Report

footprint ECOLOGY

Poole Harbour Disturbance Study

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Summary

This report addresses the impact of recreational disturbance to wintering waterfowl in Poole Harbour.

There were two separate elements to the study, with the fieldwork taking place independently. These elements were:

1. Standardised surveys (15 locations) recording behavioural responses of birds, levels of access etc., involving 294 hours of fieldwork. These focused on an area within a 500m arc of the surveyor.
2. Paired night and day counts (13 locations) where visits were timed to ensure tide height and state were directly comparable. Sixteen replicate counts were made at each of the thirteen locations.

Numbers of people and activities undertaken

A wide range of activity types were recorded. Walking without a dog was the most commonly recorded activity (36% of events or groups recorded), followed by dog walking with a dog off lead (17%) and cycling (16%). Many other types of activity were logged and included a range of watersports (kite surfing, windsurfing, canoeing, use of personal watercraft), boating activities (sailing boats, boats on outboard motors, rowing boats, people working on boats) and harvesting activities (such as bait dragging, bait digging, pump scoop dredging and cockle raking).

Bird use

In total 47 different bird species were recorded within the focal count areas. These included 18 species of wader, 18 wildfowl and 11 other species. Locations 7 (Whitely Lake) and 11 (Middle Beach, Studland) were the locations with the smallest range of species recorded. Locations 3 (Holes Bay north) and 10 (Brands Bay) were the locations with the highest number of species recorded. In general the north of Holes Bay, and the southern bays (Newton Bay and Brands Bay) held the largest numbers of birds.

Distribution of birds in relation to disturbance

After controlling for the tide state and the survey point, disturbance (expressed as the number of groups recorded during the survey, i.e. over the previous 1 hour and 45 minutes) had a significant, negative effect on the number of waders and the number of wildfowl present, indicating that birds respond to disturbance levels and redistribute as a result of disturbance.

Behavioural response of birds to the presence of people

Taking the data from all survey points, there was a response from birds to people 1.7 times per hour and birds were flushed approximately once per hour. The proportion of disturbance events involving birds being flushed was markedly higher in December, potentially as a result of the holiday period and different access patterns during that month.

Comparing between activities, water-based activities (such as canoeing, pump scoop dredging, small sailing boats and kite surfing) tended to be more likely to cause disturbance. These activities made up a relatively small proportion of the activities recorded (note that the survey was shore-based and we focused our recording within 500m of the shore), and taking into account the levels of activity,

dog walking with dogs off leads was the single activity that resulted in by far the most birds flushed. Dog walkers with the dogs off leads accounted for 40% of the birds observed flushed, walkers accounted for 17% and canoeists 15%.

The locations where birds were most frequently recorded flushed were Studland (Pilot Point, Bramble Bush Bay, Middle Beach) and at Arne. There was some evidence that at the sites with the highest levels of access (such as Baiter and Sterte), birds were less likely to respond to each event. This may be because at these busy locations the types of access are different (a high proportion of walkers and cyclists). It may also be that the distribution of the birds is different at these locations, i.e. the birds distribute themselves to avoid the disturbance.

The number of birds flushed at Pilot's Point was the highest across all survey locations, and here dunlin in particular was the species recorded flushed. At Arne most of the flight events involved oystercatcher, and the rate was comparatively high here. At Baiter, Whitley Lake and Middle Beach, dark-bellied brent goose was the main species flushed.

The probability of a major flight taking place varied depending on the species, and a range of other factors. Major flights were more likely when the activity was close to the birds; when small numbers of birds were present (small flock size); when the activity took place on the water or the intertidal, if the activity was a water-sport (i.e. kitesurfing, canoeing, personal watercraft use or windsurfing); with larger groups of people; if dogs were present; the more dogs were off leads and if the temperature was relatively warm.

Night/Day Paired Counts

Thirty-three species were recorded during the night/day paired counts. These included fourteen species of wader and eleven species of wildfowl. Spoonbill was the only species recorded at night (and not during the day). A few species were not recorded at all at night and these included three wader species (common sandpiper, lapwing and sanderling) and three species of wildfowl (gadwall, goldeneye and red-breasted merganser).

Birds were present during the day in the majority of counts (161 counts, 86%) and birds were present at night in just over half of the counts (101 counts, 54%).

In roughly one sixth (33) of the pairs of counts, the total number of birds present at night was higher than the count during the day. For curlew, dunlin, grey plover, oystercatcher, redshank, ringed plover, mute swan and teal there were at least ten counts where the number of birds was higher in the night than the day.

Levels of human activity were much lower at night, but a range of activities were recorded including walking, cycling, fishing, bait digging and bird ringing. Fishermen accounted for just over half the people recorded during the night counts (whereas they accounted for 5% of the people during the day).

There were significant correlations between the counts during the day and those during the subsequent night, suggesting that the locations and occasions when high numbers of birds were present during the day were also those when high numbers of birds were present at night.

After controlling for species, survey location and time period, there were significant effects of disturbance on the number of birds present at night. The number of waders present at night was lower when disturbance levels were higher during the day, i.e. there was no evidence that waders were in any way 'compensating' at night for the disturbance during the day. For wildfowl, the number of birds present at night was significantly related to the daytime and night time disturbance levels, indicating that at night the number of wildfowl was lower when people were present and was higher if there were high counts of people during the day.

Contents

Summary **3**

Numbers of people and activities undertaken 3

Bird use 3

Distribution of birds in relation to disturbance 3

Behavioural response of birds to the presence of people 3

Night/Day Paired Counts 4

Contents **6**

Acknowledgements **8**

1. Introduction **9**

Human disturbance to birds 9

Poole Harbour Designations and Status 10

Other work addressing birds and disturbance in Poole Harbour 11

This study and the need for further work on disturbance 12

2. Our Approach **13**

Standardised diurnal watches 13

Diary of Recreational Activity **14**

Response of the Birds **15**

Wider Count Areas **16**

Night and Day Paired comparisons 17

Analysis 19

Structure of the Report and Presentation 20

3. Results: Standard Watches during the day **21**

Levels of human activity 21

Bird Counts 27

Effect of people on bird numbers and distribution 30

Behavioural responses to the presence of people **33**

Types of activities and response of the birds 34

Variation between sites 37

Response by Species....44
Factors influencing response of birds....44
Wider counts....46
Distances displaced and time lost....46
4. Results: Night/Day Paired Counts....51
5. Discussion....60
Approach & limitations....60
Context....61
Implications....63
Shoreline Access in general....63
Beach Access at Studland....63
Awareness....63
Dog's off leads....64
Kite surfing and windsurfing....64
Canoeing....64
Pump scoop dredging and bait dragging....64
People on the mudflats....65
6. References....66
Appendix 1: Summary of survey points for standardised watches....73
Appendix 2: Summary of the recoded diary events....74
Appendix 3: Summary of Visits for Paired Night and Day counts....75

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1. Introduction

Human disturbance to birds

1.1 Disturbance can be defined as the influence on a bird's behaviour or survival, caused by human activity or the presence of humans in the environment. There are a wide variety of studies which review disturbance effects (Hockin et al. 1992; Hill et al. 1997; Carney & Sydeman 1999; Nisbet 2000; Saunders et al. 2000; Woodfield & Langston 2004; Lowen et al. 2008). The range of studies is potentially bewildering, demonstrating a range of different impacts, in different circumstances, to different species. While there is still contention about the applicability of the methods of study (Gill 2007), there is strong evidence that disturbance is a principal factor linked to population declines in a range of European bird species (Møller 2008).

1.2 Most studies of disturbance demonstrate behavioural effects, such as birds changing their feeding behaviour (Burger 1991; Fitzpatrick & Bouchez 1998; Verhulst, Oosterbeek, & Ens 2001; Thomas, Kvitek, & Bretz 2003), taking flight (Stalmaster & Kaiser 1997; Burger 1998; Fernandez-Juricic, Jimenez, & Lucas 2001; Blumstein 2003; Blumstein et al. 2003; Fernandez-Juricic et al. 2005; Webb & Blumstein 2005) or being more vigilant (Fernandez-Juricic & Schroeder 2003; Randler 2006). Other studies have focused on physiological impacts, such as demonstrating changes in the levels of stress hormones (Remage-Healey & Romero 2000; Tempel & Gutierrez 2003; Walker et al. 2007) or monitoring changes in heart rate (Nimon, Schroter, & Oxenham 1996; Weimerskirch et al. 2002). While behavioural and physiological studies show an impact of disturbance, it is usually difficult to understand whether the disturbance does actually have an impact on the population size of the species in question. For example, the fact that a bird takes flight when a person approaches is to be expected and a short flight is unlikely to have a major impact on the individual in question, let alone the population as a whole.

1.3 Certain impacts of disturbance are perhaps more likely to have consequences at a population scale. Direct mortality resulting from disturbance has been shown in a few circumstances (Liley 1999; Yasué & Dearden 2006) and many (but not all) studies have shown a reduction in breeding success where disturbance is greater (Murison 2002; Bolduc & Guillemette 2003; Ruhlen et al. 2003; Arroyo & Razin 2006). There are also many examples of otherwise suitable habitat being unused as a result of disturbance (Gill 1996; Kaiser et al. 2006; Liley et al. 2006a; Liley & Sutherland 2007). Very few single species studies have actually placed disturbance impacts in a population context, showing the actual impact of disturbance on population size (West *et al.* 2002; Liley & Sutherland 2007; Mallord *et al.* 2007; Stillman *et al.* 2007a). Where authors have looked across species, the response to disturbance (in terms of flight distance) is the single factor that significantly relates to population trends, with those species showing declining trends being those with large flight distances for their size (Møller 2008).

1.4 Studies have shown disturbance effects for a wide range of activities besides simply people, for example aircraft (Drewitt 1999), traffic (Reijnen, Foppen, & Veenbaas 1997), dogs (Lord et al. 2001; Banks & Bryant 2007) and chainsaws (Delaney et al. 1999;

Tempel & Gutierrez 2003). There is still relatively little work on the effects of different types of water based craft and the impacts from personal watercraft, kitesurfers, windsurfers etc (but see Kirby et al. 2004; Liley et al. 2011b). Some types of disturbance are clearly likely to invoke different responses. In very general terms, both distance from the source of disturbance and the scale of the disturbance (noise level, group size) will both influence the response (Delaney et al. 1999; Beale & Monaghan 2004).

1.5 Many authors define a definitive distance beyond which disturbance is assumed to have no effect and this is then used to determine set-back distances or similar (Rodgers & Smith 1995, 1997; Stalmaster & Kaiser 1997; Fernandez-Juricic et al. 2001, 2004). It is inappropriate to set such distances as responses to disturbance vary between species (Blumstein et al. 2005) and between individuals of the same species (Beale & Monaghan 2004). Particular circumstances, such as habitat, flock size, cold weather or variations in food availability will also influence birds' abilities to respond to disturbance and hence the scale of the impact (Stillman et al. 2001; Rees, Bruce, & White 2005). Birds can also modify their behaviour to compensate for disturbance, for example by feeding for longer time periods (Urfi, Goss-Custard, & Lev. Dit Durell 1996). Birds can become habituated (Nisbet 2000; Walker, Dee Boersma, & Wingfield 2006; Baudains & Lloyd 2007) to particular disturbance events or types of disturbance, and this habituation can develop over short time periods (Rees et al. 2005). The frequency of the disturbance event will determine the extent to which birds can become habituated, and therefore the distance at which they respond.

1.6 Population impacts are not necessarily relative to the scale of disturbance (Liley & Sutherland 2007; Mallord et al. 2007), i.e. small changes in disturbance can result in disproportionately large impacts and vice versa. As described previously, behavioural responses may not necessarily describe the impact of disturbance at a population scale, or reflect the true impact of disturbance.

1.7 Rather than rely on set distances, it is instead necessary to consider the species' ecology, use of an area and other factors that may influence the scale of the disturbance. This information can then be used to identify what kinds of disturbance, at which locations, are likely to have an impact. In order to make decisions about management at a site level it is necessary to understand how access levels vary around sites, which parts of the site are birds disturbed, how the birds move around the site and use the sites and ideally the distribution and abundance of prey. Within the UK a number of different studies have set about gathering and collating this information, including sites such as the Exe Estuary, the Solent and the North Kent Marshes (Fearnley, Clarke, & Liley 2010; Liley, Stillman, & Fearnley 2010; Liley et al. 2011a; b; Fearnley & Liley 2011; Liley & Fearnley 2011).

Poole Harbour Designations and Status

1.8 Poole Harbour is a European Protected Site within the Natura 2000 network and is designated as a Special Protection Area (SPA) and a Ramsar site. The designations reflect the importance of the sites for birds, plants and invertebrates. The SPA boundary is shown in Map 1. Disturbance is, of course, a particular issue for birds and is

relevant to the SPA and Ramsar designations. These designations bring particular and strict legal requirements relating to plans and projects which are not for nature conservation management.

1.9 The SPA includes the following individual species (summarised from the SPA Review account for Poole Harbour):

- Breeding: Common Tern *Sterna hirundo* and Mediterranean *Gull Larus melanocephalus*;
- Over wintering: Black-tailed Godwit *Limosa limosa* and Shelduck *Tadorna tadorna*;
- On passage: Aquatic Warbler *Acrocephalus paludicola* and Little Egret *Egretta garzetta*.

1.10 The SPA designation also qualifies for its 'waterfowl assemblage', regularly supporting 28,426 individual waterfowl including: Redshank *Tringa tetanus*, Curlew *Numenius arquata*, Dunlin *Calidris alpina alpina*, Lapwing *Vanellus vanellus*, Red-breasted Merganser *Mergus serrator*, Goldeneye *Bucephala clangula*, Pochard *Aythya ferina*, Shoveler *Anas clypeata*, Dark-bellied Brent Goose *Branta bernicla bernicla*, Cormorant *Phalacrocorax carbo*, Shelduck *Tadorna tadorna*, Black-tailed Godwit *Limosa limosa islandica*, Avocet *Recurvirostra avosetta*, Little Egret *Egretta garzetta*.

1.11 Seven species are currently flagged as declining in Poole Harbour through the WeBS Alerts system[1], with high alerts (i.e.) triggered for five species: pochard, goldeneye, lapwing, dunlin and shelduck; medium alerts are triggered for two species: red-breasted merganser and redshank. Site listings for Poole Harbour in the most recent summary of WeBS counts (Holt *et al.* 2011) shows Poole Harbour among the sites with the most marked decreases in overall bird numbers, however the extent to which this is down to survey coverage rather than a real decrease is not clear.

Other work addressing birds and disturbance in Poole Harbour

1.12 Poole Harbour has been relatively well studied. An overview of the ecology of Poole Harbour is provided by Humphreys and May (2006) There have been a series of studies relating to Poole Harbour and the wintering bird interest. These include:

- Surveys of the Harbour in the mid 1980s, funded by BP Ltd., to inform the development of the Wytch Farm (Collins 1985, 1986) and later surveys to consider the impacts of pipeline repairs
- A survey of all roost sites around the harbour (Morrison 2004)

[1] WeBS is the Wetland Bird Survey, a national survey run by the BTO and counting birds monthly across all wetland/estuary sites. Alerts are triggered through an analysis of trends conducted by the BTO. See the BTO website for more details: http://www.bto.org/sites/default/files/u18/downloads/alerts/uk9010111.pdf

- A study addressing black-necked grebes, their distribution and impacts of disturbance (Liley, Pickess, & Underhill-day 2006b)
- Night time bird and people counts around the north shore (Liley et al. 2009)
- A summary of WeBS data detailing the important birds of Poole Harbour (Pickess & Underhill-day 2002; Pickess 2007)
- Individual based models exploring the population consequences of habitat change (Durell et al. 2006)
- Analysis of prey density and wintering bird distributions (Caldow et al. 2005)

1.13 Additional context regarding the site, designations and conservation issues can be found in the condition assessment for the European Marine Site (Underhill-Day 2006), and further information about the management of the site are in the Aquatic Management Plan (Poole Harbour Study Group 2006).

1.14 The site has some particular issues. In a recent review of risks to European Marine Sites (Coyle & Wiggins 2010), Poole Harbour had the highest number of high risk activities taking place. Particular issues of concern to Natural England were:

- Illegal unlicensed fishing activity (especially for Manila clams) posing risk of disturbance, removal of prey, and habitat modification
- Bait digging and dragging posing risk of disturbance, removal of prey, and habitat modification.
- Eutrophication

This study and the need for further work on disturbance

1.15 Given the range of issues and the complex geography of Poole Harbour, Natural England commissioned this work to provide an overview of access and disturbance issues to the SPA as a whole. In particular the study fills important gaps in our understanding and meets some of the requirements set out in the risk review by:

- Providing maps of the occurrence of different activities, such as bait digging, around Poole Harbour
- Assessing the levels of different activities in different locations
- Determining the extent to which different activities result in disturbance, both in terms of the distribution of birds and the behavioural response of birds
- Identifying which factors, such as type of activity, cause disturbance
- Assessing the extent to which birds might differentially use areas by day and night in relation to disturbance levels

2. Our Approach

2.1 Two separate fieldwork elements were conducted as part of this contract. These were:

- Standardised surveys during the day at 15 survey locations around Poole Harbour, recording access levels, counting birds and recording the response of birds.
- Paired night and day counts undertaken at identical tide states at 13 locations around the harbour.

These two different elements are written up separately within the report and discrete sections within the report.

Standardised diurnal watches

2.2 Fifteen locations (Map 2) were selected for detailed observations of birds and their response to disturbance. These locations were selected through discussion with Natural England and were selected so as to provide spatial coverage of different parts of the harbour and undertaken at suitable vantage points where it was possible to obtain a reasonable view of a wide section of the harbour without causing undue disturbance.

2.3 Two of the fifteen survey points were added part way through the survey and were added to provide more detailed coverage of a particular area (Holes Bay). These two points are shown in blue in Map 2.

2.4 The thirteen original survey locations were each visited three times per month over the period November – February inclusive, while the two additional Holes Bay survey points were surveyed three times per month for January and February only. At each survey location. Each month two visits were undertaken on weekdays and one visit at the weekend. Each survey visit lasted for 1 hour and 45 minutes. This equates to 294 hours of fieldwork in total.

2.5 At each survey location a focal area for the bird fieldwork was defined, these focal areas are shown in Map 3. This area stretched up to 500m from the surveyor and included all visible areas of intertidal habitat, below mean high water mark (MHWM), within this 500m radius. The 500m radius was selected as this was the maximum distance at which surveyors felt confident counting birds at the same time as recording levels of human activity, and within which it was possible to reliably estimate distances between disturbance events and the birds.

2.6 On straight sections of shore this area was typically defined simply as an arc (radius 500m) drawn from the survey location. Where jetties, creeks, headlands etc meant that there were no clear sight-lines, then the boundaries of the focal area became more complex. The focal area encompassed a different total area at each survey point.

2.7 Counts of the birds present within the arc were made at the beginning of the survey and at the end. Counts were split into distance bands within each arc (0-50m, 50-100m, 100-150m, 150-200m, 200-250m and 250-500m), with the distance bands reflecting distance from the shore.

Diary of Recreational Activity

2.8 All recreation events during the following 1 hour and 45 minutes were recorded, in a diary form. This diary recorded all events relating to the pre-defined recording area. This therefore encompassed a wider area than the 500m count area used for the birds, as people above the MHWM and events outside the recording area could disturb birds. Regardless of whether birds are present or not, all events will be recorded in this diary – this allows us to directly compare levels of human activity in different areas. The diary will be set up as a recording form, with each row in the 'diary' corresponding to an event and assigned a letter – "A", "B" etc. These same letters will be used to cross-reference different events. For each entry in the diary, details will be recorded that include activity (categorised to standard codes, see Table 1), group size, zone (intertidal, on water or above MHWM – 'on the shore'), length of time present in area and notes relating to behaviour. Where the codes were not applicable then the activity was described as free text. The zone (intertidal, on water or shore-based) was relatively straightforward to categorise at most locations. Along the beach at Studland, people were classified as on the intertidal if the tide was low and they were on the wet sand well down the beach (flat areas of wet sand can extended well out from the beach).

Table 1: Draft codes of disturbance events

Description	Code
Dog walker	DW
Dog off lead	dx
Dog on lead	dl
Bait digger (use for Crab tiling or bait digging – but use notes to specify)	BD
Bait Dragging (small boat going round in a circle, dragging for bait)	BDD
Cockle Raking (person standing on mud flats using a hand rake to pull out cockles)	CR
Pump Scoop dredging (small boat with suction pipe, collecting clams, cockles etc)	PSD
Cycling	C
Jogger	J
Fishin/Angling (from shore)	F
Walking / rambling (without dog)	W
Kids playing (with or without parents)	KP
Picnic	P
Birdwatcher	BR
Horse Riding	HR
Metal Detecting	MD
Wildfowling	WF
Swimming	SW
Windsurfer on water	WS
Kitesurfer on water	KS
Canoe on water	Ca
Personal watercraft or jet ski on water	JS
Water skiing	WSk
Rib or similar fast small boat	SMb
Small sailing boat (e.g. Laser / dinghy)	SS
Moderate – large sailing boat, not running motor	LS
Large boat on outboard motor	LMb
Person working on boat (boat stationary)	B
Person accessing boat or water (inc e.g. windsurfers walking across mudflat)	BW
Motor vehicle	MV

Description	Code
Rowing boat	RB
Air-borne (microlights, helicopters, planes etc)	AB

2.9 The diary data were reviewed prior to analysis, and all activities simplified into few groups to facilitate analysis. In particular, where multiple codes had been used for individual events these were simplified to reduce the number of categories and types of activity included in the analysis. Overall we took human activity as the predominant category so for example where a cyclist was accompanied by a dog off lead we categorised this as a cyclist. We also introduced two new categories RES to account for activities of resident (dog in garden, strimming, painting, person on balcony etc) and OT to represent other which could not be categorised into any other field code (loud noise, gunshots, rock pooling, construction worker etc). Specific details on how diary events were re-coded are listed in appendix 1.

2.10 Surveyors did not consistently record train as a potential or disturbance across locations. Thus, references to these entries were removed from the analyses

Response of the Birds

2.11 All recreational events that occurred within 200m of birds within the focal area (or resulted in birds within the focal area being disturbed) were classed as 'potential disturbance events'. For these events – a subset from the diary of all recreational activity - the response of each species (waders, wildfowl, divers and grebes only, and that were present within 200m) was recorded. Each potential disturbance event could therefore be associated with more than one observation, where multiple species were present within the focal area.

2.12 For each species, and each potential disturbance event within 200m, the following were recorded:

- Species
- Count (number present within 200m)
- Behaviour of the birds (prior to the disturbance event), simply categorised as F (feeding) or R (roosting/preening/loafing)
- Response of the birds (see Table 2) ultimately observed
- Distance: if "No response" this distance was the minimum distance from the potential disturbance event to the nearest individual bird of a given species; if disturbance occurred then this distance was the maximum distance from one individual to the disturbance event.
- Distance displaced, i.e. the distance that the disturbed bird(s) walked/swam/flew if disturbed
- Total time until original behaviour resumed

- Notes

2.13 In order to ensure accurate and consistent estimation of we used the aerial photographs with the distance bands plotted to ensure all surveyors were familiar with the 'layout' of the focal area and the distance of different features from the shore. Surveyors also used laser range finders to measure distances and at the end of fieldwork, distances could be paced exactly as an additional check.

2.14 Where the birds flew it was not always possible to estimate distances, for example where the birds flew out of sight. In such cases the distance displaced was simply not recorded and left blank.

Table 2: Response Codes

Response	Code
No response	NR
Alert, heads up, no change in birds' position	A
Alert, birds walked/swam short distance and resumed previous behaviour	W
Birds flew short distance (<50m) and resumed previous behaviour in general area	f
Birds took flight and flew more than 50m	F

Wider Count Areas

2.15 It was recognised at the start of the project that focusing on events and responses of birds within 500m of the shore may limit the activities and bird species recorded. Given the WeBS alerts include a number of diving duck (see para 1.11), and many activities take place mostly on the water, a count of the activities and birds within a much wider area encompassing open water within the harbour was included at the end of each survey visit. These wider counts are considered a snapshot of the birds and boats/craft/people present within a wide area around each survey location.

2.16 The activities and location of all people below MHWM were mapped within a predefined count area (the blue lines in Map 3). Within the same area all bird species present were mapped and of these we extracted and plotted the data for red-breasted merganser, goosander, goldeneye and the small grebes (black-necked and slavonian), all species which were thought likely to be infrequently recorded within the main focal areas. Across all locations we also mapped the activity data. The surveyors also noted the location of 'harvesting' activities which may have been present during the bird standard watch but moved out of the wider area by the time the wider count was undertaken. An additional map which included these records was also generated.

2.17 At locations 3, 6, 12, 14 and 15 the wider count area was either very similar or the same as the focal area, but at other survey points it was possible to include a much larger area including open water and extensive areas well below the mean low water mark. The survey area was therefore different at each survey point and was defined by the area visible and which could reasonably be surveyed. It was relatively simple to record all craft and people, but for the larger areas it was felt some birds may have been missed on days when the water was rough. Surveys were 'snapshots' in that the surveyor undertook a sweep of the area using binoculars and a telescope and plotted

the location of all activities and birds when first seen, as points on a map. These were later transferred as point data to the GIS.

2.18 It was hoped that these wider area counts would at least show the distribution of the selected species within a proportion of the harbour and also show were different activities (such as kite surfing, canoeing, pump scoop dredging, bait dragging, bait digging etc) also are occurring.

Night and Day Paired comparisons

2.19 Many wader and waterfowl species are known to feed at night (McNeil, Drapeau, & Goss-Custard 1992; Mouritsen 1992, 1994; McCurdy, Boates, & Forbes 1997; Sitters 2000; Liley *et al.* 2008). One possible impact of disturbance could be that birds redistribute within Poole Harbour to avoid disturbance, and it might be therefore expected that heavily disturbed areas are used differentially at by birds. If this were the case it might be expected that the number of birds at night would be higher than during the day, where disturbance levels are high during the day.

2.20 In order to test this impact of disturbance, paired counts were undertaken at a series of locations around Poole Harbour. The paired counts involved a day and night time visit, with counts made of people and birds. The fieldwork was conducted independently of the other fieldwork described above, and while the survey points used were broadly similar, they were not the same as those used for the standard watches described above. The fieldwork was focused on foraging birds and therefore visits were made when some mud was exposed. Survey points were one which could be visited easily during the day and night and were selected with ease of access in mind, so as to facilitate being able to visit all locations within a single low-tide window. This meant that all survey locations could potentially be visited during low tide during the day and again during the night. The survey points are shown in Map 4 and summarised in Table 4.

2.21 Sixteen pairs of counts were conducted at each location, with the route and order of visit varied between pairs of counts. The night time count always followed the day time count and the counts were carefully timed so that they were undertaken with the tide at a similar state. For example if a visit was made to location 1 on a falling tide during the day, the subsequent night time visit was also on a falling tide with the tide height matched. The selection of dates and times was therefore driven by the need to match tide heights and times between subsequent tides. The same surveyors were always involved in each paired visit, and the timing was modified during the night visit to ensure a matched tide, for example by waiting at the initial survey point until the height of the tide matched the day survey. Occasionally it was necessary to omit visits to particular points during the night as the tide had risen more quickly than expected or because traffic/access delayed the surveyors reaching the survey point at the correct time.

2.22 Four of the survey points were located around the Studland peninsula. Access to these locations was complicated as the ferry between Sandbanks and Studland stops running

around 11pm and starts again at 6am. During the day it was always possible to use the ferry, but some of the night surveys required additional surveyors to cover the four Purbeck points.

2.23 Counts were made within a 200m arc of each survey point. The choice of 200m was based on previous work in Poole Harbour at night (Liley *et al.* 2008), and reflected the distance at which we were confident of counting and recording birds in the dark. During the night counts were made initially by scanning with binoculars and scanning with a night vision scope. At many locations existing lighting and (on some nights) the moonlight meant visibility was reasonable. At the end of the count a scan was made with a powerful torch to check no birds had been missed. A record was kept of any birds heard but not seen.

Table 3: Night/day survey points and details of count areas for people and birds. Numbers cross reference with map 4.

Map Ref	Name	Where to stand/park	Bird Count Area	People Count Area
1	Rockley	Right at end of track	200m arc, ignore channel to right (breakwater is edge)	Opposite shore and foreshore by survey point or on water
2	Holes Bay North	On path, by scrub (parking at MacDonalds)	200m arc	Anyone on path between freshwater outlet to N and railway line or on water/mud
3	Holes Bay Sterte	On foreshore below gate (parking at gateway with NE sign)	200m arc	Anyone on foreshore path 200m either side
4	Holes Bay Asda	By statue, corner of flats	200m arc, count birds visible within creeks (difficult)	RNLI round to opposite shore, in line with salt marsh
5	Baiter	Old ruin on shore along from Car park	200m arc (can only see c.140m each way)	Anyone on beach or shore path within 200m (ignore people on grass)
6	Parkstone Bay	At T junction in paths – two tarmac paths join	200m arc	People on shore path or mud within 200m radius
7	Blue Lagoon	Gate at block of flats	200m arc (i.e. short of roost/lagoon mouth)	Anyone on spit or around shoreline of entire lagoon, or on mud/water
8	Whitley Lake, small spit	On pavement/path (parking by blue litter bin)	200m arc	200m arc, including people on shore path
9	Whitley Lake SW	On small bay area off from path (parking opposite Harbour View, penultimate house)	200m arc	200m arc, including people on shore path
10	Houseboats	By no fires sign above houseboats (park on ferry road)	200m arc	People visible for 200m to sw and shorter distance (to point) to NE
11	Shell Bay	On beach below BBQ area, directly below where boardwalk comes out	200m arc	From ferry to 200m along beach towards P Point
12	Brands Bay Hide	Hide	200m arc	Anyone visible on shore round to point (Redhorn)
13	Middle	Car park – obs hut (need to go	200m arc	Anyone on beach within

	Beach	down to beach at night)		200m (go up to Redend point in SE)

Analysis

2.24 All statistical analysis was conducted using Minitab (Release 14) or Genstat (Release 14). GIS data extraction and presentation was conducted using MapInfo (version 9.5).

2.25 With the response data, the probabilities of a major flight taking place were modelled using logistic regression (Hosmer & Lemeshow 2000) with the flush response (i.e. major flight taking place) being the dependent variable. The data were complex in that a range of variables were likely to relate to the response of the birds. These variables related to the potential disturbance event (distance from the birds, number of people, type of activity, whether on the mud/water/shore, presence/absence of dog, number of dogs off lead); the survey (location, tide state, month, temperature) or the birds (species, flock size, whether foraging or roosting. Variables were tested individually, rather than as a maximal model including all individual variables and meaningful interactions. This was because the range of potential variables was too broad to include simultaneously.

2.26 We used a generalized linear mixed model (GLMM) with a poisson error and logarithm function within Genstat (Release 14), including location and tide as random factors, to test whether the number of birds counted at the end of each survey was related to the level of disturbance recorded during the survey (i.e. the previous 1 hour and 45 minutes). We used the number of groups recorded during the survey (i.e. the diary data) as a measure of disturbance.

2.27 We also used GLMMs with poisson error distribution and logarithm function to evaluate the effect of different factors on the number of birds recorded during the night and repeated the analysis using the count data for the day count data. We ran the analysis separately for waders and wildfowl and used species, location and time period that the night count was conducted (grouped as before 10pm, 10pm-2am, after 2 am) as random effects. Disturbance levels were simply the total count of people present for the day time and for the night time. Models were constructed by including both day and night time disturbance levels together and then separately.

Structure of the Report and Presentation

2.28 We structure the results within the report as follows:

- Visitor data, using the diary data to explore access levels at different survey locations and to list the different types of activity recorded around the harbour. We also include the wider recording area results here (for activities).
- Bird data, summarising the counts within the focal areas and the wider recording areas.
- Response data, linking the access and bird data to consider which activities result in responses from the birds and identifying the situations where disturbance occurs.
- Paired night and day counts are then analysed separately to consider the extent to which the number of birds present at sites during the day and night is linked to disturbance levels at those locations.

2.29 We present much of the information on a series of maps, most of which are presented at a standard scale to allow direct comparison of access and bird data. The maps are presented as a separate map annex rather than embedded within the report.

2.30 We use box plots frequently throughout the report. These plots describe the data for particular groupings, and typically include the following:

- Horizontal line: indicating the median value for that group
- Box: indicating the 25th and 75th percentiles (i.e. half of all the data falls within between these two lines)
- Vertical lines: “whiskers” indicating the upper and lower limits of the data
- Asterisks: indicating outlier values (i.e. any data points that fall outside the upper and lower limits of the data).

2.31 Within the report we include all bird species recorded during the survey work, regardless of whether the species is listed in the relevant designations. We group species as waders, wildfowl and others (herons, grebes etc). We treat dark-bellied and pale-bellied brent goose separately (the two are sub-species rather than separate species).

3. Results: Standard Watches during the day

Levels of human activity

3.1 The diaries described 3,584 activity observations undertaken by 3,359 groups of people in the vicinity of the bird recording areas. Taking account of group size, these events involved at least 5,787 individuals with at least 1,122 dogs (256 on lead and 666 off lead). In total 294 hours of fieldwork were undertaken across the 15 locations (paragraph 2.4). Therefore we calculate the hourly rate of visitor activity at the surveyed locations to be at least 19.7 people and 3.8 dogs.

3.2 The number of times each activity was noted and where it was undertaken in respect to the shoreline are summarised in Table 4.

3.3 Walking without a dog was the most commonly recorded activity accounting for 36% of activity records. Only 5% of the groups walking without dogs, did so on the intertidal (Table 4). The second most popular activity accounting for 17% of the activity categories was walking with a dog off lead and of these 10% of groups did so on the intertidal and a further 2% went into the water. Cycling was also very popular undertaken by 577 groups and all stayed on the shoreline.

3.4 Images showing some examples of different activities are in Figure 1.

Table 4: Different activities and their location on the shoreline by activity type. A single activity could be marked as present on the shoreline, the intertidal and the water (for example if a dog walker threw a stick into the water from the shore and the dog retrieve it – hence the sum of the total values do not correspond to the total number of survey records).

Activity	Number (%) records recorded on shoreline	Number (%) of records recorded on intertidal	Number (%) of records recorded on water	Total Number (%) of survey records
Walking (without dog)	1276 (95)	72 (5)	2 (0)	1306 (36)
Dog walker with dog off lead	596 (88)	71 (10)	11 (2)	621 (17)
Cycling	576 (100)	0 (0)	1 (0)	577 (16)
Jogger	307 (99)	2 (1)	0 (0)	307 (9)
Dog walker with dog on lead	203 (100)	1 (0)	0 (0)	204 (6)
Rib or similar fast small boat	7 (8)	0 (0)	81 (92)	82 (2)
Large boat (outboard motor)	0 (0)	0 (0)	75 (100)	75 (2)
Birdwatcher	66 (97)	2 (3)	0 (0)	66 (2)
Fishing	41 (80)	7 (14)	3 (6)	45 (1)
Kitesurfer on water	4 (9)	2 (5)	37 (86)	40 (1)
Windsurfer	8 (22)	2 (6)	26 (72)	30 (1)
Motor vehicle	29 (94)	2 (6)	(0)	29 (1)
Pump scoop dredging	0 (0)	0 (0)	29 (100)	29 (1)
Other	10 (71)	3 (21)	1 (7)	20 (1)
Canoe on water	4 (17)	1 (4)	18 (78)	21 (1)
Bait digger	9 (38)	15 (63)	(0)	19 (1)
Bait dragging	1 (6)	0 (0)	17 (94)	17 (0)
Small sailing boat	1 (7)	0 (0)	13 (93)	14 (0)
Personal watercraft/jet ski on water	4 (40)	0 (0)	6 (60)	10 (0)
Kids playing	6 (55)	5 (45)	0 (0)	10 (0)
Residents	10 (100)	0 (0)	0 (0)	10 (0)
Air-borne	0 (0)	0 (0)	0 (0)	8 (0)
Person working on boat (boat stationary)	4 (50)	0 (0)	4 (50)	8 (0)
Large sailing boat (motor not running)	0 (0)	0 (0)	8 (100)	8 (0)
Wildfowling	3 (50)	1 (17)	2 (33)	7 (0)
Dog off lead	5 (100)	0 (0)	0 (0)	5 (0)
Rowing boat	0 (0)	1 (17)	5 (83)	5 (0)
Cockle raking	1 (20)	4 (80)	0 (0)	4 (0)
Horse riding	4 (80)	1 (20)	0 (0)	4 (0)
Metal detecting	1 (50)	0 (0)	1 (50)	2 (0)
Picnic	1 (100)	0 (0)	0 (0)	1 (0)
Totals	**3177 (100)**	**192 (100)**	**340 (100)**	**3584**

Figure 1: Images of different activities. a) dog walker at Pilot's Point with Brent Geese in the background (the geese had just moved off the beach in response to the approaching walker); b) canoeists at Arne, off Shipstal; c) kite surfer off Jerry's Point, with brent geese in the foreground and gulls behind; d) angler at Jerry's Point; e) large motor cruiser (and black-necked grebes) off Pilot Point; f) pump scoop dredger working off Goathorn.

3.5 In Figure 2 we summarise the number of groups undertaking each different activity per site (note locations 14 and 15 only had half the level of survey effort as locations 1-13). The activity levels at each location are significantly different $\chi 214 = 6197$; $p<0.001$) with some locations far busier than others. A large variety of different activities were recorded during the field work. Location 5 (Parkstone Bay) was the busiest site followed by location 7 Whitley Lake. Location 15 (Holes Bay – Railway) was the quietist.

3.6 The large number of activities recorded across the different locations make it difficult to spatially present the information in its entirety. So, using the values in Table 4, Map 5

shows the number of activity records per survey for those activities which were recorded at least 40 times during the fieldwork (the values are taken from Table 4).

3.7 The most frequently recorded activities across every location were walking and dog walking. Parkstone Bay (location 5) and Holes Bay south (location 4) were popular with joggers and cyclists while Whitley Lake (location 7) was where most kitesurfing was observed (Map 5).

3.8 As well as understanding the spatial spread of activities across the harbour it is also valuable to consider where these activities takes place, be it the shore, the intertidal areas or out on the water. Again, there were differences per location in the proportion of activities that took place on the shore, the intertidal and the water (Map 6). The highest proportion of water based activities were recorded at Locations 15, 1 and 2 (Holes Bay (railway), Holton Lee and Lytchett Bay) and the highest proportion of activity on the intertidal was noted at location 11 (Middle beach, Studland) (Map 6). There was a significant difference between the proportion of activities recorded on the shore and intertidal areas to those which took place on the water between the different survey locations (locations 1 – 13) meaning the ratio of people on the water to those on the land (shore or intertidal) was not equal (χ^2_{12}=358, P<0.001).

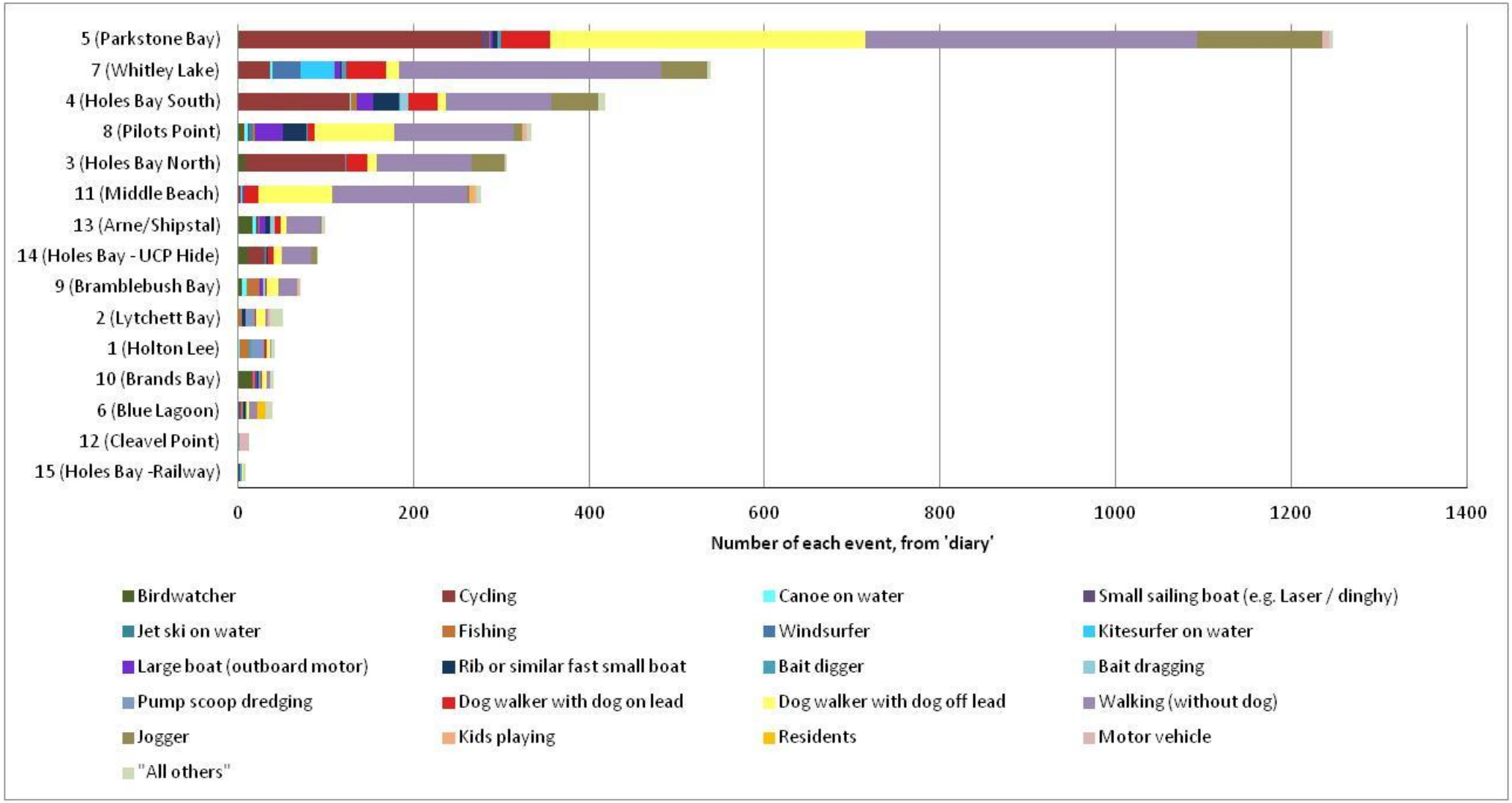

Figure 2: Total number of records per activity recorded by site. Survey effort was 21 hours per location for sites 1-13 and 10.5 hour per location for sites 14 & 15. Only those activities with at least ten observations (across all sites) are shown. "All others" includes all activities with less than 10 observations and activities which were not categorised (see methods)

3.9 Fishing was the only 'harvesting' activity with 40 or more observations across the survey locations so we thought it would be valuable to consider the distribution of 'harvesting activities' across all survey locations. Map 7 shows pump scoop dredging had been most frequently recorded at locations 1 and 2 (Holton Lee and Lytchett Bay) with cockle racking also noted at location 2 (Lytchett Bay). The general activity levels at locations 1 and 2 are low when compared to those at other survey locations across the harbour (Maps 5 and 6) and therefore the various harvesting activities make up a high proportion of events recorded at these locations..

3.10 Locations 6 (Blue Lagoon), 8 (Pilots Point), 9 (Bramblebush Bay) and 10 (Brands Bay) had the highest proportion of recorded fishing activity. No harvesting activities were recorded at locations 11 (Middlebeach) and location 14 (Holes Bay UCP Hide) (Map 7).

3.11 Map 8 shows the different levels of water based activities (those we can be sure were recreational) recorded across the harbour . The kite and windsurfing is concentrated around location 7 (Whitely Lake) at the exposed mouth of the harbour and rib (or small motorboat) activity was recorded across the harbour at every location except Middlebeach (location 11).

3.12 No dogs were recorded at location 12 (Cleavel Point) and the highest number of dogs (471) were observed at location 5 (Parkstone Bay) (Map 9). At the locations adjacent to main and busy roads, more dogs on lead than off were recorded (locations 3 (Holes Bay North) 4 (Holes Bay South) and 7 (Whitely Lake)).

Bird Counts

3.13 In total 47 different bird species were recorded within the focal count areas. These included 18 species of wader, 18 wildfowl and 11 other species (Table 4). No species was recorded from all survey points, oystercatcher was the most widespread species, recorded at 14 of the survey locations. Locations 7 (Whitely Lake) and 11 (Middle Beach, Studland) were the locations with the smallest range of species recorded. Locations 3 (Holes Bay north) and 10 (Brands Bay) were the locations with the highest number of species recorded.

3.14 The maximum counts for each species at each location are summarised in Maps 10 (waders) and 11 (wildfowl). It can be seen that the range of species and counts of birds varies markedly between locations. In general the north of Holes Bay, the southern bays, Newton Bay and Brands Bay hold large numbers of birds. Wigeon and teal dominate the counts in Holes Bay, while shelduck numbers were high at Brands Bay and Newton. For waders, black-tailed godwit accounted for a large proportion of the birds counted in Holes Bay. Dunlin were the main species in the south-west of the Harbour and were the only species counted in any abundance at Pilot Point. High counts of Oystercatcher were from Arne, involving the birds roosting opposite the survey point on long island.

Table 5: Summary of species recorded within focal areas. Data from all counts (i.e. two counts at each location at each survey visit).

	Species	No. locations where recorded	Maximum count per location														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Waders	Avocet	7		25	203							35		46	60	113	47
	Bar-t. Godwit	5							64	1	1			150	11		
	Black-t. Godwit	11	12	210	357	160		1			2	253		500	24	1200	144
	Common Sandpiper	1			1												
	Curlew	13	60	44	63	6	2	11	15		5	52		12	7	50	171
	Dunlin	10		120	164			4	2	650	108	320		230	6	110	
	Golden Plover	1														1	
	Greenshank	1		5													
	Grey Plover	6						2		64	4	57		4	2		
	Knot	5			10							92		31	2	9	
	Lapwing	4		3								125		38		17	
	Oystercatcher	14	58	114	15	24	24	45	49	14	60	82	3	25	660		14
	Redshank	13	7	102	270	14	3	32			2	94	1	81	25	90	126
	Ringed Plover	3						8		4	15						
	Sanderling	3							33	26	9						
	Snipe	1			1												
	Spotted Redshank	1			1												
	Turnstone	7			30		13	16	8		22	116		58			
Wildfowl	Canada Goose	7		10	5		1	2				3				58	30
	Common Scoter	2										2	5				
	Dark-b. Brent Goose	12	136	64	6		93	61	44	73	39	38	72	177	240		
	Eider	1								1							
	Gadwall	6	5	7	39						3					15	2
	Goldeneye	10	3	2	4	1	3	4	3		6			3	6		
	Goosander	2		1											1		
	Mallard	11	33	21	38	2	2				8	2		53	8	15	4
	Mute Swan	7		25	93	2	22	3								4	2
	Pale-b. Brent Goose	1								5							
	Pintail	6	36		29						1	70		5		8	
	Red-b. Merganser	12	5	7		6	8	8	14	12	26	9	4	20	17		
	Shelduck	11	50	13	78	13		49			28	235		390	31	81	130
	Shoveler	3			12							6				20	
	Teal	11	5	201	720	84		8			29	154		216	8	900	398
	Tufted Duck	1			2												
	Velvet Scoter	2										2			1		
	Wigeon	10	61	539	1330	48					1	135		20	92	277	170

	Species	No. locations where recorded	Maximum count per location														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Other Species	Black-n. Grebe	4					1			2	6		15				
	Cormorant	15	3	8	3	6	4	3	1	1	1	2	2	3	16	3	3
	Great-c. Grebe	11	6	2	1	1	6			1	8	2	7	3	5		
	Great N. Diver	1								2							
	Grey Heron	5			2	1		1							1		1
	Little Egret	12	6	1	7	3	1	2			2	6		2	5	1	3
	Little Grebe	4			2		1									13	16
	Red-n. Grebe	1								1							
	Shag	4							1	7	2		3				
	Slavonian Grebe	2								1			1				
	Spoonbill	1			13												
No. species total			16	20	25	12	11	16	9	11	20	24	8	22	19	18	15

Effect of people on bird numbers and distribution

3.15 If disturbance were affecting the general distribution of birds it might be expected that the survey points that were busiest (i.e. diary events) might have lower bird counts. We took the maximum count from each survey point and converted these to densities (based on the focal area at each survey point). These densities counts are shown in relation to visitor levels (diary events per hour of survey) in Figure 3. The main feature of these plots is the low bird densities (waders and wildfowl especially) at Parkstone Bay (survey point 5), which is the point at the bottom right of the wader and wildfowl plots. As these plots use the maximum bird count from all surveys, this would suggest that the Parkstone Bay area consistently supports low bird densities. Other low densities were at Middle Beach, Studland (where there are no mudflats). The survey points with the high densities of birds were mostly the Holes Bay survey points.

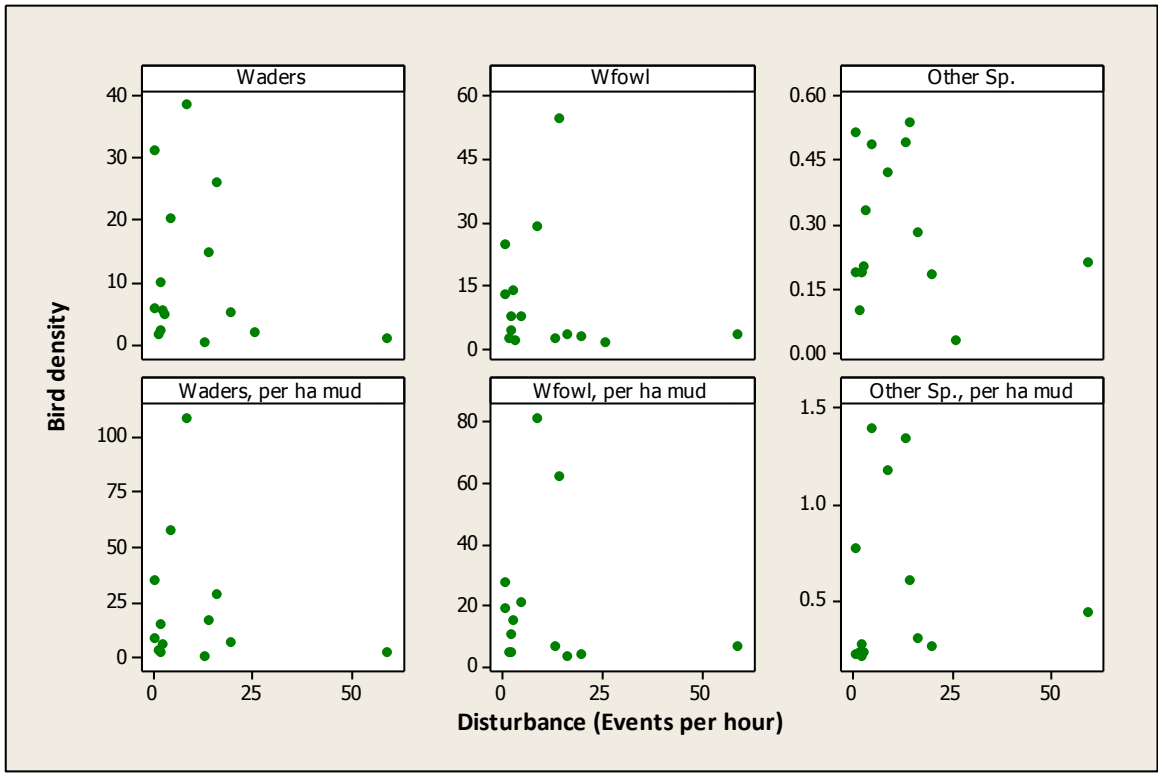

Figure 3: Maximum counts of birds at each location, converted to density (top row entire focal area; bottom row density calculated based on area of mudflat within each focal area) in relation to disturbance levels at each survey point. Note that in the bottom row pilots point and middle beach are omitted from the plots as there are no mudflats at these survey points.

3.16 We also used the bird counts from each survey visit to test whether there was any effect of disturbance on the use of different areas by birds. The total number of waders, wildfowl and other species was extracted for each survey visit. We used a generalized linear mixed model with a poisson error and logarithm function, including location and tide as random factors, to test whether the number of birds was related to the number of people, using the number of groups recorded during the same count as a

measure of disturbance. This analysis is therefore testing whether bird numbers vary in relation to disturbance in the short term – i.e. whether birds will try to use areas and then vacate them if disturbed (rather than simply avoid the areas with high disturbance levels altogether).

3.17 The number of people was significant and had a negative effect on the number of birds present at the end of the count for waders and wildfowl but not for the other species, which included a range of species (such as cormorant, shag, grebes, divers, egrets, herons etc), often with small counts. The data are shown in Figure 4 and a pattern is clear where the high bird counts tend to be those with low levels of disturbance and where high counts of people were recorded the number of birds was consistently low. These results indicate that disturbance influences the distribution of birds within Poole Harbour.

Table 6: Results of generalized linear mixed models, testing for the effect of disturbance (the total number of groups of people counted during each visit) on the number of birds (separate models run for waders, wildfowl and other species) at the end of each count. Models use poisson error and logarithm function.

	Effect	F	d.d.f	p
Waders (Location-1.2±0.5; tide=0.1±0.1)				
Total people	-0.03±0.01	5.86	109.1	0.017
Constant	4.26±0.33			
Wildfowl (Location-1.76±0.75; tide=0.2±0.03)				
Total people	-0.04±0.01	17.17	149.9	<0.001
Constant	4.21±0.37			
Other Species (Location-0.60±0.33; tide=0.0±0.0)				
Total people	-0.01±0.01	1.28	94.7	0.26
Constant	0.52±0.24			

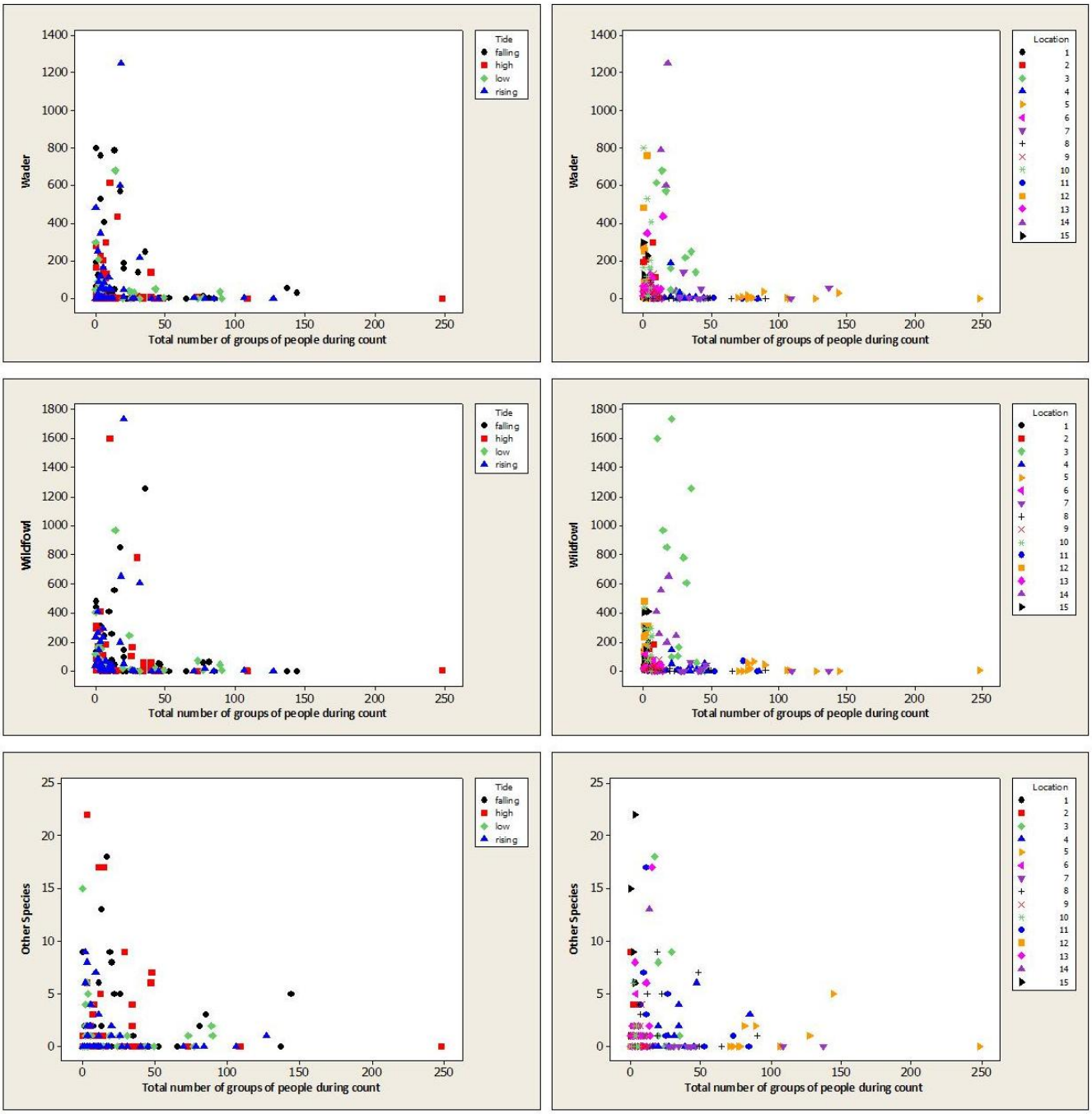

Figure 4: Scatterplots showing number of birds at the end of each survey in relation to numbers of people counted during the same survey. The three pairs of graphs relate to the same species groups (waders at the top, wildfowl in the middle, other species at the bottom). On the left hand graphs the symbols indicate tide state and on the right hand side the symbols indicate location.

Behavioural responses to the presence of people

3.19 During each survey visit the diary element essentially recorded all human activities and potential disturbance events that might affect birds within the focal recording area. This diary was maintained even when no birds were present within the recording area (for example some prior disturbance or changes in the tide might have pushed birds out of the recording area). Some of the diary events could also result in different disturbance events, involving multiple species specific observations: a single person might disturb different birds in different parts of the survey area and different species may respond differently (e.g. some might take flight, while others show no response). The data therefore consist of a number of unique diary entries, some of which could result in multiple potential disturbance events, each of which we treat as a unique observation. We use the term potential disturbance event throughout this report to highlight those diary entries that resulted in people/activities occurring within 200m of birds within the study area. Each of these potential disturbance events could be associated with multiple observations.

3.20 Across all sites there were 3584 diary entries. Of these 1981 occurred when birds were present in the focal area and either caused disturbance or were within 200m of the birds. There were therefore 1981 different potential disturbance events. Data for these events are summarised in Table 7. These potential disturbance events generated a total of 3755 species specific observations. Of these (species-specific) observations, 3257 (87%) resulted in no visible change in behaviour or any kind of response from the birds. At least 12% of observations resulted a disturbance of a given species, with 219 observations (6%) involving birds undertaking a major flight. The unassigned categories relate to particular events where the surveyor was unable to attribute the response of the birds, this was typically where multiple events occurred at once and lots of species were present and the surveyor was unable to be confident of how the birds responded.

3.21 Across all sites, 294 hours of fieldwork were conducted. Using this total to derive a rate across all survey points:

- There were 5.6 potential disturbance events per hour
- There was a response (i.e. birds of a single species became alert, walked/swam, flew) 1.7 times per hour
- A flight response (i.e. minor or major flight from a given species) was recorded every hour

Table 7: Summary of response data. We treat each potential disturbance event as a unique event. In order to calculate the totals for the diary events we attributed a single response category to each event in the diary. If an event caused a range of responses (e.g. a major flight for one species but no response for other species, then we categorised each diary event according to the most extreme response)

Response	Number (%) Observations	Number (%) Potential disturbance events
No Response	3257 (87)	1657 (84)
Alert	66 (2)	41 (2)
Walk/Swim	88 (2)	68 (3)
Short Flight	83 (2)	64 (3)
Major Flight	219 (6)	143 (7)
Unassigned	8 (0)	8 (0)
Total	3755 (100)	1981 (100)

3.22 There were significant differences between months in how birds responded. The most potential disturbance events were recorded in January (note survey effort was also higher during this month), however the marked differences occurred in December, where a much higher proportion of events involved a response from the birds, particularly involving major flight ($\chi 212=150.503$, $p<0.001$).

Table 8: Response by month. Table gives number (%) of observations within each category of response.

Month	Survey effort (hours)	No Response	Alert	Walk/ Swim	Minor Flight	Major Flight	Unassigned	Total
November	68.25	833 (88)	13 (1)	21 (2)	14 (1)	58 (6)	13 (1)	952 (100)
December	68.25	446 (74)	31 (5)	32 (5)	13 (2)	72 (12)	7 (1)	601 (100)
January	78.75	1124 (90)	17 (1)	14 (1)	27 (2)	50 (4)	12 (1)	1244 (100)
February	78.75	854 (89)	5 (1)	21 (2)	29 (3)	39 (4)	10 (1)	958 (100)
Total	**294**	**3257 (87)**	**66 (2)**	**88 (2)**	**83 (2)**	**219 (6)**	**42 (1)**	**3755 (100)**

Types of activities and response of the birds

3.23 The 3755 potential disturbance events are summarised by activity in Figure 5. A wide range of activities were recorded and for many activities the sample sizes were low. Walking without a dog was the most frequently recorded event and cyclists, dog walkers, joggers and birdwatchers were also frequently encountered. The activities with the shorter green bars are those for which there was the highest frequency of disturbance. It can be seen that, relative to other activities, those on the water such canoes, pump scoop dredging, small sailing boats and kite surfing tended to be more likely to cause disturbance. Some caution is needed with the small sample sizes, for example the continuous red bar for wildfowling relates to a single observation, which resulted in a major flight.

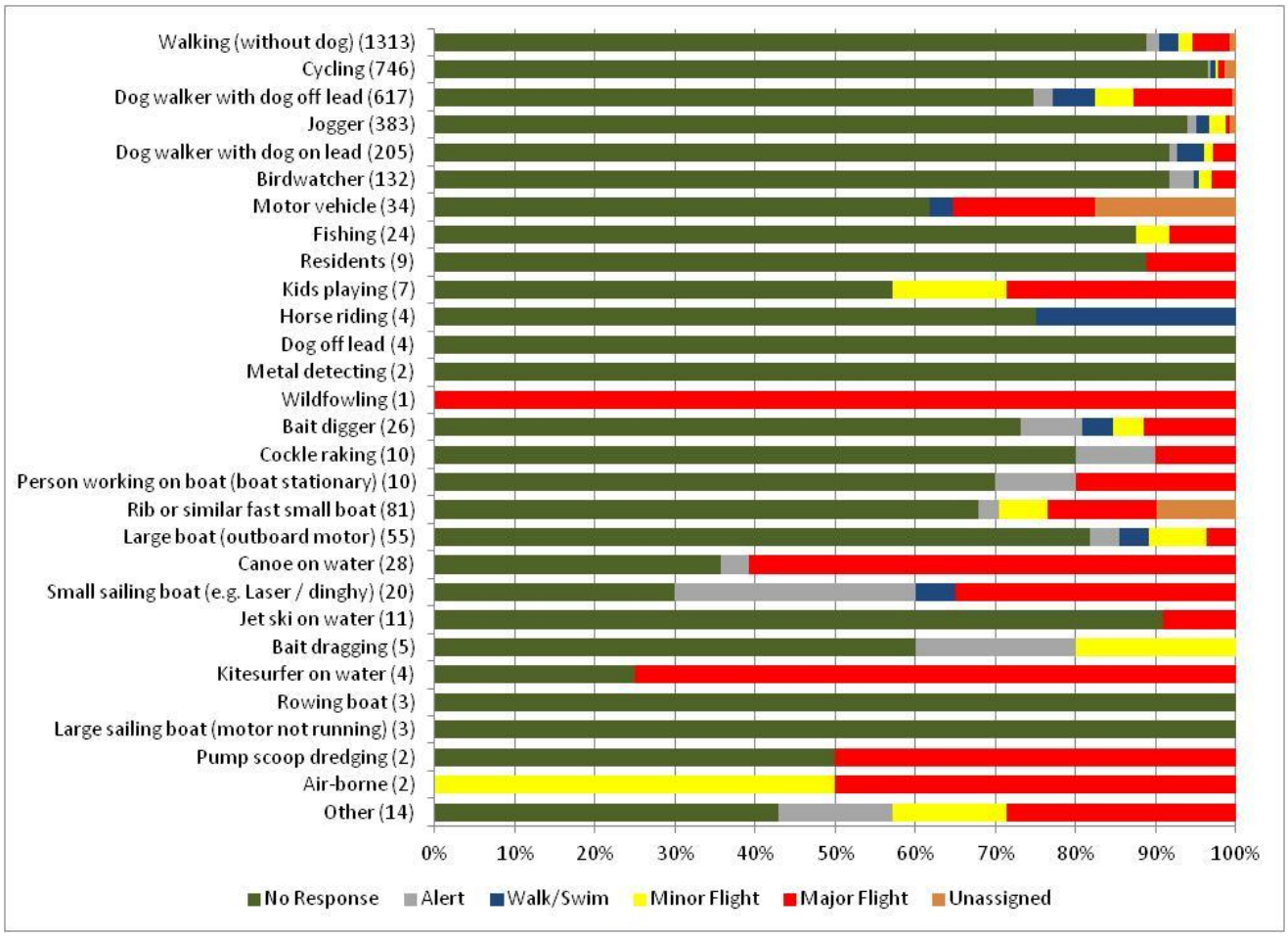

Figure 5: Responses of birds (grouped across all sites and all species) according to activity. Activities are grouped into those that are predominantly shore based, those that are predominantly based on the intertidal, those that are water based and then air-borne and "other". Within each group they are listed in order of sample size (the sample size being the number of species specific observations, given in brackets).

3.24 Table 9 summarises flight events by activity. The table gives the number of times each different activity was recorded to cause a major flight and the total number of times in total that birds were flushed (i.e. minor and major flights combined). The table also summarises the total number of birds flushed by each activity and the level of occurrence for each activity (i.e. number of potential disturbance events). Comparison of the percentages indicates which activities cause the most disturbance relative to each other and also relative to the frequency with which the activity occurs. Dog walking with the dog off the lead stands out as the activity which caused the most disturbance at the survey locations. The activity accounted for 16% of the potential disturbance events recorded yet accounted for 40% of the number of birds flushed (nearly 2000 individual birds recorded flushed) and 35% of the times birds were flushed. Notably high numbers of birds were flushed by dog walkers with dogs off leads at location 5 (Baiter), location 8 (Pilot Point) and location 11 (Middle Beach).

3.25 Walkers (without a dog) also accounted for a high proportion of major flights (28%), but given that walkers also accounted for 35% of the potential disturbance events, this

indicates that walkers without dogs off leads are much less likely to flush birds than dog walkers with dogs off leads.

3.26 Of the other activities, canoeing stands out in causing a relatively high level of disturbance (15% of the birds seen flushed; 8% of major flight events), despite the relatively low frequency at which the activity occurs (1% of potential disturbance events). Canoes were recorded flushing birds at five different locations, with particularly high numbers of birds flushed at Location 1 (Holton Lee) and at Location 13 (Arne).

Table 9: Activities and details of birds being flushed. Data from focal areas only. Table gives number of birds flushed, number of major flights, number of flights total (i.e. major and minor combined) and the number of potential disturbance events. *the single wildfowling event resulted in a number of birds flushed, but no accurate count was made.

Activity	Total number (%) birds flushed	Number of times major flight recorded (%)	Total number of times birds flushed (%)	Total number (%) of potential disturbance events
Birdwatcher	46 (1)	4 (2)	6 (2)	132 (4)
Cycling	34 (1)	5 (2)	8 (3)	746 (20)
Dog walker with dog on lead	75 (2)	6 (3)	8 (3)	205 (5)
Dog walker with dog off lead	1916 (40)	76 (35)	105 (35)	617 (16)
Dog off lead	0 (0)	0 (0)	0 (0)	4 (0)
Fishing	84 (2)	2 (1)	3 (1)	24 (1)
Horse riding	0 (0)	0 (0)	0 (0)	4 (0)
Jogger	84 (2)	2 (1)	10 (3)	383 (10)
Kids playing	24 (1)	2 (1)	3 (1)	7 (0)
Metal detecting	0 (0)	0 (0)	0 (0)	2 (0)
Motor vehicle	343 (7)	6 (3)	6 (2)	34 (1)
Residents	8 (0)	1 (0)	1 (0)	9 (0)
Walking (without dog)	796 (17)	61 (28)	84 (28)	1313 (35)
Wildfowling	*()	1 (0)	1 (0)	1 (0)
Person working on boat (boat stationary)	35 (1)	2 (1)	2 (1)	10 (0)
Bait digger	8 (0)	3 (1)	4 (1)	26 (1)
Cockle raking	5 (0)	1 (0)	1 (0)	10 (0)
Bait dragging	2 (0)	0 (0)	1 (0)	5 (0)
Canoe on water	694 (15)	17 (8)	17 (6)	28 (1)
Personal watercraft/jet ski on water	1 (0)	1 (0)	1 (0)	11 (0)
Kitesurfer on water	24 (1)	3 (1)	3 (1)	4 (0)
Large boat (outboard motor)	12 (0)	2 (1)	6 (2)	55 (1)
Large sailing boat (motor not running)	0 (0)	0 (0)	0 (0)	3 (0)
Pump scoop dredging	6 (0)	1 (0)	1 (0)	2 (0)
Rowing boat	0 (0)	0 (0)	0 (0)	3 (0)
Rib or similar fast small boat	192 (4)	11 (5)	16 (5)	81 (2)
Small sailing boat (e.g. Laser / dinghy)	48 (1)	7 (3)	7 (2)	20 (1)

Activity	Total number (%) birds flushed	Number of times major flight recorded (%)	Total number of times birds flushed (%)	Total number (%) of potential disturbance events
Air-borne	93 (2)	1 (0)	2 (1)	2 (0)
Other	248 (5)	4 (2)	6 (2)	14 (0)
TOTAL	**4778 (100)**	**219 (100)**	**302 (100)**	**3755 (100)**

Variation between sites

3.27 There was some variation between sites in the response of the birds. A number of locations were relatively quiet, with few potential disturbance events, for example just 11 potential disturbance events were recorded at Holton Lee and 18 at Cleaval Point, both where there is no public access directly to the shore. Location 15 (Holes Bay wooded spit) was also relatively quiet (note the reduced survey effort here), with just 13 potential disturbance events. At this location surveyors did not record people screened in the trees/behind the hedge using the shoreline path, and therefore the potential disturbance events are only people at the end of the spit, on the saltmarsh and on the water.

3.28 The differences in the response of birds between sites was significant: the proportion of birds disturbed (either alert, walk/swim, minor flight, major flight) and the proportion showing no response differed between locations (χ^2_{10}=772.621, p<0.001; data for locations 1,2,12 and 15 omitted due to low sample sizes). Data are summarised in Table 10, Map 12 and Figure 6. At the Holes Bay survey points and at Baiter relatively high levels of access occurred, but the proportion of disturbance events was low. No disturbance events were recorded during the 10.5 hours of survey from the hide at the north of Holes Bay (Upton Country Park). The locations where birds are most frequently being flushed are at Studland (Pilot Point, Bramble Bush Bay, Middle Beach) and at Arne.

Table 10: Response by location. Table gives the number (%) of observations. The values are expressed as a flush rate (i.e. number of species specific minor or major flight events per hour of survey effort) in the last column.

Location		No Response	Alert	Walk/Swim	Minor Flight	Major Flight	Unassigned	Total	Total number flights	Survey hours	Flights per hour
1	Holton Lee	0(0)	0(0)	1(9)	0(0)	10(91)	0(0)	11(100)	10	21	0.48
2	Lytchett Bay	10(50)	0(0)	1(5)	1(5)	8(40)	0(0)	20(100)	9	21	0.43
3	Holes Bay north	718(94)	2(0)	18(2)	7(1)	7(1)	11(1)	763(100)	14	21	0.67
4	Sterte	504(91)	5(1)	5(1)	9(2)	11(2)	19(3)	553(100)	20	21	0.95
5	Baiter/Parkstone Bay	1033(98)	6(1)	2(0)	5(0)	8(1)	0(0)	1054(100)	13	21	0.62
6	Blue Lagoon	42(62)	8(12)	3(4)	2(3)	12(18)	1(1)	68(100)	14	21	0.67
7	Whitley Lake	227(90)	4(2)	9(4)	3(1)	10(4)	0(0)	253(100)	13	21	0.62
8	Pilot Point	120(53)	17(8)	11(5)	26(12)	50(22)	2(1)	226(100)	76	21	3.62
9	Bramble Bush Bay	79(57)	7(5)	3(2)	6(4)	42(30)	1(1)	138(100)	48	21	2.29
10	Brands Bay	26(58)	0(0)	0(0)	1(2)	17(38)	1(2)	45(100)	18	21	0.86
11	Middle Beach, Studland	143(68)	6(3)	31(15)	16(8)	15(7)	0(0)	211(100)	31	21	1.48
12	Cleaval Point	9(50)	0(0)	0(0)	0(0)	3(17)	6(33)	18(100)	3	21	0.14
13	Arne, Shipstal	112(73)	11(7)	4(3)	5(3)	21(14)	0(0)	153(100)	26	21	1.24
14	Holes Bay Hide	228(100)	0(0)	0(0)	0(0)	0(0)	1(0)	229(100)	0	10.5	0
15	Holes Bay wooded spit	6(46)	0(0)	0(0)	2(15)	5(38)	0(0)	13(100)	7	10.5	0.67
Total		**3257(87)**	**66(2)**	**88(2)**	**83(2)**	**219(6)**	**42(1)**	**3755(100)**	302	294	1.03

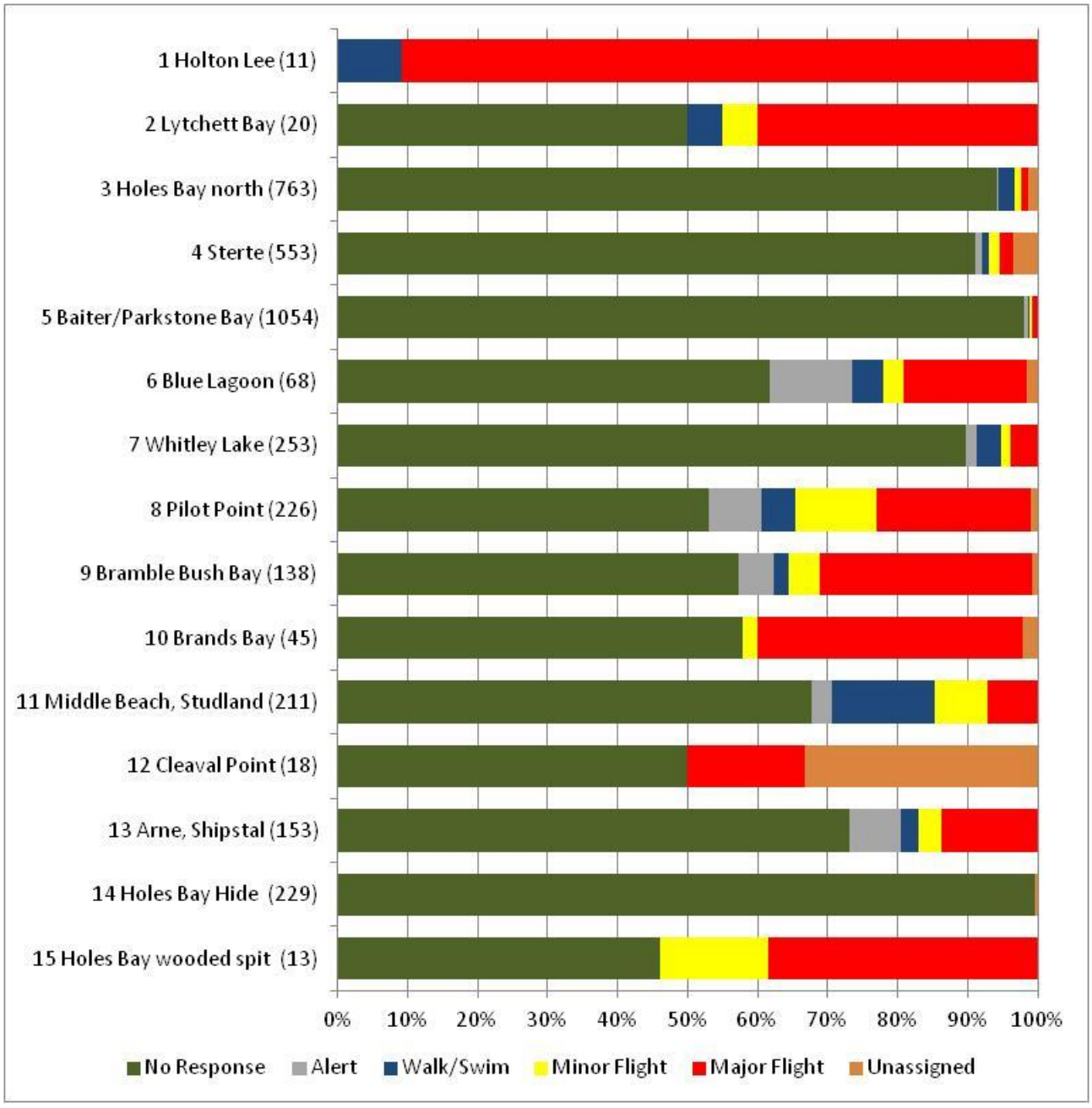

Figure 6: Response by location. Plot shows the percentage of observations by location, numbers in brackets are the total number of observations at each survey point.

3.29 We summarise the response by activity and location in Table 11. The table allows comparison between locations and the extent to which birds respond differently. The table highlights the different combinations of activities taking place at different locations. The grey cells (highlighting locations where there was a reasonable sample size – we have used the colouring to indicate 10 or more observations), tend to have relatively low percentages, indicating that in most cases where activities occur regularly the proportion of times they cause a major flight is low. Dog walkers with dogs off leads

are a notable exception: at many locations there were plenty of observations of this activity and high percentages (e.g. 51% at Pilot Point and 58% at Bramble Bush bay) of observations result involved major flights. It can be seen that in general, for the activities that occur infrequently at given locations (cells without grey shading) a high proportion of observations result in major flights. Other notable percentages on the table (i.e. locations where particular activities seem to be causing birds to move) are:

- RIBS or other small fast craft at Blue Lagoon (40% of observations resulting in major flight) and Arne (25% of observations resulting in major flight).
- Small sailing boats at Arne (25% of observations resulting in major flight).
- Large boats (on outboard motor) at Pilot Point and Arne
- Walkers (without dogs) at Pilot Point (27% of observations resulting in major flight) and Bramble Bush Bay (32% of observations resulting in major flight).
- Motor vehicles at Cleaval Point (17% of observations resulting in major flight).

Table 11: Percentage of observations at each location resulting in major flight for given activities. Grey shading indicates cells with at least 10 observations. Emboldened cells indicate values of 50% or more for the given combination of activity and location. Data for all species combined.

Activity	Location															Total Observations
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Air-borne	**100**												**100**			2
Person working on boat (boat stationary)				<0.5	<0.5	<0.5									**50**	10
Bait digger			<0.5	20	<0.5	**50**	<0.5	<0.5		<0.5					**100**	26
Bait dragging				<0.5									**50**			5
Birdwatcher			4	<0.5	<0.5			<0.5	33	4	<0.5		4	<0.5		132
Cycling			1	2	<0.5		<0.5		**100**	**100**				<0.5		746
Canoe on water	**100**					33	<0.5	67	50				**67**			28
Cockle raking		<0.5					17									10
Dog walker with dog on lead	**50**	<0.5	2	6	<0.5		6	20	<0.5	**100**	<0.5		<0.5	<0.5		205
Dog walker with dog off lead		**57**	3	10	4	**50**	24	**51**	**58**	**67**	22		22	<0.5	<0.5	617
Dog off lead						<0.5										4
Fishing		**100**				<0.5			6	**100**			<0.5			24
Horse riding								<0.5								4
Jogger			4	5	<0.5		2	<0.5	<0.5		25		<0.5	<0.5		383
Jet ski on water								**50**						<0.5		11
Kids playing		<0.5			<0.5				**100**		50		<0.5			7
Kitesurfer on water							<0.5		**100**							4
Large boat (outboard motor)				<0.5	<0.5		<0.5	15			<0.5		21			55
Large sailing boat (motor not running)				<0.5				<0.5								3
Metal detecting							<0.5									2
Motor vehicle		**100**		<0.5	<0.5				<0.5		<0.5	17				34
Other		**100**		**100**		<0.5	<0.5			**100**	**50**			<0.5		14
Pump scoop dredging	**100**	<0.5														2
Rowing boat				<0.5												3
Residents						13					<0.5					9

Activity	Location															Total Observations
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Rib or similar fast small boat	**100**			<0.5	<0.5	40		15					24	<0.5	**67**	81
Small sailing boat (e.g. Laser / dinghy)					<0.5	**57**							25			20
Walking (without dog)		<0.5	1	3	<0.5	5	4	27	32	75	11		12	<0.5		1313
Wildfowling										**100**						1

3.30 In Figure 7 we plot the disturbance in relation to access levels. Each point on the plot is a survey point; the plots use two measures of access levels (total groups per hour at each location and potential disturbance events per hour) and two measures of disturbance, the flush rate (i.e. number of times birds take flight per hour) and the percentage of events involving birds taking flight. The top two plots suggest that as disturbance levels increase, the proportion of events involving birds being flushed also decreases (Pearson correlation coefficients = -0.506; -0.571; p=0.054 and 0.026 respectively). In other words, where there is lots of activity it would appear that the birds are less likely to respond to each event. It should be noted that the locations where activity levels are high tend to be those where walkers, cyclists etc. predominate, i.e. the types of access at busy locations are markedly different. At low disturbance levels there appears to be variation between sites, with some sites seeing a high proportion of events involving birds taking flight and at other sites a much lower proportion. This could suggest that where disturbance levels are lower a range of other factors (for example the types of activities taking place) influence the behavioural response of the birds present, or could simply be a reflection of the different activities occurring at each location.

3.31 The actual flush rate, i.e. number of times birds per hour shows no pattern with disturbance levels (Pearson Correlation Coefficients = 0.032, -0.013 respectively; p>0.05 in both cases).

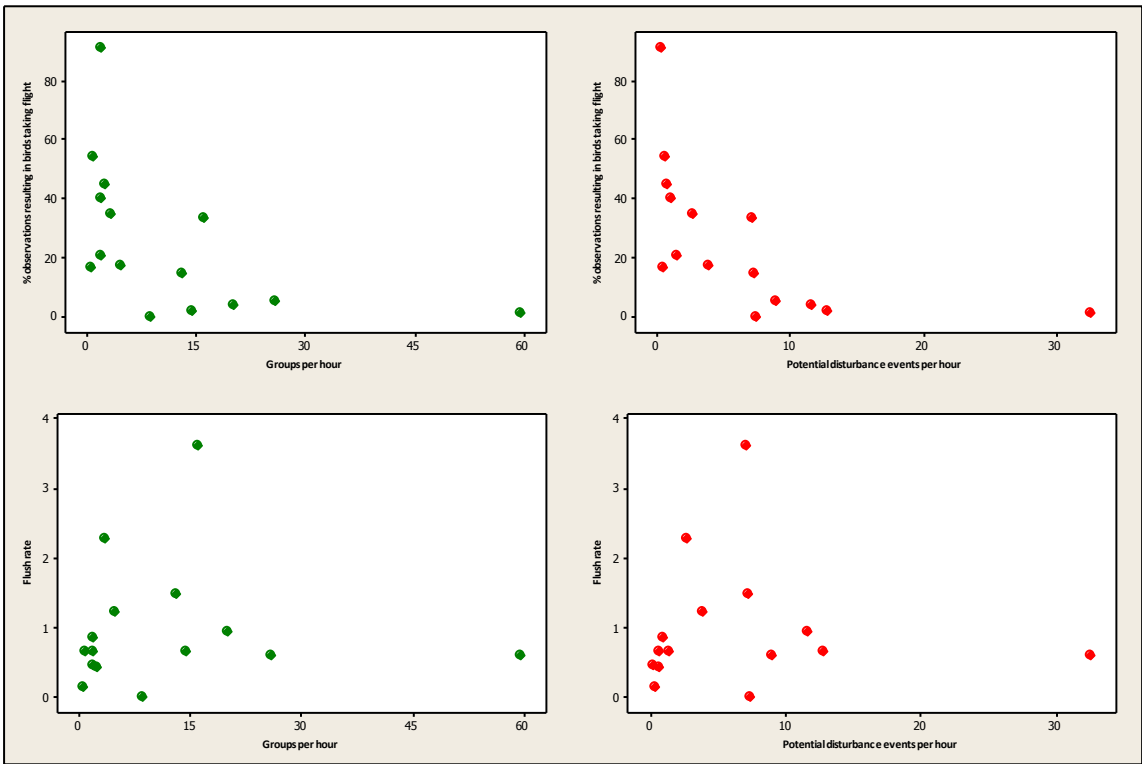

Figure 7: Disturbance in relation to access levels. Groups per hour is calculated using the total number of diary entries for each location, potential disturbance events are those events where birds were present and either caused disturbance or were within 200m of birds. Flush rate is calculated as the number of lfight events (i.e. minor or major flight) per hour.

Response by Species

3.32 In map 13 we show the number of individuals flushed (i.e. minor or major flight). The map shows flush rates, i.e. the total number of birds flushed divided by the number of hours of survey at each location. These rates allow direct comparison between locations – i.e. the bigger circles indicate higher flush rates. It can be seen that the number of birds flushed at Pilot's Point was the highest across all survey locations, and here dunlin in particular were the species recorded flushed. At Arne most of the flight events involved oystercatcher, and the rate was comparatively high here. At Baiter, Whitley Lake and Middle Beach, dark-bellied brent goose was the main species flushed.

3.33 Responses by species are summarised in Figure 8. Mute swan, mallard and great-crested grebe were species were any response to disturbance was rarely recorded. Red-breasted merganser and sanderling were the two species where the proportion of events resulting in birds being flushed was highest.

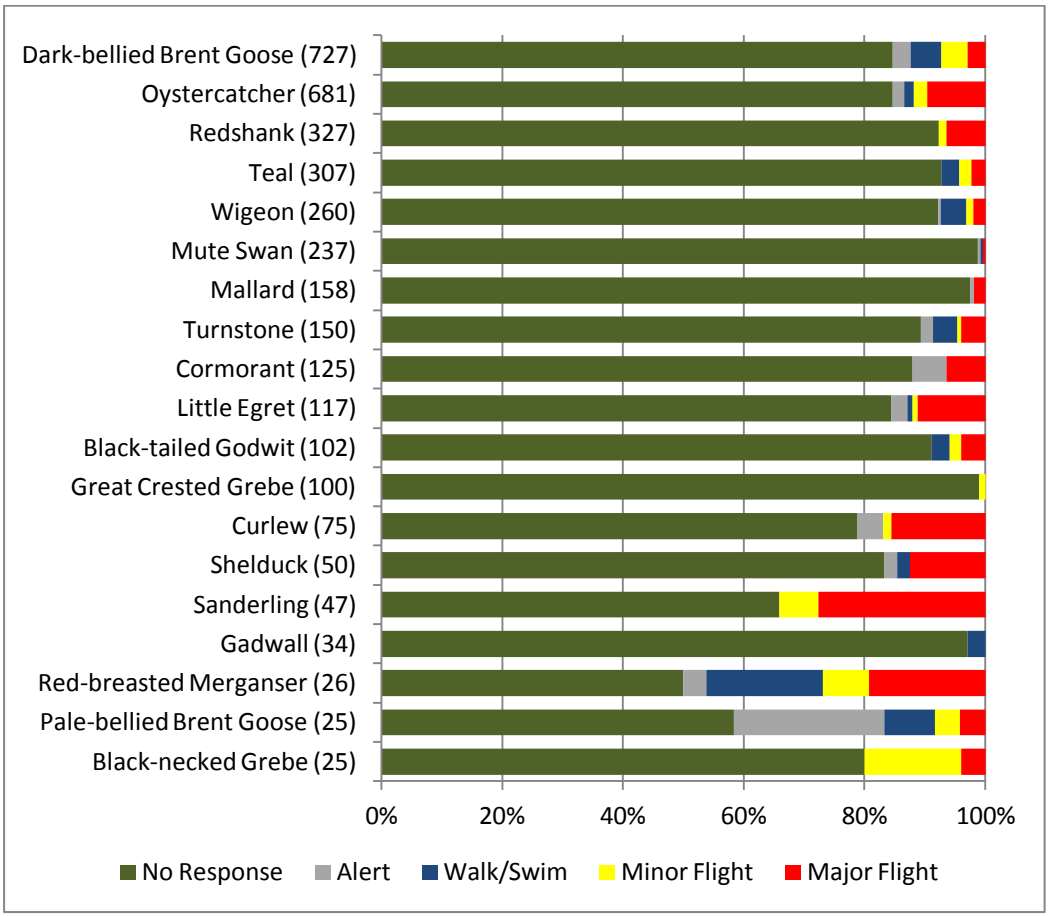

Figure 8: Response to disturbance by species. All species with at least 25 observations are shown. Percentages calculated using total number of potential disturbance events for each species.

Factors influencing response of birds

3.34 In order to explore which factors were linked to an event causing disturbance or not we tested a range of variables using logistic regression to determine which were potentially significant in relation to whether a major flight event occurred (i.e. major flight 1 or 0

was the response variable). We filtered the dataset to give a selection of wildfowl and wader species (dark-bellied brent goose, oystercatcher, redshank, teal, wigeon, turnstone, black-tailed godwit, curlew, shelduck) which were relatively widespread and likely to be relatively similar in their response to disturbance (i.e. omitting species such as mallard and mute swan which may even be positively drawn to people). A wide range of potential explanatory variables were initially tested individually, as there were too many too build an initial maximal model.

3.35 Distance (and the square root of distance) were significant ($p<0.01$), with the probability of major flight occurring decreasing with distance (i.e. when people were close to the birds, the probability of major flight increased). There were some differences between species; compared to the reference species black-tailed godwit, there were significant differences for curlew, oystercatcher and shelduck for which the positive coefficients indicated the probability of major flight was higher for these species. Flock size (number of individuals of given species) was significant ($p=0.049$), and negative in that major flight was less likely to occur when more birds were present. There was no significant effect of behaviour, with no difference in probability whether birds were roosting or foraging.

3.36 The zone of shore in which the event took place was highly significant; each event was categorised as either taking place on the shore, the intertidal or the water, with events that included multiple zones (being grouped separately as “multiple zones”). Events on the shore were the least likely to result in major flight (<0.001), and were markedly different to events in the other zones; events on the water had the highest probability of major flight ($p=0.029$). Events on the intertidal were significantly different from events on the water and events on the shore.

3.37 There were too many different activity types to use all types (the model failed to converge), but using a simplified activity variable (with activities classified as boating; watersports (i.e. kitesurfing, canoeing, personal watercraft use or windsurfing); foot/horse/bike (i.e. predominantly shore or intertidal based activities where the user is on foot or non-motorised transport) and “other”) there were significant differences. The probability of major flight was significantly lower for the foot/horse/bike grouping than all other groups ($p<0.001$). There was no significant difference between boating and “other” ($p=0.92$), but the probability of watersports resulting in major flight was significantly higher than all other groups ($p<0.001$).

3.38 Group size was significant in that larger groups of people had a significantly higher probability of causing a major flight ($p=0.045$). Similarly if a dog was present the probability of major flight was greater ($p<0.001$). We also tested the number of dogs on lead and off lead, treating these two variables as continuous rather than simply categorising events as to whether a dog was present or not. The probability of major flight showed no significance in relation to the number of dogs on leads ($p=0.300$) but was significant in relation to the number of dogs off lead ($p<0.001$).

3.39 Another significant factor was temperature (higher probability of major flight in warmer weather, p=0.031) but there was no significant difference with tide (p>0.05 for all tide categories).

Wider counts

3.40 Map 14 presents the wider count location data for the species detailed in paragraph 2.16. The most frequently recorded species were red-breasted mergansers and goldeneye which were observed across the harbour. The small grebes were most frequently recorded in Studland bay and around the harbour mouth.

3.41 Map 15 shows the locations of the activities recorded on the wider counts, these activities were present at the time when the birds in Map 14 were noted. Pump scoop dredging was noted in Lytchett Bay, to the north west of Wareham Channel, to the west of Brownsea Island, just to the East of Long Island, in Newton Bay and in Brands Bay. Bait dragging was noted in Arne Bay and around Long Island in Newton and Brands Bay and in Holes Bay. Bait digging was noted at Rockley, Brands Bay, Shell Bay, Whitely Lake, The Blue Lagoon, Parkstone Bay and Holes Bay. Fishing was noted either side of the chain ferry at between Sandbanks and Studland and at Rockley Sands.

3.42 Kite and wind surfing were concentrated in the more exposed areas around Whitely Lake at Sandbanks (Map 15). Wildfowling was most frequently noted around Lytchett Bay and to the North West of Wareham channel near Holton Heath and a single wildfowler was also observed in Brands Bay. Surprisingly a relatively small number of boats were recorded but we expect this reflects the seasonal nature of the activity given the wider counts were undertaken over the winter.

3.43 Map 16 shows some additional anecdotal records where particular activities were noted by the surveyors but were outside the wider counts. Bait digging has been observed in the North East of Holes Bay with bait dragging and cockle raking noted nearer the mouth of the bay. Map 16 also reiterates the locations of harvesting activities and shows that pump scoop dredging was recorded in Lytchett Bay and to the north west of Wareham Channel, in Brands and Newton bays (as in Map 15) and bait dragging was concentrated around Long Island.

Distances displaced and time lost

3.44 The distance birds were displaced was estimated where possible. It was not always possible to see where the birds landed as sometimes they would fly out of sight. In total there were 218 major flight observations accounting for the movement of 3584 birds. Of the 218 observations 134 records (involving 2399 birds) contained an estimate of the displacement distance.

3.45 Across all species of the 134 observations the mean distance birds were displaced was 226.0m (standard error 15.0m). If, for instances where the displacement could not be estimated, we assume the bird flew out of sight, then displacement distance is likely to be high. It is therefore possible to calculate the median disturbance distance value for all observations. After ranking the 134 records with distance we took the average of

the 109th and 110th observation (the mid-point if there had been 218 observations) giving a median displacement distance of 400m.

3.46 The recorded displacement distances are summarised by species in Figure 9. Median displacement distances were comparative low for bar tailed godwit at 60m (n=3) with the highest distance recorded of 650m for dunlin (n=2).

3.47 We also considered whether the displacement distance varied between the different survey locations. Observations at location 11 (Holton Lee) and location 10 (Brand's Bay) showed the greatest median displacement distance at 400m (n=3) and 300m (n=16) respectively. Observations at locations 12 (Cleaval Point), 5 (Baiter/Parkstone Bay) and 7 (Whitely Lake) showed the shortest displacement distances of 20m, (n=1), 90m (n=5) and 90m (n=7) (Figure 10). There were significant difference in the median distance values of birds across the survey locations (Kruskal-Wallis test, H=27.9, 13 df, P<0.01, N=134.

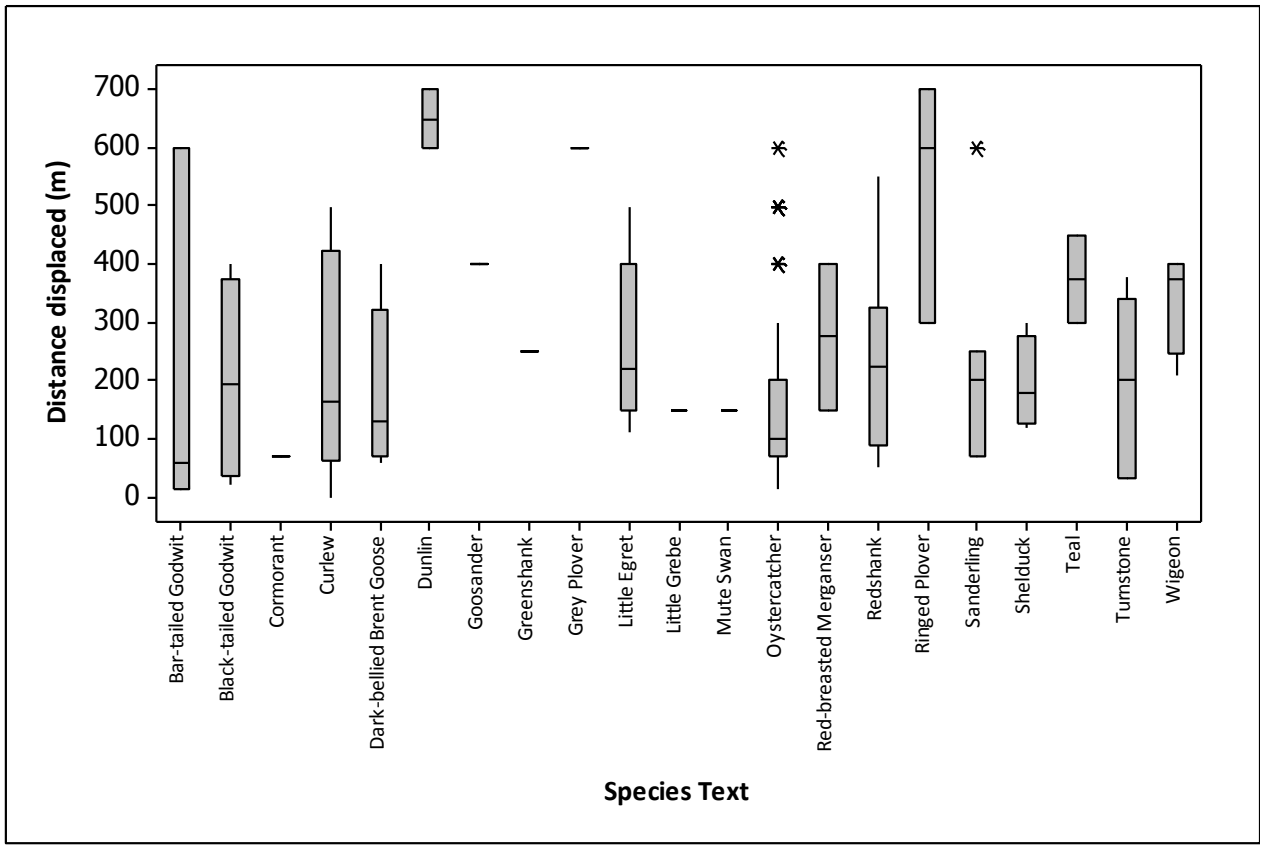

Figure 9: Recorded displacement distances groups by species

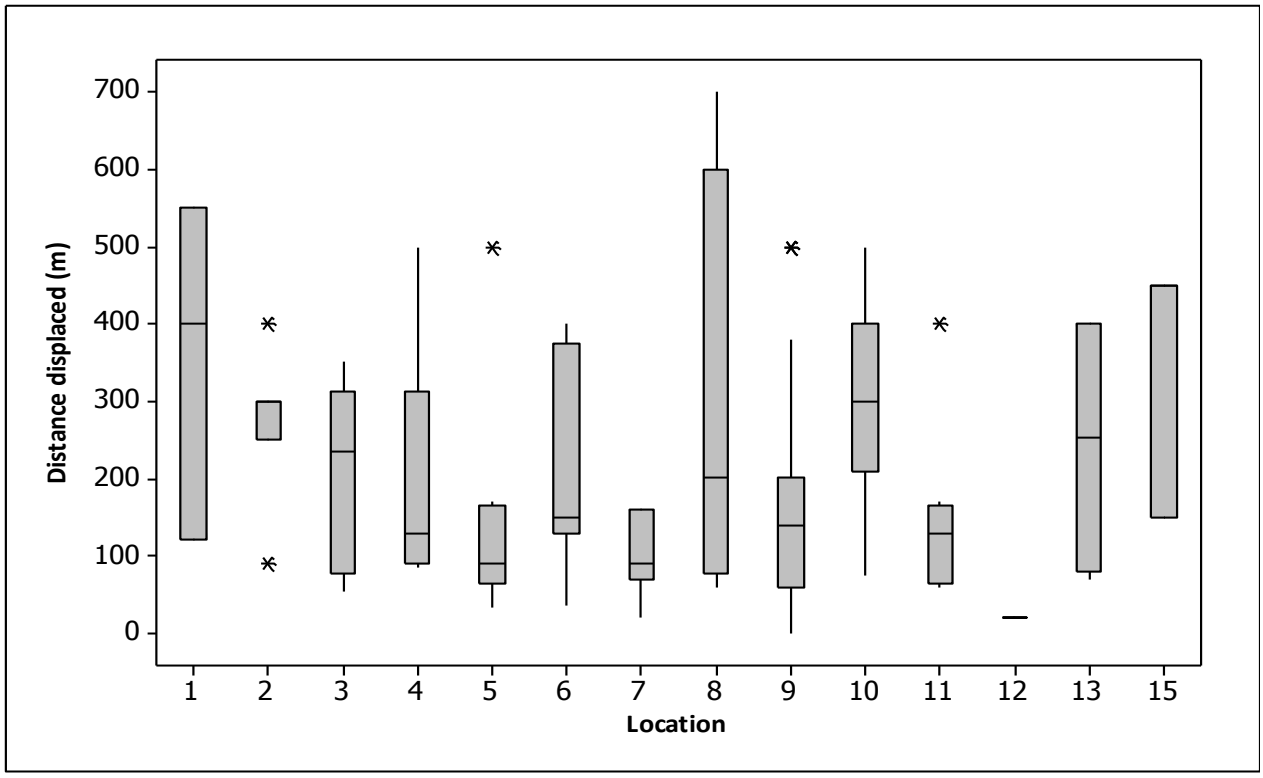

Figure 10: The displacement distance of birds following major flight per survey location

3.48 As with the distances displaced, the time taken for birds to return and resume feeding/roosting was difficult to estimate. In many cases the birds did not return and individual identification of each bird is impossible, so it was not always possible to ascertain when a particular group of individuals had returned.

3.49 In fact it was only possible to estimate the time until the normal behaviour was resumed for 90 major flight observations which accounts for the movement of 1162 individual birds. This ranged from 0 seconds to just over 3 minutes. Most observations (97% or 87 records) were of less than 2 minutes (Figure 11).

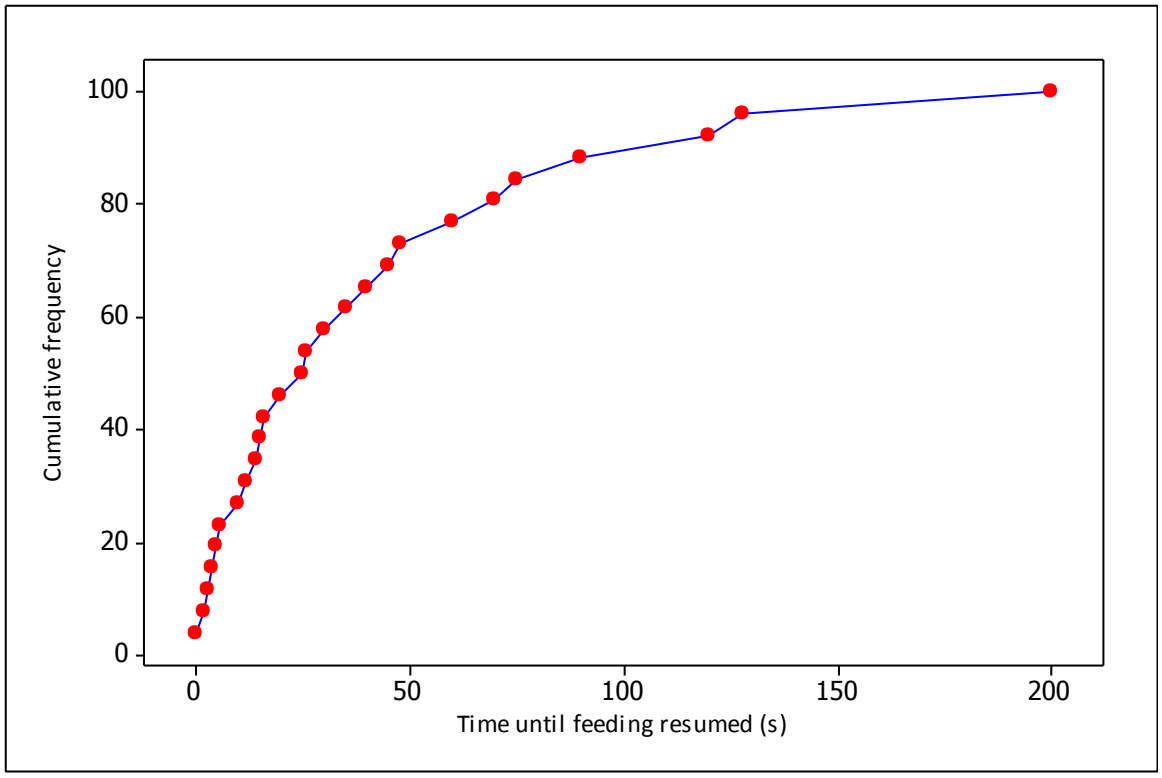

Figure 11: The length of time it took birds from 90 observations to resume feeding after a major flight expressed as cumulative percentage.

3.50 Birds which responded in major flight were displaced different distances dependent on the activity which caused the disturbance (Figure 12; Kruskal-Wallis test H=8.93, 3df, p=0.30, n=134). From the observations boats displaced the birds the greatest distance a median of 400m (n=10) and watersports the least a median of 53m (n=4), however the low sample sizes will reflect a number of instances where birds were displaced out of the line of sight and thus higher displacement distances could be substantially under represented. The median distance that birds were displaced by walkers was 160m (n=112).

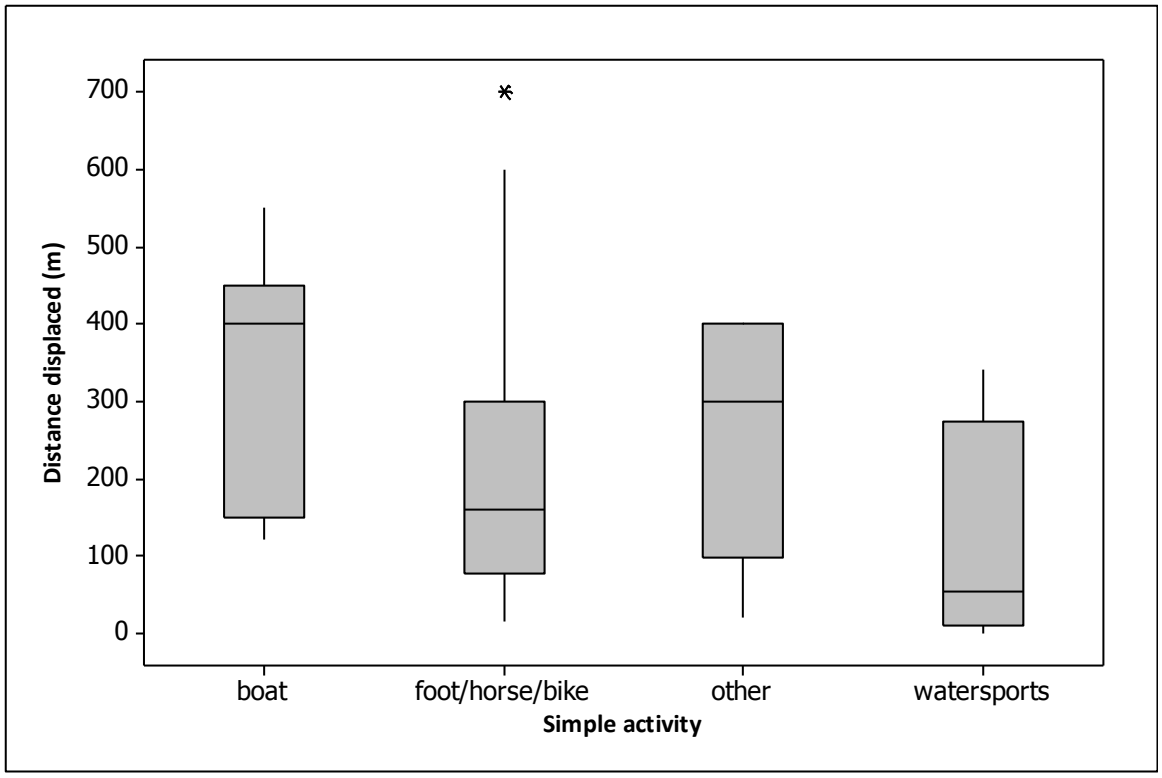

Figure 12: The displacement distance of birds undertaking a major flight categorised by activity

4. Results: Night/Day Paired Counts

4.1 Thirty-three species were recorded during the night/day paired counts. These included fourteen species of wader and eleven species of wildfowl. All but one of the 32 species were recorded during the day (spoonbill was the only species recorded at night and not during the day). A few species were not recorded at all at night and these included three wader species (common sandpiper, lapwing and sanderling) and three species of wildfowl (gadwall, goldeneye and red-breasted merganser). Direct comparison (for species with data from both day and night) showed day counts were significantly higher for oystercatcher, for all waders, all wildfowl and all "other" species combined. The results (across all counts and locations) are summarised by species in Table 12.

Table 12: Summary of count data by species. Data from all locations and all visits, where tide matched. Asterisks indicate significance of Mann-Whitney tests, **p<0.001; *p<0.05).

Group	Species	Day	Night
		Median (range)	Median (range)
Waders	Avocet	0 (0-11)	0 (0-5)
	Bar-tailed Godwit	0 (0-56)	0 (0-6)
	Black-tailed Godwit	0 (0-215)	0 (0-100)
	Common Sandpiper	0 (0-1)	
	Curlew	0 (0-31)	0 (0-30)
	Dunlin	0 (0-290)	0 (0-180)
	Greenshank	0 (0-3)	0 (0-4)
	Grey Plover	0 (0-2)	0 (0-2)
	Lapwing	0 (0-42)	
	Oystercatcher	1 (0-57)	0 (0-30)
	Redshank	0 (0-43)	0 (0-40)
	Ringed Plover	0 (0-15)	0 (0-8)
	Sanderling	0 (0-24)	
	Turnstone	0 (0-5)	0 (0-4)
Wildfowl	Canada Goose	0 (0-14)	0 (0-150)
	D-b Brent Goose	0 (0-146)	0 (0-300)
	Gadwall	0 (0-12)	
	Goldeneye	0 (0-2)	
	Mallard	0 (0-22)	0 (0-30)
	Mute Swan	0 (0-44)	0 (0-19)
	Pintail	0 (0-43)	0 (0-23)
	Red-b Merganser	0 (0-8)	
	Shelduck	0 (0-67)	0 (0-30)
	Teal	0 (0-550)	0 (0-300)
	Wigeon	0 (0-278)	0 (0-250)
Other	B-n Grebe	0 (0-4)	
	Cormorant	0 (0-2)	
	G-c Grebe	0 (0-2)	
	Grey Heron	0 (0-1)	0 (0-1)
	Kingfisher	0 (0-1)	
	Little Egret	0 (0-6)	
	Shag	0 (0-1)	
	Spoonbill		0 (0-1)
	Total waders	4 (0-387) **	0 (0-181)

Group	Species	Day	Night
		Median (range)	Median (range)
	Total wildfowl	3 (0-683)**	0 (0-559)
	Total other	0 (0-6)**	0 (0-1)
	All birds	15.5 (0-705)**	1 (0-598)

4.2 Data are summarised by species and location in Table 13. In total there were 188 paired counts where the tide state meant that the counts could be paired and were included in the analysis. Birds were present during the day in the majority of counts (161 counts, 86%) and birds were present at night in just over half of the counts (101 counts, 54%).

4.3 In roughly one sixth (33 pairs) of pairs, the total number of birds present at night was higher than the count during the day. It can be seen that for curlew, dunlin, grey plover, oystercatcher, redshank, ringed plover, mute swan and teal there were at least ten counts where the number of birds was higher in the night than the day. Particular locations where the night time counts were often higher were Rockley (survey point 1), Baiter (Survey Point 5), Parkstone Bay (Survey Point 6), Blue Lagoon (Survey Point 7), Whitley Lake (Survey Point 8) and Shell Bay (Survey Point 11).

4.4 Across all species, all waders and all wildfowl there was a significant correlation between the day time and the night time counts (Pearson Correlation Coefficients = 0.677; 0.454; 0.734; n=188, $p<0.001$ in all cases), suggesting that the locations and occasions when high numbers of birds were present during the day were also those when high numbers of birds were present at night.

Table 13: Number of times the night count was higher than the day count, by location and species. The table also gives the number of day time counts where the species was recorded, the number of night time counts where the species was present and the number of counts where the species was present in both counts in a pair. Grey cells indicate all non-zero cells.

		Number of day time counts >1	Number of night time counts >1	Number of counts present both day and night	Location													Total
					1	2	3	4	5	6	7	8	9	10	11	12	13	
	TOTAL NO. OF COUNTS				15	14	13	15	15	15	15	15	16	14	14	14	13	188
Wader	Avocet	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	Bar-tailed Godwit	5	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Black-tailed Godwit	19	3	1	0	0	1	1	0	0	0	0	0	0	0	0	0	2
	Common Sandpiper	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Curlew	56	34	19	2	3	0	3	1	1	1	1	0	2	3	4	0	21
	Dunlin	15	20	7	2	1	2	0	1	1	4	5	0	2	0	0	0	18
	Greenshank	3	6	0	2	0	1	0	1	1	0	0	0	0	0	1	0	6
	Grey Plover	8	15	2	3	0	0	0	3	1	0	0	0	3	2	1	0	13
	Lapwing	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Oystercatcher	100	34	28	1	1	1	2	1	3	1	0	1	0	1	1	0	13
	Redshank	44	27	20	0	4	2	2	2	0	1	0	0	0	0	1	0	12
	Ringed Plover	3	19	1	2	0	0	0	6	0	0	2	0	6	2	0	0	18
	Sanderling	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Turnstone	9	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wildfowl	Canada Goose	4	5	1	0	0	0	1	0	3	0	0	0	0	0	0	0	4
	D-b Brent Goose	37	9	3	0	0	0	0	1	1	4	0	0	0	1	1	0	8
	Gadwall	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Goldeneye	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mallard	18	11	3	2	0	0	2	0	1	0	0	0	0	1	3	0	9
	Mute Swan	21	18	7	2	0	1	6	1	2	2	0	0	0	0	0	0	14
	Pintail	9	2	0	0	1	0	0	0	0	0	0	0	0	0	1	0	2
	Red-b Merganser	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Shelduck	30	15	13	1	1	1	0	0	0	3	0	0	0	0	0	0	6
	Teal	43	36	28	0	1	1	4	1	0	4	0	0	0	1	2	0	14
	Wigeon	25	9	7	0	3	0	0	0	0	1	0	0	0	1	0	0	5
Other	B-n Grebe	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cormorant	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G-c Grebe	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Grey Heron	3	4	1	2	0	0	1	0	0	0	0	0	0	0	0	0	3
	Kingfisher	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		Number of day time counts >1	Number of night time counts >1	Number of counts present both day and night	Location													Total
					1	2	3	4	5	6	7	8	9	10	11	12	13	
	Little Egret	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Shag	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Spoonbill	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
	Total waders	134	76	64	5	3	2	2	4	2	4	6	1	3	4	0	0	36
	Total wildfowl	105	61	52	3	1	1	2	2	3	5	0	0	0	1	1	0	19
	Total other	42	5	3	1	1	0	0	0	0	0	0	0	0	0	0	0	2
	All birds	161	101	97	2	0	2	2	4	4	6	5	1	3	3	1	0	33

4.5 Data on the number of people counted during the night and day visits are summarised in Table 14 In total 609 people were counted during the day and 86 at night, indicating that the day time is roughly seven times busier than at night. Fishermen accounted for just over half the people counted during the night time visits but accounted for 5% of the day time total. During the day walkers and dog walkers were the main types of access recorded. No water based activity was recorded during the night at all, but night time activity did include people on the mud flats, for example bait digging (recorded twice at night) and bird ringers (recorded twice).

Table 14: Total number of people and number of times people recorded for day and night visits. Data summarised for all thirteen sites. The total people row at the bottom is the sum of all the other rows, omitting those rows that are dogs.

Activity	Number days activity recorded	Total people	Range	Percentage	Number nights activity recorded	Total people	Range	Percentage
Top of beach/shore/wall								
Dog walkers	12	126	0-63	21	3	6	0-3	7
(Dogs on leads)	9	26	0-8	4	3	3	0-1	3
(Dogs off lead)	9	89	0-54	15	2	3	0-2	3
Fishermen	8	30	0-15	5	9	47	0-18	55
Joggers	9	40	0-9	7	3	3	0-1	3
Walkers	13	257	2-61	42	5	17	0-11	20
Cyclists	7	42	0-13	7	2	5	0-4	6
Sitting	2	3	0-2	0	0	0	0-0	0
Birdwatchers	4	10	0-4	2	0	0	0-0	0
Kite surfers	1	15	0-15	2	0	0	0-0	0
Wind surfers	2	10	0-5	2	0	0	0-0	0
bait diggers	1	7	0-7	1	0	0	0-0	0
Other/misc	2	7	0-6	1	0	0	0-0	0
On the mudflats/intertidal								
Walkers	3	7	0-5	1	1	3	0-3	3
Dog walkers	5	11	0-4	2	0	0	0-0	0
Dogs off lead	6	12	0-3	2	0	0	0-0	0
Fishermen	2	3	0-2	0	0	0	0-0	0
Bait Diggers	3	17	0-9	3	2	2	0-1	2
Kite surfers	1	10	0-10	2	0	0	0-0	0
Bird ringers	0	0	0-0	0	2	3	0-2	3
Wind surfers	0	0	0-0	0	0	0	0-0	0
Birdwatchers	1	2	0-2	0	0	0	0-0	0
On the water								
Wind surfers	1	1	0-1	0	0	0	0-0	0
Kite surfers	2	2	0-1	0	0	0	0-0	0
Small motor boat	2	4	0-3	1	0	0	0-0	0
Large motor boat	1	1	0-1	0	0	0	0-0	0
Sailing dinghy	1	1	0-1	0	0	0	0-0	0
Working on boat	1	1	0-1	0	0	0	0-0	0
Canoe	1	2	0-2	0	0	0	0-0	0
Dog	1	1	0-1	0	0	0	0-0	0
TOTAL PEOPLE	13	609	4-190	100	12	86	0-31	100

4.6 The plots in Figure 13 show the bird count during the day in relation to the count during the night for a selection of species. The different colours for the symbols indicate the level of disturbance during the day, i.e. red points indicate busier counts (more than ten people counted), while the black points indicate the counts with fewer people (less than 2). The x and y axis in each plot are the same scale and the diagonal line shows the 1:1 ratio. Where points are below the line the count was higher during the day and points above the line indicate high night time counts. Were disturbance during the day to affect bird distributions such that high day time disturbance resulted in low day time counts and high night time counts it might be expected that the plots would show the black dots below the diagonal line and the red dots above the diagonal line.

4.7 For species such as teal it would appear that the counts tended to be higher during the night but when lots of birds were recorded during the day there were still relatively high counts during the night. By comparison for species such as oystercatcher and redshank it appears that there are counts that were high during the night and low during the day and vice versa. None of the plots provide visually compelling evidence that the count of birds during the night is higher when the levels of disturbance are higher during the day.

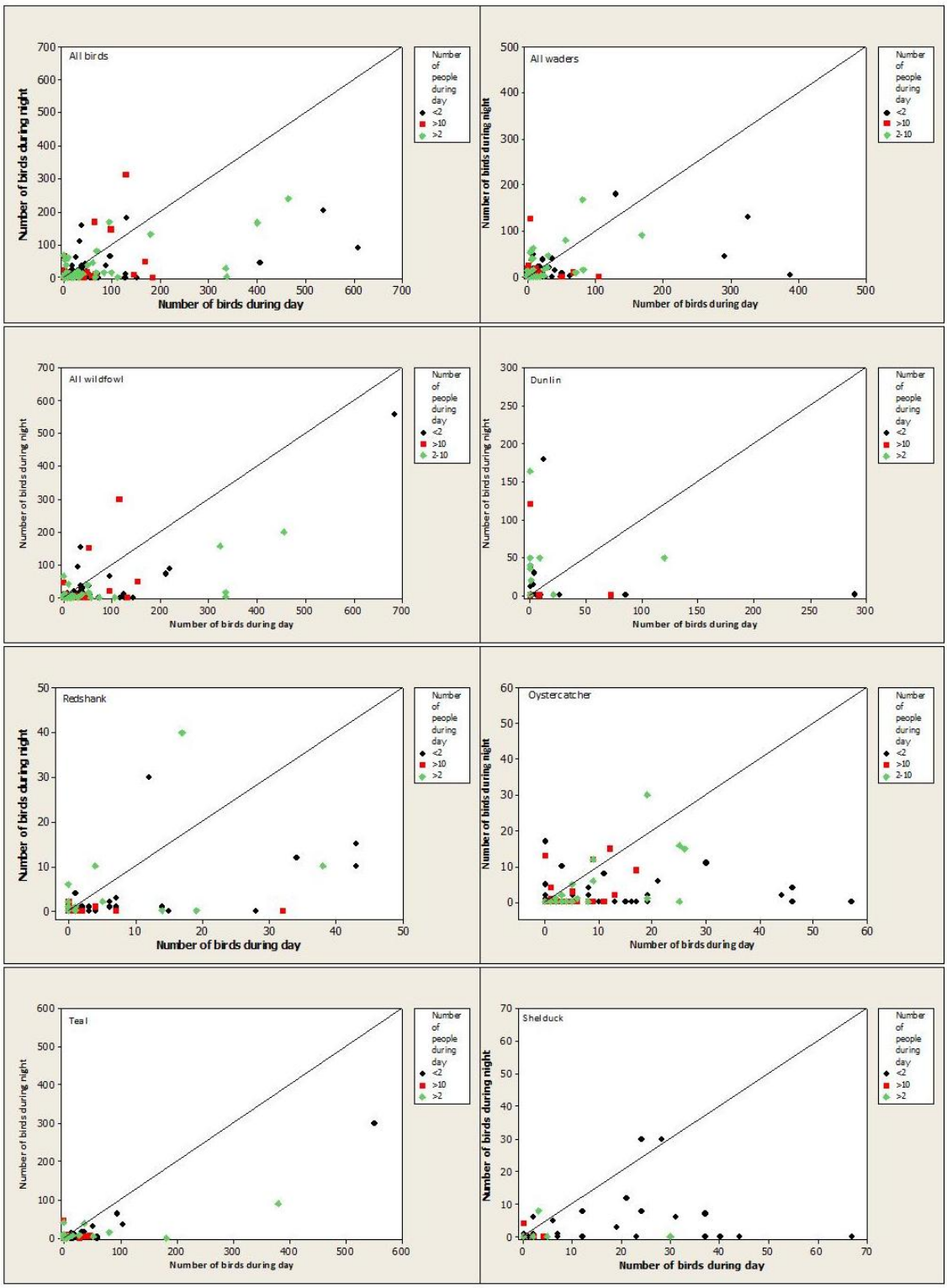

Figure 13: Scatter plots showing numbers of birds counted during the day and during the night. Graphs show different species and species groupings. Diagonal lines on all plots shows the 1:1 ratio, i.e. points above the line indicate counts where the night time count was higher.

4.8 We used generalized linear mixed models to test whether the levels of access counted during the day or night were significant predictors of the number of birds present.

Separate models were run for waders and wildfowl and for the counts made during the day and during the night.

4.9 After for controlling for the time period during which the night visit took place, location and species, the level of disturbance during the day, but not the level of disturbance during the night, was a significant term in the generalized linear mixed model for the number of waders counted during the night (Table 15). The effect of day time disturbance was negative, indicating that birds **avoided** areas heavily disturbed during the day. Day time counts of waders showed no significant effect of either the night or the day time disturbance levels (Table 16), although there is some suggestion that the number of people has an effect as the p value (0.074) is relatively low.

4.10 By contrast both day and night time disturbance were significant factors relating to the number of wildfowl counted during the night (Table 17), with day time disturbance having a positive effect and night time disturbance having a negative effect, in other words night time counts of wildfowl were higher when there were fewer people counted during the night and when there were more people present during the day. There was no significant effect of either day time or night time disturbance levels on the number of wildfowl recorded during the day.

Table 15: Significance of different disturbance factors in relation to the count of waders at night. Results from generalized linear mixed model with poisson error and logarithm function. Location (0.85±0.42), species (3.23±1.53) and night time period (0.03±0.05) were included as random terms.

Model Term	Effect ± SE	F	d.d.f	p
People count night	-0.067±0.054	1.48	1534.9	0.225
People count day	-0.02±0.012	4.56	2071.9	0.033
Constant	-2.09±0.602			

Table 16: Significance of different disturbance factors in relation to the count of waders during the day. Results from generalized linear mixed model with poisson error and logarithm function. Location (0.85±0.42), species (3.23±1.53) and time period (0.03±0.05) were included as random terms.

Model Term	Effect ± SE	F	d.d.f	p
People count night	-0.09±0.05	3.20	2508.8	0.127
People count day	-0.02±0.01	2.33	1809.0	0.074
Constant	-1.08±0.56			

Table 17: Significance of different disturbance factors in relation to the count of wildfowl at night. Results from generalized linear mixed model with poisson error and logarithm function. Location (2.93±1.47), species (2.87±1.63) and time period (0.13±0.17) were included as random terms.

Model Term	Effect ± SE	F	d.d.f	p
People count night	-0.38±0.19	4.26	1148.9	0.04
People count day	0.04±0.01	16.75	1139.2	<0.001
Constant	-1.83±0.80			

Table 18: Significance of different disturbance factors in relation to the count of wildfowl during the day. Results from generalized linear mixed model with poisson error and logarithm function. Location (1.41±0.66), species (2.64±1.39) and time period (0.11±0.12) were included as random terms.

Model Term	Effect ± SE	F	d.d.f	p
People count night	-0.09±0.06	2.02	1798.8	0.156
People count day	0.002±0.01	0.11	1674.4	0.816
Constant	-0.79±0.67			

5. Discussion

5.1 This report provides an overview of access levels, bird distribution and numbers and disturbance levels across Poole Harbour. The results provide a snapshot for the Harbour and a baseline data set that can be repeated in the future. It was a relatively mild winter and a wide range of activities were recorded. We highlight the following:

- A wide range of activities were recorded. Each activity varies in the locations and intensity, resulting in a complex pattern of access around the Harbour.
- Disturbance levels currently affect the distribution of birds within the harbour. It would appear that Parkstone Bay consistently supports low densities of birds and that at the other survey areas birds respond to access levels by vacating areas that are disturbed.
- Water based activities including kite surfing, windsurfing, canoeing and pump-scoop dredging were the activities most likely to result in birds being flushed.
- Dog walking, with dogs off leads, accounted for the majority of birds flushed and was the activity that caused the most disturbance (i.e. most flushing events) to birds. Dog walking was particularly commonly recorded and dogs off leads appear to be a particular issue.
- There was no evidence that waders responded to disturbance during the day by differentially using disturbed areas at night. In fact waders appeared to avoid areas at night when disturbance levels were high during the day.
- Wildfowl numbers during the night did however appear to relate to numbers of people during the day, with day-time disturbance levels having a positive effect on the number of birds present at night.

Approach & limitations

5.2 There are a number of key points which are important considerations in the interpretation of the results. The methods used for the standard watches have been developed over a series of other projects, including work on the Exe (Liley *et al.* 2011b), in North Kent (Liley & Fearnley 2011) and the Solent (Liley *et al.* 2010). The approach has therefore been tested and direct comparison with other sites is possible. It is important to recognise the following:

- We have explored how birds respond to disturbance and the extent to which the use of a sample of intertidal areas is related to disturbance. We have not considered disturbance in relation to the distribution of prey or the consequences of disturbance in terms of population size.
- The selection of sites was pragmatic, to provide spatial coverage of Poole Harbour but also to facilitate access and ensure good vantage points. The survey points are therefore not random.

- Survey effort was consistent (at least across survey locations 1-13). Visits were spread evenly between months and were split between weekends (1 visit per month) and weekdays (2 visits per month), comparison between locations is therefore justified. Due to the complexities of the tidal cycle within Poole Harbour and the variation between locations in the behaviour of tide, it was impossible to stratify visits according to tide. Surveyors ensured that all sites were visited in a range of tide states.

- Visits were all during daylight hours and the survey was focused on a 500m arc around each survey point. This will very much influence the range and intensity of activities recorded. In particular many water based activities were under recorded as they take place around the open parts of the Harbour. The survey times will also mean that some activities (such as bird ringing and wildfowling) that are more likely to be focused around dawn or dusk are likely to be under-recorded.

- The night time survey work used a 200m recording radius at each survey point. This results in a relatively small recording area and a relatively small area of mudflats sampled during the paired counts. While adding more survey locations would have been preferred, the logistics of surveying within a given time window made the inclusion of additional survey points impossible.

Context

5.3 There is good evidence that disturbance is a widespread factor associated with the population declines of a number of species (Møller 2008). Disturbance can potentially affect wintering birds in a variety of ways, for example through birds avoiding otherwise suitable areas of habitat (e.g. Gill 1996; Burger et al. 2007); through reduced intake rates as a result of vigilance etc. (e.g. Riddington 1996; Goss-Custard et al. 2006; Klaassen et al. 2006) and through physiological impacts such as stress (e.g. Thiel et al. 2011). Such impacts have the potential to affect fitness of individuals and have consequences at a population scale.

5.4 The distribution of birds within sites is likely to be governed by a range of factors, in particular the abundance and distribution of their food. Many studies illustrate that the distribution of birds is related to the distribution of prey (Sutherland 1983; Kennedy & Gray 1993; Farnsworth & Beecham 1997). In addition other factors such as the availability/accessibility of the prey (Stillman et al. 2000a; Goss-Custard et al. 2002; Stillman et al. 2005; West et al. 2007), weather (Dugan 1982) or proximity to roost sites (Rehfisch, Insley, & Swann 2003) can be important. In order to understand the impact of disturbance on the distribution of birds the ideal is therefore to consider the disturbance in relation to the distribution of resources that are important to the birds (see for example Gill 1996; Gill, Sutherland, & Watkinson 1996).

5.5 Within Poole Harbour previous studies have indicated that there are lower numbers of birds in some areas than might be expected given the amount of prey available in those areas (Thomas *et al.* 2004). Results from this study would suggest that disturbance may be a factor in the reduced numbers of birds using some areas, for example the mudflats

in Parkstone Bay hold particularly high levels of invertebrate prey biomass (see Figure 9 in Thomas *et al.* 2004). The amount of algal cover in Parkstone Bay is low (see Figure 6 in Thomas *et al.* 2004), indicating that the prey is accessible, and yet the densities of birds at the Parkstone Bay survey point were particularly low. This point also has the highest levels of disturbance. The results presented here indicate that bird numbers will be lower in areas that are highly disturbed and that, for waders at least, the disturbed areas are not differentially used at night.

5.6 It is therefore possible for disturbance to have a marked effect on how birds use a site, without any birds actually being flushed. Many species of wader and wildfowl are long-lived and site faithful (Rehfisch *et al.* 1996; Austin & Rehfisch 2005), it therefore might be expected that individuals learn where and when to feed to avoid disturbance, or at least where the most profitable feeding locations are. It is within this context that the response of birds – in terms of birds being flushed etc. – must be viewed.

5.7 The behavioural response of birds is not necessarily a good indication of the impact of disturbance (Gill, Norris, & Sutherland 2001; Beale & Monaghan 2004), and the results relating to the activities and amount birds are flushed should therefore be interpreted with some care. Birds are perhaps more likely to take flight when they have alternative sites at which to feed/roost; when there is little to lose from taking flight (e.g. if full and therefore not needing to feed intensively) and therefore demonstrating that birds are flushed is not necessarily indicative that there are impacts from disturbance.

5.8 Poole Harbour is currently in Favourable Condition for non-breeding birds despite some apparent declines in five featured species and a decline in the overall assemblage from much higher levels during the 1980s and 1990s (S. Burton pers comm; see also Underhill-Day 2006). Recent WeBS data suggests a 12% decrease in the number of waterbirds using the harbour over a five year period (Holt *et al.* 2011), yet the extent to which this decline is related to poor survey coverage is not clear. Further work analysing more recent WeBs data may help to determine whether changes are site based and whether disturbance or other factors are resulting in these changes.

5.9 One approach to understand the consequences of disturbance at a site is to consider the energetic consequences of disturbance in terms of lost feeding time, reduced intake rate etc. within models which consider the survival of birds over a winter in relation to prey availability, prey distribution. Such individual based models have been developed for a number of sites, but are complex and in particular require detailed information on prey biomass (Stillman et al. 2000b; West et al. 2002; see Stillman et al. 2007b; Stillman & Goss-Custard 2010). An individual based model does exist for Poole Harbour (Durell *et al.* 2006) but does not consider disturbance directly. The model does highlight that there are relatively low levels of large worms within Poole Harbour and that curlew and black-tailed godwit are likely to be particularly vulnerable to any future changes within the harbour, and potentially therefore the most vulnerable to disturbance.

Implications

5.10 The results here can be used to start to consider how disturbance may be affecting the birds. Bird numbers are lower when higher numbers of people are present and in addition the results show birds are fairly regularly flushed/responding to disturbance. We have identified the activities that are causing disturbance and we describe the spatial distribution of access and people within Poole Harbour. The data indicate that activities on the intertidal/beach and on the water (including watersports and canoeing) and dogs off leads are the ones where birds are mostly likely to respond. Busy areas appear to be underused by the birds. We highlight the following as points to consider in the long-term management of access around Poole Harbour:

Shoreline Access in general

5.11 While there is some evidence that the sheer number of people at some locations may mean reduced bird densities at those locations, activities such as cycling, jogging, walking etc. that are focused on linear routes well above the mean high water mark (for example on seawalls/banks) tended to invoke relatively few disturbance events from the birds. Notes and anecdotal discussion with the surveyors seems to suggest that birds tended to not respond where there was a steady flow of people moving purposefully tangential to the birds, for example along the shore of Holes Bay where there is also considerable space for birds to easily relocate if disturbed. The actual events that resulted in birds responding tended to be those where people stopped or paused. It is notable that there were no major flights recorded from the north west corner of Holes Bay, where access at Upton Country Park is largely screened by tall trees, scrub etc. and the paths are set back slightly from the shore, yet high levels of disturbance were recorded at Studland, where people walk along the water's edge. Clearly at many locations inside the Harbour it could be possible to increase the amount of scrub and push access back from the shore, while still ensuring people had a sense of being close to the Harbour. Parkstone Bay and the eastern side of Holes Bay would be priorities for such approaches.

Beach Access at Studland

5.12 At Studland people walk along the beach and close to the water's edge. Historically Pilot's Point in particular has held large wader roosts and was used by a range of species including knot and bar-tailed godwit (Harvey 1984). Such roosts do not occur anymore at Pilot Point and Brownsea is the main roost site in the Harbour. Directing access inland around Pilot's Point may allow the roost to become established again. While the area is outside the SPA, the birds that use the area are the interest features of the SPA and the beaches at Studland are clearly integrally linked to the SPA. Increasing the range of roost sites available to birds within the Harbour would be desirable in terms of the long-term protection of the bird interest.

Awareness

5.13 It was clear many people were not aware of their impact, for example it was rare for people to notice that they had disturbed birds or modify their behaviour as a result of birds being present. Regularly dog walkers were seen encouraging their dogs to run across sandflats or mudflats where birds were feeding. In few locations around the

harbour is there clear guidance that the site is designated or guidance on how people should behave, and there is potentially scope to improve people's awareness of the issues and their impact.

Dog's off leads

5.14 At a range of sites (including Studland), dog's off leads were a particular issue. Measures to reduce dogs off leads along the shoreline, especially where they are running over intertidal habitats (Studland, Parkstone Bay, Bramble Bush Bay, Whitley Lake, Arne) would be beneficial.

Kite surfing and windsurfing

5.15 Kite surfing was largely concentrated in the Whitley Lake area. Kite surfing was also observed in the area south of the Harbour mouth, off Jerry's Point and Bramble Bush Bay. Here a lone kite surfer can cover a large area and potentially disturb a number of roost sites and important feeding areas. Ensuring use is focussed north of the Harbour Mouth and in a limited area would minimise it's impact.

5.16 Access to the water for kite surfers and windsurfers would be best if it did not involve walking across the mudflats in Whitley Lake or setting up kites etc. on the mudflats. If users accessed the water at a single point, ideally towards the sandbanks end of Whitley Lake, this would ensure disturbance was reduced.

Canoeing

5.17 Canoeing was recorded causing disturbance at a number of locations. Canoeists coming in close to the shore or landing will cause the most disturbance – for example a group from Kingston Maurward college were seen to land at Bramble Bush Bay during one survey, with the group landing and carrying their boats up the shore to a trailer/minibus parked on Ferry Road. Canoeists are potentially attracted to the quieter areas of the harbour where sandy beaches and narrow creeks provide more attractive paddling. Ideally activity would be concentrated away from these areas. Canoes were recorded during the survey flushing birds at Holton Lee, Blue Lagoon, Pilot Point, Bramble Bush Bay and at Arne.

Pump scoop dredging and bait dragging

5.18 Pump scoop dredging and bait dragging were not recorded within the focal areas very often at the same time as birds were present. As with some of the other water-based activities this is likely to be in part as a result of the activities taking place outside the focal area. From the wider count area recording it is however clear that pump scoop dredging activity was concentrated off Holton Lee, in Holes Bay, off Arne and off Goathorn and occurring very frequently. Bait dragging was regularly observed off Arne and then scattered at some other locations within the Harbour. In some of these locations – notably Wareham Channel and off Arne - there is the scope for considerable disturbance from these activities and they are also of particular concern given the low density of large worms in the Harbour (Durell *et al.* 2006).

People on the mudflats

5.19 People were recorded on the intertidal at a range of locations. Three activity types accounted for the majority of intertidal use, these were walking, dog walking (dogs off leads) and bait digging. Walkers were regularly recorded on the intertidal at Whitley Lake, Bramble Bush Bay and Middle Beach. Dog walkers with their dogs off leads were recorded on the intertidal particularly at Parkstone Bay, Bramble Bush Bay and Middle Beach. Bait digging was observed at Pilot's Point, Brands Bay, Whitley Lake, Parkstone Bay, off Holton Lee, at Holes Bay and at Blue Lagoon. Measures to limit people to the shore and confine the extent to which people are roaming across the mudflats would reduce disturbance.

6. References

Arroyo, B. & Razin, M. (2006) Effect of Human Activities on Bearded Vulture Behaviour and Breeding Success in the French Pyrenees. *Biological Conservation*, **128**, 276–284.

Austin, G.E. & Rehfisch, M.M. (2005) Shifting Nonbreeding Distributions of Migratory Fauna in Relation to Climatic Change. *Global Change Biology*, **11**, 31–38.

Banks, P.B. & Bryant, J.V. (2007) Four-legged Friend of Foe? Dog-walking Displaces Native Birds from Natural Areas. *Biology Letters*, **3**, 611–613.

Baudains, T.P. & Lloyd, P. (2007) Habituation and Habitat Changes Can Moderate the Impacts of Human Disturbance on Shorebird Breeding Performance. *Animal Conservation*, **10**, 400–407.

Beale, C.M. & Monaghan, P. (2004) Behavioural Responses to Human Disturbance: a Matter of Choice? *Anim. Behav.*, **68**, 1065–1069.

Blumstein, D.T. (2003) Flight-initiation Distance in Birds Is Dependent on Intruder Starting Distance. *J. Wildl. Manage.*, **67**, 852–857.

Blumstein, D.T., Anthony, L.L., Harcourt, R. & Ross, G. (2003) Testing a Key Assumption of Wildlife Buffer Zones: Is Flight Initiation Distance a Species-specific Trait? *Biol. Conserv.*, **110**, 97–100.

Blumstein, D.T., Fernandez-Juricic, E., Zollner, P.A. & Garity, S.C. (2005) Inter-specific Variation in Avian Responses to Human Disturbance. *Journal of Appled Ecology*.

Bolduc, F. & Guillemette, M. (2003) Human Disturbance and Nesting Success of Common Eiders: Interaction Between Visitors and Gulls. *BIOLOGICAL CONSERVATION*, **110**, 77–83.

Burger, J. (1991) Foraging Behaviour and the Effects of Human Disturbance on the Piping Plover (Chararius Melodus). *J. Coastal Res*, **7**, 39.

Burger, J. (1998) Effects of Motorboats and Personal Watercraft on Flight Behavior over a Colony of Common Terns. *Condor*, **100**, 528–534.

Burger, J., Carlucci, S.A., Jeitner, C.W. & Niles, L. (2007) Habitat Choice, Disturbance, and Management of Foraging Shorebirds and Gulls at a Migratory Stopover. *Journal of Coastal Research*, **235**, 1159–1166.

Caldow, R.W.G., McGrorty, S., West, A.D., Le V. dit Durell, S.E.A., Stillman, R.A. & Anderson, S. (2005) Macro-invertebrate Fauna in the Intertidal Mudflats. *The Ecology of Poole Harbour* (eds J. Humphreys & V. May), pp. 91–108. Elsevier.

Carney, K.M. & Sydeman, W.J. (1999) A Review of Human Disturbance Effects on Nesting Colonial Waterbirds. *WATERBIRDS*, **22**, 68–79.

Collins, D.R. (1985) *Poole Harbour Ornithological Survey: First Stage Winter/spring 1984-85*. RSPB, Exeter.

Collins, D.R. (1986) *Poole Harbour RSPB Ornithological Survey 1984 - 1986*. The RSPB, Sandy, Beds.

Coyle, M.D. & Wiggins, S.M. (2010) *European Marine Site Risk Review*. Natural England Research Report NERR038.

Delaney, D.K., Grubb, T.G., Beier, P., Pater, L.L. & Reiser, M.H. (1999) Effects of Helicopter Noise on Spotted Owls. *Journal of Wildlife Management*, **63**, 60–76.

Drewitt, A. (1999) *Disturbance Effects of Aircraft on Birds*. English Nature, Peterborough.

Dugan, P.J. (1982) Seasonal Changes in Patch Use by a Territorial Grey Plover: Weather-Dependent Adjustments in Foraging Behaviour. *Journal of Animal Ecology*, **51**, 849–857.

Durell, L.V. dit S.E.A., Stillman, R.A., Caldow, R.W.G., McGrorty, S., West, A.D. & Humphreys, J. (2006) Modelling the Effect of Environmental Change on Shorebirds: A Case Study on Poole Harbour, UK. *Biological Conservation*, **131**, 459–473.

Farnsworth, K.D. & Beecham, J. (1997) Beyond the Ideal Free Distribution: a More General Model of Predator Distribution. *Journal of Theoretical Biology*, **187**, 389–396.

Fearnley, H., Clarke, R.T. & Liley, D. (2010) *The Solent Disturbance and Mitigation Project. Phase II. On-site Visitor Survey Results from the Solent Region*. Footprint Ecology/Solent Forum.

Fearnley, H. & Liley, D. (2011) *North Kent Visitor Survey Results*. Footprint Ecology.

Fernandez-Juricic, E., Jimenez, M.D. & Lucas, E. (2001) Alert Distance as an Alternative Measure of Bird Tolerance to Human Disturbance: Implications for Park Design. *Environmental Conservation*, **3**, 263 – 269.

Fernandez-Juricic, E., Jokimaki, J., McDonald, J.C., Melado, F., Toledano, A., Mayo, C., Martin, B., Fresneda, I. & Martin, V. (2004) Effects of Opportunistic Predation on Anti-predator Behavioural Responses in a Guild of Ground Foragers. *Oecologia*, **140**, 183–190.

Fernandez-Juricic, E. & Schroeder, N. (2003) Do Variations in Scanning Behavior Affect Tolerance to Human Disturbance? *Appl. Anim. Behav. Sci.*, **84**, 219–234.

Fernandez-Juricic, E., Venier, M.P., Renison, D. & Blumstein, D.T. (2005) Sensitivity of Wildlife to Spatial Patterns of Recreationist Behavior: A Critical Assessment of Minimum Approaching Distances and Buffer Areas for Grassland Birds. *Biol. Conserv.*, **125**, 225–235.

Fitzpatrick, S. & Bouchez, B. (1998) Effects of Recreational Disturbance on the Foraging Behaviour of Waders on a Rocky Beach. *Bird Study*, **45**, 157–171.

Gill, J.A. (1996) Habitat Choice in Wintering Pink-footed Geese:quantifying the Constraints Determining Winter Site Use. *Journal of Applied Ecology*, **33**, 884–892.

Gill, J.A. (2007) Approaches to Measuring the Effects of Human Disturbance on Birds. *Ibis*, **149**, 9–14.

Gill, J.A., Norris, K. & Sutherland, W.J. (2001) Why Behavioural Responses May Not Reflect the Population Consequences of Human Disturbance. *Biological Conservation*, **97**, 265 – 268.

Gill, J.A., Sutherland, W.J. & Watkinson, A.R. (1996) A Method to Quantify the Effects of Human Disturbance on Animal Populations. *Journal Of Applied Ecology*, **33**, 786–792.

Goss-Custard, J.D., Stillman, R.A., West, A.D., Caldow, R.W.G. & McGrorty, S. (2002) Carrying Capacity in Overwintering Migratory Birds. *Biological Conservation*, **105**, 27–41.

Goss-Custard, J.D., Triplet, P., Sueur, F. & West, A.D. (2006) Critical Thresholds of Disturbance by People and Raptors in Foraging Wading Birds. *Biological Conservation*, **127**, 88–97.

Harvey, P. (1984) *Poole Harbour Monitoring Programme: Wintering Birds (1983-84)*. Dorset Oilfield Development ecological report.

Hill, D., Hockin, D., Price, D., Tucker, G., Morris, R. & Treweek, J. (1997) Bird Disturbance: Improving the Quality and Utility of Disturbance Research. *Journal of Applied Ecology*, **34**, 275–288.

Hockin, D., Ounsted, M., Gorman, M., Hill, D., Keller, V. & Barker, M.A. (1992) Examination of the Effects of Disturbance on Birds with Reference to Its Importance in Ecological Assessments. *Journal of Environmental Management*, **36**, 253–286.

Holt, C.A., Austin, G., Calbrade, N., Mellan, H., Mitchell, C., Stroud, D., Wotton, S. & Musgrove, A. (2011) *Waterbirds in the UK in 2009/10*. BTO, RSPB, JNCC.

Hosmer, D.W. & Lemeshow, S. (2000) *Applied Logistic Regression*. John Wiley and Sons.

Humphreys, J. & May, V. (2006) *The Ecology of Poole Harbour*. Elsevier.

Kaiser, M.J., Galanidi, M., Showler, D.A., Elliott, A.J., Caldow, R.W.G., Rees, E.I.S., Stillman, R.A. & Sutherland, W.J. (2006) Distribution and Behaviour of Common Scoter Melanitta Nigra Relative to Prey Resources and Environmental Parameters. *Ibis*, **148**, 110–128.

Kennedy, M. & Gray, R.D. (1993) Can Ecological Theory Predict the Distribution of Foraging Animals? A Critical Analysis of Experiments on the Ideal Free Distribution. *Oikos*, **68**, 158 – 166.

Kirby, J., Davidson, N., Giles, N., Owen, M. & Spray, C. (2004) *Waterbirds and Wetland Recreation Handbook*. Wildfowl and Wetlands Trust, Slimbridge, Gloustershire.

Klaassen, M., Bauer, S., Madsen, J. & Tombre, I. (2006) Modelling Behavioural and Fitness Consequences of Disturbance for Geese Along Their Spring Flyway. *Journal of Applied Ecology*, **43**, 92–100.

Liley, D. (1999) *Predicting the Consequences of Human Disturbance, Predation and Sea-level Rise for Ringed Plover Population Size*. University of East Anglia, School of Biological Sciences, Norwich.

Liley, D., Clarke, R.T., Mallord, J.W. & Bullock, J.M. (2006a) *The Effect of Urban Development and Human Disturbance on the Distribution and Abundance of Nightjars on the Thames Basin and Dorset Heaths*. Natural England / Footprint Ecology.

Liley, D., Cruickshanks, K., Lake, S., Sharp, J., Stillman, R.A., Underhill-Day, J. & White, J. (2011a) *What Do We Know About the Birds and Habitats of the North Kent Marshes?: Baseline Data Collation and Analysis*. Natural England Commissioned Report, Footprint Ecology.

Liley, D., Cruickshanks, K., Waldon, J. & Fearnley, H. (2011b) *Exe Disturbance Study*. Footprint Ecology/Exe Estuary Management Partnership.

Liley, D. & Fearnley, H. (2011) *Bird Disturbance Study, North Kent 2010-2011.* Footprint Ecology.

Liley, D., Pickess, B. & Underhill-day, J.C. (2006b) *The Number and Distribution of Black-necked Grebes and Other Waterbirds at Studland, Dorset*. Footprint Ecology/Poole Harbour Study Group, Wareham Dorset.

Liley, D., Sharp, J., Underhill-Day, J. & Caldow, R. (2008) *Comparison of the Abundance and Distribution of Birds Along the Northern Shore of Poole Harbour by Day and by Night*. Natural England Commissioned Report, Footprint Ecology / Natural England.

Liley, D., Sharp, J., Underhill-Day, J. & Caldow, R. (2009) *Comparison of the Abundance and Distribution of Birds Along the Northern Shore of Poole Harbour by Day and by Night*. Natural England Commissioned Report, Footprint Ecology / Natural England.

Liley, D., Stillman, R.A. & Fearnley, H. (2010) *The Solent Disturbance and Mitigation Project Phase II. Results of Bird Disturbance Fieldwork, 2009/10.* Footprint Ecology / Solent Forum.

Liley, D. & Sutherland, W.J. (2007) Predicting the Population Consequences of Human Disturbance for Ringed Plovers Charadrius Hiaticula: a Game Theory Approach. *Ibis*, **149**, 82–94.

Lord, A., Waas, J.R., Innes, J. & Whittingham, M.J. (2001) Effects of Human Approaches to Nests of Northern New Zealand Dotterels. *Biol. Conserv.*, **98**, 233–240.

Lowen, J., Liley, D., Underhill-Day, J. & Whitehouse, A.T. (2008) Access and Nature Conservation Reconciliation: Supplementary Guidance for England.

Mallord, J.W., Dolman, P.M., Brown, A.F. & Sutherland, W.J. (2007) Linking Recreational Disturbance to Population Size in a Ground-nesting Passerine. *Journal of Applied Ecology*, **44**, 185–195.

McCurdy, D.G., Boates, S.J. & Forbes, M.R. (1997) Diurnal and Nocturnal Foraging by Semipalmated Sandpipers Calidris Pusilla. *Journal of Avian Biology*, **28**, 353–356.

McNeil, R., Drapeau, P. & Goss-Custard, J.D. (1992) The Occurrence and Adaptive Significance of Nocturnal Habitats in Waterfowl. *Biological Reviews*, **67**, 381–419.

Møller, A.P. (2008) Flight Distance and Population Trends in European Breeding Birds. *Behavioral Ecology*, **19**, 1095 –1102.

Morrison, S.J. (2004) *Wader and Waterfowl Roost Survey of Poole Harbour - Winter 2002 / 03*. Poole Harbour Study Group.

Mouritsen, K.N. (1992) Predator Avoidance in Night-Feeding Dunlins Calidris Alpina: A Matter of Concealment. *Ornis Scandinavica*, **23**, 195–198.

Mouritsen, K.N. (1994) Day and Night Feeding in Dunlins Calidris Alpina: Choice of Habitat, Foraging Technique and Prey. *Journal of Avian Biology*, **25**, 55–62.

Murison, G. (2002) *The Impact of Human Disturbance on the Breeding Success of Nightjar Caprimulgus Europaeus on Heathlands in South Dorset, England*. English Nature, Peterborough.

Nimon, A.J., Schroter, R.C. & Oxenham, R.K.C. (1996) Artificial Eggs: Measuring Heart Rate and Effects of Disturbance in Nesting Penguins. *Physiology & Behavior*, **60**, 1019–1022.

Nisbet, I.C.T. (2000) Disturbance, Habituation, and Management of Waterbird Colonies - Commentary. *waterbirds*, **23**, 312–332.

Pickess, B.P. (2007) *Important Birds of Poole Harbour and Their Status 1998/99-2004/05*. Natural England.

Pickess, B. & Underhill-day, J.C. (2002) *Important Birds of Poole Harbour*. Poole Harbour Study Group.

Poole Harbour Study Group. (2006) *Poole Harbour Aquatic Management Plan 2006*. Poole.

Randler, C. (2006) Disturbances by Dog Barking Increase Vigilance in Coots Fulica Atra. *European Journal of Wildlife Research*, **52**, 265–270.

Rees, E.C., Bruce, J.H. & White, G.T. (2005) Factors Affecting the Behavioural Responses of Whooper Swans (Cygnus C. Cygnus) to Various Human Activities. *Biol. Conserv.*, **121**, 369–382.

Rehfisch, M.M., Clark, N.A., Langston, R.H.W. & Greenwood, J.J.D. (1996) A Guide to the Provision of Refuges for Waders: An Analysis of 30 Years of Ringing Data from the Wash, England. *Journal of Applied Ecology*, **33**, 673–687.

Rehfisch, M.M., Insley, H. & Swann, B. (2003) Fidelity of Overwintering Shorebirds to Roosts on the Moray Basin, Scotland: Implications for Predicting Impacts of Habitat Loss. *Ardea*, **91**, 53–70.

Reijnen, R., Foppen, R. & Veenbaas, G. (1997) Disturbance by Traffic of Breeding Birds: Evaluation of the Effect and Considerations in Planning and Managing Road Corridors. *Biodiversity and Conservation*, **6**, 567–581.

Remage-Healey, L. & Romero, L.M. (2000) Daily and Seasonal Variation in Response to Stress in Captive Starlings (Sturnus Vulgaris): Glucose. *Gen Comp Endocrinol*, **119**, 60–8.

Riddington, R. (1996) The Impact of Disturbance on the Behaviour and Energy Budgets of Brent Geese. *Bird Study*, **43**, 269 – 279.

Rodgers, J.A. & Smith, H.T. (1995) Set-Back Distances to Protect Nesting Bird Colonies From Human Disturbance In Florida. *Conservation Biology*, **9**, 89–99.

Rodgers, J.A. & Smith, H.T. (1997) Buffer Zone Distances to Protect Foraging and Leafing Waterbirds from Human Disturbance in Florida. *Wildlife Society Bulletin*, **25**, 139–145.

Ruhlen, T.D., Abbott, S., Stenzel, L.E. & Page, G.W. (2003) Evidence That Human Disturbance Reduces Snowy Plover Chick Survival. *J. Field Ornithol.*, **74**, 300–304.

Saunders, C., Selwyn, J., Richardson, S., May, V. & Heeps, C. (2000) *A Review of the Effects of Recreational Interactions Within UK European Marine Sites*. UK CEED & Bournemouth University.

Sitters, H.P. (2000) *The Role of Night-feeding in Shorebirds in an Estuarine Environment with Specific Reference to Mussel Feeding Oystercatchers*. Oxford, Wolfson College / EGI, Oxford.

Stalmaster, M.V. & Kaiser, J.L. (1997) Flushing Responses of Wintering Bald Eagles to Military Activity. *Journal Of Wildlife Management*, **61**, 1307–1313.

Stillman, R.A., Caldow, R.W.G., Goss-Custard, J.D. & Alexander, M.J. (2000a) Individual Variation in Intake Rate: The Relative Importance of Foraging Efficiency and Dominance. *Journal of Animal Ecology*, **69**, 484–493.

Stillman, R.A. & Goss-Custard, J.D. (2010) Individual-based Ecology of Coastal Birds. *Biological Reviews*, **85**, 413–434.

Stillman, R.A., GossCustard, J.D., West, A.D., Durell, S.E.A.L.D., Caldow, R.W.G., McGrorty, S. & Clarke, R.T. (2000b) Predicting Mortality in Novel Environments: Tests and Sensitivity of a Behaviour-based Model. *Journal of Applied Ecology*, **37**, 564–588.

Stillman, R.A., Goss-Custard, J.D., West, A.D., Durell, S., McGrorty, S., Caldow, R.W.G., Norris, K.J., Johnstone, I.G., Ens, B.J., Van der Meer, J. & Triplet, P. (2001) Predicting Shorebird Mortality and Population Size Under Different Regimes of Shellfishery Management. *J. Appl. Ecol.*, **38**, 857–868.

Stillman, R.A., West, A.D., Caldow, R.W.G. & Durell, S.E.A.L.V.D. (2007a) Predicting the Effect of Disturbance on Coastal Birds. *Ibis*, **149**, 73–81.

Stillman, R., West, A.D., Caldow, R. & Durell, S.E.A. le V. dit. (2007b) Predicting the Effect of Disturbance on Coastal Birds. *Ibis*, **149**, 73–81.

Stillman, R.A., West, A.D., Goss-Custard, J., McGrorty, S., Frost, N.J., Morrisey, D.J., Kenny, A.J. & Drewitt, A.L. (2005) Predicting site quality for shorebird communities : a case study on the Humber estuary, UK, http://cat.inist.fr/?aModele=afficheN&cpsidt=17422837

Sutherland, W.J. (1983) Aggregation and the 'Ideal Free' Distribution. *Journal of animal ecology*, **52**, 821 – 828.

Tempel, D.J. & Gutierrez, R.J. (2003) Fecal Corticosterone Levels in California Spotted Owls Exposed to Low-intensity Chainsaw Sound. *Wildl. Soc. Bull.*, **31**, 698–702.

Thiel, D., Jenni-Eiermann, S., Palme, R. & Jenni, L. (2011) Winter Tourism Increases Stress Hormone Levels in the Capercaillie Tetrao Urogallus. *Ibis*, **153**, 122–133.

Thomas, N.S., Caldow, R.W.G., McGrorty, S., Le V. dit Durell, S.E.A., West, A.D. & Stillman, R.A. (2004) *Bird Invertebrate Prey Availability in Poole Harbour*.

Thomas, K., Kvitek, R.G. & Bretz, C. (2003) Effects of Human Activity on the Foraging Behavior of Sanderlings Calidris Alba. *Biological Conservation*, **109**, 67–71.

Underhill-Day, J.C. (2006) *A Condition Assessment of Poole Harbour European Marine Site*. Natural England / Footprint Ecology.

Urfi, A.J., Goss-Custard, J.D. & Lev. Dit Durell, S.E.A. (1996) The Ability of Oystercatchers Haematopus Ostralegus to Compensate for Lost Feeding Time: Field Studies on Individually Marked Birds. *Journal of Applied Ecology*, **33**, 873–883.

Verhulst, S., Oosterbeek, K. & Ens, B.J. (2001) Experimental Evidence for Effects of Human Disturbance on Foraging and Parental Care in Oystercatchers. *Biol. Conserv.*, **101**, 375–380.

Walker, B.G., Dee Boersma, P. & Wingfield, J.C. (2006) Habituation of Adult Magellanic Penguins to Human Visitation as Expressed Through Behavior and Corticosterone Secretion. *Conservation Biology*, **20**, 146–154.

Walker, K.J., Warman, E.A., Bhogal, A., Cross, R.B., Pywell, R.F., Meek, B.R., Chambers, B.J. & Pakeman, R. (2007) Recreation of Lowland Heathland on Ex-arable Land: Assessing the Limiting Processes on Two Sites with Contrasting Soil Fertility and pH. *Journal of Applied Ecology*, **44**, 573–582.

Webb, N.V. & Blumstein, D.T. (2005) Variation in Human Disturbance Differentially Affects Predation Risk Assessment in Western Gulls. *Condor*, **107**, 178–181.

Weimerskirch, H., Shaffer, S.A., Mabille, G., Martin, J., Boutard, O. & Rouanet, J.L. (2002) Heart Rate and Energy Expenditure of Incubating Wandering Albatrosses: Basal Levels, Natural Variation, and the Effects of Human Disturbance. *J Exp Biol*, **205**, 475–83.

West, A.D., Goss-Custard, J.D., Stillman, R.A., Caldow, R.W.G., Durell, S. & McGrorty, S. (2002) Predicting the Impacts of Disturbance on Shorebird Mortality Using a Behaviour-based Model. *Biol. Conserv.*, **106**, 319–328.

West, A.D., Yates, M.G., McGrorty, S. & Stillman, R.A. (2007) Predicting Site Quality for Shorebird Communities: A Case Study on the Wash Embayment, UK. *Ecological Modelling*, **202**, 527–539.

Woodfield, E. & Langston, R. (2004) *Literature Review on the Impact on Bird Populations of Disturbance Due to Human Access on Foot*. Royal Society for the Protection of Birds, Sandy, Beds.

Yasué, M. & Dearden, P. (2006) The Effects of Heat Stress, Predation Risk and Parental Investment on Malaysian Plover Nest Return Times Following a Human Disturbance. *Biological Conservation*, **232**, 472–480.

Appendix 1: Summary of survey points for standardised watches

Reference Number	Location	Description of location	Survey effort
1	Holton Lee	From top of beach below railway bridge	21 hours
2	Lytchett Bay	End of spit into saltmarsh. Accessed with care to limit disturbing birds	21 hours
3	Holes Bay north	Opposite macdonalds & s end car park, north end of gap in scrub. On concrete path.	21 hours
4	Sterte	First bench by beginning of scrub (heading east from opposite mercedes garage)	21 hours
5	Baiter/Parkstone Bay	Bob Willmore bench (first bench heading E from sign about the outflow)	21 hours
6	Blue Lagoon	At/just below gate through from block of flats. No view onto shore outside blue lagoon. Access provided by Salterns Marina.	21 hours
7	Whitley Lake	Below litter bin, c.50m east of slip way. Below no. 59 (tall white building with balconies etc)	21 hours
9	Bramble Bush Bay	Bramble Bush bay, just above houseboats, on grass above beach	21 hours
12	Cleaval Point	On beach just by track to pumping station	21 hours
13	Arne, Shipstal	On beach, just round from RSPB sign and picnic bench	21 hours
8	Pilot Point	Top of dune ridge, above large dune slack	21 hours
11	Middle Beach, Studland	From car-park, viewing area with fence etc above cafe	21 hours
10	Brands Bay	National Trust Bird Hide overlooking Brands Bay	21 hours
14	Holes Bay Hide	Bird hide in Upton Country Park	10.5 hours
15	Holes Bay wooded spit	End of wooded spit	10.5 hours

Appendix 2: Summary of the recoded diary events

Activity description	Recoded as
Artist	Walker
Birdwatcher with dog off lead	Birdwatcher
Cyclists with dogs of lead (x4)	Cyclists
Canoeists on water that were fishing	Canoeists
Canoeists with dog off lead	Canoeist
Dog in garden, Painting, People in garden, Person on balcony (x2), Strimming, In garden (x2)	RES (Resident)
Dog walker with dog on and off lead (x20)	Dog walker with dog off lead
Fishing with dog off lead	Fishing
Loud noise, gunshots (x8), Peregrine (x2), Buzzard, Loud generator, Construction worker (x6), Marina worker, Rock Pooling (x3), Loud ship blast (x1), Blank records (x2)	OT (other)
Kids playing and having a picnic	Kids playing
Litter collecting	Walker
Motorised buggy (x2)	Motor vehicle
Motor vehicles with dogs off lead (x3)	Motor vehicles
Walkers and kids playing (x7)	Walkers
Walker and Cyclist	Walker
Fishing from small boat	Fishing
Jogging with dog on lead	Jogging
Jogging with dog off lead (x13)	Jogging
All entries referring to train removed	
Those categorised as BW	Associated with activity either kite surfing, windsurfing or canoeist

Appendix 3: Summary of Visits for Paired Night and Day counts

Grey rows indicate weekend counts, bold indicates night visit. Tide state indicates general state for most of the sites during the visit – R=rising, F=falling, L=low, H=high.

Visit code	Date	Day of week	Start Time	Tide state	weather notes
A	30/11/2011	Wed	07:40	R	wind picking up, grey
	30/11/2011	**Wed**	**20:45**	**R**	**windy, heavy rain showers**
B	07/12/2011	Wed	12:00	F	SW moderate, dry patchy cloud, 4/8
	07/12/2011	**Wed**	**00:00**	**F**	**Hazy moonlight, light wind, calm, dry. Excellent visibility**
C	11/12/2011	Sun	10:15	H	overcast, SW breezy picking up, drizzle becoming rain from 11:00
	11/12/2011	**Sun**	**21:37**	**H**	**light SW wind, full moon (hazy)**
D	14/12/2011	Wed	12:15	H	strong winds but dry
	15/12/2011	**Thurs**	**00:00**	**H**	**strong winds, with occasional heavy hail storms**
E	22/12/2011	Thurs	11:10	f	fairly strong westerly wind throughout
	22/12/2011	**Thurs**	**00:36**	**F**	**F3-4 dry, breeze, 4/8 cc**
F	06/01/2012	Fri	10:40	F	clear, sunny, light NW wind, cloudy by end
	06/01/2012	**Fri**	**00:00**	**F**	**overcast, W light to mod wind**
G	15/01/2012	Sun	07:55	R	SE breeze strengthening, patchy cloud clearing to no cloud.
	15/01/2012	**Sun**	**20:46**	**R**	**patchy cloud, light wind SE, becoming breezy**
H	30/12/2011	Fri	07:45	R	no wind, dry
	30/12/2011	**Fri**	**21:00**	**R**	**drizzle at 21:40, breezy**
I	19/01/2012	Thurs	12:25	R	cloud with sunny patches, light W wind
	19/01/2012	**Thurs**	**01:00**	**R**	**clear, mod W wind**
J	22/01/2012	Sun	12:45:00	F	strong winds (increasing)
	22/01/2012	**Sun n**	**01:23**	**F**	**hardly any wind now**
K	30/01/2012	Mon	08:37:00	R	strong E/NE wind, cold drizzle, some light sleet occasionally, 3c
	30/01/2012	**Mon**	**20:52**	**R**	**breezy NE wind, dry, 0c**
L	03/02/2012	Fri	08:47	F	clear, cold, -3c at start, brisk NE wind
	03/02/2012	**Fri**	**21:45**	**F**	**at start -5c , at end -6.5c, still, clear**
M	08/02/2012	Wed	13:39	F	8/8 cloud, 1c at start & end, strengthening NE wind
	09/02/2012	**Wed**	**02:34**	**F**	**cloudy and cold**
N	14/02/2012	Tues	07:27	L	at start 5c, 7/8 cloud, light northerly wind
	14/02/2012	**Tues**	**19:34**	**L**	**at start 7c, moderate NW wind, 7/8 cloud**
O	18/02/2012	Sat	07:04	H	mod wind, overcast, over high tides
	18/02/2012	**Sat**	**16:56**	**H**	**clear sky, light w wind.**
P	21/02/2012	Tues	13:00	F	overcast, breezy
	22/02/2012	**Wed**	**01:43**	**F**	**overcast, windy, occasional light rain, mild**