area 1	n	Area 2	n
Mute Swan	summer/autumn			√	6
	winter	√	1	√	1
Light-bellied Brent Goose	summer/autumn				
	winter	√	83	√	83
Ruddy Shelduck	summer/autumn	√	7		
	winter				
Shelduck	summer/autumn	√	74	√	36
	winter	√	84	√	87
Wigeon	summer/autumn	√	5	√	2
	winter	√	76	√	79
Teal	summer/autumn	√	19	√	22
	winter	√	81	√	84
Mallard	summer/autumn	√	7	√	9
	winter	√	23	√	16
Pintail	summer/autumn	√	4		
	winter	√	61	√	70
Shoveler	summer/autumn	√	3	√	2
	winter	√	67	√	39
Red-breasted Merganser	summer/autumn				
	winter	√	1		
Little Grebe	summer/autumn	√	4	√	6
	winter	√	1		

Little Egret	summer/autumn	√	50	√	45
	winter	√	25	√	18
Grey Heron	summer/autumn	√	5	√	21
	winter	√	7	√	8
Oystercatcher	summer/autumn	√	40	√	77
	winter	√	34	√	30
Ringed Plover	summer/autumn	√	10	√	2
	winter				
Golden Plover	summer/autumn	√	11	√	2
	winter	√	51	√	15
Grey Plover	summer/autumn	√	3	√	1
	winter	√	40	√	9
Lapwing	summer/autumn	√	70	√	28
	winter	√	20	√	2
Knot	summer/autumn	√	13	√	4
	winter	√	3	√	1
Dunlin	summer/autumn	√	21	√	14
	winter	√	21	√	7
Snipe	summer/autumn				
	winter	√	1		
Black-tailed Godwit	summer/autumn	√	53	√	35
	winter	√	78	√	81
Bar-tailed Godwit	summer/autumn			√	3
	winter				
Whimbrel	summer/autumn	√	5	√	5
	winter				
Curlew	summer/autumn	√	78	√	35
	winter	√	67	√	82
Greenshank	summer/autumn			√	31
	winter	√	10	√	1
Redshank	summer/autumn	√	51	√	49
	winter	√	79	√	84
Turnstone	summer/autumn				
	winter	√	3		
Mediterranean Gull	summer/autumn			√	5
	winter				
Black-headed Gull	summer/autumn	√	87	√	86
	winter	√	45	√	56
Common Gull	summer/autumn	√	35	√	16
	winter	√	5	√	11
Lesser Black-backed Gull	summer/autumn	√	42	√	4
	winter			√	3
Herring Gull	summer/autumn	√	66	√	41
	winter	√	14	√	31
Great Black-backed Gull	summer/autumn	√	54	√	4
	winter	√	2	√	11

Common Tern	summer/autumn	√	1	√	2
	winter				
Kingfisher	summer/autumn			√	1
	winter				

4.4 Total waterbird numbers and relationship with tidal state

The total number of waterbirds peaked within Area 1 during November 2018 when a total of 2,802 waterbirds was counted in a single hourly count. Similar peak numbers were retained for the following two months (Table 7). Numbers in Area 2 peaked during December 2018 (2,895 waterbirds). Overall numbers within the two areas during winter were relatively similar. No obvious pattern between waterbird numbers and tidal state is evident from the data with the exception of some trend for greater numbers during the two hour period either side of high tide (HT-1/HT+1); more evident during winter in Area 1 (Figures 2a and 2b, Figures 3a-3d).

Table 7. Peak waterbird counts per month (across all tidal states)

Area	June	July	August	September	November	December	January	February
1	330	631	927	734	2,802	2,385	2,445	1,825
2	154	579	1,397	804	2,397	2,895	1,821	1,723

Table 8. Peak waterbird counts per month and per tidal state (peak monthly count overall in bold font).

Area	Tide	Jun	Jul	Aug	Sep	Nov	Dec	Jan	Feb
1	HT-1	202	375	793	**734**	2,182	**2,385**	1,981	1,713
	HT-2	216	455	827	342	2,663	673	1,042	**1,825**
	HT-3	148	179	54	162	1,041	851	711	1,187
	HT+1	163	**631**	**927**	377	**2,802**	2,383	**2,445**	1,280
	HT+2	**330**	259	380	666	1,602	1,702	1,802	835
	HT+3	236	186	197	418	1,076	1,220	1,011	636
2	HT-1	89	**579**	532	729	**2,397**	1,731	1,597	1,409
	HT-2	72	274	481	803	1,478	2,048	1,146	1,141
	HT-3	59	201	**1,397**	43	1,333	835	886	1,036
	HT+1	153	348	483	**804**	1,452	1,495	836	1,293
	HT+2	**154**	306	472	632	1,590	1,854	1,356	1,594
	HT+3	99	74	81	92	1,625	**2,895**	**1,821**	**1,723**

Figure 2a Mean number of total waterbirds per tidal state

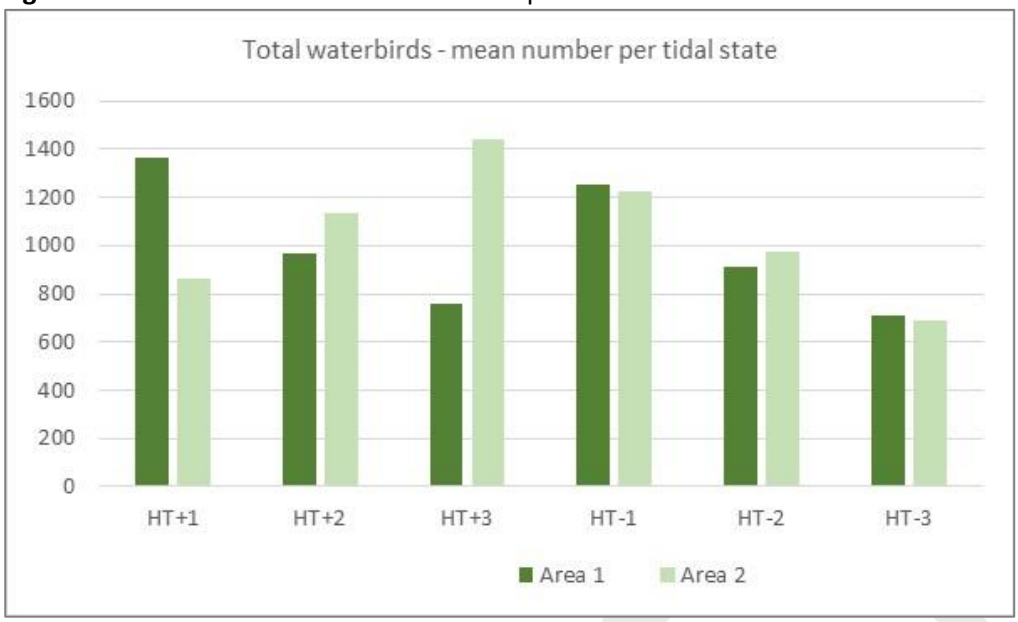


Figure 2b Peak number of total waterbirds per tidal state

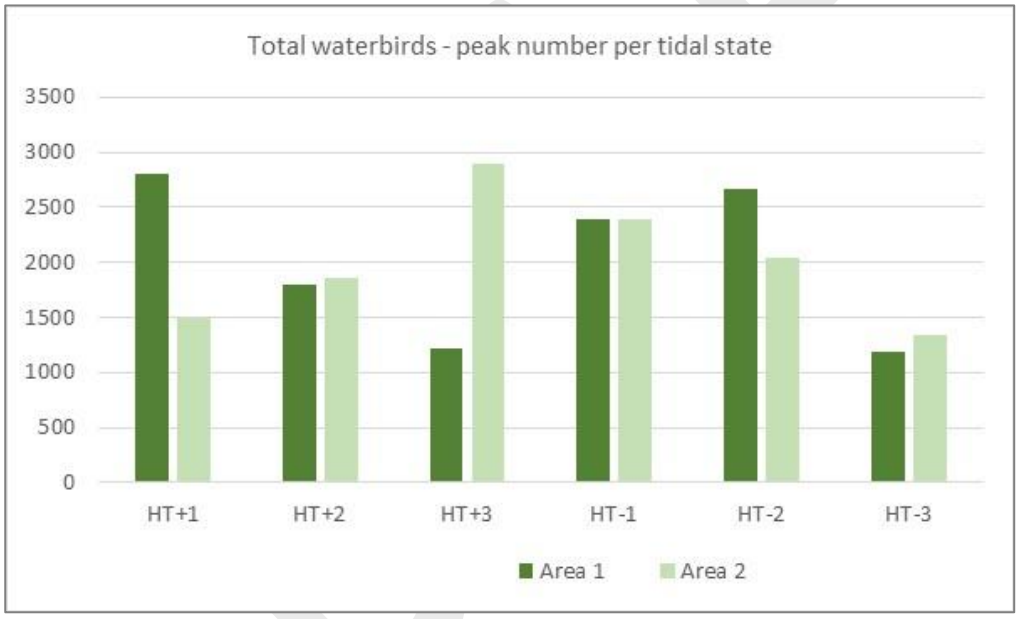


Figure 3a. Peak number of total waterbirds per month and tidal state – Area 1 summer/autumn season.

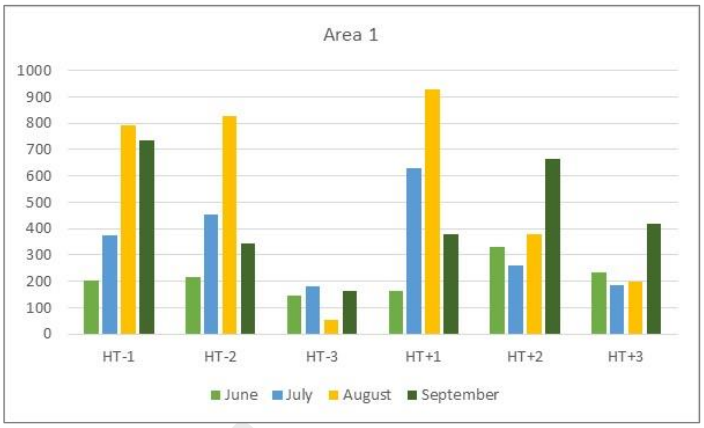


Figure 3b. Peak number of total waterbirds per month and tidal state – Area 2 summer/autumn season.

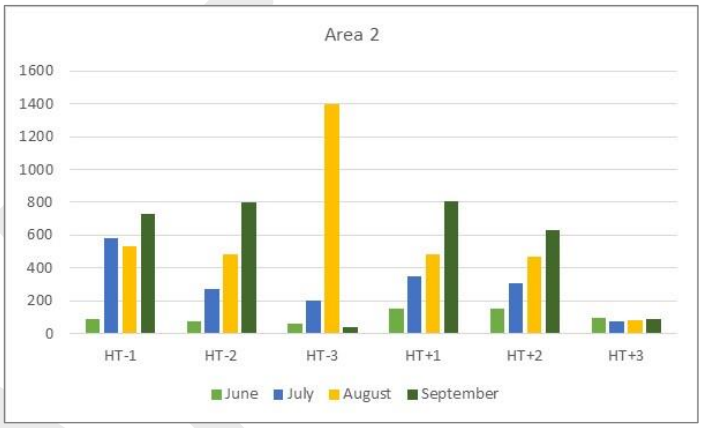


Figure 3c. Peak number of total waterbirds per month and tidal state – Area 1 winter season.

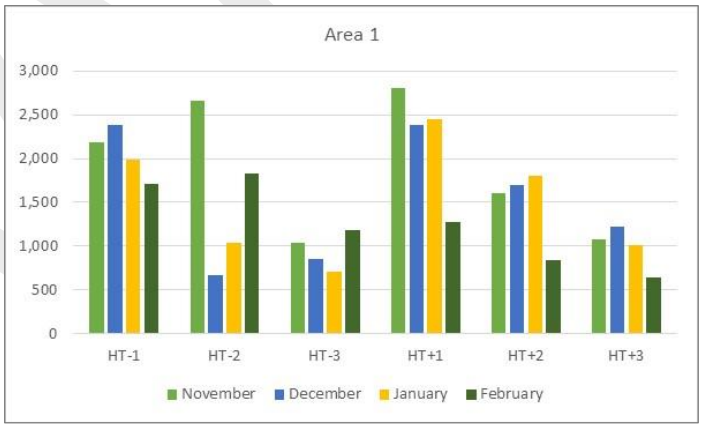
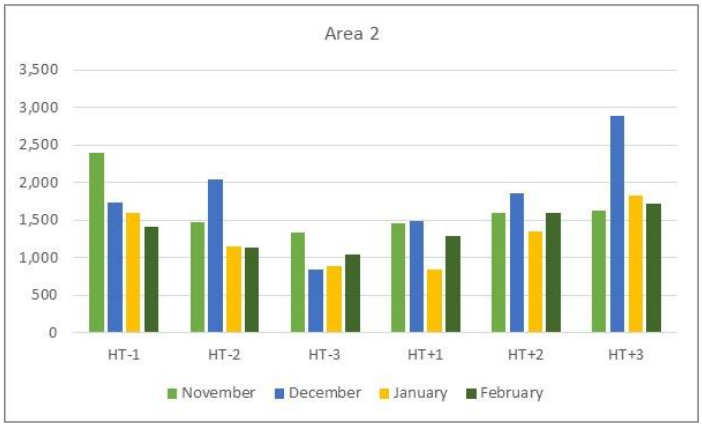


Figure 3d. Peak number of total waterbirds per month and tidal state – Area 2 winter season.



4.5 Monthly abundance of waterbirds per count area

Counts in June were dominated by gulls but this month also recorded the peak overall count of Curlew (193 birds in Area 1) (Table 10). During July, the numbers of wading birds began to rise, and notably, the peak count of Black-tailed Godwits in Area 1 exceeded the threshold for all-Ireland importance. Numbers of Redshank also rose to a peak count of greater than 200 birds in both count areas. During August the peak count of Black-tailed Godwits in Areas 1 and 2 exceeded the threshold for all-Ireland importance. A large count of 1,100 Dunlin in Area 2 exceeded the threshold for all-Ireland importance, as did the peak count of Redshank in Area 1. During September the peak count of Black-tailed Godwits and Redshank in Areas 1 and 2 again exceeded the threshold for all-Ireland importance. The peak count of Greenshank in Area 2 in August and September also surpassed the threshold for all-Ireland importance (Table 10). Higher numbers of waterbirds during August and September is consistent with the numbers of these migratory species rising generally as birds return from their breeding grounds.

Winter counts were dominated by large numbers of Light-bellied Brent Goose; this species occurring in numbers of international importance in both areas in nearly all months. Many species increased in number during winter but notable exceptions to this were Dunlin, Lapwing and Redshank. Of note was the presence of Pintail and Shoveler in numbers of all-Ireland importance in both areas. Golden Plover and Grey Plover showed a preference for Area 1. Greenshank showed a preference for Area 2 during summer/autumn, and Area 1 during winter.

Over the entire study, a total of ten species occurred in numbers of all-Ireland importance namely: Black-tailed Godwit, Dunlin, Greenshank, Grey Plover, Golden Plover, Pintail, Redshank, Shelduck, Shoveler and Teal.

Table 10. Species peak monthly count per count area ** denotes numbers of international importance; * denotes numbers of all-Ireland importance.

Species Name	Area	Jun	Jul	Aug	Sep	Nov	Dec	Jan	Feb
Mute Swan	1					1			
	2			1	8		2		
Light-bellied Brent Goose	1					1,160**	1,105**	295	610**
	2					790**	2,450**	967**	878**
Shelduck	1	53	40	5	54	340*	605*	274*	210*
	2	11	45	5	6	730*	660*	185*	307*
Wigeon	1				41	255	321	108	81
	2				130	280	461	42	47
Teal	1	2	13	35	35	335	450*	371*	247
	2			55	60	346	369*	256	419*
Mallard	1	3		12	37	6	8	12	6
	2			10	4	5	10	12	
Pintail	1				3	42*	116*	255*	128*
	2					74*	178*	84*	160*
Shoveler	1				23*	28*	74*	60*	78*
	2				16	17	124*	32*	35*
Red-breasted Merganser	1							3	
Little Grebe	1	3		1			5		
	2				4				
Little Egret	1	4	8	12	14	5	3	1	3
	2	2	6	4	18	3	2	1	
Grey Heron	1	1	1		1	3	1		2

	2	1	1	1	3	2	1		
Species Name	**Area**	**Jun**	**Jul**	**Aug**	**Sep**	**Nov**	**Dec**	**Jan**	**Feb**
Oystercatcher	1	4	19	126	8	190	14	410	190
	2	6	36	33	147	52	30	77	152
Ringed Plover	1		6	23					
	2		2	38					
Golden Plover	1				44	470	1,200*	520	330
	2				2	395	300	340	260
Grey Plover	1			1	4	22	35*	210*	220*
	2				1	7	10	2	45*
Lapwing	1	28	44	50	16	45	12	34	36
	2	5	2		39	4			
Knot	1			4	105		150		
	2			1	25		4		
Dunlin	1		2	135	470*	420	280	110	150
	2			1,100*	250*	50		80	230
Snipe	1								2
Black-tailed Godwit	1	2	244*	505*	473*	677*	520*	957*	205*
	2		11	256*	236*	770*	555*	550*	770*
Bar-tailed Godwit	2				11				
Whimbrel	1		1	1					
	2		2	1	1				
Curlew	1	193	33	20	26	91	24	148	128
	2	3	10	25	14	57	123	348	319
Greenshank	1					12	23*	1	4
	2		9	23*	39*	1			
Redshank	1	20	203	567*	258*	130	90	120	176
	2		232	296*	525*	168	97	156	143
Turnstone	1								48
Mediterranean Gull	2		1						
Black-headed Gull	1	121	111	78	47	45	46	160	192
	2	79	328	200	120	76	136	230	130
Common Gull	1	6	103	42	17				135
	2		34	2	15				38
Lesser Black-backed Gull	1	13	14	6	2				
	2		1	2			1		4
Herring Gull	1	150	100	87	94	23	22		25
	2	70	8	6	3	12	35	35	38
Great Black-backed Gull	1	52	46	17	28	1			1
	2		2	2	1	4	3	1	7

[a] International thresholds from AEWA (2018);

[b] All-Ireland thresholds from Burke et al. (2018)

4.6 Activities and disturbance events

Three replicate counts of activities were carried out during each hourly count on each survey date, therefore a total of 288 activity counts were undertaken during the summer/autumn season, and 270 activity counts were carried out during the winter season. The proportion of counts where activities were recorded was therefore relatively low during summer/autumn, but rose to a maximum of over 50% of counts during winter in Area 1, and to about a third of counts in Area 2 (Table 11, Figure 4).

Table 11. Proportion (%) of the total number of activity counts where an activity was recorded

	Area 1	Area 2
June	5	8
July	8	1
August	5	5
September	4	5
November	58	33
December	44	28
January	23	14
February	41	30

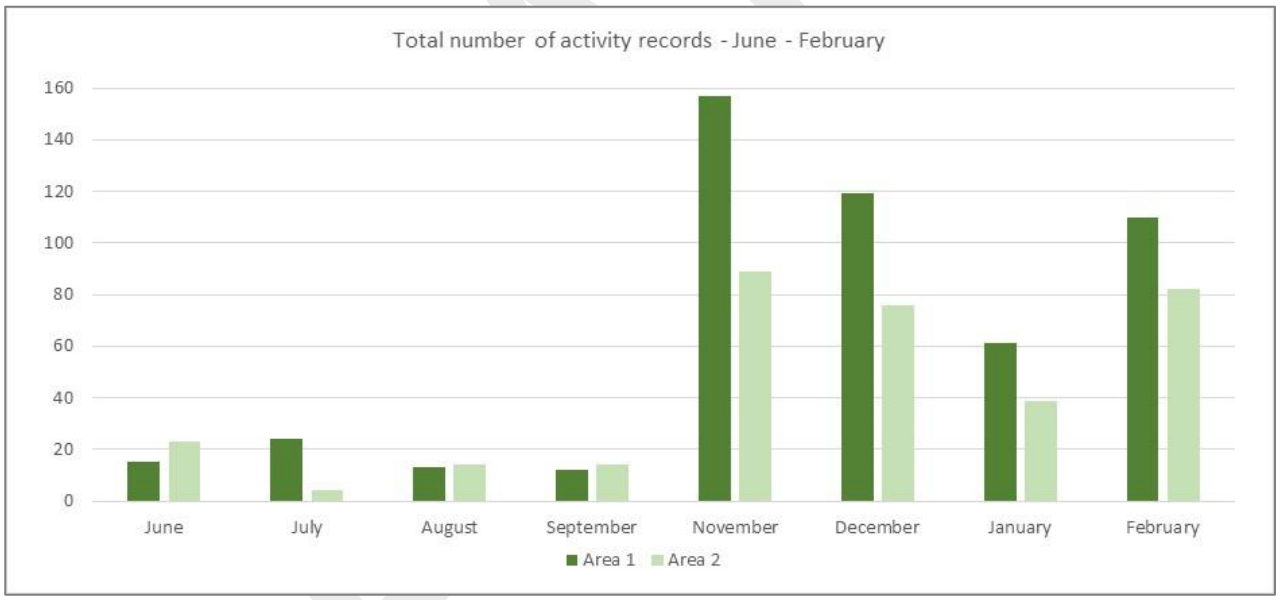


Figure 4. Total number of activities recorded throughout the study

People walking, with or without dogs were the most numerous activity records (Table 12a & 12b) and the data suggest that people, with or without dogs, are more likely to go off trail, that stay on the current trail. The number of recorded activities increased greatly during the winter season. 79% of activity records during winter (both areas combined) were 'off trail' as opposed to 'on the trail.'

Table 12a. Activities recorded in Area 1 – number of replicate counts in which activity was recorded

Area 1	Jun	Jul	Aug	Sep	Nov	Dec	Jan	Feb
Walker on trail	10	7	5	2	4	1	1	4
Walker off trail	4				101	70	46	78
Human on trail walking with dog on lead	1	4	6	8				
Human on trail walking with dog off lead						6		4
Human off trail walking with dog off lead					21	17	6	13
Cyclist off trail					21	18	5	2
Cyclist on trail								1
Person searching for golf balls		9						
Runner		1						
Litter picking					1			2
Photographer		3						
Birdwatcher			2		6	6		3
Other					3		3	3

Table 12b. Activities recorded in Area 2 – number of replicate counts in which activity was recorded

Area 2	Jun	Jul	Aug	Sep	Nov	Dec	Jan	Feb
Walker on trail	5	4	2	3				
Walker off trail	2				54	51	31	61
Human on trail walking with dog on lead	2			2				
Human on trail walking with dog off lead	14			2				5
Human off trail walking with dog on lead						1		
Human off trail walking with dog off lead			12	8	10	5	4	7
Birdwatcher					14	13	1	3
Cyclist					11	5	1	2
Other						1	2	4

A total of ten disturbance events were recorded during the summer/autumn surveys (Table 13a). In context, this amounts to ten disturbance events during 96 hours of survey. Eight of these disturbance events involved dogs, with five events involving dogs running off the lead. The duration of the events was relatively short with no disturbance event lasting more than ten minutes, however the response from waterbirds was often instantaneous i.e. a high response where the bird(s) flew up and out of the count area, not to return.

A total of 23 disturbance events were recorded during the winter surveys that yielded a response from waterbirds (Table 13b). A further five events (not tabulated) yielded no response from waterbirds. In context, this amounts to 23 disturbance events during 90 hours of survey. 20 of the events were recorded in Area 1 and three within Area 2. All waterbird responses were 'moderate' in that they flew up but landed again in another part of the count area. All birds were disturbed from either upper or lower saltmarsh habitat and a maximum number of 480 birds was affected on one occasion (Table 13b).

Table 13a. Summary of activities recorded during the summer/autumn waterbird surveys

*Species Codes - BH Black-headed Gull; CU Curlew; ET Little Egret; HG Herring Gull; L. Lapwing; LB Lesser Black-backed Gull; RK Redshank; SU Shelduck

** Duration timed to the nearest five minutes.

Event	Area	Date	Activity	Zone Of Activity	Distance (m)	Species affected*	Number Affected	Position of birds	Response	Duration (Mins)**
D1	2	24:06:18	Dog running off lead	Upper SM	10	ET	1	Upper saltmarsh	High	0.5
D2	1	02:07:18	Walker	Upper SM	40	RK, L., BH, SU, CU, LB, HG	7	Upper & Lower SM	High	5
D3	1	25.07.18	Photographer	Upper SM	30	RP, BH	2	Intertidal	Moderate	3
D4	1	10.08.18	Dog walking on lead	Upper SM	50	CU, BH.	7	Intertidal	Moderate	10
D5	1	10.08.18	Walker	Upper SM	100	ET	9	Intertidal	High	5
D6	2	18.08.18	Dog walking off lead	Upper SM	50	CU.	1	Upper SM	High	5
D7	2	18.08.18	Dog walking off lead	Upper SM	100	CU, ET	5	Upper SM	Moderate	5
D8	2	07.09.18	Dog running off lead	Upper SM	100	ET	1	Upper saltmarsh	High	5
D9	2	22.09.18	Dog running off lead	Upper SM	40	CU, ET, RK,	9	Upper saltmarsh	High	10
D10	2	25.09.18	Dog walking on lead	Upper SM	100	CU	3	Upper saltmarsh	Moderate	5

Table 13b. Summary of activities recorded during the winter waterbird surveys

*Species Codes – BW Black-tailed Godwit, CU Curlew; ET Little Egret; H. Grey Heron; PB Light-bellied Brent Goose; RK Redshank; SU Shelduck; T. Teal.

** Duration timed to the nearest five minutes.

Event	Area	Date	Activity	Zone of Activity	Distance (m)	Species affected*	Number Affected	Position of birds	Response	Duration (mins)**
D11	1	23.11.18	Walker	Upper SM	75	RK	2	Upper SM	Moderate	5
D12	1	23.11.18	Walker	Upper SM	100	RK, CU, ET	17	Upper SM	Moderate	5
D13	1	24.11.18	Dog walking on lead	Upper SM	100	RK	4	Upper SM	Moderate	5
D14	1	24.11.18	Cyclist	Upper SM	100	PB	3	Upper SM	Moderate	5
D15	1	25.11.18	Walker	Lower SM	75	PB, SU	160	Lower SM	Moderate	5
D16	1	25.11.18	Litter picking	Lower SM	75	BW, PB	480	Lower SM	Moderate	5
D17	1	25.11.18	Walker	Upper SM	50	PB	15	Upper SM	Moderate	5
D18	2	26.11.18	Walker	Upper SM	75	RK	5	Upper SM	Moderate	5
D19	1	26.11.18	Walker	Upper SM	50	RK	5	Lower SM	Moderate	5
D20	1	26.11.18	Walker	Upper SM	50	RK	6	Upper SM	Moderate	5
D21	1	26.11.18	Dog walking on lead	Upper SM	50	H., CU, RK	12	Upper SM	Moderate	5
D22	1	09.12.18	Walker	Upper SM	50	RK	1	Upper SM	Moderate	5
D23	1	09.12.18	Cyclist	Upper SM	75	RK	3	Upper SM	Moderate	5
D24	1	09.12.18	Walker	Upper SM	50	RK	1	Upper SM	Moderate	5
D25	1	23.12.18	Walker	Lower SM	50	RK	5	Lower SM	Moderate	5
D26	1	23.01.19	Walker	Upper SM	50	BW, CU, RK	63	Upper SM	Moderate	5
D27	2	23.01.19	Walker	Upper SM	50	RK, CU,	41	Upper SM	Moderate	5
D28	1	23.01.19	Walker	Upper SM	50	BW, PB	5	Upper SM	Moderate	5
D29	2	23.01.19	Dog walking off lead	Upper SM	50	CU	1	Upper SM	Moderate	5
D30	1	23.01.19	Dog walking on lead	Upper SM	50	BA, T., RK	67	Upper SM	Moderate	5
D31	1	06.02.19	Walker	Upper SM	75	CU	2	Upper SM	Moderate	5
D32	1	07.02.19	Dog walking on lead	Upper SM	13	RK	13	Upper SM	Moderate	5
D33	1	19.02.19	Walker	Upper SM	70	PB	70	Upper SM	Moderate	5

One way to test the effects of disturbance was to calculate the percentage change in waterbird numbers between the count that was carried out in the hour that the disturbance event took place, and the count that was made in the hour following the disturbance event. One might expect numbers to drop following a disturbance event, although given that the counts were undertaken hourly, some re-distribution of numbers may have occurred which could also lead to no difference. However Figure 5 shows that in 12 out of the 19 counts (63%) for which both 'before' and 'after' counts were made, numbers were indeed lower after the disturbance event.

Figure 5. Change in waterbirds numbers before and after disturbance events (n= 19)

5. Discussion

Recreational use of coastal and inland wetlands is widespread and increasing (Stigner *et al.* 2016). Recreation brings important benefits to human well-being, and allowing people to experience nature in protected areas can be important in raising biodiversity awareness, as well as providing support for conservation initiatives. However, not all recreational activities are compatible with environmental management goals and where human use and biodiversity value coincide, conservation conflicts can easily arise (Redpath *et al.* 2013). Sustainable use of wetland sites is therefore of paramount importance and to this end, the Bull Island Management Plan 2009 (McCorry & Ryle 2009) was an important first step towards safeguarding the conservation interests of Bull Island, considering environmental and recreation and tourism matters in an integrated manner.

The aim of the study was to establish whether waterbirds are being disturbed by human activities that occur through the saltmarsh habitat at Bull Island. Undertaken during both summer/autumn and winter months, waterbird diversity and abundance was relatively high throughout. While both diversity and numbers were expected to be higher during winter, species diversity was actually slightly lower during winter and several species were highest in abundance during late summer/autumn including Dunlin, Greenshank and Lapwing suggesting that the saltmarsh may be an important area for waterbirds post-migration.

One species occurred in numbers of international importance (Light-bellied Brent Goose) and ten species occurred regularly in numbers of all-Ireland importance despite the study area only being a relatively small part of the overall Bull Island wetland system. This suggests that the study area is very important for waterbirds of the greater Dublin Bay system. For instance, the peak count of Light-bellied Brent Goose in Area 2 in December represents 53% of the total mean number of this species occurring in Dublin Bay during the period 2011/12-2015/16. Similarly, the peak counts of Shelduck (recorded in in both areas) represents over 50% of the Dublin Bay population (2011/12-2015/16), while the peak count of Pintail (255) is greater than the mean or peak number recorded during the entire of Dublin Bay between 2011/12-2015/16. The importance of the study area for waterbirds is therefore unquestionable.

While the number of activities recorded was relatively low during summer/autumn, the number increased during the winter months, with up to a half of activity counts recording activities taking place. A greater majority of activities also took place off the trail rather than on meaning that people and dogs were actively encroaching into the saltmarsh habitat. However the number of recorded disturbance events was relatively low overall. For example, the total of 23 disturbance events recorded during the winter surveys is equivalent to 23 events during 90 hours of survey. However the majority of events overall resulted in moderate or high responses from waterbirds. The level of recorded responses is perhaps not surprising given the habitat in question. Many waterbirds use saltmarsh habitat as an area to roost or rest, and therefore cover, shelter and safety are key requirements particularly as the vegetation cover of saltmarsh hinders the 'usual' vigilant behavior of a waterbirds compared to when they are positioned in open habitat. Indeed, a large proportion of birds may be sleeping at a roost (Rogers 2003). Because of this, the response to activities and the significance of a disturbance event to roosting birds within saltmarsh habitat at high tide may be greater than when the waterbird is in open habitat (Navedo & Herrera 2012). Some waterbirds, especially wading birds, are digestively constrained in that they must roost to digest their food during times of low tide. Therefore saltmarsh habitat may be equally an important habitat at low tide as at high tide when birds roost because the tide has encroached and covered open areas of intertidal habitat. Because of this, disturbance to birds during periods of roosting may be more deleterious than at times when they are actively foraging.

While the number of disturbance events during our study was relatively low overall, the significance of these events, and those that go un-recorded, should not be understated. This study found that several waterbird species occurred at times in very high numbers. Had a disturbance event caused these larger numbers of birds to be displaced then this could be viewed as a substantial impact upon a significant proportion of the overall site population. For example, a disturbance that displaced the recorded peak count of Light-bellied Brent Goose would be equivalent to displacing 53% of the total Dublin Bay population (based on the five-year mean peak 2011/12 – 2015/16). The consequences of repeated such disturbances should not be underestimated.

In areas such as Bull Island, where human use and high biodiversity value coincide, acceptable levels of human disturbance may therefore need to be determined and managed (e.g. Beale 2007; Gill 2007). Disturbance may cause displacement, both within and between sites, influence feeding and resting behaviour, result in increased daily and seasonal energy expenditure overall, and increase the chance of predation. Overall this may affect the condition and fitness of migratory species (Kirby *et al.* 2008). This study is especially pertinent given the recently published and updated waterbird population estimates and trends for Ireland, that show that Ireland has lost 40% of its wintering waterbirds in the past 20 years; with the majority of wading bird species in decline over both the short-and long-term periods (Burke *et al.* 2018). Waterbirds are clearly under pressure from a range of factors, of which recreational disturbance is just one.

Methods of managing human presence and subsequent disturbance can include creating buffer areas, exclusion zones (where activities in a given area are prevented e.g. by fencing) or zoning (Adcock et al. 2018). Generally, signage is lacking at wetland sites, and given that many people simply do not know the consequences of letting dogs run through a bird roost for example, the provision of signs that explain the importance and sensitivities of a wetland area may well result in positive behavioural change. A recent study has suggested that by restricting dogs to areas already heavily used for recreation, waterbird numbers overall may increase (Stigner *et al.* 2016). Another measure which is highly recommended is the temporary cessation/exclusion of human activities during and after periods of bad weather such as sub-zero temperatures or storms, when waterbirds will be particularly challenged at this time to meet their daily energy requirements. Another period of time when waterbirds are challenged is on arrival after migration from breeding grounds; at this time energy reserves will be low. The current study found relatively high numbers of waterbirds during late summer and early autumn months, and many of these birds would have been newly arrived after migration. At such times, safe roosting sites close to feeding areas are of prime importance.

The importance of safe roosting sites for waterbirds is well documented (e.g. Rogers 2003), but one final point relating to this is the importance of the relative abundance of roost sites across a site. Displaced birds clearly require an alternative place to go. Hence where the number of high tide roosting sites across a site is limited, the effects of disturbance may be greater. The importance of Bull Island as a key high tide roost site within Dublin Bay is well known (e.g. Tierney *et al.* 2017) and the current study has shown the areas under observation to be used by particularly high numbers of waterbirds on regular occasions. Hopefully the results of this study can lead to a focused effort to manage the saltmarsh habitat and prevent an increase in disturbance in the area that could ultimately be very detrimental to the waterbirds of Dublin Bay.

6. Acknowledgements

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