An assessment of the effects of Kitesurfing and other activities on the waterbirds using Dollymount Strand

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A report commissioned by Dublin City Council and prepared by BirdWatch Ireland

November 2017

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Table of Contents

Summary

Dollymount Strand is located on the eastern (seaward) side of North Bull Island in County Dublin. The extensive sandy beach is included within the North Bull Island Special Protection Area designated under the European Union Birds Directive. Dollymount Strand is also a highly popular recreational area, and is becoming increasingly used for kitesurfing. During 2016, a detailed desk-based ecological assessment was undertaken of the potential impacts of placing a central hub for catering for kitesurfers. The study indicated that further information is required to examine whether or not there would be an impact either directly due to the placement of the hub and increased numbers moving between this hub and the water, or indirectly through the disturbance caused by increased levels of kitesurfing activities. Given that the highest volume of kitesurfing activity is undertaken during the months of June to September it follows that impacts upon waterbirds will be highest during these months. BirdWatch Ireland was therefore commissioned to undertake a study of the interactions between kitesurfers, together with other recreational users, and the waterbirds using Dollymount Strand during the months outside of the winter period. This report presents the results of this study carried out between June and September 2017.

Dollymount Strand was divided into two waterbird survey areas known as Area 1 and Area 2, to the north and south respectively. A total of twelve survey days were completed. In 2017, a single high- and low-tide survey were undertaken in the month of June. A single rising and falling tide survey were conducted in July, and two rising and falling tide surveys were completed during each of the months of August and September. Counts were conducted across both of the survey areas from their respective vantage points. In addition to counts of waterbirds, counts of activities, classified into various categories, were also undertaken as well as periods of time devoted to disturbance recording whereby the responses of waterbirds were recorded in detail.

Overall a total of 22 waterbird species were recorded throughout the survey season, with a total of 18 species in Area 1, and 21 species in Area 2, including 11 out of the17 waterbird species listed as Special Conservation Interest species (SCIs) for North Bull Island SPA. While gulls were the most abundant waterbirds in terms of the peak numbers recorded; with Herring Gull the most numerous during all four months, numbers of wading bird and in particular, Bar-tailed Godwit and Black-tailed Godwit were also found to be numerous.

Walking was the most frequently recorded activity type within both study areas, and was almost constant at times, while dogs, recorded in several categories as to whether they were on or off the lead were very prevalent; with notably the category 'off the lead' being the most frequent. Kitesurfing was the second most frequent activity type in Area 1 but does not generally occur further north along Dollymount Strand into Area 2. For Area 1, negative relationships were evident between the amount of walking, and the amount of kitesurfing and waterbird numbers, meaning that as the activities increase, the numbers of waterbirds decrease. While not all of these relationships were statistically significant when assessed singularly, it is easy to understand that the relationships would have been more significantly negative if two or more activities had been assessed in combination. No relationships between activities and waterbird numbers were evident for Area 2 which suggests that the effects of activities upon waterbirds are greater in Area 1 than Area 2.

Dogs running off lead were found to elicit the highest levels of response behaviour from waterbirds, followed by dogs walking off lead and runners. Proportionally, the greatest number of disturbance records resulted in a weak response from waterbirds (i.e. little movement), while the proportion of 'no responses' and 'weak responses' combined for all activity types was higher than the combined 'moderate' and 'high' responses, suggesting that most activities elicit little responses from waterbirds. However, in areas under heavy recreational pressure, such as Dollymount Strand, even low levels of disturbance can have deleterious effects on waterbird survival due to its sustained nature and in-combination effects. Gull species were found to be involved in a higher proportion of kitesurfing disturbance events than wading birds or other waterbird species. This may have been due to the prevalence of gulls in the landing and launching area in comparison

to wading birds and other species; and follows the pattern that wading bird numbers tend to be lower when kitesurfing is occurring.

Overall the results of the study indicate that kitesurfing does effect the numbers and behaviour of waterbirds but to a lower extent than some other activities. Perhaps more importantly, the study indicates that waterbirds are also under pressure from other activities, particularly dogs running and walking off lead, walkers and runners. Therefore, while the singular effects of kitesurfing may not be highly deleterious to waterbirds, given the high levels of recreational use on Dollymount Strand, the cumulative effects may be at a serious level. We discuss the implications of these results including the difficulty in quantifying the effect of human activities on waterbird populations. Finally we discuss potential management measures and how any put such measures in place would benefit from monitoring studies, to not only measure success, but also to inform further decision making and highlight where further detailed studies may be needed.

Introduction

Dollymount Strand (Fig. 1) is located on the eastern (seaward) side of North Bull Island in County Dublin. The extensive sandy beach is included within the North Bull Island Special Protection Area designated under the European Union Birds Directive[1]. This SPA supports in excess of 30,000 waterbirds during the mid-winter months although the site is also used by substantial numbers of birds during other months of the year (Tierney *et al.* 2017).

Dollymount Strand is also a highly popular recreational area, and is becoming increasingly used for kitesurfing. During 2016, a detailed desk-based ecological assessment was undertaken of the potential impacts of placing a central hub for catering for kitesurfers. The study indicated that further information is required to examine whether or not there would be an impact either directly due to the placement of the hub and increased numbers moving between this hub and the water, or indirectly through the disturbance caused by increased levels of kitesurfing activities. Given that the highest volume of kitesurfing activity is undertaken during the months of June to September it follows that impacts upon waterbirds will be highest during these months. BirdWatch Ireland was therefore commissioned to undertake a study of the interactions between kitesurfers, together with other recreational users, and the waterbirds using Dollymount Strand during the months outside of the winter period. This report presents the results of this study carried out between June and September 2017.

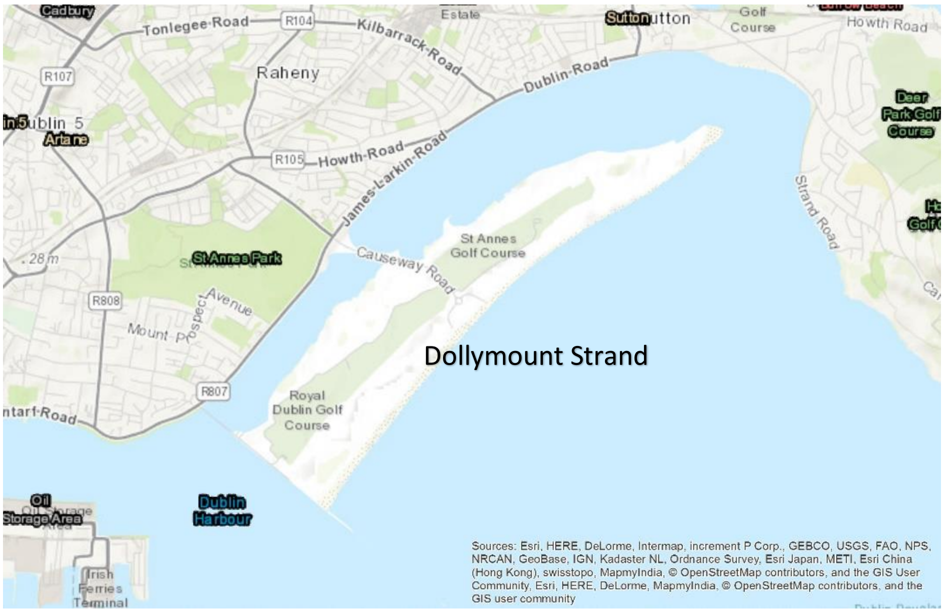


Figure 1. Dollymount Strand, Dublin.

Background to kitesurfing

Kitesurfing is a relatively recent sport and the impacts of this recreational activity on waterbirds are currently under investigation (Davenport & Davenport 2006). It is a wind propelled water sport, whereby a kite and board are used to harness the power of the wind to surf across the water. Kitesurfing can be enjoyed year-round, but the months of March to October are considered the most favourable. Winds from ten to twenty-five knots from the east, south east and south west are considered the most suitable for kitesurfing on Dollymount Strand. High tides are optimal, but kitesurfing can occur across all tidal states.

[1] Directive 2009/147/EC (Birds Directive) on the conservation of wild birds (the codified version of Council Directive 79/409/EEC as amended).

A code of conduct was drawn up by Dublin City Council as part of the Management Plan for North Bull Island in 2008 and agreed upon with the Irish Kitesurfing Association (IKSA). As part of this plan, kite surfers were given a designated area to launch, land, set up and pack down their kites on the southern end of the beach, outside of which such activities are prohibited (see Fig. 2). Kitesurfing typically occurs in the proximity of this designated area at the southern end of the beach, but kite surfers are permitted to use the full extent of the beach once they are on the water (IKSA, 2008).

In 2016, a detailed desk based study of the impact of placing a centralized hub for kitesurfing activity was undertaken. The proposed hub will be a temporary structure consisting of four shipping containers arranged in a cruciform shape located immediately north of the car park at the south end of the beach. This structure will be in place from mid - April to mid - September each year when kitesurfing activity is at its peak. It will serve as a base for storing equipment while kitesurfers are on the water, providing wheelchairs to beach users, and an educational facility for the general public about the significance of North Bull Island as a Nature Reserve (Brid Brosnan, DCC, pers comm).

Figure 2. Map showing the area designated by Dublin City Council for kite surfers to launch, land, pack up and set down their equipment. Most water – based kitesurfing activity occurs within this vicinity.

Methods

Aims of the study

The aims of this study were to assess the interactions of waterbirds and kitesurfers during months outside of the winter period, and assess the potential disturbance to waterbirds by the creation of a central hub for kitesurfers on Dollymount Beach. The research questions were as follows:

- To what extent does kitesurfing disturb waterbirds at Dollymount Strand outside of the winter months?

- What is the impact of other potential sources of disturbance such as walkers and dogs on birds at the site outside of winter months?
- Is the centralisation of kitesurfing activities on the beach likely to adversely impact waterbird distribution and behaviour?

Survey areas

Dollymount Strand was divided into two survey areas known as Area 1 and Area 2. A separate vantage point overlooking each of the survey areas was located on the upper shore/dunes (Fig. 3), with VP 1 overlooking Area 1, and VP2 overlooking Area 2.

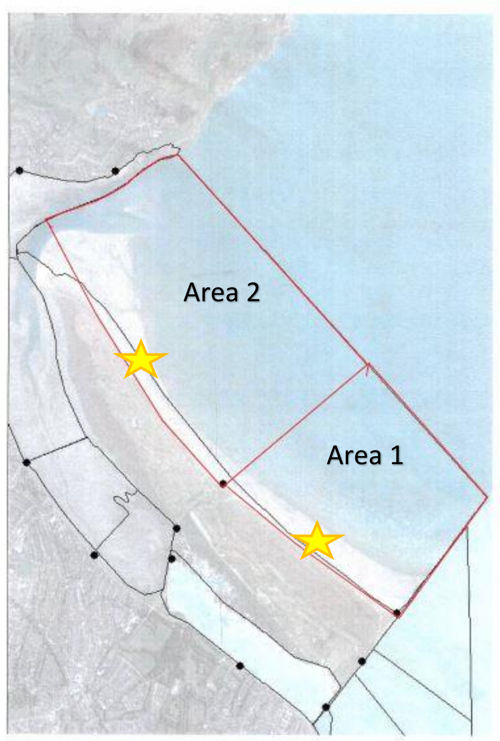


Figure 3. Survey areas used during the study

Survey schedule

The study was carried out between June and September 2017 and comprised both high- and low-tide waterbird counts. In the month of June, 'through-the-tide-surveys' were conducted, which aimed to provide a clear indication of the use of the study area by waterbirds at all tidal stages. However, following a review of the waterbird count data collected in June 2017, the methodology was adjusted because waterbird numbers proved to be extremely low during observation sessions centered around high tide. In light of this finding, from July to September 2017, counts were conducted across rising and falling tides. It was felt this would provide a clearer indication of the use of the study area by waterbirds and disturbance impacts across all tidal states. Note that the data collected in the month of June are directly comparable to those collected for the remainder of the survey period, as the observation sessions conducted in June also incorporated rising and falling tides.

A total of twelve survey days were completed. A single high- and low-tide survey were undertaken in the month of June 2017. A single rising and falling tide survey were conducted in July 2017, and two rising and falling tide surveys were completed during each of the months of August and September 2017.

In the month of June on each survey day, three two-hour survey sessions were completed at each of the two vantage points overlooking the two survey areas. The first count session commenced 3.5 hours prior to either low or high tide at one vantage point, and extended until 1.5 hours before the time of low or high tide respectively. The field surveyor then moved to the second vantage point and commenced a second two-hour survey session of the second area which began one hour prior to the tide time and extended to one hour after the low/ high tide. At the end of this session, the field surveyor then moved to the first vantage point and undertook a final observation session 1.5 hours after the high/ low tide and extending to 2 hours beyond this tide time (Table 1).

Between the months of July to September 2017, two three – hour survey sessions were completed at each of the two vantage points. The first observation session commenced on the low tide or 6.5 hours prior to the low tide. Observations were recorded over a three – hour period, after which time the field surveyor moved to the second vantage point. The second three - hour observation session commenced three hours prior to the high/ low tide and finished on these tidal states (Table 2).

Table 1. Breakdown of sessions in June 2017

Session	Start	End	Observation Point
1st Session	3.5 hours before high/ low tide	1.5 hours before high/ low tide	1st vantage point
2nd Session	1 hour before high/ low tide	1 hour after high/ low tide	2nd vantage point
3rd Session	1.5 hours after high/ low tide	3.5 hours after high/ low tide	1st vantage point

Table 2. Breakdown of sessions July to September 2017

Session	Start	End	Observation Point
1st Session	On low tide/ 6.5 hours prior to low tide	3.5 hours prior to high/low tide	1st vantage point
2nd Session	3 hours prior to high/low tide	At high/low tide	2nd vantage point

Field survey methods

Bird counts

In each three-hour count session at a vantage point, three counts of bird species were made as follows (a) one count at the start; (b) one count in the middle; and (c) one count at the end of the three-hour period. The counts were constrained to 30-minute time period.

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

Activity counts

During each 30-minute bird count, the field surveyor obtained a count of the number of activities. Activities were categorized as shown in Table 3.

Table 3. Activity categories

Kitesurfing
Walker
Runner
Swimming
Bait diggers
Non-powered watercraft
Powered watercraft
Other water based recreation(wind surfers/surfing)
Land Vehicle
Dog walking on lead
Dog walking off lead
Dog running on lead
Dog running off lead
Dog swimming on lead
Dog swimming off lead
Other

Disturbance recording

The remainder of each three-hour count session was used for recording the responses of waterbirds to disturbances. Each time waterbirds were observed to be disturbed by an activity then this was recorded as a separate 'disturbance event'. Each event was referenced separately (e.g. D1, D2, D3, and so on) and for each the following recorded:

- Start and end time of activity causing disturbance (if the activity was already in place when the count started then this was also noted; likewise if an activity continued after a count session ended then this was also recorded);
- Direction of activity;
- Estimated distance between source of disturbance (activity) and the waterbirds which reacted;
- The zone the waterbirds were in when they reacted to the disturbance event (lower, middle, and upper shore);
- 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, the waterbird species affected were recorded and a letter code system 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).

Data were also collected on events which occurred but did not cause an alteration in the behavior of waterbirds in the vicinity of the event.

Data compilation, analysis and report

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 hourly blocks and then categorized into tidal stages as follows:

1	LT-3	3-hour period prior to Low Tide;
2	LT+3	3-hour period following Low Tide;
3	HT-3	3-hour period prior to High Tide;
4	HT+3	3-hour period following High Low Tide.

This report provides summary waterbird count data, largely peak or average counts of waterbirds within count areas. The scientific names of all bird species recorded are presented in Table 6; common bird names used in the report text.

To examine the effects of kitesurfing and other activities upon waterbirds, the number of activities (sometimes singularly, sometimes combined) that occurred within each count session was averaged over the three counts and divided by the length of the shoreline in the count area (as measured in GIS) to give a standardized index of activity (after Gill et al. 2001). Length was used because shore-based and water-based activities generally take place along linear axes of the shoreline or water. The relationship between the peak number of waterbirds within a count session and the standardized index of activity was then examined using linear regression.

Results

Survey schedule and conditions

Table 4. Weather conditions and survey constraints

Date	Wind	Cloud	Rain	Visibility	Notes
21.06.17	Breezy	0-33%	None	Good/ Poor	Heat haze led to poor visibility of some *Larus* species during the 1st and 2nd hour.
27.06.17	Breezy/Strong	0-100%	None	Good	Wind speeds increased during the 4th hour. Cloud cover decreased in 3rd hour.
15.07.17	Breezy/Strong	0-33%	None	Good	Wind speeds increased in 3rd hour.
27.07.17	Breezy	66-100%	None/Showers	Good/ Moderate	Showers during the 1st – 3rd hours and 6th hour. Moderate visibility the result of falling light during the 6th hour of the survey.
02.08.17	Breezy	33-66%	None	Good/ Moderate	Visibility of tern species in flight moderate at distance.
11.08.17	Breezy/Strong	66-100%	None/Showers	Good - Poor	Wind speeds decreased to breezy during 3rd hour. Showers during the 2nd hour. Visibility of some *Larus* species was moderate/ poor due to heat haze.
16.08.17	Breezy/Strong	66-100%	None	Good	Wind speeds decreased during the 5th hour.
19.08.17	Breezy	33-100%	None	Good	Cloud cover decreased from 66-100% to 33-66% after the 1st hour.

03.09.17	Breezy	66-100%	None - Drizzle	Good	Near constant drizzle for first 2 hours. Showers in 3rd hour. No rain for remainder of survey.
13.09.17	Breezy	66-100%	None/Showers	Good	Showers in the 3rd and 5th hour.
23.09.17	Strong	66-100%	None	Good	
27.09.17	Strong	66-100%	None - Heavy	Moderate/ Poor	Heavy rain during the 1st, 4th and 5th hour. No rain 2nd hour. Drizzle 3rd hour. Showers 6th hour. Strong onshore winds resulted in low water bird numbers on the beach during the survey period. Visibility poor – however cycled stretch of beach prior to commencing the survey and water bird numbers were low. Therefore low counts not considered inaccurate despite poor visibility.

Table 5. Survey schedule – tidal states

Date	Time of Low Tide/High Tide	Number of Replicate Counts			
		LT-3	LT+3	HT-3	HT+3
21.06.17	LT: 15:36	4*	0	0	0
27.06.17	HT: 15:08	0	0	4*	1
15.07.17	LT: 10:00 HT: 16:40	0	3	3	0
27.07.17	HT: 15:31 LT: 20:50	3	0	0	3
02.08.17	LT: 14:27 HT: 20:57	0	3	3	0
11.08.17	HT: 14:55 LT: 20:20	3	0	0	3
16.08.17	LT: 12:39 HT: 19:26	0	3	3	0
19.08.17	HT: 10:24 LT: 16:04	3	0	0	3
03.09.17	HT: 10:34 LT: 16:32	3	0	0	3
13.09.17	LT: 11:00 HT: 17:24	0	2**	3	0
23.09.17	HT: 14:25 LT: 19:55	3	0	0	3
27.09.17	LT: 10:27 HT: 16:58	0	3	3	0

* Observer error

** Observer error in reading tide table

Waterbird Species diversity

Waterbirds were present during the majority of counts undertaken. A total of 22 waterbird species were recorded overall throughout the survey season, with a total of 18 species in Area 1, and 21 species in Area 2. The species list included three wildfowl and allies, 12 species of wading bird, five gull species and two tern species (Table 6).

Species of conservation interest

The species list includes 11 out of the17 waterbird species listed as Special Conservation Interest species (SCIs) for North Bull Island SPA (Oystercatcher, Golden Plover, Grey Plover, Knot, Sanderling, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Curlew, Turnstone and Black-headed Gull), and with the exception of Knot (Area 2 only) and Turnstone (Area 1 only), all species were recorded from both survey areas.

Overall, five species listed under Annex I of the EU Bird's Directive were recorded (Little Egret, Golden Plover, Bar-tailed Godwit, Roseate Tern and Common Tern). The two tern species were recorded in Area 2 only.

The species list also includes 17 species that are on the *Birds of Conservation Concern in Ireland* lists (Colhoun & Cummins 2013), including four species (Knot, Curlew, Black-headed Gull and Herring Gull) that are Red-listed and are of highest concern, and a further 13 species that are Amber-listed.

Table 6. Species recorded within the two survey areas throughout the study period (shading denotes which count area the species was recorded in). The table also highlights species listed on Annex I of the EU Birds Directive, and Red (R) and Amber (A) listed species under 'Birds of Conservation Concern' (Colhoun & Cummins 2013). *Species listed as Special Conservation Interests for North Bull Island SPA.

Species Name	Latin name	Annex_I	BoCCI	Area 1	Area 2
Cormorant	*Phalacrocorax carbo*		A		
Little Egret	*Egretta garzetta*	Y			
Grey Heron	*Ardea cinerea*				
Oystercatcher*	*Haematopus ostralegus*		A		
Ringed Plover	*Charadrius hiaticula*		A		
Golden Plover*	*Pluvialis apricaria*	Y	A		
Grey Plover*	*Pluvialis squatarola*		A		
Knot*	*Calidris canutus*		R		
Sanderling*	*Calidris alba*				
Dunlin*	*Calidris alpina*		A		
Black-tailed Godwit*	*Limosa limosa*		A		
Bar-tailed Godwit*	*Limosa lapponica*	Y	A		
Whimbrel	*Numenius phaeopus*				
Curlew*	*Numenius arquata*		R		
Turnstone*	*Arenaria interpres*				
Black-headed Gull*	*Chroicocephalus ridibundus*		R		
Common Gull	*Larus canus*		A		
Lesser Black-backed Gull	*Larus fuscus*		A		
Herring Gull	*Larus argentatus*		R		
Great Black-backed Gull	*Larus marinus*		A		
Roseate Tern	*Sterna dougallii*	Y	A		
Common Tern	*Sterna hirundo*	Y	A		

Total waterbird numbers by month

Numbers in Area 1 rose from a peak count of 63 waterbirds in June 2017 to a survey peak count of over 5,000 waterbirds during July 2017. The peak count then dropped back to just under 3,000 waterbirds during the month of September. Peak waterbird numbers in Area 2 (VP2) remained relatively low during June and July, but like Area 1, peaked during August at over 3,000 waterbirds, numbers then dropping back in September (Fig. 4).

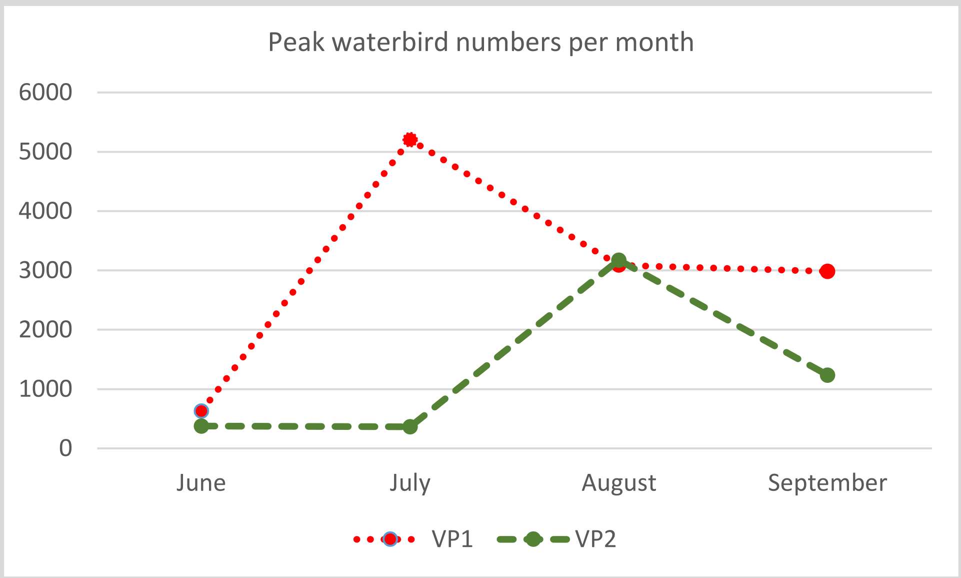


Figure 4. Peak counts of waterbirds recorded in Area 1 (VP1) and Area 2 (VP2) throughout the study period (all species combined)

Overview of waterbirds within Survey Area 1

A total of 18 waterbird species were recorded in Area 1 overall. Monthly species diversity peaked in August and September (15 species).

Herring Gull was the most regularly-occurring species recorded in nearly half of all counts (Table 7). Thereafter, six regularly occurring species (occurring in more than 20% of counts) were ranked in descending order as follows: Black-headed Gull, Common Gull, Dunlin/Oystercatcher, Bar-tailed Godwit and Black-tailed Godwit.

Gulls were the most abundant waterbirds in terms of the peak numbers recorded; with Herring Gull the most numerous during all four months. Of the wader species, Bar-tailed Godwit and Black-tailed Godwits were the most numerous, occurring in numbers of national importance in most months while Black-tailed Godwits occurred in numbers of international importance during September 2017. Sanderling occurred during September only but the peak count exceeded the threshold for national importance (Table 7).

Overview of waterbirds within Survey Area 2

A total of 21 waterbird species was recorded in Area 2. Monthly species diversity peaked in August (20 species).

As with Area 1, Herring Gull was the most regularly-occurring species in Area 2; recorded in nearly half of all counts (Table 8). Thereafter, the three regularly occurring species (occurring in more than 20% of counts) were ranked in descending order as follows: Black-headed Gull, Common Gull and Cormorant.

Gulls were the most abundant waterbirds in terms of the peak numbers recorded; with Herring Gull and Black-headed Gulls recording peak numbers overall in the month of August. Black-tailed Godwits occurred in numbers of national importance in August, while peak numbers of Sanderling exceeded the national threshold in August and September (Table 8).

Table 7. Area 1 - Waterbird occurrence (number of counts a species was present in and % of the total number of counts) and waterbird abundance (peak numbers/month).
* denotes numbers of all-Ireland importance (after Crowe & Holt 2013); ** denotes numbers of international importance (after Wetlands International 2012).

Species Name	No. counts (% Occurrence)	Peak count per month			
		Jun	Jul	Aug	Sep
Cormorant	8 (13)		1	27	29
Little Egret	1 (2)				1
Grey Heron	2 (3)		1	1	
Oystercatcher	17 (28)		165	208	327
Ringed Plover	8 (13)			41	7
Golden Plover	1 (2)			36	
Grey Plover	2 (3)			4	
Sanderling	6 (10)				182*
Dunlin	17 (28)		190	277	38
Black-tailed Godwit	13 (21)		288*	584*	694**
Bar-tailed Godwit	14 (23)		350*	137	334*
Curlew	9 (15)			1	6
Turnstone	1 (2)				3
Black-headed Gull	25 (41)	24	1,440	733	600
Common Gull	22 (36)		1,065	483	221
Lesser Black-backed Gull	5 (8)		2	1	1
Herring Gull	29 (48)	618	1,705	1,340	966
Great Black-backed Gull	8 (13)	3	3	2	5

Table 8. Area 2 - Waterbird occurrence (number of counts a species was present in and % of the total number of counts) and waterbird abundance (peak numbers/month).
* denotes numbers of all-Ireland importance (after Crowe & Holt 2013).

Species Name	No. counts (% Occurrence)	Peak count per month			
		Jun	Jul	Aug	Sep
Cormorant	20 (32)	9	15	44	23
Little Egret	5 (8)		1	1	3
Grey Heron	5 (8)	1	1	1	2
Oystercatcher	19 (31)	47	83	251	122
Ringed Plover	3 (5)			38	4
Golden Plover	2 (3)			4	
Grey Plover	3 (5)			48*	
Knot	2 (3)			24	
Sanderling	9 (15)			105*	122*
Dunlin	16 (26)		65	497	102
Black-tailed Godwit	13 (21)		2	328*	166
Bar-tailed Godwit	10 (16)			84	79
Curlew	11 (18)			19	6
Whimbrel	1 (2)		4		
Black-headed Gull	24 (39)	7	139	799	164

Common Gull	21 (34)		95	540	146
Lesser Black-backed Gull	6 (10)			1	4
Herring Gull	29 (47)	307	48	868	620
Great Black-backed Gull	15 (24)	17	3	12	14
Roseate Tern	1 (2)			7	
Common Tern	2 (3)			32	4

Herring Gull (Photo credit: Brian Burke)

Bar-tailed Godwit (Photo credit: Shay Connolly)

Waterbird behaviour and influence of tides

Wading birds were almost exclusively foraging during the surveys; Oystercatcher being the exception with roosting/other behaviour recorded within five counts of Area 1 and 12 counts of Area 2 with the average proportion of birds undertaking this behaviour during these counts being 33% and 43% respectively (Appendix 1).

The small numbers of Little Egret and Grey Heron recorded were also largely foraging. Cormorants foraged subtidally or were recorded roosting subtidally or intertidally. Black-headed Gulls and Common Gulls, on average, were most likely to be recorded foraging, while Herring Gulls roosted in a greater number of counts overall, with on average around two-thirds of the total number counted on these occasions being classed as roosting/other behaviour.

Average total waterbird numbers (all species combined) were higher within Area 1 during the low tide stage LT-3 (i.e. the three hours leading up to low tide) (Fig. 5a). Waterbird counts on average were then highest during the three hour period after low tide with numbers of waterbirds around the high tide stages substantially lower (Figure 5a). A similar pattern was evident for Area 2 although the three hour period before high tide recorded the second largest number of waterbirds on average (Fig. 5b).

Figure 5a. Total waterbird numbers within Area 1 in relation to tidal stage (Mean ± S.D).

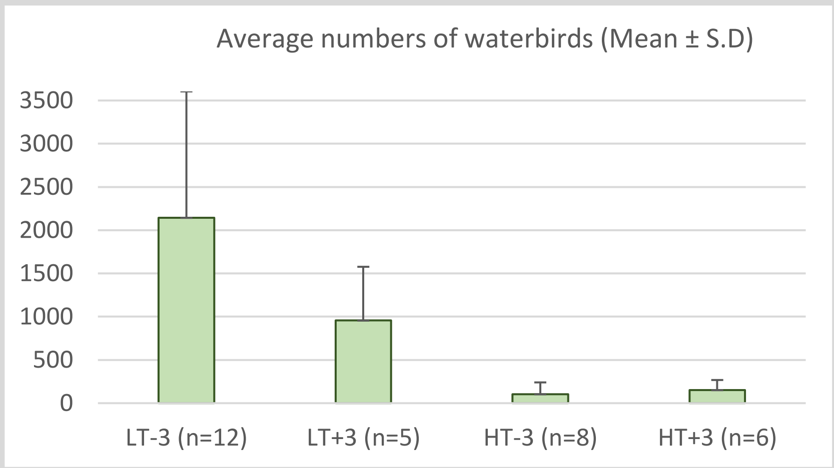
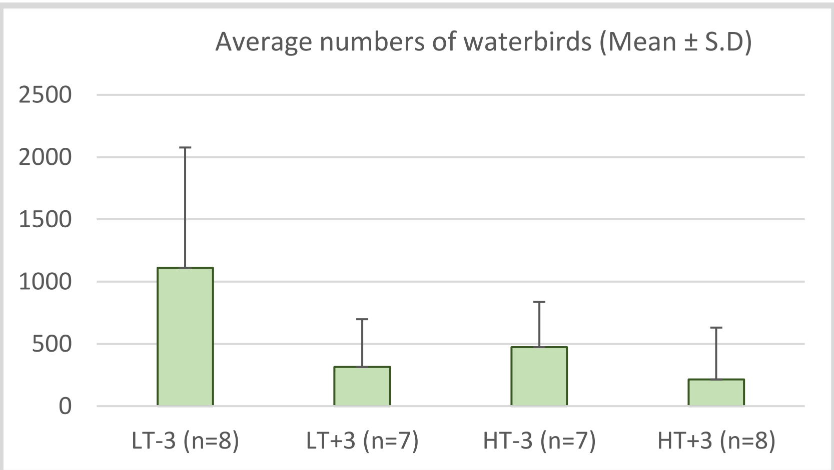


Figure 5b. Total waterbird numbers within Area 2 in relation to tidal stage (Mean ± S.D).



As gulls were the most numerous birds, these species were examined separately, and this reveals that for Area 1 the pattern is the same as for all waterbirds i.e. gulls were most numerous during the low tide stage LT-3 - i.e. the three hours leading up to low tide (Fig. 6).

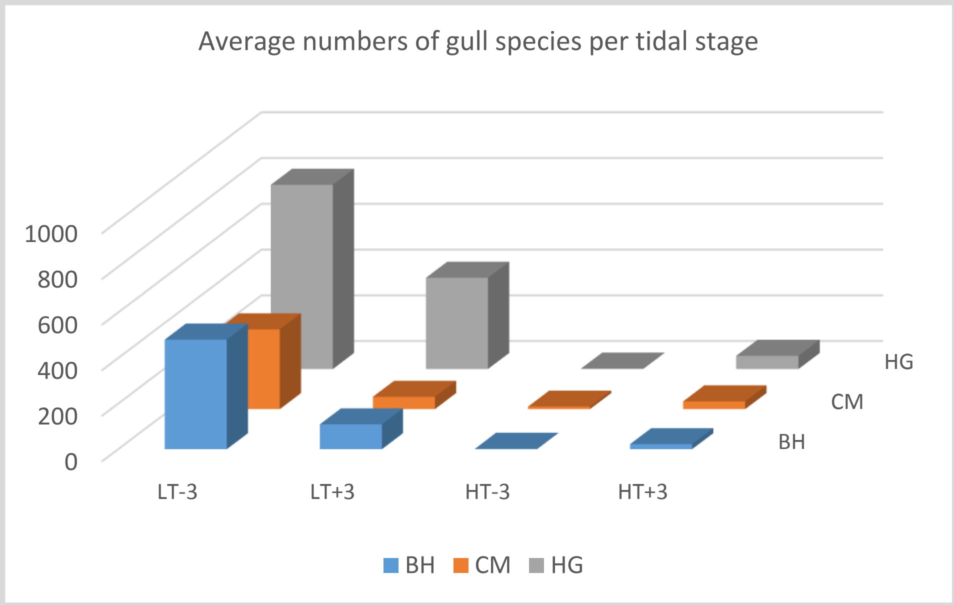
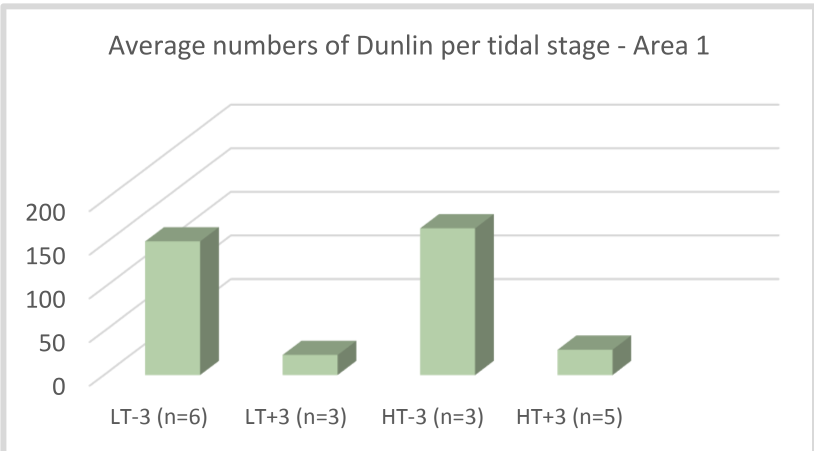


Figure 6. Average numbers of Black-headed (BH), Common (CM) and Herring Gulls (HG) within Area 1 in relation to tidal stage

Within Area 1, the waders Bar-tailed Godwit and Black-tailed Godwit were recorded almost exclusively during tidal stages 1 and 2 (three hours before and after low tide) with average numbers higher during the three hours leading up to low tide. In contrast Dunlin, recorded in 17 counts overall, were on average most numerous during HT-3 followed by LT-3 (Fig. 7).

Within Area 2, Bar-tailed Godwits were recorded during ten counts overall of which five were during tidal stage 1 (three hours before low tide), although the peak count of this wader was recorded during the three hours after high tide (stage 4 HT+3). Black-tailed Godwits followed the same pattern with the peak count again recorded during the three hours after high tide (stage 4 HT+3); however this count, a mixed flock of Bar- and Black-tailed Godwits was recorded on a single occasion only. Dunlin also followed the pattern as seen in Area 1 whereby peak numbers were recorded during the tidal stage HT-3; three hours before high tide.

Figure 7. Average numbers of Dunlin within Area 1 in relation to tidal stage (n = number of counts).



Activities along Dollymount Strand

Activities were recorded in a total of 33 and 30 counts of Area 1 and 2 respectively. Walking was the most frequently recorded activity type along Dollymount Strand, and within both Areas 1 and 2 (Figs. 8a and 8b). Kitesurfing was the second most frequent activity type in Area 1 but this activity does not generally occur further north along Dollymount Strand into Area 2. Thereafter dogs, recorded in several categories as to whether they were on or off the lead were the most frequently-occurring activities, with notably the category 'off the lead' being the most frequent. The activity type 'other' was used for activities that did not fit into the preassigned categories; in most cases they related to either stationary people (e.g. stood talking) or to cyclists.

Figure 8a. Activity types and frequency of occurrence (%) – Area 1 (n=33)

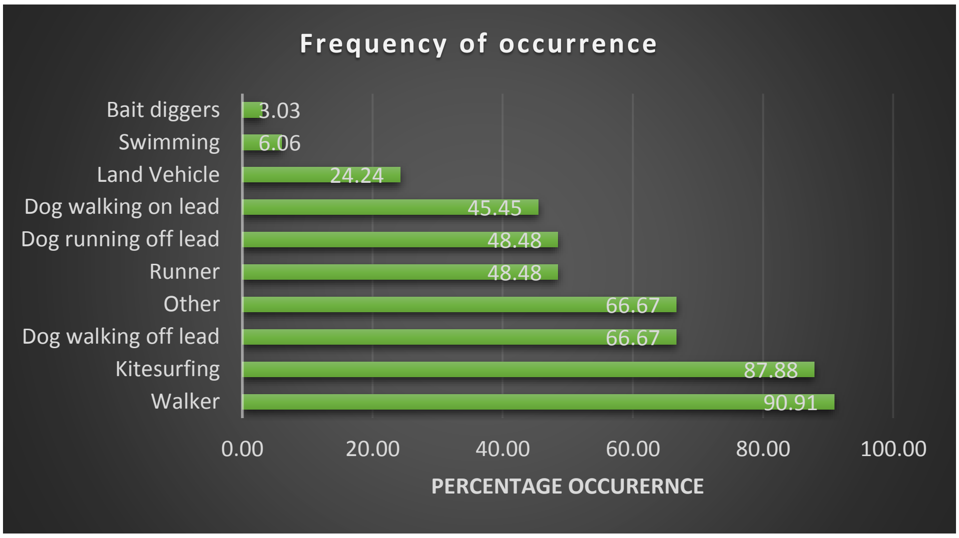
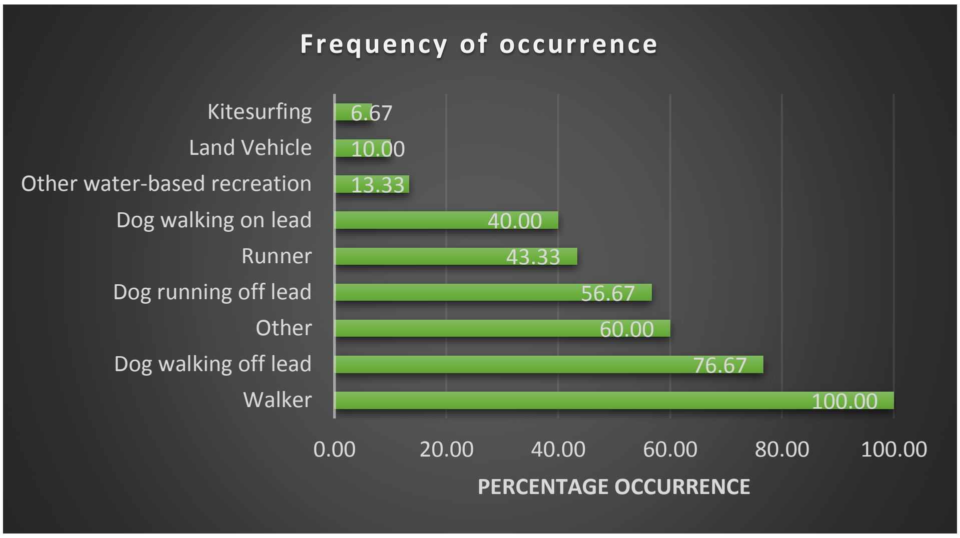


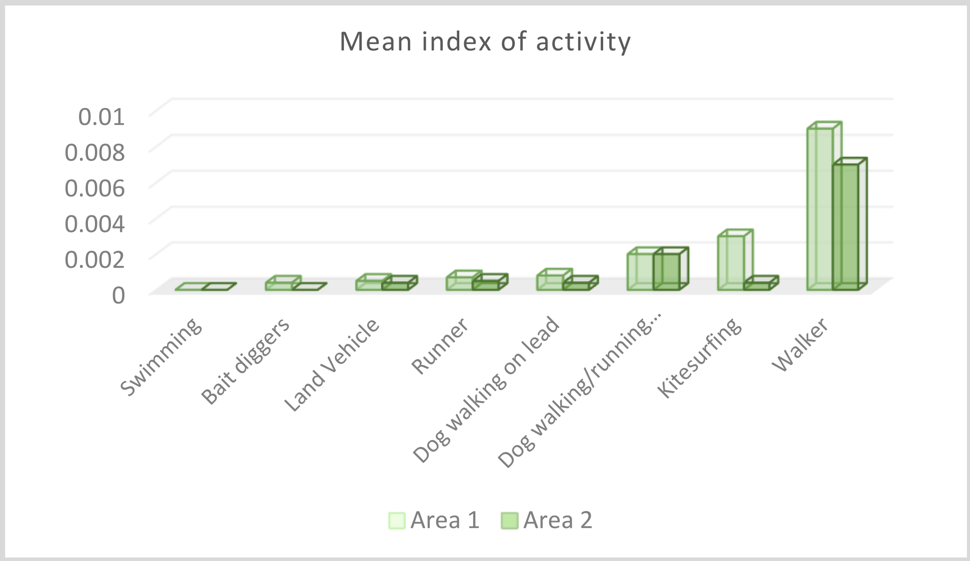
Figure 8b. Activity types and frequency of occurrence (%) – Area 2 (n=30)



The average number of activities (all combined) within Area 1 was 38 per count session (±40 S.D); with this average slightly lower for Area 2 (35 per count session ± 37 S.D.). On average, 20 walkers were present within counts of Area 1 (± 11 S.D), with is relatively similar to Area 2 (Mean 19 ± 24 S.D.).

The mean index of activity across the study period, an indication of the level and potential impacts of the various activities, was greatest for walking in both Areas 1 and 2, followed by kitesurfing (Area 1) and dogs (off the lead) (Fig. 9).

Figure 9. Mean index of activity across the study period for Areas 1 and 2.

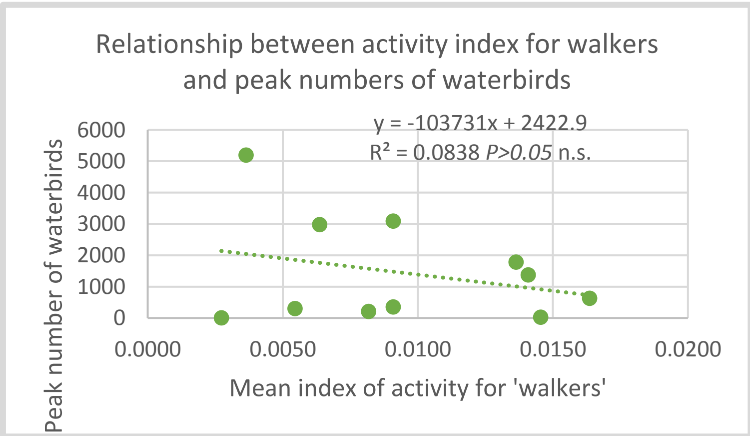


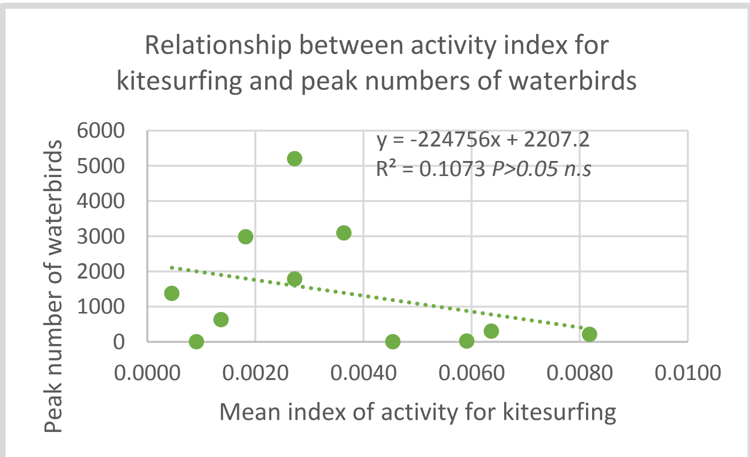
Activities and waterbird numbers

Within Area 1 there was no relationship between the mean index of activity for dogs (off the lead) and the peak number of waterbirds (all species combined). However, negative (but non-statistically significant) relationships were revealed for walkers and kitesurfing, i.e. the greater the activities the lower the numbers of waterbirds recorded (Fig. 10a, Fig. 10b).

Examination of the same relationships for Area 2 revealed no patterns or relationships at all between the index of activity for walkers or dogs, and the peak number of waterbirds recorded.

Figure 10. Relationship between the mean index of activity for (a) walkers and (b) kitesurfing and the peak number of waterbirds – Area 1.





As gulls often dominated the waterbird counts, relationships were examined for wading birds separately (waders). For Area 1, a negative relationship was found between walkers and the numbers of waders, and although this was statistically non-significant this means that the greater the number of walkers, the lower the numbers of waders recorded. The relationship between the index of activity for kitesurfing and waders was also negative and on the border of statistical significance (*P=0.056*) (Fig. 11).

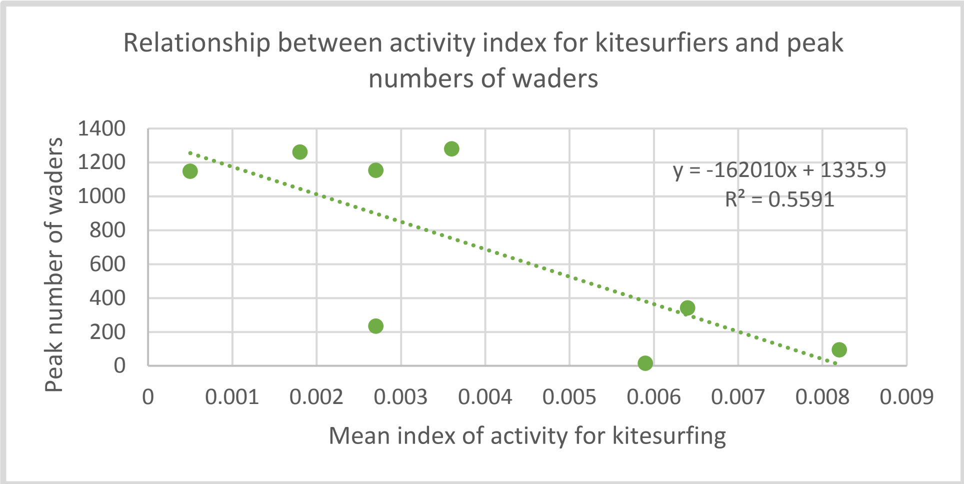


Figure 11. Relationship between the mean index of activity for kitesurfing and the peak number of wading birds – Area 1.

Patterns revealed by disturbance recording

Overview of Disturbances

A total of 547 disturbance events were recorded over the twelve survey dates. Of these, kitesurfing was the most frequently recorded disturbance type (n = 224). However, the proportion of kitesurfing disturbances does not reflect the prevalence of this activity, as an emphasis was placed on gathering information related to kitesurfing disturbance events in order to gain a clearer understanding of its effects on waterbirds. A closer analysis of the proportions of responses to kitesurfing is instead a better indication of the effect of this sport on waterbird species.

Dogs were involved in a total of 134 disturbance events. Of these events, dogs running off lead was the predominant disturbance type (n = 73), followed by dogs walking off lead, (n = 40) and dogs walking on lead (n = 20). Walkers were the third most commonly observed activity involved in disturbance events (n = 126), followed by runners (n = 47) and other (n= 31) (Fig. 12). Table 9 below shows the breakdown of disturbance types included in the class 'Other'. Note that the records and hence sample size for the activity 'dogs walking on lead' was considered too small to be included in any further analysis.

Table 9. Disturbance types categorised as 'Other'

Disturbance Type	Number of disturbances invoked or contributed toward
Swimming	2
Land vehicle	11
Other water based recreation	6
Standing/ Cycling	13
Powered watercraft	1

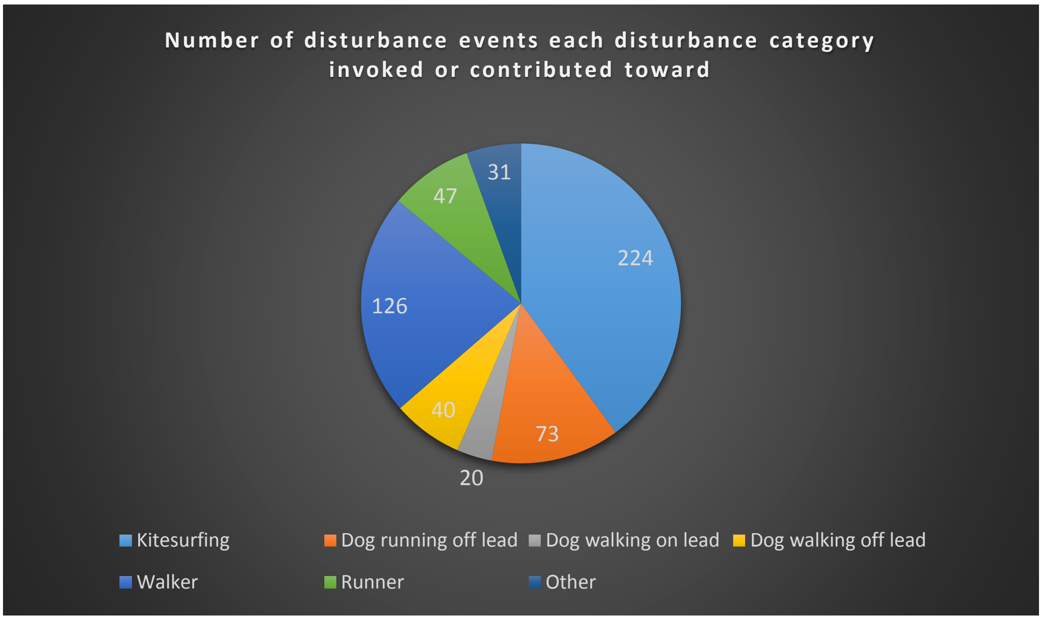


Figure 12. The number of disturbance events each disturbance type was involved in.

While kitesurfing was typically confined to relatively discrete areas, and largely occurred in Area 1, other disturbance types were generally spread across the beach in both Area 1 and Area 2.

A comparison of waterbird responses to disturbance types across Dollymount Strand

Dogs running off lead elicited the largest proportion of High and Moderate responses combined (55% of all interactions), with 7% of all interactions resulting in birds leaving the survey area, while 48% of interactions resulted in waterbirds moving to another part of the survey area (Fig. 13). Thereafter the proportions of High and Moderate responses combined were ranked highest for activities in the following order: 'dogs walking on lead' > 'dogs walking off lead' > kitesurfing > running > walking. Dogs running off lead was the only activity where over 50% of interactions resulted in moderate or high responses from waterbirds. In contrast, 73% of disturbance events involving kitesurfing recorded no response or only weak response from waterbirds. Proportionally, the greatest number of disturbance records resulted in a Weak response from waterbirds, while the proportion of No Responses and Weak responses combined for all activity types was higher than for the Moderate and High responses combined (with the exception of dogs running off lead).

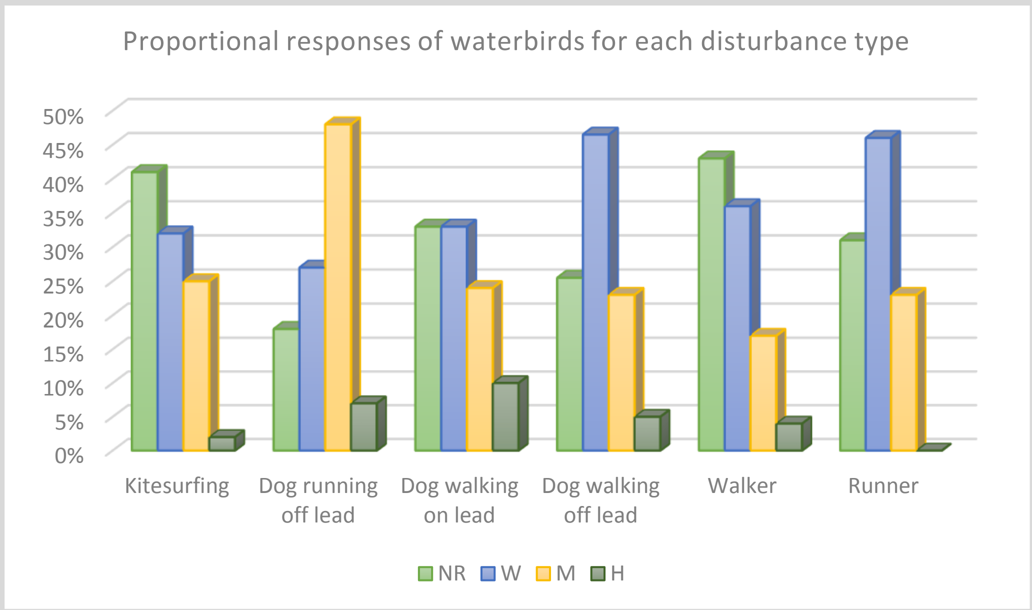


Figure 13. Proportions of response categories for each disturbance type (NR=no response; W=weak response; M=moderate response; H=High response)

Comparison of disturbance events recorded in Area 1 and Area 2

The number of disturbance events recorded within each of the survey areas was relatively similar, with 300 disturbance events recorded in Area 1 compared to 247 recorded in Area 2. However, the proportions of disturbance types differed between the two areas, most notably with regard to kitesurfing which occurs largely in Area 1 (Fig. 14).

Analysing the proportions of all disturbance types with the exception of kitesurfing, indicates similar trends across both survey areas for most disturbance classes with the exception of dogs running off lead and runners. The proportion of disturbances recorded for dogs running off lead were 8% higher in Area 2 than in Area 1. Disturbance events involving runners were 14% more common across the data set for Area 1 than for Area 2. However, these data are not necessarily reflective of a genuine difference in the frequency of each disturbance type because the study placed an emphasis on gathering information related to kitesurfing disturbance events - therefore for a comparison of activities between the two areas please refer back to the section 'Activities along Dollymount Strand'.

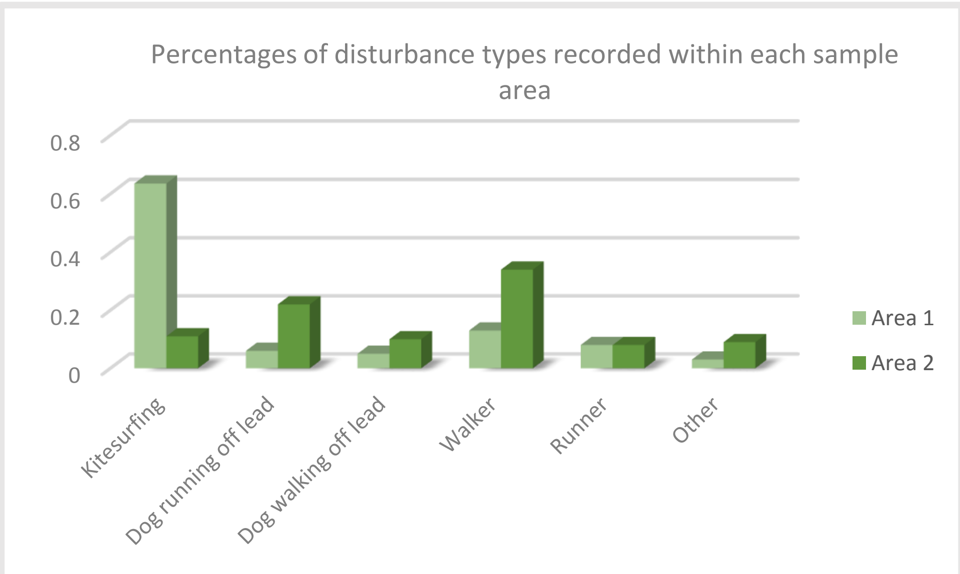


Figure 14. Comparison of the percentages of each disturbance type recorded in sample areas one and two.

Proportional responses to disturbance types in Area 1 compared to Area 2

The proportions of the various response categories of waterbirds to disturbance types in Areas 1 and 2 are shown in Table 11. Kitesurfing was not compared here as this activity generally occurs in Area 1 only.

Combining the proportions of moderate and high responses of waterbirds and comparing these across the two survey areas suggests a similar level of response in both areas for all disturbance categories with the exception of walking where Area 1 (37%) recorded a higher level of responses than Area 2 (13%)

Moderate responses were greater within Area 1 for two disturbance types. These were Dog walking off lead, (31% and 19% for Areas 1 and 2 respectively) and Walker (30% and 10% Areas 1 and 2 respectively). The level of High responses did not appear to differ greatly between the two survey areas (Table 11).

Table 11. Proportions of responses by waterbirds to disturbance types in Area 1 versus Area 2

Area	Disturbance Type	No Response %	Weak %	Moderate %	High %
Area 1	Kitesurfing	43.5	31.5	23	2
Area 2	Kitesurfing	-	-	-	-
Area 1	Dog walking off lead	12.5	56	31	0
Area 2	Dog walking off lead	33	41	19	7
Area 1	Dog running off lead	19	24	47.5	9.5
Area 2	Dog running off lead	17	28	49	6
Area 1	Walker	35	28	30	7
Area 2	Walker	47	40	10	3
Area 1	Runner	21.5	57	21.5	0
Area 2	Runner	45	30	25	0
Area 1	Other	40	50	10	0
Area 2	Other	77	11.5	11.5	0

A comparison of the effect of disturbance types on waterbird species

A total of fifteen species were involved during disturbance recording. Three gull species, Herring Gull, Black headed Gull and Common Gull were involved in a high rate of disturbance events (n = 243, 142, and 105 respectively). The wader species most commonly recorded in disturbance events were Dunlin *(n = 115)* and Oystercatcher (n= 76). These species were more commonly observed in areas with higher activity levels than other waterbirds, across a greater number of tidal stages, and in comparison to some species, such as Sanderling which also frequented more disturbed areas of the beach, were present during a higher quantity of surveys.

Due to the low number of some of the species during disturbance events, waterbirds were grouped into three categories for the purposes of analysis. These categories were gull (*Larus*) species, wading species and ‘others’ (terns, Cormorants and Shelduck) (Table 13). Terns, Shelduck and Cormorants were recorded interacting almost exclusively with kitesurfers except on two occasions, so these species will be examined in relation to kitesurfing only later in this report.

Table 13. Waterbird species involved in disturbance events and the number of events recorded for each.

Species	Number of disturbance events
Larus Species	
Herring Gull	243
Black headed Gull	142
Common Gull	97
Great black backed Gull	7
Wading Bird Species	
Dunlin	115
Oystercatcher	76
Sanderling	35
Black-tailed godwit	28
Ringed plover	20
Bar-tailed godwit	7
Curlew	2
Golden Plover	1
Other Category	
Cormorant	22
Tern Species	12
Shelduck	1

Kitesurfing was observed to interact with *Larus* species to a greater extent than wading bird species. In comparison to all other disturbance types, kitesurfers were found to interact with wading bird species to a lower extent (Fig. 17).

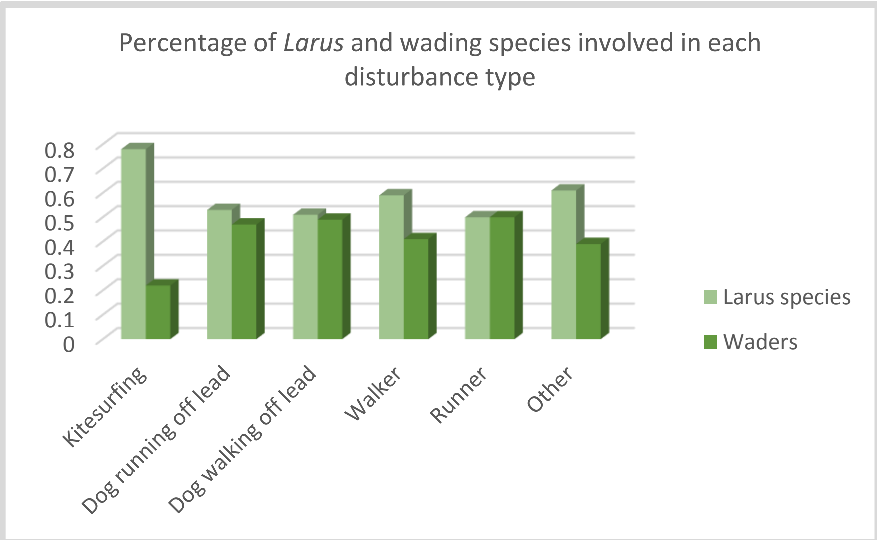


Figure 17. Comparison of the proportions of wading and *Larus* species effected by each disturbance type.

Dogs running off lead elicited the largest proportion of High responses overall for wading species (10%), compared to just 4% for *Larus* species (Table 14). Wading birds also exhibited higher proportions of Moderate responses than *Larus* species across all disturbance types except Other (Table 14) although the difference for 'Dogs running off the lead' was small suggesting both these waterbird groups largely respond in a similar way to this activity. Interestingly, *Larus* species were most strongly affected by walkers, with 8% of interactions resulting in High responses. In contrast, waders exhibited High responses to walkers on only 2% of occasions (Table 14). Kitesurfing appeared to effect wading birds and *Larus* species in relatively similar ways; the proportional responses being very similar across the categories.

Table 14: Proportional (%) effects of all disturbance types on wading birds and *Larus* species

Activity	Waterbird Category	No Response	Weak	Moderate	High
Dog running off lead	Wading species	19	19	52	10
Dog running off lead	*Larus* species	18	31	47	4
Dog walking off lead	Wading species	30	39	26	4
Dog walking off lead	*Larus* species	28	48	20	4
Walker	Wading species	41	34	23	2
Walker	*Larus* Species	44	36	12	8
Runner	Wading species	24	44	32	0
Runner	*Larus* Species	42	46	12	0
Other	Wading species	80	13	7	0
Other	*Larus* Species	64	24	12	0
Kitesurfing	Wading species	38	27	33	2
Kitesurfing	*Larus* Species	42	32	24	2

Effects of disturbance events on intertidal vs. subtidal birds

Disturbance events were most often observed impacting upon birds in the intertidal zone. A total of 475 events across all disturbance types involved waterbirds within this area (87% of the total number) compared with 72 events involving waterbirds roosting or feeding in the subtidal zone. Of the 475 events in the intertidal zone, 94% impacted upon birds in the low to mid zone of the intertidal zone (lower shore). This is in line with waterbird counts which revealed a consistent pattern of waterbird use of the intertidal area, particularly the low – mid zone, in comparison to the subtidal or mid – high area of the intertidal zone.

Overview of kitesurfing disturbances

Kitesurfing activity was principally confined to Area 1, and was observed in Area 2 on only four out of the 12 survey dates. On those four dates, 28 disturbance events were recorded in Area 2 in comparison to 197 events in Area 1 over the 12 survey days. In Area 1, kitesurfing disturbances typically occurred within a relatively discrete area at the southern end of the beach. By comparison, in Area 2 most disturbance events occurred either at the Sutton Wall at the northern tip of Dollymount Strand or on very few occasions at the portion of the beach opposite the Causeway roundabout.

Disturbance events from kitesurfing were recorded in the subtidal and intertidal zones. In total 72% of all kitesurfing disturbances were recorded when kitesurfing activity was subtidal, and 28% of incidences were recorded when kitesurfers were present in the intertidal zone (Table 15).

A comparison of the location of waterbirds during kitesurfing disturbance events indicates that while the majority of kitesurfing disturbances were recorded when kitesurfers were present in the subtidal area, waterbirds were more typically found on the intertidal zone, particularly the low–mid section, in all disturbance events (72%) (Table 15). Only three events were observed where waterbirds were in the mid–high intertidal zone. This suggests that disturbance caused by kitesurfing activity was more predominant on the intertidal zone, particularly the low-mid section, than within the subtidal area.

Table 15. A comparison of disturbance events across the tidal zones

Location of Kitesurfing Activity	Location of Waterbirds	Percentage of Disturbance Events
Intertidal	Intertidal	27%
Intertidal	Subtidal	1%
Subtidal	Intertidal	45%
Subtidal	Subtidal	27%

The proportion of 'No Responses' exhibited by waterbirds to kitesurfing was found to be much higher when kitesurfing activity was in the subtidal zone and effecting subtidal waterbird species (60%) (Table 16). By comparison, 30% and 39% of birds in the intertidal area did not modify their behaviour in response to kitesurfing activity when kitesurfing was intertidal and subtidal respectively. The highest proportion of Weak responses was found for waterbirds in the intertidal zone, reacting to kitesurfers in the same area (41%). This may be due to the necessity of kitesurfers to often walk through, or by, flocks of birds in the intertidal zone *en route* to the sea. Weak responses were roughly proportionate to one another for birds in the intertidal and subtidal zones, interacting with kitesurfing activity in the subtidal area (28% and 29% respectively).

Moderate responses were lowest for birds in the subtidal region interacting with kitesurfers in the same zone (10%), compared to intertidal birds reacting to intertidal (26%) and subtidal (30%) kitesurfing activity. High responses were proportionate across all three categories. Interactions between intertidal kitesurfing activity and subtidal waterbirds were only recorded on two occasions illustrating the lower effect of intertidal kitesurfing activity on the subtidal zone compared to the other categories (Table 16).

Table 16. A comparison of responses by waterbirds in the intertidal and subtidal zones to kitesurfing in the intertidal and subtidal areas

Location of Kitesurfing	Location of Waterbirds	No Response	Weak	Moderate	High
Intertidal	Intertidal	30%	41%	26%	3%
Intertidal	Subtidal	n/a*	n/a	n/a	n/a
Subtidal	Intertidal	39%	28%	30%	3%
Subtidal	Subtidal	60%	29%	10%	3%

* Sample size of interactions between kitesurfers in the subtidal zone and waterbirds in the intertidal zone, *n = 2.* Therefore, it is too small a sample size to draw any meaningful conclusions from.

The effect of distance on waterbird behavioural responses to kitesurfing

Due to the smaller sample size of distances above 40m and the lower proportion of weak responses found for this distance and above compared to 30m and below, distances have been categorised into two classes. These are ≤30m and ≥40m.

A correlation between distance of kitesurfing activity and waterbirds was found across the dataset. At distances of ≤30m, waterbirds did not modify their behavior 30% of the time, with the greatest proportion of responses being 'Weak'. In contrast the greatest proportion (63%) of interactions with kitesurfers at distances of 40m or greater, waterbirds showed no behavioural changes in response to kitesurfing activity (Fig. 18).

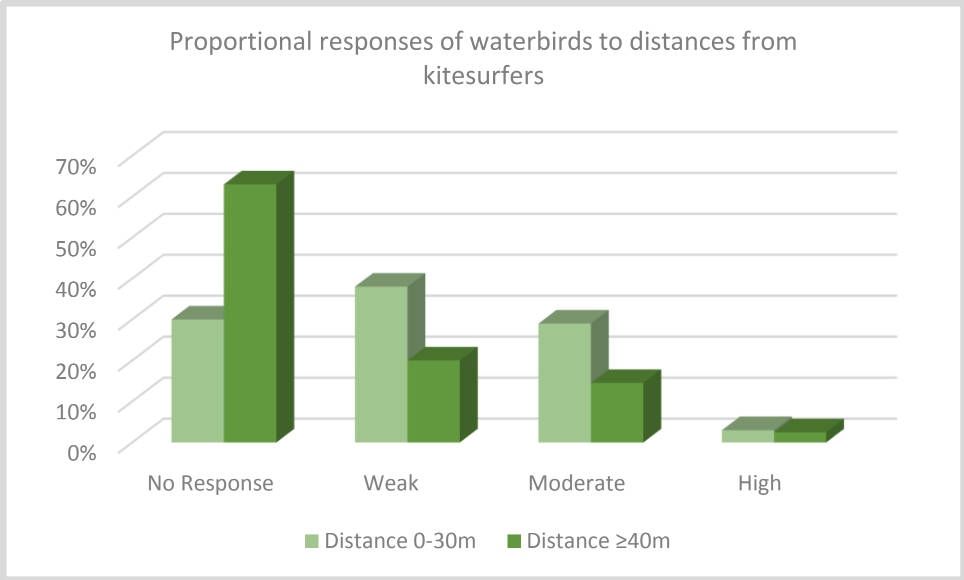


Figure 18. Proportional responses of waterbirds to kitesurfers at distances of ≤30m and ≥40m.

Effect of kitesurfing activity at each tidal stage on waterbirds in the intertidal and subtidal areas

A comparison of the tidal zones effected by kitesurfing at each tidal state indicates that during the low tide tidal stages (Tide 1 and Tide 2)[2], disturbance events were highly skewed toward birds on the intertidal zone (86% and 91% respectively). In contrast, during high tidal stages (Tide 3 and Tide 4), the difference between birds in the intertidal and subtidal zones was less marked (Table 17).

Table 17. A comparison of the impact of kitesurfing on waterbirds in the intertidal and subtidal zone across all tidal stages

Tidal State	Percentage of interactions with waterbirds in the intertidal zone	Percentage of interactions with waterbirds in the subtidal zone
Tide 1	86%	14%
Tide 2	91%	9%
Tide 3	56%	44%
Tide 4	56%	44%

Comparison of the effects of kitesurfing to walkers and dogs running off lead by tidal stage

A comparison of the responses of waterbirds to three disturbance classes: kitesurfing, dogs running off the lead, and walkers is shown in Table 18.

A higher proportion of combined 'no responses' and 'weak responses' was evident for the activity walking during all four tidal stages, followed by kitesurfing. Dogs running off lead were responsible for the highest proportions of 'moderate' and 'high' responses combined, across all four tidal stages, while the proportion of only 'high' responses was also higher for this activity across all tidal stages with the exception of Tide 4 (three hour period following high tide).

A higher proportion of 'no response' from waterbirds was recorded for kitesurfing during Tide 1 and Tide 3, with 'moderate' responses being proportionally higher at Tide 2, and 'weak' at Tide 4.

[2] Tide 1 = 3-hour period prior to Low Tide; Tide 2 = 3-hour period following Low Tide; Tide 3 = 3-hour period prior to High Tide; Tide 4 = 3-hour period following High Tide.

Table 18. A comparison of proportionate responses for kitesurfing and all other disturbance types across the four tidal stages

Disturbance Type	Tidal Stage	No Response	Weak	Moderate	High
Kitesurfing	Tide 1	42%	37%	21%	0%
Dogs running off lead	Tide 1	0%	28%	64%	7%
Walker	Tide 2	57%	22%	22%	0%
Kitesurfing	Tide 2	39%	18%	43%	0%
Dogs running off lead	Tide 2	17%	26%	48%	9%
Walker	Tide 2	36%	36%	24%	4%
Kitesurfing	Tide 3	52%	29%	16%	3%
Dogs running off lead	Tide 3	24%	16%	48%	12%
Walker	Tide 3	47%	38%	11%	4%
Kitesurfing	Tide 4	29%	39%	21%	11%
Dogs running off lead	Tide 4	22%	39%	39%	0%
Walker	Tide 4	38.5%	38.5%	18%	5%

Effects of kitesurfing on different waterbird species

Disturbance events featuring kitesurfing involved Larus species to a greater extent than wading bird species, cormorants or terns; in total, 176 kitesurfing disturbance events involved Larus species, compared to 51 events involving wading birds, and 32 events involving cormorants and tern species. A breakdown by species indicates that Herring Gulls were by far the most common waterbird species recorded during kitesurfing disturbance events, with 137 disturbances involving this species (Table 19). Other species were recorded at much lower levels, with Black-headed Gulls the second most frequently recorded species, (n = 46), and Common Gulls the third most common species recorded during these events (n = 38). Of the waders involved in disturbance events, Oystercatchers were the most frequently observed, (n = 28). Cormorants were the sixth most frequent waterbird observed interacting with kitesurfers (n = 20). Wading bird shows the greatest proportion of 'moderate' responses to kitesurfing compared to *Larus* species and cormorants, shelduck and tern species (Fig. 21).

Table 19. The number of kitesurfing disturbance events observed for each species

Species	Number of disturbance events recorded for each species
***Larus* species**	
Herring Gull	137
Black headed Gull	46
Common Gull	38
Wading bird species	
Oystercatcher	28
Dunlin	15
Black–tailed godwit	8
Sanderling	5
Bar-tailed godwit	4
Ringed plover	2
Great black backed Gull	2
Curlew	1
Godwits	1
Cormorant, terns and Shelduck	
Cormorant	20
Tern Species	12
Shelduck	1

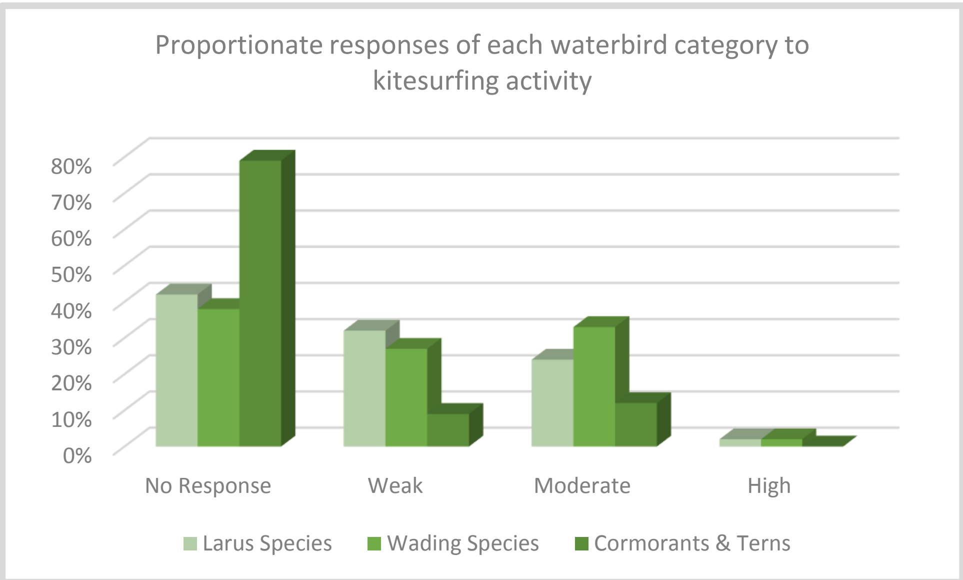


Figure 21. A comparison of responses to kitesurfing activity for each waterbird category

Effect of kitesurfing activity on waterbird categories across the four tidal stages

Across all tidal stages, gull species were often most observed interacting with kitesurfers. This ranged from 76% of all interactions at Tide 4 (three hour period after high tide) to 65% of interactions during Tide 2 (Table 21). Wading bird interactions were greatest during Tide 1 (three hour period prior to low tide) and Tide 2 (three hour period after low tide).

Table 21. A comparison of kitesurfing interactions with waterbird groups across tidal stages

Tidal State	Percentage of interactions with *Larus* species	Percentage of interactions with wading species	Percentage of interactions with cormorants and terns
Tide 1	66%	28%	6%
Tide 2	65%	22%	14%
Tide 3	68%	8%	24%
Tide 4	76%	16%	8%

Discussion

Waterbird use of Dollymount Strand outside of the wintering season

Despite the survey being undertaken outside of the wintering bird period; typically October – March, a good diversity of waterbird species was found to use Dollymount Strand including 11 out of the 17 waterbird species listed as Special Conservation Interest species (SCIs) for North Bull Island SPA. Gulls dominated in terms of frequency of occurrence and numbers, contributing to relatively high counts on occasion, but numbers of wading bird species and notably Bar- and Black-tailed Godwit were relatively high on occasion. These waders were either first year birds that did not migrate to breeding grounds due to their immaturity, or possibly birds that had arrived back early into Ireland after a failed attempt on the breeding grounds. The presence of Black-tailed Godwits in numbers of all-Ireland importance is interesting as this species is usually associated with muddy estuaries in contrast to the open sand of Dollymount Strand that is more favoured by the Bar-tailed Godwit. However, Black-tailed Godwits have been shown to adapt to novel feeding opportunities (e.g. Percival, 2011) and often feed at the tide edge. Furthermore, these birds were likely to have stopped off at Dollymount for a short period only. Dollymount does not support large numbers of this wader during winter (I-WeBS Office), so the birds recorded during the current study may reflect those stopping off on passage and *en route* to other parts of Dublin Bay, or indeed to other sites. While the wader Oystercatcher was present in most months, August saw an increase in diversity of wading birds such as Ringed Plover and Dunlin. Overall therefore, despite the study months being outside of the main wintering period, an interesting and often numerous diversity of waterbirds was present, perhaps also highlighting the importance of Dollymount, and Dublin Bay as a whole, for passage waterbirds.

How and when waterbirds utilise the area is also an important consideration, especially when assessing the potential impacts of activities, and this study showed clearly that wading birds were mostly foraging during the surveys. Gulls differed somewhat, as while Black-headed Gulls and Common Gulls were most likely to be recorded foraging, Herring Gulls were most often roosting/loafing. The tidal cycle also plays an important part in determining numbers of waterbirds present and a general pattern of greater numbers during the low tide stages was found, a pattern that held true for both wading birds and gulls and was in agreement with the results of Wilson (2017).

Do activities along Dollymount Strand affect waterbird numbers?

It is clear that Dollymount Strand is a very popular location for human recreation. Walking was the most frequently recorded activity type within both study areas, and almost constant, while dogs, recorded in several categories as to whether they were on or off the lead were very prevalent; with notably the category 'off the lead' being the most frequent. Kitesurfing was the second most frequent activity type in Area 1 and does not generally occur further north along Dollymount Strand into Area 2, but it should be noted that the study was focused on assessing kitesurfing and therefore the study days were chosen when the weather conditions were optimal for this activity. The frequency of kitesurfing occurring, for example, total average number of days per month, is not known, but should be considered in any future impact assessment as the activity may not occur with the regularity and frequency of human recreational/dog walking.

Assessing the effects of activity levels on waterbird numbers is inherently difficult but the approach we adopted (calculating a mean index of activity) aimed to determine any possible relationships. That said, given the huge variability in waterbird counts, patterns can be very hard to discern and hence the finding of no relationships between activities and waterbird numbers in Area 2 was not considered unusual. For Area 1 however, negative relationships were evident between the amount of walking, and the amount of kitesurfing and waterbird numbers, meaning that as the activities increase, the numbers of waterbirds decrease. While these relationships were not statistically significant when assessed singularly, it is easy to understand that the relationships would have been more significantly negative if the two activities had been assessed in combination. The difference between Areas 1 and 2 suggests that the effects of activities upon waterbirds are greater in Area 1 than Area 2, as a consequence of the mean index of activity for walking and kitesurfing being greater in this area.

Responses of waterbirds to disturbance

Differences in behavioural responses to various forms of disturbance have been noted for waterbirds (Lafferty 2001; Kirby et al., 1993). In the current study, dogs running off lead were found to elicit the highest levels of response behaviour from waterbirds, followed by dogs walking off lead and runners. This is in accordance with previous research (Randler 2005; Phalan & Nairn 2007; Borgman 2011). But dogs running off lead was the only activity where over 50% of interactions resulted in moderate or high responses from waterbirds. Proportionally, the greatest number of disturbance records resulted in a weak response from waterbirds (i.e. little movement), while the proportion of 'no responses' and 'weak responses' combined for all activity types was higher than the combined 'moderate' and 'high' responses, suggesting that most activities elicit little responses from waterbirds. However, in areas under heavy recreational pressure, such as Dollymount Strand, even low levels of disturbance can have deleterious effects on waterbird survival due to its sustained nature (Phalan & Nairn 2007). The effects of disturbance at even low levels will be discussed more below.

Disturbance events were found to particularly effect waterbirds within the intertidal zone, specifically the low–mid section of the beach. While subtidal kitesurfing activity predominantly effected birds on the tide line, all other land-based disturbance activity impacted principally upon the upper portion of the tidal flats. This is an important result, as the upper tidal flats remain exposed for the longest period of time, allowing birds to maximise their prey intake (Granadeiro et al., 2006). Therefore, in areas where kitesurfing activity occurs along the tideline, the amount of intertidal area free from disturbance may be limited to an even greater extent than when subtidal activities are not occurring.

Larus species were found to be involved in a higher proportion of kitesurfing disturbance events than wading birds or other waterbird species. The proportional difference was also higher than that observed for any other disturbance type. This may have been due to the prevalence of gulls in the landing and launching area in comparison to wading birds and other species; and follows the pattern that wading bird numbers tend to be lower when kitesurfing is occurring.

Gull species were also the most frequently observed waterbird species on Dollymount Strand. The difference in avoidance responses by wading birds and *Larus* species to kitesurfing could be an indication of a lower impact of this activity on gulls than wading birds (Klein 1993). However, while avoidance has been found to often be a reliable predictor of disturbance impacts (Gander & Ingold 1997), constraining effects such as competition, alternative habitat and predation risk can also influence avoidance behaviour (Gill et al., 2001). It therefore follows that the lower avoidance rates to kitesurfing activity observed for *Larus* in comparison to wading bird species may not have been due to a lesser impact on these waterbirds compared to wading species, but the result of other environmental constraints.

High responses to kitesurfing were greatest (11%) during Tide 4 i.e. the three-hour period following high tide, potentially due to the reduced level of intertidal habitat at this time bringing the activity closer to waterbirds on the shoreline. Moderate responses were found to be highest during Tide 2, the three-hour period after low tide. Following on from the potential rationale for high responses, the result for moderate responses is unexpected as during this time a greater intertidal area would be available to waterbirds and it would be assumed that when a greater expanse of intertidal zone was available, waterbirds less vulnerable to disturbances. One possible explanation is that during Tide 2 foraging waterbirds may have traded off increased food intake for avoidance of kitesurfing activity, due to having at least partially fulfilled this physiological need during Tide 1; which was shown to be the most important tidal stage. However, if this theory applied it would be expected that similar results would be observed across all disturbance types for this tidal stage which was not the case.

Understanding the effects of disturbance upon waterbirds

The need to determine the effects of human activities within the coastal zone has grown in recent decades due to both an increase in environmental awareness and environmental legislation (Caldow 2003), not least the Appropriate Assessment process, as required under Article 6 of the EU Habitat's Directive (EU Commission 2001).

Disturbance relates to any activity that results in a waterbird being displaced from an area. Moving 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 area. Disturbance can also act upon roosting habitat thereby increasing a bird's energy expenditure in the same way.

The effects of disturbance upon waterbirds has been a topic of interest and some concern to ecologists and wildlife managers for a number of years. Behavioural responses to disturbance can vary from subtle declines in intake rates to more serious changes such as avoidance of entire areas or sites (Mitchell *et al.* 1989). Of importance is the determination of the magnitude (significance) of any disturbance impact. However this is inherently difficult to understand. For instance, the fact that a bird flies away from a disturbance does not automatically imply a serious negative effect if the bird has alternative habitat to go to, of similar quality and/or if birds return to the former area once the disturbance event has finished. In this context, it can become impossible to distinguish between animals that do not respond to disturbance because they are unaffected by it and those that are constrained to stay in the area but may suffer severe costs (e.g. reduced foraging time or nest defence) as a result (Gill *et al.* 2007). The response of waterbirds to disturbance events also varies with each individual event and can be related to the type of activity (e.g. mechanical vs human activity), length of time, number of people, and area over which the activity occurs, amongst other factors, so the interpretation of the responses of waterbirds are necessarily confounded by a range of other factors that operate so as to influence a waterbirds' distribution.

However in some cases even a short-term displacement can be of significance, if the birds have no similar quality habitat to move to, or if displacement leads to knock-on ecological effects such as increased competition within and/or between different species for a common food source. In areas subject to heavy or on-going disturbance waterbirds may be disturbed so frequently that their displacement is equivalent to habitat loss. Birds will also suffer more of an impact when already under pressure, for example, in cold weather events when struggling to feed enough to survive. Birds stopping off on migration may also be vulnerable when energy levels have been depleted; a point that is pertinent in the current study given that the study was undertaken not only during the summer months, but during late summer when waterbirds were arriving on migration. When the effects of disturbance reduce species fitness[3] (i.e. reduce survival or reproductive success) then consequences at population level may result in that population declines are observed, and numbers of birds decline, at site-level and beyond. This highlights the importance of long-term monitoring of site waterbird populations.

[3] Defined as a measure of the relative contribution of an individual to the gene pool of the next generation.

Conclusions and recommendations

There is growing concern about the impact of kitesurfing on waterbirds (Davenport & Davenport 2006; Liley & Fearnley 2012). Overall the results of the study indicate that kitesurfing does effect the numbers and behaviour of waterbirds but to a lower extent than some other activities. Perhaps more importantly, the study indicates that waterbirds are also under pressure from other activities, particularly dogs running and walking off lead, walkers and runners. Therefore, while the singular effects of kitesurfing may not be highly deleterious to waterbirds, given the high levels of recreational use on Dollymount Strand, the cumulative effects may be at a serious level. However, quantifying the effect of human activities on habitat use by waterbirds is only a first step, because, as discussed above, altering the distribution and habitat use of waterbirds does not necessarily have consequences for the population as a whole (Gill, Norris & Sutherland 2001). But impacts upon waterbird fitness are inherently difficult to determine. In recent years, individual based models (IBMs), a modelling technique, have been developed and used to investigate a range of disturbance impacts (e.g. Stillman *et al*., 2012) but these are often beyond the scope and budget of projects.

Dublin Bay is well monitored by the Irish Wetland Bird Survey (I-WeBS) and more recently by the Dublin Bay Birds Project (Tierney et al., 2017). While these data provide the means to assess waterbird population trends at site level, where sufficient data exist for smaller areas or 'subsites', there is no reason why waterbird population trends cannot be calculated for smaller-scale areas (e.g. Wright et al. 2008; Austin & Calbrade 2010) to provide an early warning mechanism that waterbirds may be displaced, or numbers may be declining.

Finding a balance between human activities and protecting bird populations is a challenge for conservation managers (Batey 2013). Acceptable levels of human disturbance may need to be determined and then managed (e.g. Beale 2007; Gill 2007). Human/activity management measures can include buffer areas, exclusion zones (where activities in a given area are prevented) or zoning. The temporary cessation of human activities during and after periods of bad weather such as sub-zero temperatures or storms is highly advisable as waterbirds will be particularly challenged at this time to meet their daily energy requirements. However, very few studies measure the success of management measures to reduce disturbance impacts (i.e. the impact of human activity before and after measures are put in place) or compare different management options (Batey 2013). Any management measures put in place would benefit from monitoring studies, to not only measure success, but also to inform further decision making and highlight where further detailed studies such as IBMs may be needed.

Acknowledgements

This project was commissioned by Dublin City Council. We would like to extend sincere thanks to Shane Casey (Dublin City Counil), Catherine Etienne, Francois Colussi, Nicolas Beinars, Seb Vachen and Christophe Kensauven of Pure Magic, and Colm Murphy of the Irish Kitesurfing Association for their information and advice throughout.

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Appendix 1

Summary of waterbird behaviour in Areas 1 and 2

Table A1.1 Summary of waterbird behaviour in Area 1

Species	No. counts overall	Foraging		Roosting/other		Flight/interaction	
		No. counts (% total)	Average proportion %	No. counts (% total)	Average proportion %	No. counts (% total)	Average proportion %
Cormorant	8	3 (38)	78	5 (63)	93	-	-
Little Egret	1	1 (100)	100	-	-	-	-
Grey Heron	2	2 (100)	100	-	-	-	-
Oystercatcher	17	17 (100)	86	5	33	-	-
Ringed Plover	8	7 (88)	100	1 (13)	100	-	-
Golden Plover	1	1 (100)	100	-	-	-	-
Grey Plover	2	2 (100)	100	-	-	-	-
Sanderling	6	6 (100)	100	-	-	-	-
Dunlin	17	16 (94)	100	1	100	-	-
Black-tailed Godwit	13	13 (100)	99	1	2 (8)	-	-
Bar-tailed Godwit	14	14 (100)	100	-	-	-	-
Curlew	9	9 (100)	100	-	-	-	-
Turnstone	1	1 (100)	100	-	-	-	-
Black-headed Gull	25	20 (80)	74	13 (52)	58	2 (8)	27
Common Gull	22	19 (86)	91	7 (32)	68	-	-
Lesser Black-backed Gull	5	2 (40)	100	3 (60)	100	-	-
Herring Gull	29	16 (55)	48	20 (69)	66	11 (38)	36
Great Black-backed Gull	8	2 (25)	100	6 (75)	100	-	-

Table A1.2 Summary of waterbird behaviour in Area 2

Species	No. counts overall	Foraging		Roosting/other		Flight/interaction	
		No. counts (% total)	Average proportio n %	No. counts (% total)	Average proportion %	No. counts (% total)	Average proportion %
Cormorant	20	4 (20)	59	17 (85)	95	-	-
Little Egret	5	5 (100)	100			-	-
Grey Heron	5	3 (60)	100	1 (20)	100	-	-
Oystercatcher	19	19 (100)	73	12 (63)	42	1 (5)	2
Ringed Plover	3	3 (100)	100	-	-	-	-
Golden Plover	2	2 (100)	100	-	-	-	-
Grey Plover	3	2 (67)	100	1 (33)	100	-	-
Knot	2	2 (100)	100			-	-
Sanderling	9	9 (100)	93	2 (22)	13	-	-
Dunlin	16	16 (100)	96	1 (6)	61	-	-
Black-tailed Godwit	13	13 (100)	100	-	-	-	-
Bar-tailed Godwit	10	10 (77)	100	-	-	-	-
Curlew	11	11 (100)	96	1 (9)	42	-	-
Whimbrel	1	1 (100)	100			-	-
Black-headed Gull	24	21 (88)	75	14 (58)	49	3 (13)	20
Common Gull	21	18 (86)	90	6 (29)	68	-	-
Lesser Black-backed Gull	6	4 (67)	100	2 (33)	100	-	-
Herring Gull	29	16 (55)	42	23 (79)	60	8 (28)	26
Great Black-backed Gull	15	3 (20)	85	12 (80)	95	1 (7)	6
Roseate Tern	1	-	-	1 (100)	100	-	-
Common Tern	2	-	-	1 (50)	100	1 (50)	100