Influence of the Disturbance on Shorebird Behaviour

Ciara Sexton

CARL Research Project

in collaboration with

Leave No Trace Ireland

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- provide their services on an affordable basis;
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- create equitable and supportive partnerships with civil society organisations;
- enhance understanding among policymakers and education and research institutions of the research and education needs of civil society, and
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Author (year) *Dissertation/Project Title*, [online], Community-Academic Research Links/University College Cork, Ireland, Available from: http://www.ucc.ie/en/scishop/completed/ [Accessed on: date].

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Influence of disturbance on shorebird behaviour.

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Abstract

Human disturbance is an issue affecting many animal species. The presence of perceived predators disturbs wildlife and may reduce foraging success and species abundance. Birds are a common focal group in studies of anthropogenic disturbance as they are at risk of increased exposure to human presence

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and activities. This can lead to decreased bird diversity and increased energetic costs. Humans that are accompanied by dogs pose a greater disturbance threat to birds. Species differ in their response to disturbances which influences flight-initiation distance (FID), site use and vulnerability to changing environmental conditions. Species may exhibit a certain degree of habituation to human presence but this does not alleviate the negative effects entirely. Estuaries are important habitats and resource providers for migratory shorebirds. Shorebirds using mudflats and estuaries as winter foraging grounds are experiencing high levels of human disturbance at these sites. This causes problems because of the constraints tidal fluctuations already place on foraging opportunities. This study investigated how anthropogenic and natural disturbances are affecting birds at two estuarine sites, the Douglas Estuary and Harbour View Beach near Kilbrittain, using Black-tailed Godwit (*Limosa limosa*), Curlew (*Numenius arquata*) and Teal (*Anas crecca*) as focal species. Differences in how species responded to disturbance and their foraging rates were also monitored. Data was collected by behavioural observations of the birds at multiple stations within each site. Species abundances during the study, details of disturbance events, and scans of feeding rates of the focal species were all recorded. Anthropogenic disturbance occurred more frequently at the open Kilbrittain site than at the Douglas Estuary mudflats. Disturbance events at Kilbrittain led to a higher proportion of birds being disturbed and bird responses were more severe. Differences within species in foraging rates were primarily exhibited at the Kilbrittain site. Curlews were the species most significantly affected by disturbance events. The study highlighted their vulnerability to increasing levels of anthropogenic disturbance at important shorebird habitats. Identifying and protecting such habitats is a vital part of conservation and management of shorebird populations.
(WC: 334)

1. Introduction

Human contact with wildlife and the issues associated with these interactions are becoming more common in many areas (Ikuta & Blumstein 2003). Animals are often disturbed by the presence of humans, who they perceive as potential predators, and/or encroaching human activity (Beale & Monaghan 2004b; Yasue, 2005). Persistent disturbance of wildlife by humans can cause a variety of

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negative consequences ranging from reduced species diversity and population density to decreased foraging and breeding success (Hockin *et al.* 1992; Klein 1993; Rodgers & Smith 1997; Whitfield, Ruddock & Bullman 2008; Yasue 2005). High levels of human disturbance can also lead to decreased species abundance (Pfister, Harington & Lavine 1992). The strength of an animal's behavioural response to human presence is a commonly used measure of susceptibility to disturbance. These behavioural responses are likely to be dependent on an animal's condition, the extent of the perceived threat and the possible fitness consequences associated with responding (Yasue & Dearden 2006). Therefore, the individuals showing little or no response to a disturbance may be those for whom a change in behaviour would result in the greatest loss to fitness. Variation among individuals must also be taken into consideration (Beale & Monaghan 2004a).

Birds are commonly used as a focal group for studying the influence of disturbance on both behaviour and fitness of wildlife. Humans are a significant cause of disturbance to birds and birds often take flight when they are present (Yalden 1992). Although they are seen as relatively low impact, nature based recreation activities (hiking, running, wildlife viewing etc.) can have negative environmental effects that includes being a disturbance to birds. In particular, activities that involve rapid movement or close proximity to birds have a higher probability of causing a disturbance event (Burger 1981; Glover *et al.* 2011). Some ways in which disturbance negatively impacts birds is by increasing energetic costs, limiting access to good foraging sites and enhancing predation risk, all of which impact on individual fitness (Peters & Otis 2007; Schalacher, Nielson & Weston 2013). As a result of anthropogenic disturbance, bird diversity has been negatively affected across a broad range of habitats, climatic zones and regions of the world (Steven, Pickering & Castley 2011). Anthropogenic disturbance can also negatively affect breeding success by increasing nest abandonment rates and chick predation rates (Anderson & Keith 1980; Baudains & Lloyd 2007; Hockin *et al.* 1992; Ikuta & Blumstein, 2003; Keller, 1989).

The distance at which birds respond to human disturbance (flight initiation distance or FID) is a species-specific trait that has important management implications. It is influenced by time of day and year, weather conditions, species, site, and exposure to and behaviour of humans (Blumstein 2003; Blumstein *et al.* 2003; Smith & Visser 1993). Features of the life history and natural history of a species determines how 'flighty' it is likely to be and enhances the understanding of interspecific differences in FID (Blumstein 2006). There is also individual variation in response to human disturbance based on previous experience and the reactions of nearby birds. Birds that take flight in response to humans draw the most

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attention (Smith & Visser 1993). The quality of the site they are in, distance to and quality of other sites, relative predation risk and the density of competitors are factors that influence the decision by birds to leave disturbed areas (Gill, Norris & Sutherland 2001). FIDs are often used to set distances of buffer zones and usually the most sensitive species is chosen as a guide (Rodgers & Smith 1997; Whitfield, Ruddock & Bullman 2008).

Interspecific differences exist in how birds respond to human disturbance that affect site use, distribution, abundance and vulnerability to environmental change (Blumstein 2006; Hockin *et al.* 1992). For some species, responses to human disturbance are altered as birds habituate to persistent human presence and disturbance (Glover *et al.* 2011; Ikuta & Blumstein 2003; Lord *et al.* 2001). Birds that experience higher rates of human disturbance allow closer approach by humans than those in areas of low human disturbance. This can help alleviate the negative impacts of human disturbance (Baudains & Lloyd 2007; Blumstein 2003; Peters & Otis 2007; Verhulst, Oosterbeek & Ens 2001). However, habituation is a species-specific phenomenon and certain species will remain sensitive to human presence. It is important to note that even those species that do habituate still move out of the path of humans and take flight if frightened (Blumstein *et al.* 2003; Burger & Gochfeld 1991; Holm & Laursen 2009; Schalacher, Nielson & Weston 2013). Some species have been observed foraging at night to avoid the presence of humans at feeding sites (Burger & Gochfeld 1991).

Birds see both humans and dogs as potential predators which cause them to be vigilant to their presence and often to abandon their natural habitats as a result. Increasing vigilance behaviour in response to humans is done as a trade-off against other important activities such as foraging (Fernandez-Juricic & Schroeder 2003; Randler 2006). Response to the presence of humans in their habitat will vary between species but it typically involves a reduction in resource use by birds (Burger & Gochfeld 1998; Gill, Sutherland & Watkinson 1996; Holm & Laursen 2009). Birds are more wary to the presence of dogs than the presence of humans and dogs are the cause of more disturbance events. There is a lack of experimental evidence of the ecological impacts of dog walking, which may reduce bird diversity and abundance (Banks & Bryant 2007; Lafferty 2001; Lord *et al*. 2001; Randler 2006; Yalden & Yalden 1990). Burger and Gochfeld (1998) observed that human presence had an overall negative effect on foraging behaviour of birds. When humans were present, birds devoted less time to feeding. The existence of alternative undisturbed habitats that bids can move to is important in alleviating the negative effects of human disturbance (Burger and Gochfeld, 1998). During winter birds increase foraging efforts due to increased

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energy demands brought about by low temperatures (Puttick 1979). Having suitable alternative habitats nearby that they can relocate to when disturbed is important for birds being exposed to increasing levels of human presence.

Shorebirds are at risk of exposure to increasing levels of human disturbance as many of the aquatic sites they use for foraging are attractive to outdoor recreationalists. Shorebirds generally avoid sites with the high levels of human presence and the disturbances associated with recreation activities (Baudains & Lloyd 2007; Burton, Evans & Robinson 1996; Rodgers & Smith 1997). Foraging birds are commonly disturbed by conspecifics, predators or humans (Verhulst, Oosterbeek & Ens 2001). Wading birds will take flight if humans are present on their intertidal feeding and roosting grounds (Goss-Custard *et al.* 2006). By increasing their vigilance to stimuli perceived as threatening shorebirds reduce the time they spend foraging and engaging in other important activities (Schalacher *et al.* 2013). Tidal fluctuations strongly influence the foraging patterns of shorebirds in estuaries by regulating the availability of intertidal invertebrate prey (Puttick 1979). Shorebirds that are disturbed while foraging may have difficulty in obtaining sufficient food resources due to these tidal restrictions. It is not just foraging habitats that are being negatively affected by anthropogenic factors; human disturbance has resulted in a loss of breeding habitats for Black-tailed Godwits, a species that is disturbed by human presence (Holm & Laursen 2009). Human disturbance of shorebirds is an important issue to address due to the negative effects it can have on breeding success, foraging success and resource/habitat use by birds.

The aims of this study were to investigate the types of disturbance that are affecting shorebirds (specifically Black-tailed Godwit, Curlew and Teal) at two different estuarine sites; the Douglas Estuary and Harbour View Beach, Kilbrittain. Both sites are important wintering habitats for large numbers of the focal species. The study aimed to determine what source of disturbance was most prevalent at each of the two study sites; anthropogenic or natural. The relative proportions of each of these disturbance types would provide insight into the effect that human presence is having at these sites in relation to the total amount of disturbance occurring. The study looked to identify any differences in both disturbance frequency and type within both sites (at the various stations); how often each type of disturbance was occurring at the study sites, which sources of disturbance were most common, and whether any noteworthy differences existed amongst the various stations within study sites. How each of the three focal species differed in their response to disturbance (severity of response to disturbance, how often they were disturbed, and the proportion of the total that was disturbed) was also a focus of the study.

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Interspecific differences were examined between and within the study sites. The study also investigated any differences in responses based on the type of disturbance that occurred. Finally the study compared feeding rates of the focal species between and within the study sites to identify any differences which may be caused by the presence of disturbance.

It was expected that differences in disturbance type and frequency would be observed between the two study sites due to the differences in human access to foraging areas of birds at Douglas Estuary (paved walkway along estuary) and Kilbrittain (open access beachfront). It was predicted that there would be low variation in disturbance type and frequency across the Douglas Estuary site because of the similarity of each station. In contrast, the stations at Kilbrittain would be expected to show some variations in disturbance type and frequency due to the layout of the site. Interspecific differences in response to disturbances were expected to be observed. How frequently and severely each species responded was likely to vary between the two study sites. Feeding rates of easily disturbed species were expected to be lower than less easily disturbed species due to increased time devoted to vigilance.

(WC: 1,633)

2. Materials and Methods

2.1 Study Sites

The two study sites were located at the Douglas Estuary (51˚52’44.12”N, 8˚23’28.97”W) and at Harbour View Beach, Kilbrittain (51˚39’04.83”N, 8˚40’26.22W, referred to as the Kilbrittain site). At each location the site was divided into stations where the study would be conducted. Four stations (1, 2, 3 and 4) were identified at the Douglas Estuary (Site 1) and five stations (5, 6, 7, 8 and 9) were identified at Kilbrittain (Site 2). A Google Earth image of each study site, with the locations of the individual stations

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marked on it, is provided in the appendices (Figure 1). The Douglas Estuary is situated where the Douglas River joins the River Lee just before it reaches the Atlantic Ocean. The area is tidal and has vast exposed mudflats at low tides. The site at Kilbrittain is also estuarine in nature; it is located where a river meets the ocean. This site is a designated SAC (Special Areas of Conservation) for Birds and Dune system habitat due in part to its ornithological importance for many wading shorebirds. Many migratory shorebirds use estuaries as stopping points at which they rest and feed for an extended period of time. Estuaries are therefore very important ecosystems and provide resources for many species.

Although both sites are tidal estuaries they have some slight differences. The Douglas Estuary site consists entirely of mudflats on which shorebirds forage and direct human access to the areas where birds are present is limited/restricted. There is a paved walkway set back from and slightly above the mudflats where the majority of human activity is concentrated. This ensures that there is a separation between people and the birds that are foraging on the mudflats, the separation distance varies with tidal fluctuations. The Kilbrittain site contains mudflats but also has an area of open beachfront; birds forage in both habitats at the site. In contrast with the Douglas Estuary site, humans have open access to all areas of the site including those where birds are foraging. Most of the human activity tends to be concentrated on the beach front and dune areas but sometimes people venture to areas on/near the mudflats (Figure 1). These observations are consistent with findings in the literature about human disturbance to birds foraging on beachfronts and mudflats. Burger and Gochfeld (1991) noted that on beachfronts there are varying degrees of human presence while mudflats tend to have lower levels of human disturbance.

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Figure 1: Photograph of people walking with dogs on the open beachfront area at station 5 of the Kilbrittain study site.

2.2 Study Species

The study focused on Black-tailed Godwits (*Limosa limosa*), Curlew (*Numenius arquata*), and Teal (*Anas crecca*) (Figure 2). Black-tailed Godwits are large wading birds with a brown/grey coloured winter plumage. The mostly breed in Iceland but winter at or near Irish estuaries and coastal mudflats in large numbers. Curlews are a larger species of wading bird that are also present on Irish estuaries and coastal areas in winter. They are brown coloured with long legs and a very distinctive long, down-curved bill. Teals are a small species of dabbling duck. Females are a mottled brown colour while males more brightly coloured; chestnut heads, green eye-patches, grey flanks, and a yellow tail with black edges. This species congregates in large flocks at coastal wetlands during winter. Both of the study sites play host to large numbers of each of the three focal species during winter months. The Kilbrittain site holds internationally important wintering numbers of Black-tailed Godwits.

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a)  b)  c)

Figure 2: Photograph of the study species a) Black-tailed Godwit and b) Curlew at the Douglas Estuary site and c) Teal at the Kilbrittain site.

2.3 Study Details

The two sites were visited on eight days during the study, this included four weekdays and four weekend days at each location. At the beginning of each day of data collection a number of important variables were recorded at the study site; date, time of day, temperature, and tide times (high and low). Measures of average wind speed for each day were obtained from the Met Éireann records from Cork Airport at the end of each day. It is known that wading birds and shorebirds that feed only at low tide have foraging schedules that are dictated primarily by tidal cycles, while time of day and weather conditions are also important (Klein 1993). Variations in bird density are mainly due to tide and season while human presence varies primarily between weekend and weekdays (Lafferty 2001). All of the recorded variables were therefore important to the study as they were possibly influencing bird behaviour. The methods of study were replicated in precisely the same manner at each study site and across all stations within the study site. At each station the individual birds of the three focal species that were present were observed over a 45 minute period. The observer remained in the same predetermined location for the duration of the observation period; this location was consistent for all observations carried out during the study. A set of Atlas Optics Radian 8x42 Binoculars and a Swarovski Optik spotting scope were used to identify and monitor the behaviour of the birds being observed.

2.4 Observational Procedure

At the beginning of each 45 minute observation the presence and estimated abundance of the three focal species was recorded. The arrival or departure of any other individuals of these species during the observation period was noted if the observer saw it. Throughout the duration of the observation any event in which an individual or group of individuals of the focal species were disturbed was recorded. Several definitions of disturbance can be found in the literature including 'any situation in which a bird behaves differently from its preferred behaviour' (Boere 1975 as read in Smith & Visser 1993) or 'any situation in which human activities cause a bird to behave differently from the behaviour it would exhibit without the presence of that activity' (Oranjewoud 1982 as read in Smith & Visser 1993). Disturbances caused by both natural and human sources were of interest in this study, human disturbance is an activity of humans that results in a change in physiology and/or behaviour of an animal (Bolduc & Guillemette 2003; Glover *et al.* 2011) and natural behaviour is any disturbance with a natural source that causes the same result. Behavioural measurements of response to disturbance stimuli are a feasible indicator of a species' response to human disturbance and have been used in many studies of wildlife disturbance (Gill, Norris & Sutherland 2001). This study also used behavioural changes as a measure of response to disturbance events and a disturbance event was defined as an event in which birds were observed to change their behaviour from the preferred activity due to outside forces. This was mainly observed as moving/flying away from their original position. Several details relating to the disturbance event were recorded each time one occurred; the cause of the disturbance (anthropogenic, natural or unclear), which species of bird was disturbed, the number of birds that were affected by the disturbance, and the response

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that the birds exhibited. The cause of a disturbance was listed as unclear if the observer could find no apparent/obvious reason for the birds being disturbed. The response of the bids was categorised according to the distance they moved from their original position as a result of the disturbance event (moved <50m, moved >50m or left the area/station in which the observation was taking place).

2.5 Scan Samples

In addition to recording disturbance events, instantaneous scan samples of the three focal species were carried out at each station. These scans were conducted every 10 minutes after the observation began which allowed for four scan samples to be obtained during each 45 minute observation. Instantaneous scan sampling involves recording the behavioural profile of a group of individuals. In the context of this study, the number of individuals feeding and the number not feeding were of interest and so during the scan samples a bird's behaviour was recorded as either feeding or not feeding.

2.6 Statistical Analysis

Statistical analysis of results was carried out using IBM SPSS Statistics 20 software. The data concerning the number of disturbances occurring per hour at each site was not normally distributed and so non-parametric techniques were used in the analysis. Kruskal-Wallis tests were used to compare the disturbances occurring per hour at each site and across stations within each site. The same tests were also used to compare the disturbance types (anthropogenic, natural or unclear) occurring at each study site and across stations within each study site. The data for how birds responded to disturbance events was analysed using linear mixed models. Using this method, variables such as day (weekday or weekend), mean daily temperature and wind speed, time to nearest low tide, and time of day could be controlled for in the analysis. First the effect of a number of variables and interactions between variables on the percentage of total birds disturbed was tested. Then the effect of variables and important interactions between them was tested against the observed response to disturbance by individual birds. The data obtained from the scan samples was not normally distributed so non-parametric techniques of analysis were required. The same analysis was carried out for each of the three focal species individually. Mann-Whitney U tests were used to determine if there were differences in the proportion of individuals feeding at each of the two study sites. Within each of the two study sites, Kruskal-Wallis tests were initially used to determine if there were differences in the proportion of individuals feeding across the stations (four at the Douglas Estuary site and five at the Kilbrittain site). If a difference was indicated post-hoc analysis involved performing multiple Mann-Whitney U tests to compare individual station and determine where

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the difference lay.

(WC: 1,642)

3. Results

3.1 Number of Disturbances

A significantly higher amount of total disturbance events occurred per hour at the Douglas Estuary site compared with the Kilbrittain site (p=0.038). However, when each type of disturbance was analysed separately anthropogenic disturbances occurred more frequently at the Kilbrittain study site than the Douglas site (p=0.003) and there was no significant difference in how often natural disturbances occurred at either site (p=0.105). The disturbance type that caused the Douglas Estuary site to have more overall disturbances per hour was that for which the source of disturbance was unclear (Figure 3).

Focusing specifically on the Douglas Estuary study site, the number of disturbances per hour occurring at each of the four stations was not significantly different (p=0.607). There was also no difference in the amount of anthropogenic disturbance or natural disturbance occurring at each station if these disturbance types were analysed individually (p=0.559 and p=0.628 respectively). However, when the amount of anthropogenic disturbance occurring at Douglas Estuary was compared to the amount of natural disturbance observed, the amount of natural disturbance events recorded per hour was significantly higher ($p<0.001$, Figure 4).

At the Kilbrittain study site, there was no significant difference in the number of disturbances occurring per hour across the five stations (p=0.149). There was a significant difference in the amount of anthropogenic disturbance observed at stations 6 and 9 at this site (p=0.010, Figure 5). Similar to study site 1, there was no significant difference in the amount of natural disturbances that occurred per hour (p=0.071). In contrast with the Douglas Estuary site, there was no significant difference in how often anthropogenic versus natural disturbance occurred at the Kilbrittain site (p=0.814).

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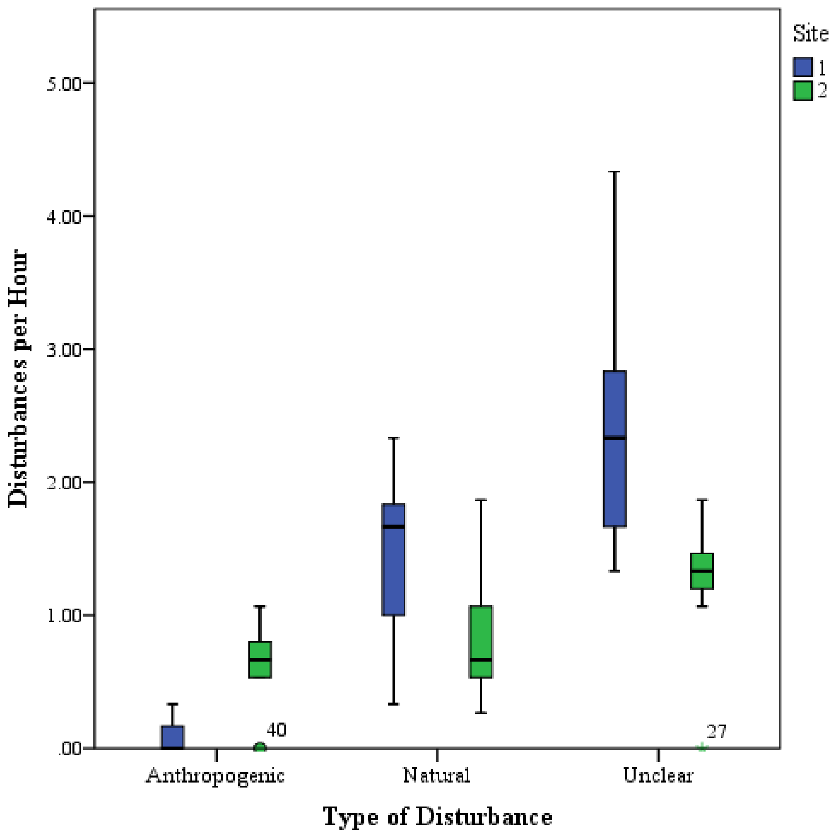

Figure 3: Boxplot showing the number of disturbances occurring per hour at each site, separated by type of disturbance and study site.

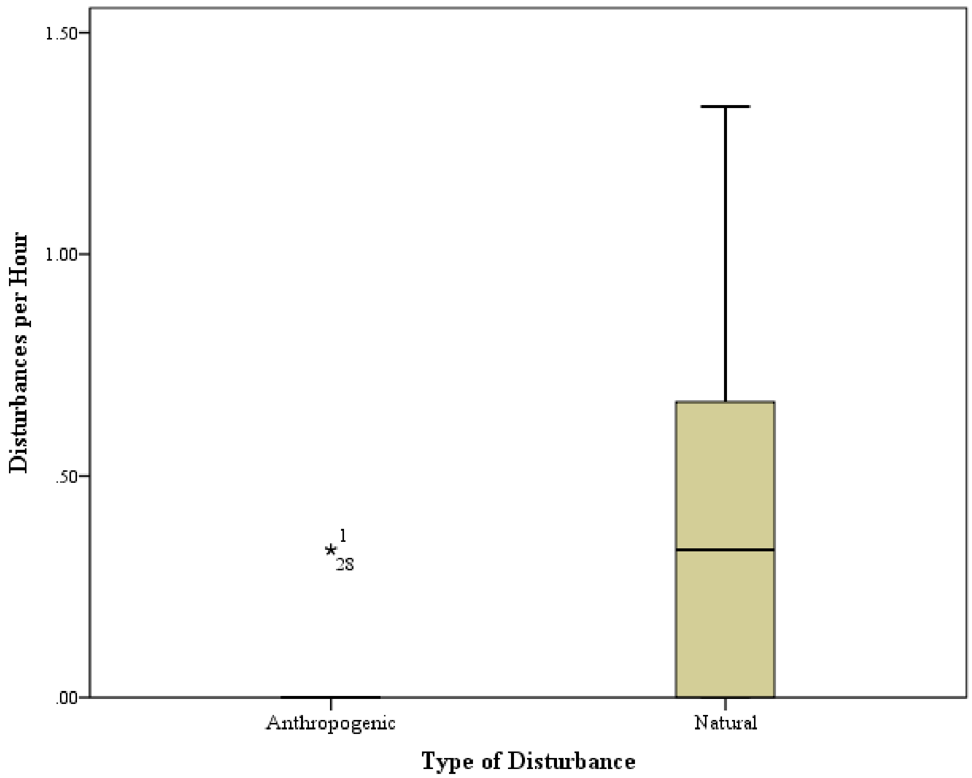

Figure 4: Boxplot showing the number of anthropogenic and natural disturbance events occurring per hour at the Douglas Estuary.

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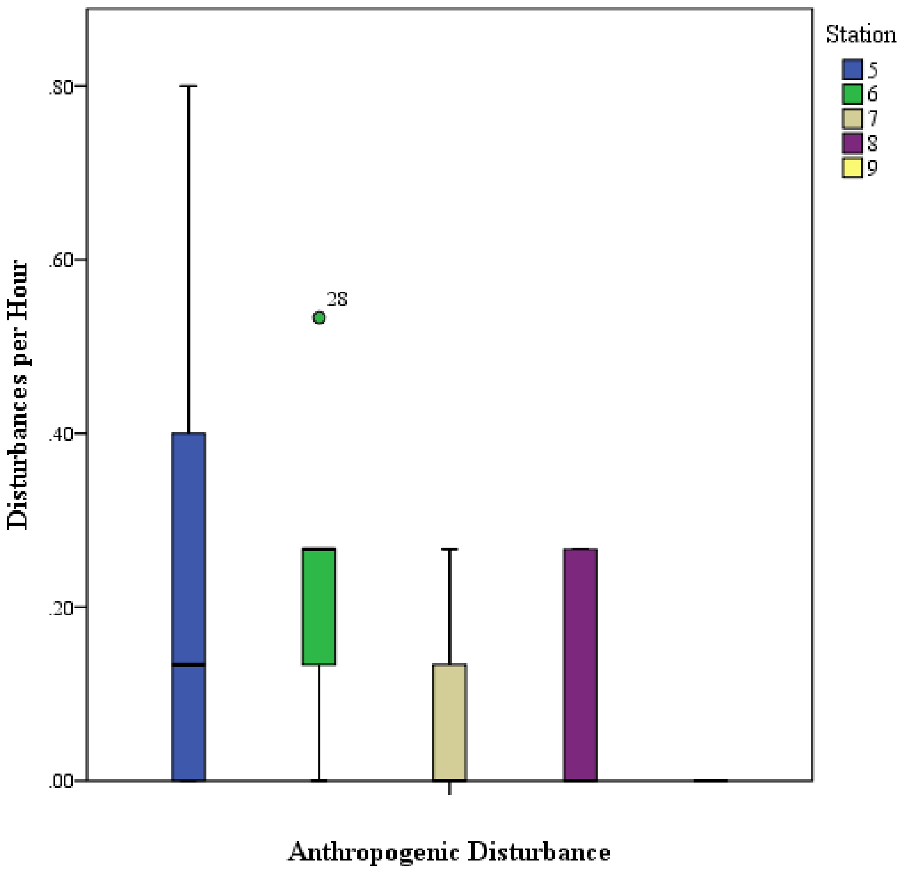

Figure 5: Boxplot showing the number of anthropogenic disturbance occurring at the Kilbrittain stations, significant difference occurred between site 6 and 9.

3.2 Bird Responses

Table 1: The p-values relating to the effect of several variables and interactions on the percentage of birds disturbed are presented.

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	368.000	8.674	.003
Site	1	368.000	10.728	.001
Species	2	368	3.945	.020
Day	1	368	.000	.991

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Disturbance Type	2	368	1.753	.175
Temperature	1	368.000	2.824	.094
Wind	1	368.000	.141	.708
Time of Day	1	368	.576	.448
Tide	1	368	1.500	.221
Site * Species	2	368	18.739	.000
Site * Disturbance Type	2	368	.547	.579

a. Dependent Variable: Percent Disturbed.

The proportion of birds that were disturbed out of the total numbers present varied significantly based on the study site, species of bird, and the interaction between study site and bird species (p=0.001, p=0.020, and p<0.001 respectively). At the Kilbrittain site a higher percentage of the total birds present were disturbed than at the Douglas Estuary site. When the three focal species of birds were compared Curlews were the species which were disturbed in the highest proportions followed by Teal and then Black-tailed Godwits. The interaction between site and bird species has a significant effect on the percentage of birds that were disturbed. A much higher proportion of Curlews were disturbed at the Kilbrittain site than at the Douglas Estuary site. A higher proportion of Teals were also disturbed at Kilbrittain when compared with the Douglas Estuary. The proportion of Black-tailed Godwits disturbed was similar across both sites (Figure 6).

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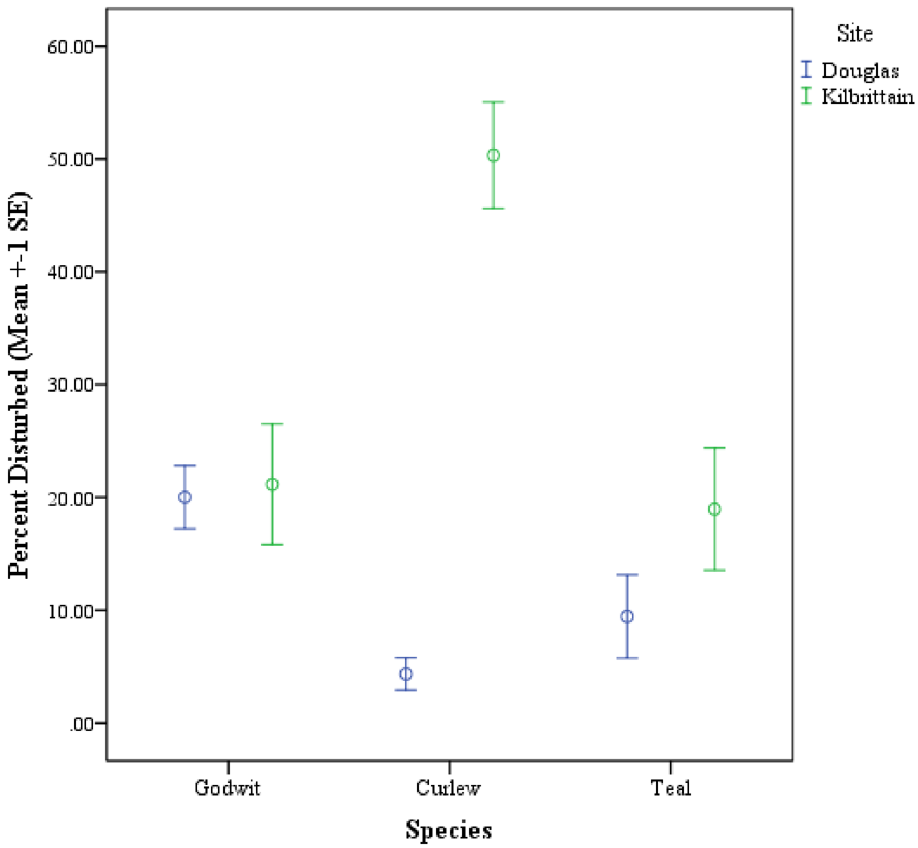

Figure 6: Error bars showing the mean (+-1 SE) of the percentage of birds disturbed for each focal species separated by site.

Table 2: The p-values corresponding to the effect of several variables and interactions on the response to disturbance recorded for birds.

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	511	13.366	.000
Species	2	511	20.883	.000
Temperature	1	511.000	1.323	.251
Wind	1	511	3.878	.049
Time of Day	1	511.000	1.595	.207
Tide	1	511.000	.097	.756

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Site	1	511.000	2.821	.094
Disturbance Type	2	511	.008	.992
Site * Species	2	511	29.481	.000
Site * Disturbance Type	2	511	.325	.723
Species * Disturbance Type	4	511	5.928	.000

a. Dependent Variable: Response.

The response of individual birds to disturbance events that was recorded was found to be significantly influenced by species, wind, the interaction between site and species, and the interaction between species and disturbance type ($p<0.001$, $p=0.049$, $p<0.001$ and $p<0.001$ respectively). Response type varied greatly depending on what species of bird was looked at. If instances when the species showed no response to a disturbance event were excluded, the most frequently observed response was flying <50 metres for Black-tailed Godwit and leaving the area (station) in which the disturbance event occurred for both Curlew and Teal (Figure 7). The effect of average wind speed on the response observed in birds was only slightly significant. The interaction effect between site and species was highly significant. For Black-tailed Godwit, flying <50 metres was the most common response to disturbance at the Douglas Estuary but at Kilbrittain it was leaving the area. This was also the case for Curlew at each of the sites. Teal that were disturbed at the Douglas Estuary mostly left the area but in Kilbrittain flying <50 metres and leaving the area occurred in equal proportions for this species (Figure 8).

The interaction effect between species and type of disturbance was also highly significant. For Black-tailed Godwit, anthropogenic disturbances always resulted in disturbed individuals flying <50 metres from their original location. Flying <50 metres was always the most common response of this species for natural sources of disturbance, followed by leaving the area and then flying >50 metres. For Curlew, the response that was observed the most across all disturbance types was leaving the area but it was highest for anthropogenic disturbance (58.82% of individuals responded in this way to human disturbance). There was a lot of variation across the disturbance types in how Teal responded. For anthropogenic disturbance they mostly flew <50 metres, while for natural disturbance their observed response was divided equally between both flying <50 metres and flying >50m (Figure 9). Natural disturbance events included being disturbed by gulls, crows, or conspecifics.

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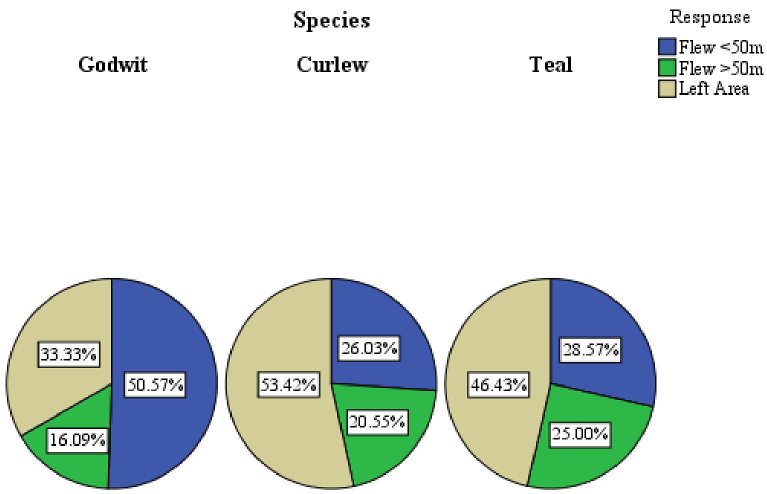

Figure 7: Pie-charts showing the response to disturbance that was recorded for the three species.

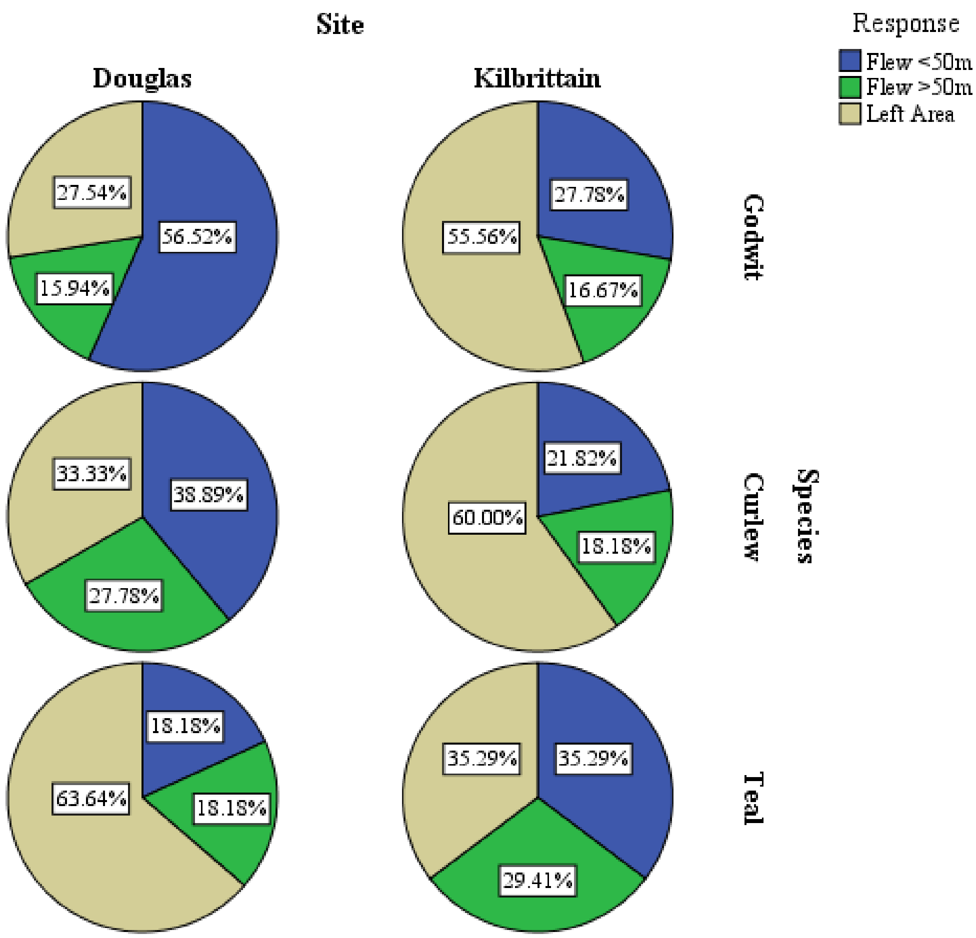

Figure 8: Pie-charts showing the response to disturbance of the three focal species at the Douglas Estuary and Kilbrittain study sites.

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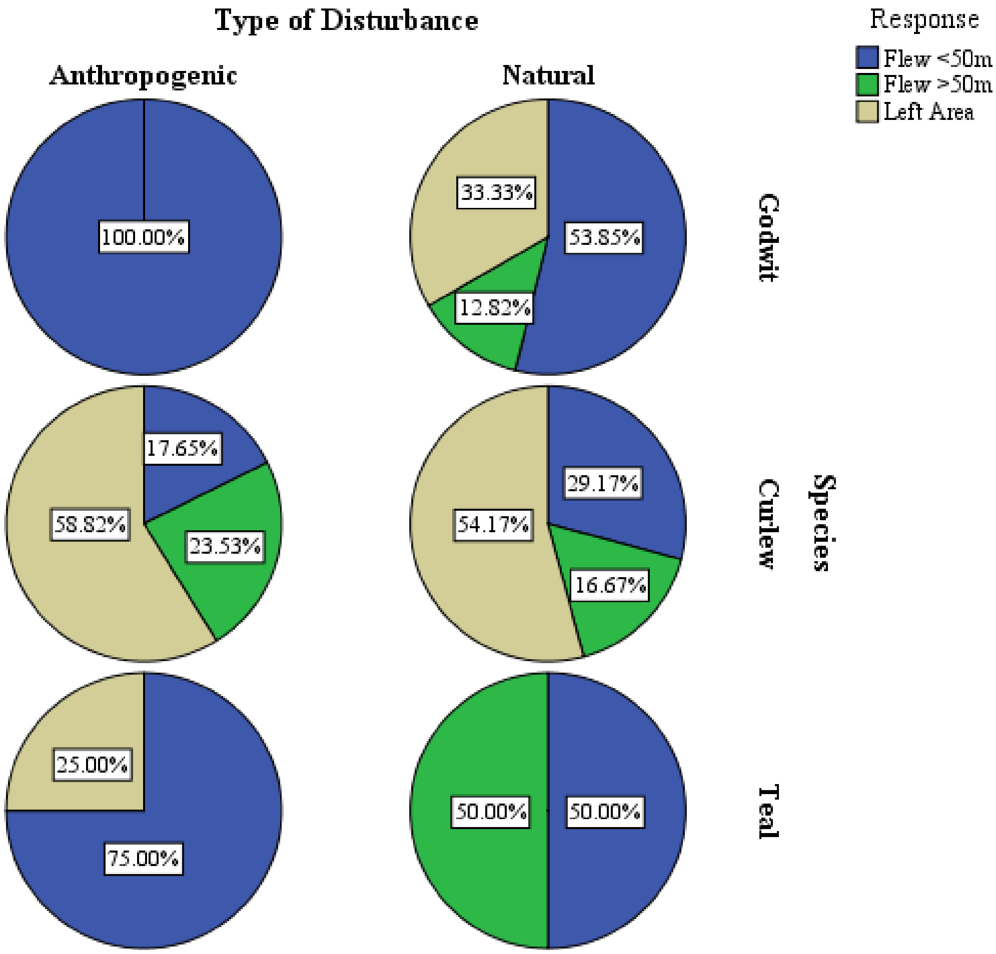

Figure 9: Pie-charts showing the response to disturbance of the three focal species separated into anthropogenic and natural disturbance events.

3.3 Scan Samples

The proportion of Black-tailed Godwits (species 1) that were feeding was higher at the Douglas Estuary site than at the Kilbrittain site (p<0.001). Within each site, there was no significant difference in the proportion of Black-tailed Godwits feeding across the four stations at the Douglas Estuary but there was a significant difference across the five stations at Kilbrittain (p=0.348 and p<0.001 respectively). The differences at the Kilbrittain study site are significant for all pairwise comparisons of stations except for station 7 versus 8, station 7 versus 9, and station 8 versus 9 (p-values in appendix).

The proportion of Curlew (species 2) that were feeding was also higher at the Douglas Estuary than at Kilbrittain (p=0.019). Within the Douglas Estuary site there was no significant difference in the

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proportion of Curlew feeding across the four stations ($p=0.772$). Within the Kilbrittain site there was a statistically significant difference in the proportion of Curlew feeding across the five stations ($p<0.001$). This was true for the pair-wise comparisons between stations 5 and 8, stations 6 and 8, stations 7 and 8, stations 7 and 9, and stations 8 and 9 (p-values in appendix).

For Teal (species 3) there was no statistically significant difference in the proportion of individuals feeding at the Douglas Estuary and Kilbrittain study sites ($p=0.078$). Within the Douglas Estuary site, there was a statistically significant difference in the proportion of Teal feeding across the four stations ($p<0.001$). The difference was significant for all pair-wise comparisons except for station 1 and station 3 (p-values in appendix). Within the Kilbrittain study site, there was a significant difference in the proportion of Teal feeding across the five stations ($p<0.001$). The difference was significant for all pair-wise comparisons of stations except for station 5 versus 6 and station 8 versus 9 (p-values in appendix).

(WC: 1,415)

4. Discussion

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4.1 Anthropogenic versus Natural Disturbance

Human disturbance can have both long and short term effects on birds, most of which tend to be negative. Understanding how birds are influenced by specific human activities is vital for the planning and implication of conservation management plans (Carney & Sydeman 1999; Collins-Kreiner *et al.* 2013). Concerns regarding long-term effects of human disturbance and birds are related to impacts on individual fitness and population sizes. When time and energy costs are included, disturbance could potentially be as, if not more, damaging than habitat loss (West *et al*. 2002). Factors to be considered when assessing impact of disturbance on bird species include frequency of the disturbance, whether rare or especially sensitive species are affected, and whether alternative habitats are available nearby (Hill *et al.* 1997). Anthropogenic disturbance occurred more frequently at the Kilbrittain study site than at the Douglas Estuary. This is probably due to differences between the sites in accessibility of the shorebird foraging areas to people. Studies have found that local levels of disturbance vary according to access and that at times close to low tide birds out on mudflats are usually unaffected by human presence due to spatial separation (Goss-Custard & Verboven 1993). The mudflats at the Douglas Estuary are not easily accessible to people as they are bordered by a section of large boulders. The site also has a paved walking path that spans the entire length of the estuary and people tend to remain on this path, resulting in a spatial separation between humans and the foraging shorebirds at low tides. In contrast, the Kilbrittain study site is an open beachfront area with sand dunes. People have access to all areas of the site and this means that there is potential for anthropogenic disturbance to occur wherever birds are foraging. This is likely why a higher rate of anthropogenic disturbance occurred at the Kilbrittain site. Natural disturbance events, caused by gulls, crows and conspecifics, occurred at similar rates at both sites, this is not surprising as the sites are similar habitats.

The finding that more natural disturbance occurred per hour than anthropogenic disturbance at the Douglas Estuary is consistent with the idea that lack of human access to shorebird foraging areas at this location prevents humans from disturbing birds. At Kilbrittain, where more anthropogenic disturbance occurred, there was no significant difference in the amount of natural and anthropogenic disturbance being observed. This supports the hypothesis that the open aspect of the Kilbrittain site leads to anthropogenic disturbance being more of an issue here. There were some differences between stations within Kilbrittain; stations 6 and 9 differed significantly in the number of anthropogenic disturbances recorded. This is likely due to the location of the stations within the site. Presence of people on feeding

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grounds tends to be concentrated at particular locations such as beachfronts at low tide (Goss-Custard & Verboven 1993). Station 6 is located on the open beachfront where there is a lot of human activity and station 9 is located behind the dunes in an area of mudflats that is rarely used by people (Figure). Different levels of human presence at stations leads to different levels of anthropogenic disturbance occurring. Disturbance events for which the cause was unclear represent those for which the observer was unable to identify the source of disturbance and are likely due to natural movement or behaviours of birds as they occurred when humans were not present or were present in a manner that was not clearly disturbing birds.

a)  b) 

Figure: Photographs showing a) Station 6 and b) Station 9 at the Kilbrittain site.

4.2 Bird Responses to Disturbance

Avoidance behaviour of birds will likely vary between different locations (Gill, Norris & Sutherland 2001). In this study, the proportion of total birds disturbed during disturbance events varied significantly depending on study site, species of bird, and the effect of the interaction between study site and bird species. Higher percentages of birds were disturbed at the Kilbrittain site than the Douglas site which could be explained by the open nature of the site making birds more vulnerable to disturbance events. Curlews were the species most sensitive to events. Curlews tended to be present in the low numbers at stations and so when they were disturbed it was usually in quite high proportions of the total numbers present. Curlews at the Kilbrittain site were disturbed in much higher proportions than at the Douglas Estuary. Again, this is probably due to the openness of the site allowing human access to foraging areas and exposing shorebirds to higher levels of disturbance. Low abundance of this Curlews and high sensitivity to human presence makes them vulnerable to increasing levels of anthropogenic disturbance. Responses to human disturbance will vary between species and are influenced by a species' ability to

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habituate to human presence (Fitzpatrick & Bouchez 1998). The results reflect this as responses to disturbance events varied according to species, wind speed, the effect of the interaction between site and species, and the effect of the interaction between species and disturbance type. Curlew and Teal, if disturbed, were likely to leave the area they were in, while Black-tailed Godwit primarily moved <50 metres from their original position when a disturbance occurred. This indicates that of the three focal species Black-tailed Godwits were least affected by disturbance events and it highlights the importance of having alternative sites nearby to which disturbed Curlew and Teal can move. The influence of the interaction between species and site was important. Both Black-tailed Godwits and Curlews showed a more severe prevalent response to disturbance at Kilbrittain (leaving the area) than at the Douglas Estuary (flying <50 metres). This difference in response could be due to the fact that the more exposed site forced birds to leave the area to avoid the source of the disturbance, while at the Douglas Estuary birds could avoid the disturbance by travelling a short distance from their original location. It is important to note that while the proximity of the birds to the source of this disturbance is an important factor, it was not recorded during this study. Different species responded differently to the various types of disturbance recorded. Curlews predominantly left the area when disturbed by anthropogenic causes. In contrast, Black-tailed Godwits and Teal mostly flew <50 metres in response to anthropogenic disturbance. These results indicate that Curlews are more susceptible to being greatly disturbed by human presence and activity than the other focal species.

4.3 Foraging Behaviour of Birds

Competition between birds and humans in habitats important for bird survival has led to population decreases. As human presence increases the expected result would be that birds spend more time running or flying away from humans (increasing energy expenditure) and less time foraging (Burger & Gochfeld 1991; Fitzpatrick & Bouchez 1998; Thomas, Kvitek & Bretz 2003). Human disturbance of foraging shorebirds, in addition to tidal restrictions, may negatively affect the ability of shorebirds to meet their nutritional needs (Fitzpatrick & Bouchez 1998). Birds tend to adjust their vigilance levels based on the level of disturbance they are experiencing (Fitzpatrick & Bouchez 1998). Black-tailed Godwits devoted less time to foraging and more to other activities such as vigilance at the exposed Kilbrittain site. The proportion of individual Curlews feeding also decreased at Kilbrittain. Fitzpatrick and Bouchez (1998) observed a decrease in the amount of time spent foraging by Curlew in response to disturbance. This suggests that Curlew allocate more time to vigilance when disturbance events are occurring. These

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findings support the idea that a more exposed site will require increased levels of vigilance in birds and less time will be allocated to foraging as a result. Eventually, birds will be unable to offset the cost of disturbance by supplementary feeding and so preventing disturbance when feeding conditions are hardest is especially important (West *et al*. 2002).

4.4 Conclusions

The attitude of the public towards wildlife is extremely important in reducing negative consequences of disturbance to birds. Information sources and educational programmes should be used to raise awareness of the issues associated and ways of reducing disturbance (Klein 1993; Schalacher, Nielson & Weston 2013). This study identified the vulnerability of shorebirds, Curlews in particular, to anthropogenic disturbance at exposed sites. Protecting important winter foraging areas of migratory species is an important issue for conservation. By restricting animals' access to resources, human recreational activities may threaten biodiversity. Distinguishing between scenarios when human presence is threatening to conservation and when it is not is vitally important (Gill 2007). Any management plans should take into consideration the species in question, habitat, season and the source of disturbance (Richardson & Miller 1997). Various methods that may help to alleviate the negative effects associated with disturbance include the allocation of refuge areas (Pfister, Harrington & Lavine 1992) and enforcement of leash laws where dogs are present (Baudains & Lloyd 2007; Thomas, Kvitek & Bretz 2003).

(WC: 1,479)

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Appendices

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a) 

b) 

Figure 1: Aerial view of the study sites, a) Douglas Estuary and b) Harbour View Beach, Kilbrittain, with each station circled in red and labelled.

a) b) c) d)

Figure 2: Photographs of a) Station 2 and b) Station 3 at the Douglas Estuary and c) Station 7 and d) Station 8 at the Kilbrittain site.

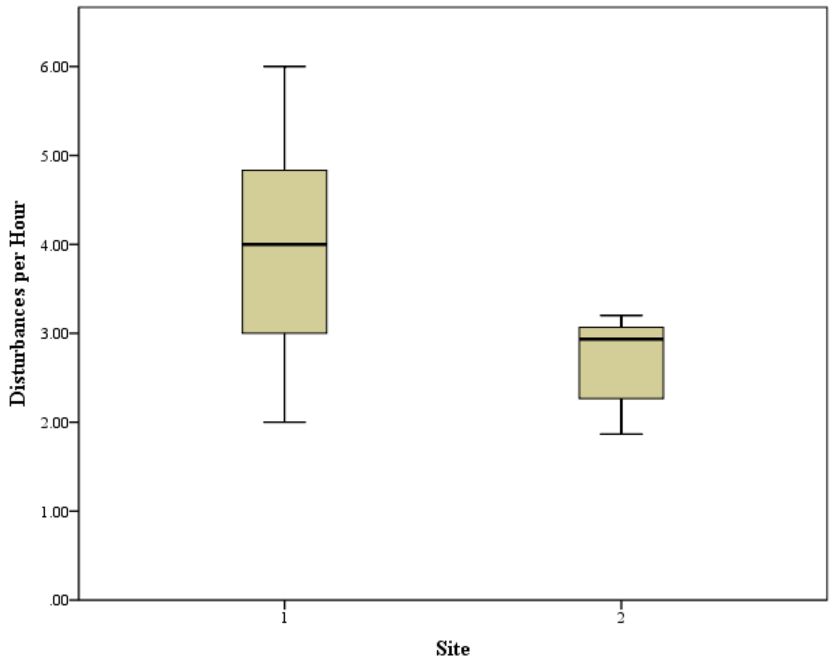

Figure 3: Boxplot showing the number of disturbances occurring per hour at the Douglas Estuary (site 1) and Kilbrittain (site 2).

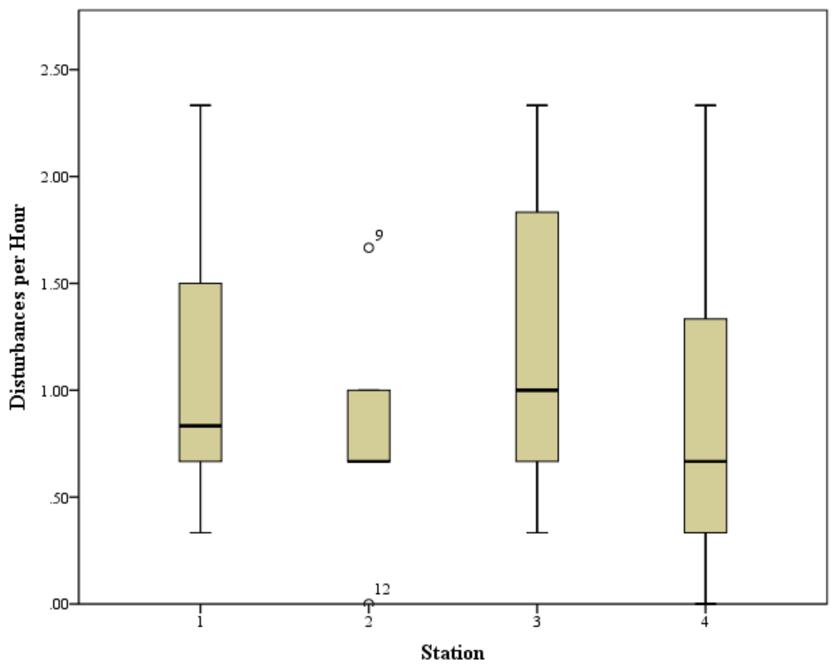

Figure 4: Boxplot showing the number of disturbances occurring per hour across the four stations at the Douglas Estuary.

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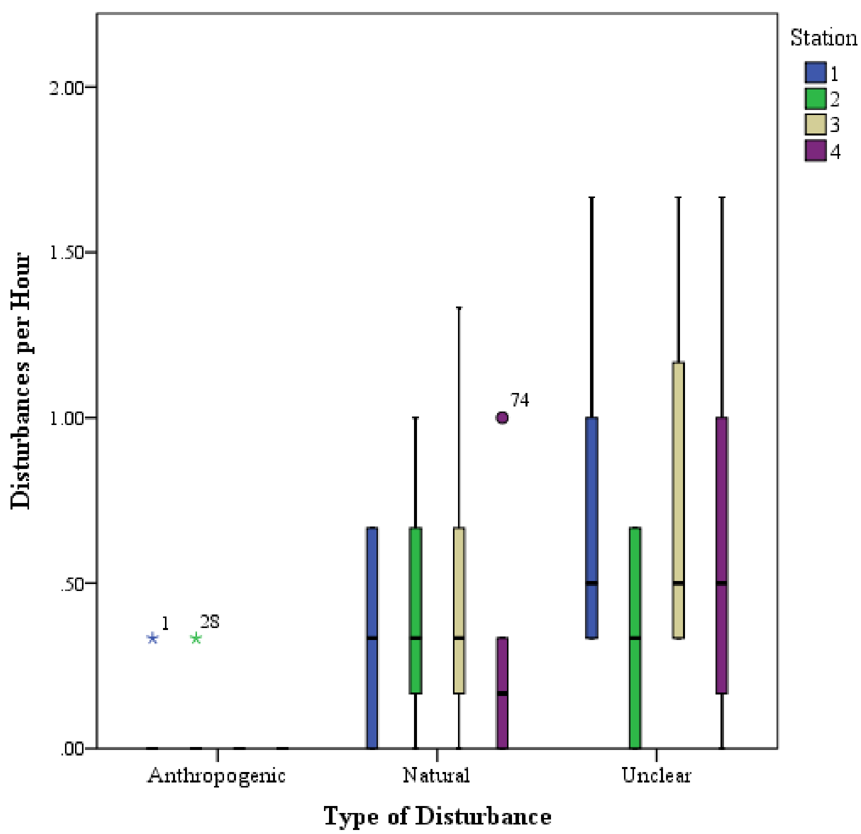

Figure 5: Boxplot showing the number of disturbances occurring per hour at the Douglas Estuary separated by both station and type of disturbance.

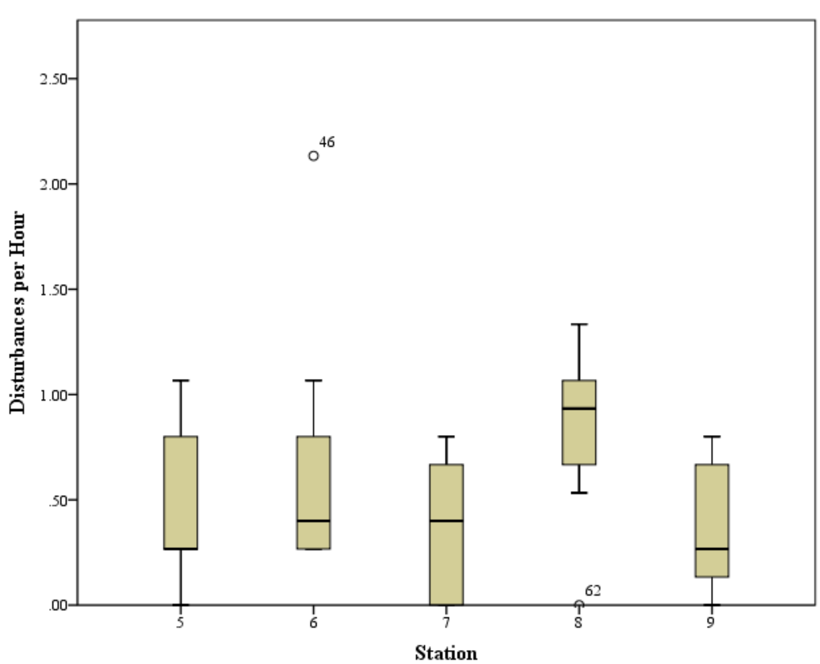

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Figure 6: Boxplot showing the number of disturbances occurring per hour across the five stations at the Kilbrittain study site.

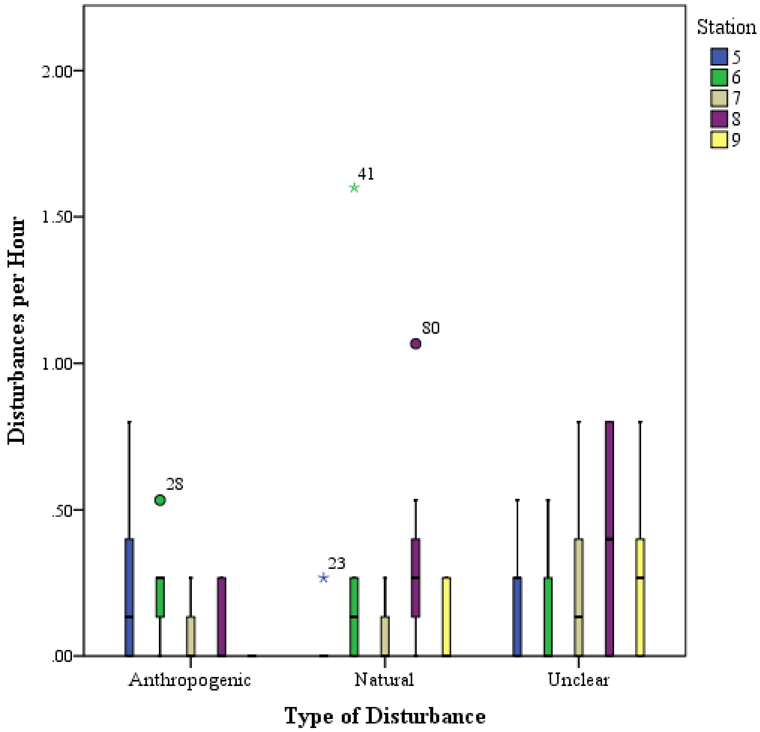

Figure 7: Boxplot showing the number of disturbances per hour occurring at Kilbrittain separated by both station and type.

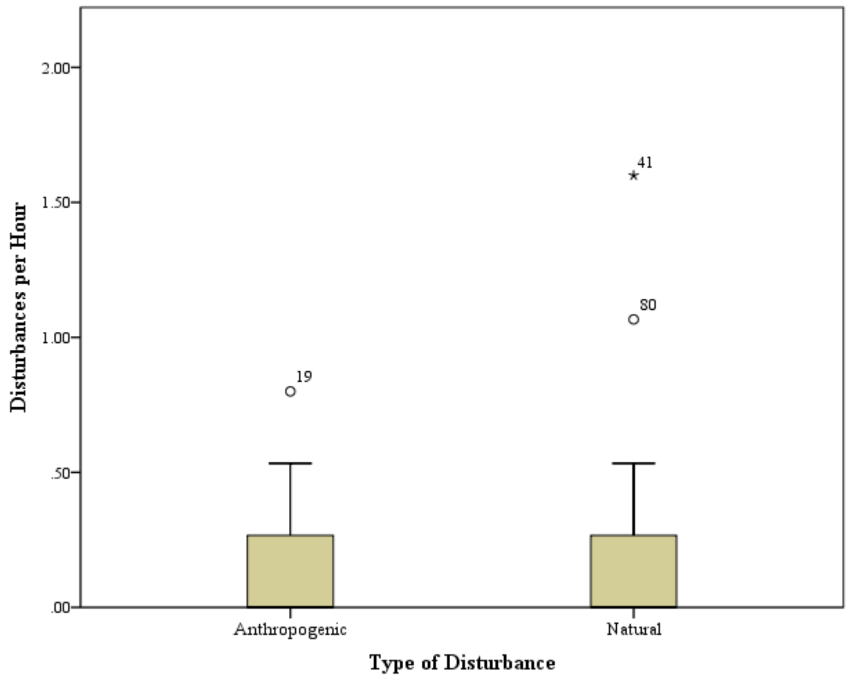

Figure 8: Boxplot showing the number of anthropogenic versus natural disturbance occurring at the Kilbrittain study site (data from all stations included).

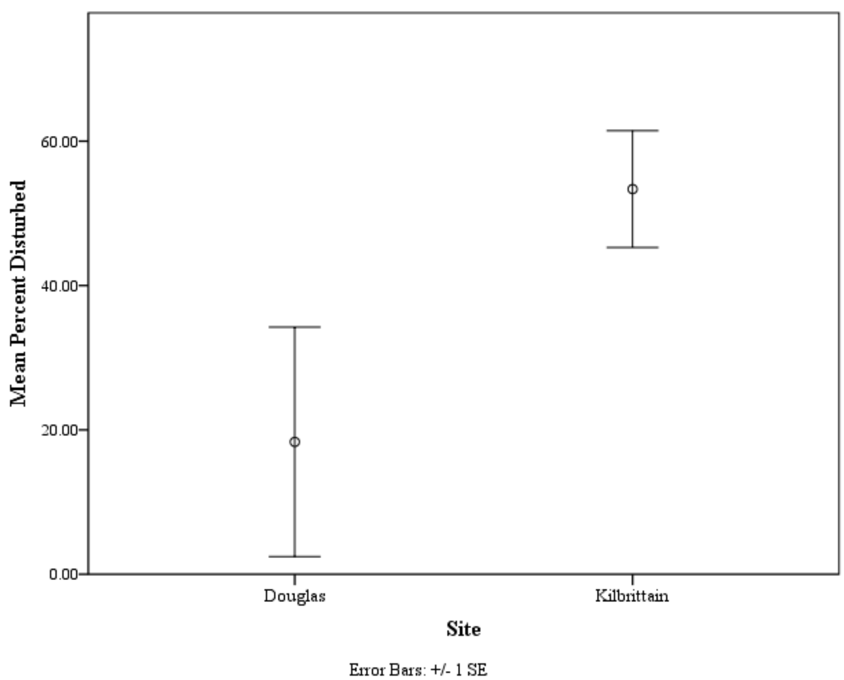

Figure 9: Error bars showing the mean percentage of birds disturbed at the Douglas Estuary and Kilbrittain sites.

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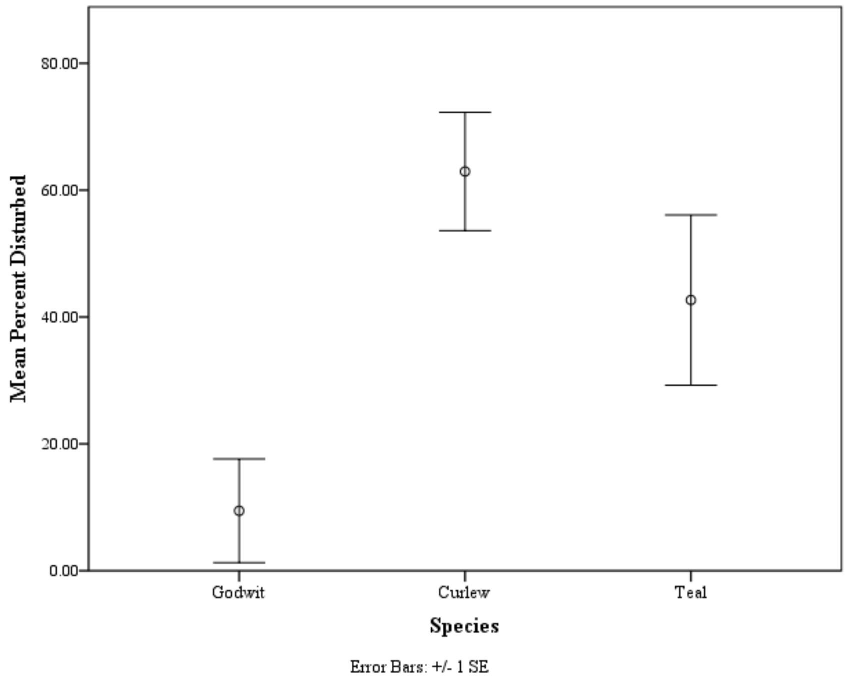

Figure 10: Error bars showing the mean percentage of birds disturbed separated by species.

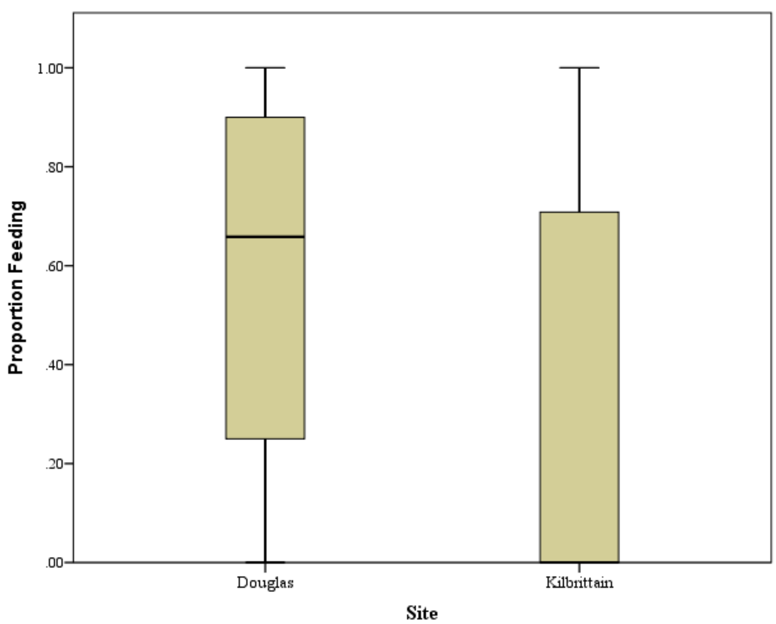

Figure 11: Boxplot showing the proportions of Black-tailed Godwits that were feeding at the Douglas Estuary and at Kilbrittain.

Table 1: Table showing the p-values for all pairwise comparisons of stations for the proportion of Black-tailed Godwits feeding at Kilbrittain (statistically significant results in bold).

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Comparison	**p-value**
5 vs 6	**0.040**
5 vs 7	**0.000**
5 vs 8	**0.000**
5 vs 9	**0.000**
6 vs 7	**0.002**
6 vs 8	**0.044**
6 vs 9	**0.044**
7 vs 8	0.083
7 vs 9	0.085
8 vs 9	0.969

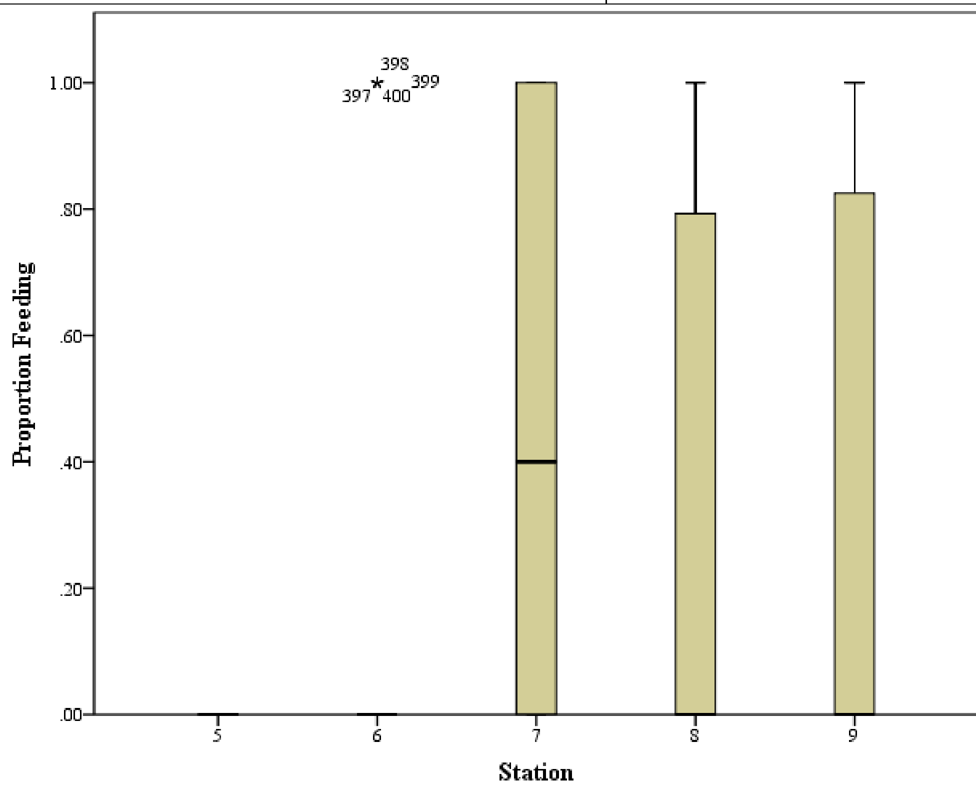

Figure 12: Boxplot showing the proportions of Black-tailed Godwits feeding across the five stations at Kilbrittain.

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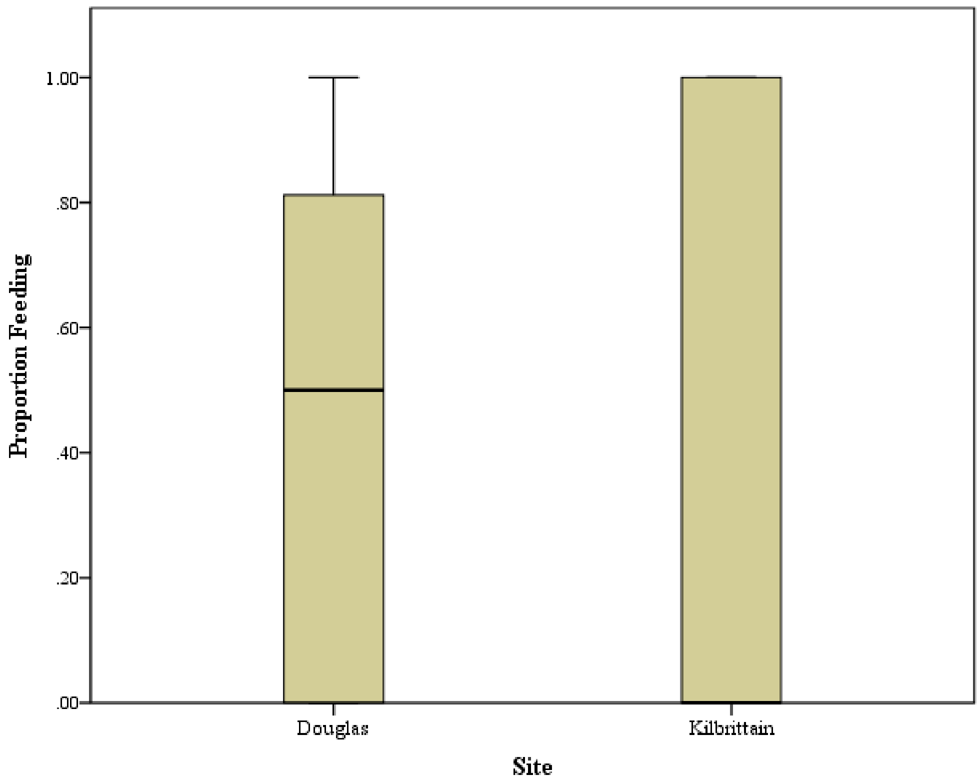

Figure 13: Boxplot showing the proportions of Curlew feeding at the Douglas Estuary and Kilbrittain sites.

Table 2: Table presenting the p-values for all pair-wise comparisons of stations for proportion of Curlew feeding at Kilbrittain (statistically significant results in bold).

Comparison	**p-value**
5 vs 6	0.294
5 vs 7	0.576
5 vs 8	**0.000**
5 vs 9	0.148
6 vs 7	0.115
6 vs 8	**0.001**
6 vs 9	0.665
7 vs 8	**0.000**
7 vs 9	**0.043**
8 vs 9	**0.000**

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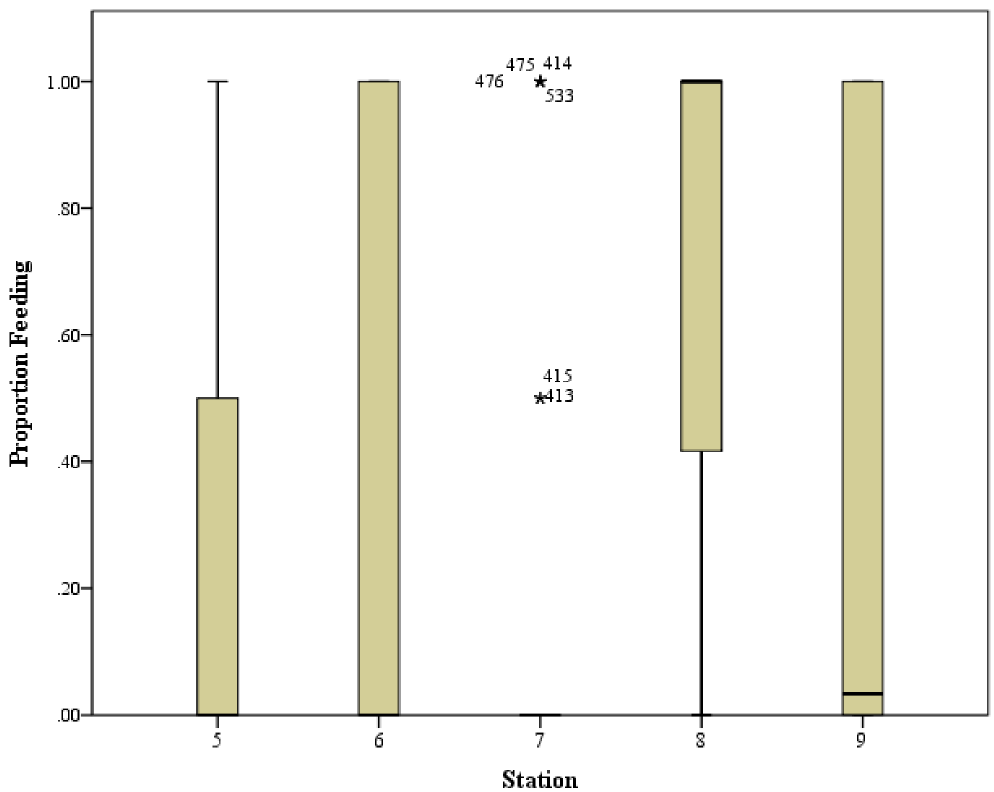

Figure 14: Boxplot showing the proportions of Curlew feeding across the five stations at Kilbrittain.

Table 3: Table presenting the p-values for all pair-wise comparisons of stations for the proportion of Teal feeding at the Douglas Estuary.

Comparison	**p-value**
1 vs 2	**0.000**
1 vs 3	0.277
1 vs 4	**0.012**
2 vs 3	**0.001**
2 vs 4	**0.000**
3 vs 4	**0.000**

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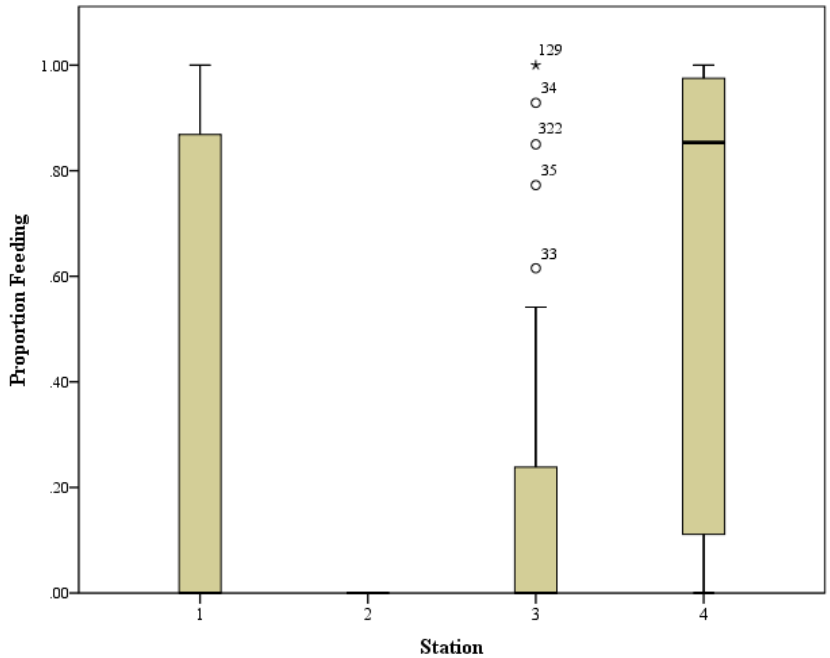

Figure 15: Boxplot showing the proportions of Teal feeding across the four stations at the Douglas Estuary.

Table 4: Table presenting the p-values for all pair-wise comparisons of stations for the proportion of Teal feeding at Kilbrittain.

Comparison	**p-value**
5 vs 6	1.000
5 vs 7	**0.000**
5 vs 8	**0.003**
5 vs 9	**0.001**
6 vs 7	**0.000**
6 vs 8	**0.003**
6 vs9	**0.001**
7 vs 8	**0.001**
7 vs 9	**0.004**
8 vs 9	0.653

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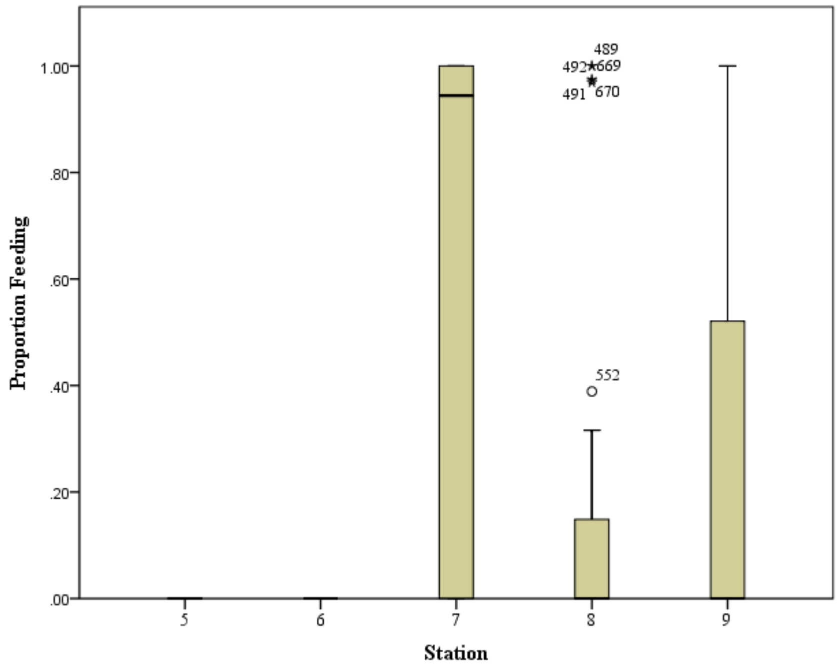

Figure 16: Boxplot showing the proportions of Teal feeding across the five stations at Kilbrittain.

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