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Poole Harbour Disturbance Study 2019/20

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Summary

This report presents the findings of a large-scale bird disturbance study carried out in Poole Harbour between December 2019 and February 2020 inclusive. It follows on from a similar study carried out in the harbour in the winter of 2011/12, with those surveys also undertaken by Footprint Ecology using the same methods and locations.

The study incorporated 15 different survey points, which were each surveyed on four occasions (twice on weekdays and twice on weekend days) during each of the three months of the study. The winter of 2019/20 was typified by recurrent storms and periods of associated extreme weather, and a large proportion of low tides within Poole Harbour occurred during the hours of darkness. These circumstances are reflected in the dataset and detailed in one of the appendices.

Two complimentary survey methods were used: Standard Watches and Wider Area Counts. Standard Watches involved continuous recording for one hour and forty-five minutes, logging all human activity within a set recording area surrounding the survey point, as well as the number of birds and interactions between people and birds. Wider Area Counts comprised a snapshot count of waterfowl species and recreational activity across a larger survey area visible from the survey point, targeting those species and activities more prevalent in deeper water areas.

At the conclusion of the current study a comparison was made between the novel data and that included in the previous 2011/12 study, in order to identify any changes in activity levels, species presence/numbers, and disturbance responses.

Key findings included:

Number of people and activities

- In total, 315 hours of fieldwork were undertaken across the 15 survey locations;
- A total of 5,358 individual activity events were recorded within 39 categories across the survey period, equating to 5,320 human activity event observations carried out by at least 10,246 individuals;
- The average hourly rate of visitor activity across all surveyed locations was at least 32.5 people and 5.4 dogs;
- Walking (without a dog) was the most commonly recorded activity, accounting for 32% of observations, with dog walking a close second (31% of records). Cycling (14%) and jogging (12%) were also commonly recorded;
- 65 individual dog walking observations (4% of the total) comprised individuals/groups carrying out a secondary activity, for example cycling with a dog or jogging with a dog;
- The majority (95%) of activity events occurred on or above the shoreline, and this was the case at each individual survey location (with the exception of Holton Lee);

- Parkstone Bay was the busiest survey location, with Whitley Lake in second place. Lytchett Fields, and Brands Bay were the quietest locations;
- Walking and dog walking were the most frequently recorded activities at the majority of survey locations;
- 1,690 dogs were recorded in total , with animals observed at every survey location (with the exception of Lytchett Fields);
- The largest number of dogs were recorded at Parkstone Bay (50% of all observations);
- Very few activity events (10%) took place on the intertidal area and/or on the water, with RIBs the most commonly recorded (although still comprising <1% of all activity records);
- The largest proportion of water-based activities were recorded at Holton Lee, followed by Bramble Bush Bay, and Arne/Shipstal, although the largest number of watersports observations were made at Whitley Lake, and;
- The largest number of harvesting observations were made at Holton Lee, where pump scoop dredging was proportionally by far the most dominant harvesting activity type.

Bird numbers and distribution

- A total of 47 species, excluding gulls, were recorded during Standard Watches carried out at the 15 survey locations over the entire survey period, comprising 17 species of wader, 16 species of wildfowl, and 14 other waterbird species;
- Holes Bay (railway) and Brands Bay recorded the largest species totals (28 and 27 species respectively), with the smallest number (9 species) recorded at both Whitley Lake and Middle Beach;
- The largest numbers of waders were concentrated in the north of Holes Bay and within Brands Bay, whilst much smaller numbers were recorded from survey sites in the immediate proximity of Poole and Studland (e.g. Parkstone Bay, Whitley Lake, and Middle Beach), and;
- Survey locations which exhibited a larger number of activity events generally supported a lower density of both waders and wildfowl.

Bird responses to disturbance

- Of the 5,358 individual activity events recorded across the entire survey period, 3,725 (70%) comprised potential disturbance events (i.e. they took place when birds were also present in the recording area);
- 12% of potential disturbance events generated a behavioural response in the birds present, with 5% leading to a major flight;
- The 3,725 potential disturbance events generated a total of 9,708 species-specific behavioural observations, of which 8,994 (93%) resulted in no visible change to the birds' behaviour or any direct response;
- On average, 11.8 potential disturbance events/hour occurred across all survey locations over the entire survey period. These events caused, on average, a single species response 2.3 times/hour during the same period, with a flight response (short or major, i.e. birds flew more than 50m) occurring approximately once an hour;
- Month and day type (weekday versus weekend) had little effect upon the responses observed;

- The majority of the most frequently recorded activities (i.e. walking, dog walking, cycling, and jogging) led to proportionately relatively few disturbance events;
- Water-based activities, and those that included loud noises (e.g. wildfowling or aircraft), generally led to a larger proportional disturbance response;
- Dog walking causing the second largest number of potential disturbance events (29% of the total), which resulted in 9% of the total number of birds flushed, and also led to the largest number of both major and combined (short and major) flight responses (28% and 26% of the respective totals);
- Parkstone Bay and Holes Bay (UCP Hide) recorded the largest number of potential disturbance events (3,927 and 2,379 events, respectively), whilst Holton Lee, Brands Bay, and Cleaval Point recorded the fewest (26, 22, and 9 events, respectively);
- Sites with fewer disturbance events tended to have a higher proportion of extreme responses (birds taking flight), whereas at sites with higher levels of activity a lower proportion of responses involved birds taking flight;
- Responses varied between species, although across all species at least 80% of all recorded disturbance events did not evoke a disturbance response;
- Wigeon exhibited the largest proportion of responses overall (18%), with Oystercatcher (11%), Curlew (11%), Turnstone (11%), and Dunlin (10%) exhibiting a slightly lower proportion;
- The largest number of birds overall were flushed from Holes Bay (UCP Hide), with other large flush rates seen at Whitley lake, Brands Bay, and Lytchett Fields;
- Of the potential disturbance events recorded across all survey locations, 261 resulted in a major flight response (involving 7,146 individual birds);
- The displacement distance of birds carrying out a short or major flight (i.e. how far the birds moved when flushed) was estimated where possible. The mean displacement distance across the 224 flight responses for which displacement distance could be recorded was 286.9m;
- Median displacement distance ranged from 50m for Spotted Redshank to 650m for Shoveler (based on very small samples). For those species for which >10 observations were made, displacement distance ranged from 100m for Redshank to 375m for Dark-bellied Brent Goose;
- Displacement distances varied between survey location, with Holton Lee, Parkstone Bay, and Holes Bay (railway) sharing the largest median displacement distances of 500m, whilst Lytchett Fields recorded the smallest at 100m;
- Aircraft and watersports activities displaced birds the greatest distance (both with median displacement distances of 500m), whereas trains induced the shortest displacement (median displacement distance of 90m);
- Dog walking and walking (the two most commonly recorded activity types in the diary dataset) exhibited median displacement distances of 190m and 300m, respectively, and;
- The amount of time taken for normal behaviour to resume for birds identified during 149 separate major flight events (comprising 5,549 individuals) ranged from 10 seconds to 13 minutes, with the birds in 91% of observations taking less than two minutes to resume normal behaviour.

Bird and activity distribution within the wider Poole Harbour area

- The distribution of species recorded during the Wider Area Counts varied significantly, although the majority of the scarcer grebe and duck species were primarily found within sheltered bays, with the Bramble Bush/Brands Bay area and Studland Bay being particularly well-used;
- The distribution of activities recorded during the Wider Area Counts indicated that watersports were concentrated at Whitley Lake and off Sandbanks, and pump scoop dredging within the Wareham Channel, and;
- RIB and large motorboat activity was concentrated within the main channel between Brownsea Island and the Harbour's north-eastern/eastern shoreline, and there was some indication from the Wider Area Count bird data that wildfowl may have avoided these areas.

Comparisons between the 2011/12 & 2019/20 Poole Harbour disturbance studies

- 12 of the 15 locations surveyed during the 2019/20 surveys received the same level of survey effort as during the previous surveys in 2011/12. A comparison was therefore undertaken between these 12 localities to identify any changes in the intervening study period;
- The combined level of use (i.e. human activity) across all 12 of the survey locations has significantly increased between the current study and the last, with significant increases at the site level seen at Lytchett and Parkstone Bays, Whitley Lake, and Middle Beach;
- The largest combined increases in the activity types observed across all 12 survey locations were in the number of records of dog walking (791 additional records; 112% increase), walking (368 additional records; 33% increase), and jogging (239 additional records; 83% increase);
- Overall wader and wildfowl numbers across all 12 survey points, and at the site-level for the majority of survey locations, remained similar between the two study periods, although statistically significant declines were observed at Middle Beach, Cleaval Point, and Arne/Shipstal, and;
- Similar levels of flight response were observed across all 12 survey locations combined, and at the majority of individual survey localities, between the study periods, although statistically significant increases were seen at Lytchett Bay and Whitley Lake, and a statistically significant decrease was observed at Middle Beach.

Recommendations and implications

The data would suggest a marked increase in recreational use since the previous study and consequently increased pressure from recreation on Poole Harbour's wintering bird interest. The increase in use in certain activities, such as dog walking, walking, and jogging, are likely linked to increases in the local population (as well as reflecting current national trends in access to the countryside). These findings highlight the importance of implementing effective measures which carefully manage and promote recreation, so as to ensure that there is space for both increasing visitor use and for wintering birds. In particular:

- Given the apparent marked increase in dog walking, this activity should be a focus for any future mitigation effort linked to housing growth. The results highlight the likely importance of regular and frequent dog walker engagement and awareness raising outreach activities at key locations (i.e. Parkstone Bay, Middle Beach, etc) during the winter months, alongside signage, interpretation, and the provision of dedicated spaces for dog walking away from sensitive locations;
- Dog walking off lead was a clear issue and measures to promote and encourage the walking of dogs on leads at particularly sensitive locations are likely to help reduce the pressure from increased levels of use;
- The Whitley Lake beach area is a focus for watersports and there is relatively little space for birds at key stages of the tide. The situation could be improved through the use of buoys to mark discrete areas for watersports enthusiasts to access the water and refuge areas for waders over the changing tide;
- In general the observations highlight that most users seem to be complying with sensitive bird areas and general guidance/zoning for recreational activities. Given the increases in access at Whitley Lake and Middle Beach, the Harbour shoreline on the Studland peninsula is perhaps likely to be subject to increasing use and is vulnerable given the presence of bird roosts and important feeding areas here, and;
- There is merit in scheduling a future repeat of this study in the winter of 2027/28 in order to maintain the same monitoring frequency and to assess the impact of any mitigation or public engagement measures initiated in the interim period.

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The majority of the fieldwork was carried out by Dave Chown, Neil Gartshore, Nick Hopper, Shaun Robson, and Phil Saunders (Footprint Ecology), with assistance from Zoe Caals and Durwyn Liley (both Footprint Ecology). Data were entered and digitised by Zoe Caals.

All images Footprint Ecology.

1. Introduction

1.1 This report presents the findings of a large-scale bird disturbance study carried out in Poole Harbour between December 2019 and February 2020. It follows on from a similar study carried out in the Harbour in the winter of 2011/12, with those surveys also undertaken by Footprint Ecology using the same methods and survey locations. This report details the results of the repeat winter 2019/20 surveys, and compares them with those from the previous study, in order to understand any patterns or trends in disturbance impacts upon Poole Harbour's wintering wader and wildfowl assemblages.

Poole Harbour

1.2 Poole Harbour is recognised nationally and internationally for its ecological value. Spanning some 3,600ha of water at high tide, and encompassing over 100km of enclosed coastline and many channels, bays and inlets, the Harbour is one of Europe's largest lowland estuaries (Humphreys & May, 2006). The hinterland of the Harbour comprises the heathland and wetland landscapes of Purbeck to the south and west, with the urban centres of Poole and Bournemouth to the north.

1.3 The Harbour draws visitors and local residents for a wide range of recreational activities, ranging from terrestrial ones (such as dog walking) to water-based ones (such as kitesurfing, canoeing, and boating). The commercial port has expanded in recent years and covers around 25ha. Commercial activities centred around the Harbour include boat building, cross-Channel ferries, and fishing.

1.4 The Harbour is a Ramsar site and was notified as a Special Protection Area (SPA) under EC Directive 79/409 on the Conservation of Wild Birds (Birds Directive) in 1999, with the SPA subsequently extended to include additional areas and species in 2017 (see Map 1). Poole Harbour meets the qualifying criteria under Article 4.1 of the Birds Directive, by supporting populations of rare or vulnerable species listed in Annex I (Article 4.1) or regularly occurring migratory species (Article 4.2). Qualifying features for the SPA are:

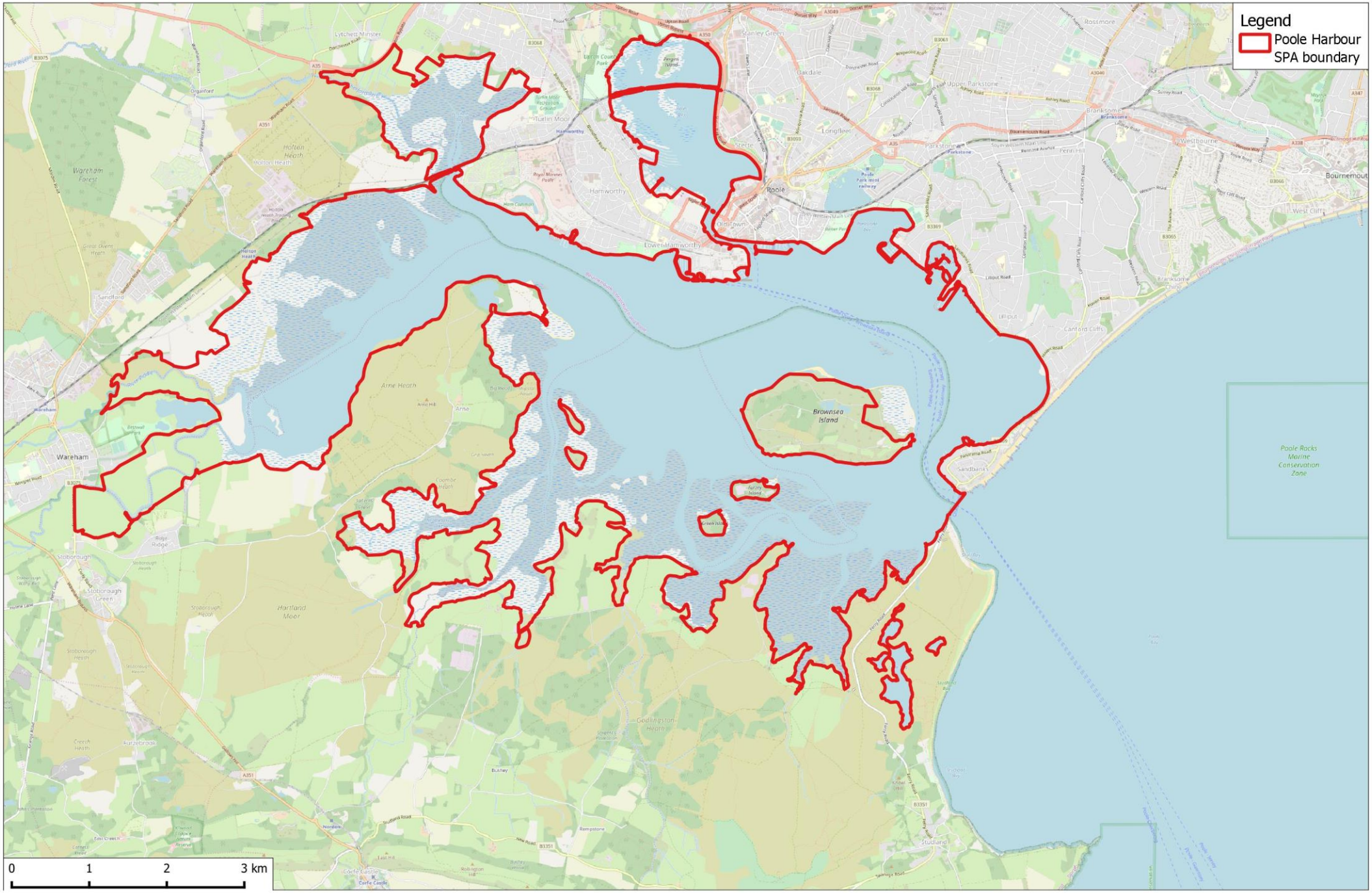
- Little Egret *Egretta garzetta* (non-breeding);
- Eurasian Spoonbill *Platalea leucorodia* (non-breeding);
- Common shelduck *Tadorna tadorna* (non-breeding);
- Avocet *Recurvirostra avosetta* (non-breeding);
- Black-tailed Godwit *Limosa limosa* (non-breeding);

- Mediterranean Gull *Larus melanocephalus* (breeding);
- Sandwich Tern *Sterna sandvicensis* (breeding);
- Common Tern *Sterna hirundo* (breeding), and;
- A waterfowl assemblage regularly supporting 25,176 individual waders and waterfowl.

1.5 Poole Harbour SPA also directly adjoins the recently designated Solent and Dorset Coast SPA at the harbour mouth. The latter SPA is however designated solely for its value to breeding seabirds, namely;

- Common Tern;
- Sandwich Tern, and;
- Little Tern *Sternula albifrons*.

Map 1: Poole Harbour Special Protection Area



Legislative context and impacts from recreation

1.6 The strict protection afforded to SPAs places particular legal duties on local planning authorities and government bodies. The relevant European legislation is the Habitats Directive 1992[1] and the Wild Birds Directive 2009[2], which are transposed into domestic legislation through the Conservation of Habitats and Species Regulations 2017 (as amended). These Regulations are normally referred to as the 'Habitats Regulations.'

1.7 The legislation sets out a clear step by step approach for decision makers considering any plan or project that may have implications for a European site. The cumulative, in-combination, effects of housing over a wide area can however be difficult to assess. Housing development is linked to an increase in the local human population and is therefore associated with a range of pressures to nearby sites, including increased recreational use.

1.8 New development in proximity to European wildlife sites must consider the potential effects that the new development may have upon them. There is now a strong body of evidence showing how increasing levels of development, even when well outside the boundary of protected wildlife sites, can have negative impacts on the sites and their wildlife interest. The issues are particularly acute in southern England, and on coastal sites (Clarke, Sharp, & Liley, 2008; Liley, 2008; Liley & Sutherland, 2007; Randall, 2004; Ross et al., 2014; Saunders, et al., 2000; Stillman et al., 2009).

1.9 The nature conservation impacts of development are varied (e.g. Underhill-Day, 2005). One particularly difficult and challenging impact relates to the use of sites to meet recreational needs, and the resultant disturbance to waterfowl on coastal sites. Disturbance has been identified by Natural England as a generic issue across many European Marine Sites (see Coyle & Wiggins, 2010), and can be an issue for a range of species.

1.10 Disturbance to wintering and passage waterfowl can result in:

- A reduction in the time spent feeding due to repeated flushing/increased vigilance (Bright, et al., 2003; Fitzpatrick & Bouchez, 1998; Stillman & Goss-Custard, 2002; Thomas, Kvitek, & Bretz, 2003; Yasué, 2005);

[1] Council Directive 92/43/EEC
[2] Council Directive 2009/147/EC

- Increased energetic costs (Nolet, et al., 2002; Stock & Hofeditz, 1997)
- Avoidance of areas of otherwise suitable habitat, potentially using poorer quality feeding/roosting sites instead (Burton, et al., 2002; Burton, Rehfisch, & Clark, 2002; Cryer,et al., 1987; Gill, 1996), and;
- Increased stress et al., 2006; Weimerskirch et al., 2002).

1.11 Whereas a single dwelling is unlikely to have implications in terms of disturbance, large, but gradual, changes in housing over a wide area over a number of years may well result in marked changes in local access levels.

1.12 At a national level, reviews of estuary sites have highlighted Poole Harbour as having relatively high levels of surrounding housing (Ross et al. 2014). Habitats Regulations Assessments on the relevant Local Plans have identified disturbance to Poole Harbour. The relevant local authorities have been working on a joint Supplementary Planning Document (SPD)[3] which sets out a range of mitigation measures and monitoring, designed to ensure adverse effects on integrity can be ruled out for the SPA and recreation issues linked to new housing.

Previous studies and the monitoring strategy

1.13 Monitoring is essential to ensure the successful delivery of any mitigation work, acting as an early warning system and providing feedback to hone mitigation actions. Monitoring is necessary to ensure approaches are working as anticipated and whether further refinements or adjustments are necessary. The winter 2019/20 surveys were therefore commissioned to identify current disturbance issues around the harbour and to help inform future mitigation. The results can then be used to identify locations of concern, and the key types of activities that are causing disturbance.

1.14 The winter 2019/20 surveys were commissioned following recommendations set out in the Poole Harbour SPA monitoring strategy (Liley 2018) and comprise a repeat of the previous study (Liley & Fearnley 2012a) commissioned by Natural England. The earlier study showed a range of recreation activities taking place within the SPA and indicated that the number of people present at the different survey locations had a negative effect on the distribution of waders and wildfowl. Birds were flushed

[3] Poole Harbour Recreation SPD

approximately once per hour at the survey points, and dog walkers with dogs off the lead were the main cause of disturbance.

1.15 The previous study also included night-time fieldwork and comparisons between use of the harbour by people and birds during the day and night. It showed that low levels of recreation were carried out in the Harbour after dark, with fishing (angling) forming a large proportion of such activities. It also indicated that large numbers of birds used certain areas within the Harbour at night, although there was no direct evidence that birds were compensating for disturbance during the day by differentially using disturbed areas for feeding after dark (Liley & Fearnley, 2012a).

1.16 The study did however show that night counts of birds at some busier locations (e.g. Baiter, Whitley Lake, and Parkstone Bay) were often higher than during the day. Further modelling of the data also showed a significant positive relationship between daytime disturbance levels at individual sites and the number of birds present after dark (D. Liley & Fearnley, 2012a).

1.17 The monitoring strategy recommended a repeat of the diurnal fieldwork but did not suggest there was a need to repeat the night-time work.

Aims of this study

1.18 The primary aim of this study is to provide an update to the previous surveys carried out over winter 2011/12. It provides detailed information on the distribution and numbers of wintering waders and wildfowl at 15 survey points located around Poole Harbour, and identifies the key types of commercial/recreational activities at each. It then identifies the type and frequency of impact that each of the observed activities have upon any birds present.

1.19 The results of the current study are then used to identify any trends, differences, or similarities with the winter 2011/12 data. Lists of those activities currently causing the highest levels of disturbance, and those localities currently subject to the greatest amount of disturbance, are provided. Finally, the data is used to identify any locations where increased levels of disturbance could be an issue in the future. The findings will help focus mitigation efforts by highlighting which activities in which kinds of locations are causing disturbance, how visitor use is changing, and how the response of birds varies around the Harbour,

2. Methods

Identification of survey sites

2.1 Fifteen survey points were used (see Map 2), mirroring the number surveyed during the 2011/12 disturbance study (Liley & Fearnley, 2012). They encompassed locations across the Poole Harbour SPA/Ramsar site, as well as areas on the periphery of the harbour which provide supporting habitat for many of its birds (i.e. Middle Beach (Studland), which lies outside of the SPA boundary but with which it is functionally linked). The majority of the survey points were identical to those used during the 2011/12 disturbance study, with the exception of the following:

- The previously surveyed Point 8 (Pilot Point) was excluded from the current study, as wader presence/numbers occurring there are now sporadic and or/extremely low due to the very high levels of recreational disturbance (Morrison, 2019) and;
- A new survey point (Point 16) located at Lytchett Fields RSPB Reserve was incorporated in order to include the extended SPA boundary, and to monitor bird numbers/disturbance at this important post-2012 created site.

2.2 Further details on the location and access of each of the 2019/20 survey points in provided in Appendix 1.

Sampling approaches

2.3 The survey methodology matched that of the 2011/12 study, comprising two different approaches:

- ***Standard Watches***, involving continued observation within a 500m arc over a fixed time period (1 hour and 45 minutes), recording the birds present, human activity, and any interactions between people and birds, and;
- ***Wider Area Counts***, involving quicker, 'snapshot', counts recording the number of birds present, and the distribution of human activity, in a larger area extending out past the standard watch 500m arc.

2.4 Standard watches provided detailed data relating to the responses of birds, and prolonged observation across a fixed (but relatively small) recording area. Wider Area Counts were much quicker and easier to carry out, covered

a much wider area, and targeted deeper-water affiliated species (e.g. diving duck, divers, and grebes) which were potentially recorded less frequently closer to the shoreline.

Standard Watches

Recording elements

2.5 Each count involved the following elements:

- Two counts of birds, one count at the start and one at the end of the survey period;
- A diary of all potential disturbance events observed during the 1 hour and 45 minutes following the first count;
- A record of the response of selected bird species to each of the potential disturbance events recorded in the 'diary', including counts of birds present and the number of birds flushed, etc, and;
- Any additional information.

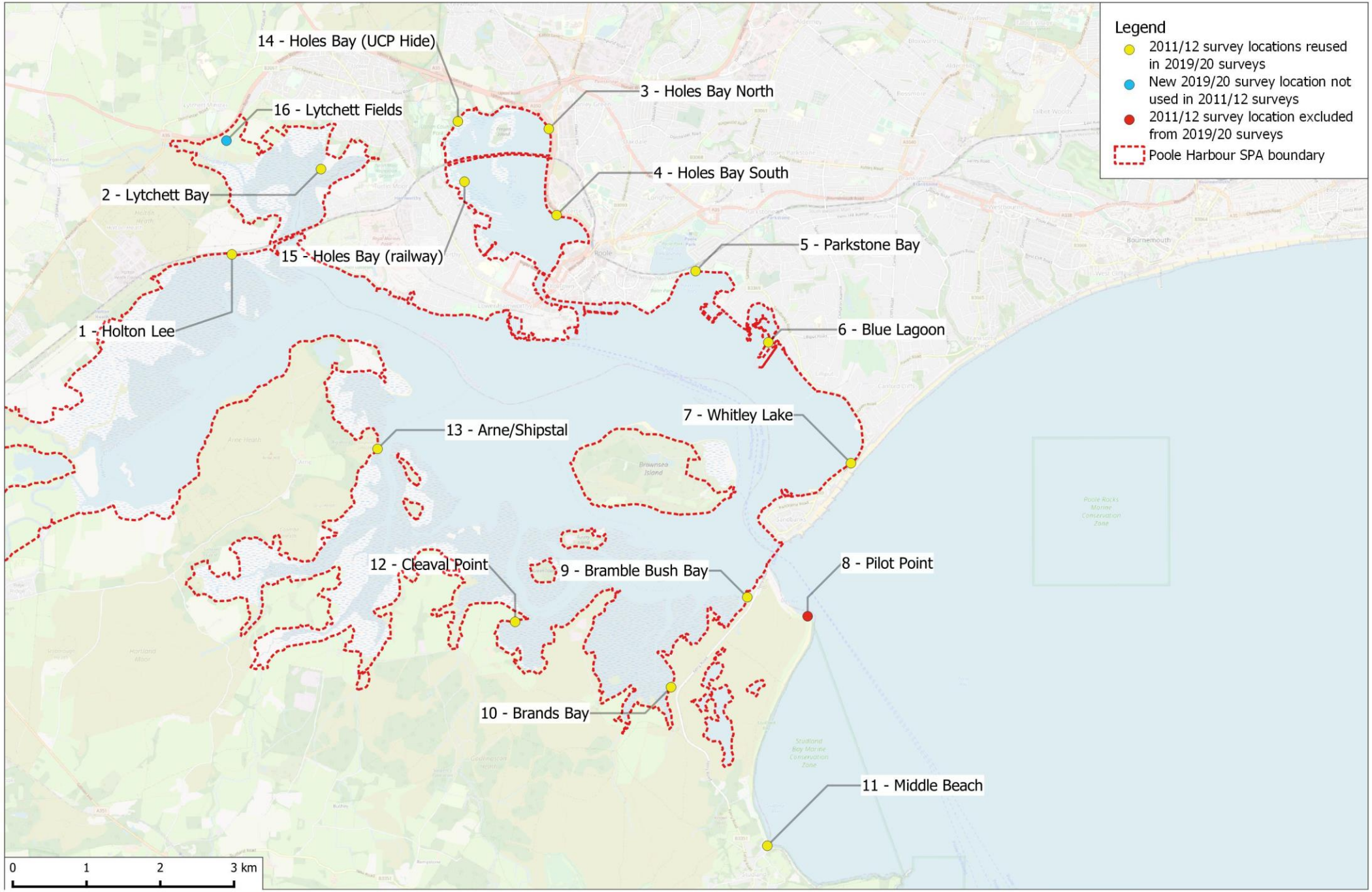
2.6 These different elements are described in more detail below, but in summary the bird counts provided a detailed level of use within the core area, the diary recorded the level of human activity, the response data detailed any behavioural response to disturbance shown by the birds present, and the additional information provided context and background.

Bird count

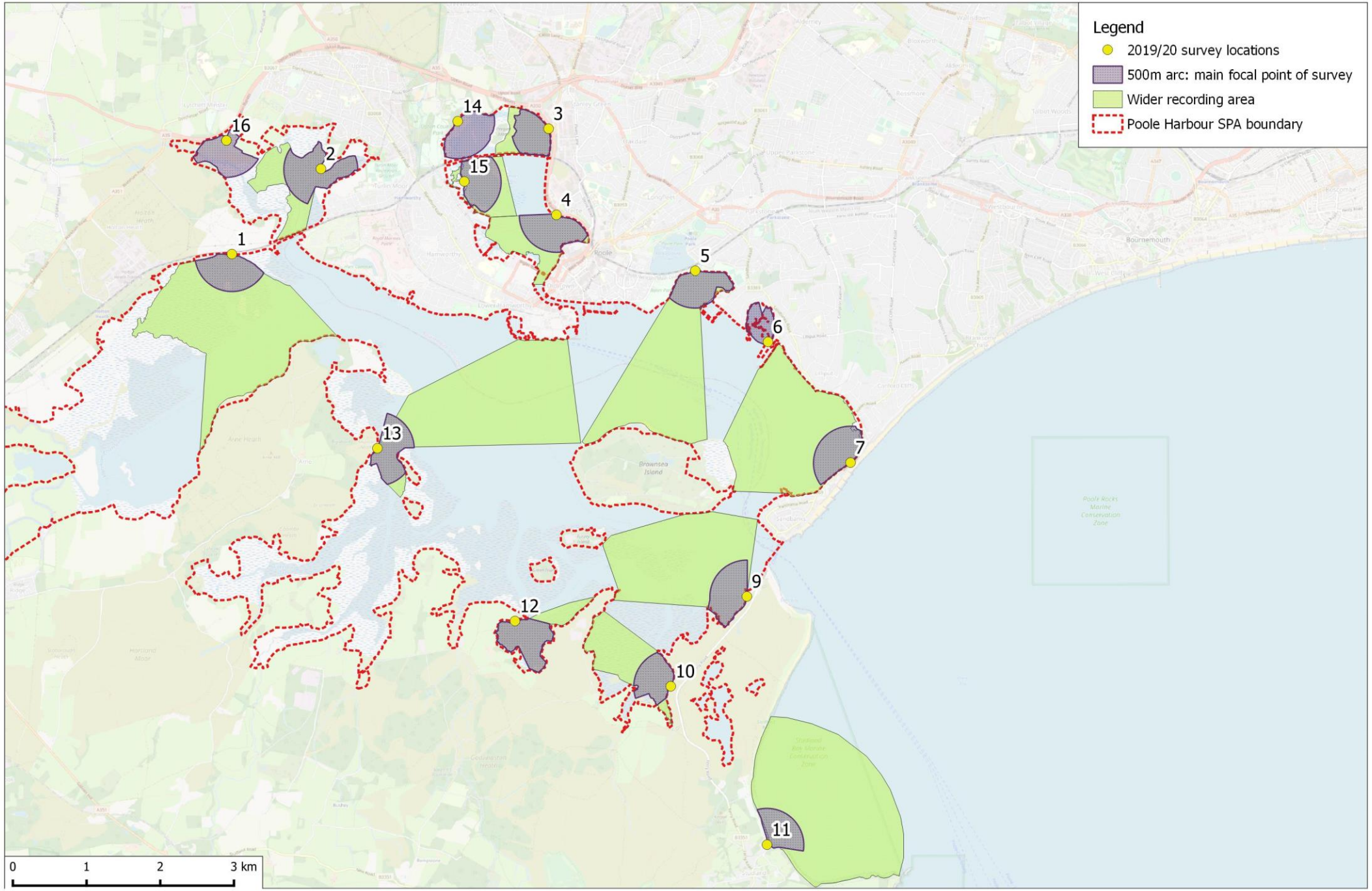
2.7 At the start of each survey visit, a count of the birds present was conducted, comprising all waders, terns, wildfowl, grebes, divers, and herons/egrets. The count only recorded the birds present within a pre-defined recording area that extended to a maximum of 500m from the watch point (see Map 3). This area was carefully mapped for each location, using aerial photographs.

2.8 All mapped areas had a clear line of sight, with their entire extent (within 500m) visible to the recorder from the fixed watch point. Each fixed watch point was selected to be at a point where any disturbance caused by the presence of the surveyor could be minimised/avoided, although the size of the recording area varied at each location due to differences in topography/hydrology, etc.

Map 2: Standard watch survey points and numerical identifiers



Map 3: Standard watch survey points with 500m arcs and wider recording areas (the latter where relevant)



Diary

2.9 All recreation events (and events which could disturb birds, such as trains, aircraft, contractor work, birds of prey, etc.) which occurred during the following 1 hour and 45 minutes were recorded in a diary format. This diary involved all observed events that could affect birds within the recording area, including those that occurred outside (but still in the vicinity of) the recording area. This was due to the fact that activities above the Mean High Water Mark (MHWM), and events outside the recording area, could still disturb birds. Regardless of whether birds were present or not, all events were recorded in the diary, allowing comparisons of the levels of human activity in different areas.

2.10 Each activity type was categorised using pre-determined activity codes (see Appendix 2). Each diary entry was assigned a unique identifier, indicating a single unique event, with details recorded including activity (categorised to standard codes), group size, zone (intertidal, on water, or above MHWM), length of time present in area, and notes relating to behaviour.

2.11 Any individuals exercising dogs were identified as 'dog walking', although any 'secondary' activity (e.g. jogging, birdwatching, etc) was also recorded.

Bird response

2.12 Events in the diary were categorised as a 'potential disturbance event' if:

- They coincided with birds being present within the count area; and/or,
- They occured within 200m of birds within the recording area; and/or,
- There was a behavioural response recorded for birds within the recording area (i.e. seen to become alert, change position, or were flushed).

2.13 For each potential disturbance event, the response of the birds was recorded, even if no behavioural response was logged – i.e. if the birds were not visibly disturbed.

2.14 The disturbance data recorded the number of birds within 200m of the potential source of disturbance, with each group of birds of a given species being recorded as an observation. There could therefore be multiple observations for the same potential disturbance event, for example

someone walking across the intertidal zone might pass various groups of birds of different species.

2.15 For each observation, bird behaviour was categorised simply as (1) feeding or (2) roosting/preening/loafing. The response of the birds was categorised, using simple categories ('Alert', 'walk/swim', 'short flight (<50m)', 'Major Flight (>50m)', or 'No Response') and the number of birds falling into each response category recorded (see Appendix 3). Each observation might therefore involve a range of responses, for example some birds in a flock might remain *in situ* whilst a part of the flock undertakes a major flight. To simplify the data presentation, we also used single response codes, assigning each observation a single code representing the strongest response observed (e.g. if any of the birds in a group undertook a major flight, major flight would be the single response code assigned to the observation).

2.16 For each activity/event where disturbance occurred the maximum distance from the birds to the event was estimated, as the straight-line distance from the source of disturbance to the birds. If there was no response from the birds, then the minimum distance from each species present to the disturbance event was recorded (i.e. how close the disturbance event was to the birds). If the birds were in a tight flock, or only a single individual was involved, then this distance was relatively easy to measure.

2.17 If the birds were scattered over a wide area, and all were disturbed, then the distance will be the approximate range (i.e. 20m – 50m). In all cases distances were estimated to the nearest 5m. In order to ensure consistency in recording distances we:

- Used aerial photographs, with distance bands plotted, at each location. When blown up and printed on good quality paper, with distance bands overlaid, such images show creeks, buoys, marker posts, and landmarks clearly;
- Used laser rangefinders to determine the distance to key landmarks/features and the birds;
- Triangulated or paced out some of the distances at the end of the survey – this can be helpful where distances are hard to estimate during the survey period (for example due to the angles between the observer, source of disturbance, and the birds), and;
- Ensured that observers were well trained, and occasionally did counts together to check that the data were collected in a standard fashion.

Additional Information

2.18 Additional information provided context and background and included tide times, tide coverage, and weather. A free text box allowed any anecdotal information, such as particular events or activities taking place that might make the birds jumpy (e.g. wildfowling or military training), to also be recorded.

Wider Area Counts

2.19 In order to maximise the activities and bird species recorded, including diving duck numbers and predominantly water-based activities, a count of activities and birds within a much wider area, encompassing open water within the harbour, was carried out at twelve of the survey points at the end of each survey visit (see Map 3).

2.20 Three survey locations (namely: Blue Lagoon (Survey Point 6), Holes Bay Hide (Survey Point 14), and Lytchett Fields (Survey Point 16)) were exempt from these counts, as little to no open water was visible at >500m range from each. The data collected comprised a snapshot (i.e. observations resulting from a relatively quick scan of the relevant area) of the birds and boats/craft/people present within a wide area around each survey location.

2.21 The activities and location of all people below the MHWM were mapped within the predefined wider count areas, which encompassed the 500m standard watch arc at each relevant survey point. All bird species present within the same areas were also mapped. Surveyors additionally noted the location of 'harvesting' activities which were present within the wider count area during the standard watch survey period, but which had moved out of the wider area by the time the Wider Area Count was undertaken.

Timing and logistics (including coverage of tide states, etc.)

2.22 Following commission of the study in November 2019, surveys were carried out for three months between December 2019 and February 2020. Each survey point was visited four times per month (twice on a weekday and twice at the weekend), resulting in twelve visits to each survey point over the entire study period. Individual survey dates and timings are provided in Appendix 4.

2.23 This survey effort was equal to that of the 2011/12 study, in terms of hours spent at each survey location, although the previous study consisted of three

(monthly) survey visits to each survey point, between November and February inclusive (i.e. over four months). Furthermore, due to the shorter, three-month, survey period in 2019/20, survey visits were split equally at each survey location between week and weekend days, whereas two thirds of survey visits in 2011/12 were carried out on weekdays.

2.24 It should also be noted that both Holes Bay (UCP Hide) (Survey Point 14) and Holes Bay (railway) (Survey Point 15) were each only subject to 10.5hrs of survey (6 survey visits) during the 2011/12 study.

2.25 Visits were spread over different days and times of day to ensure a range of conditions and circumstances were covered. As far as possible, visits included the following:

- A range of weather conditions, including some dates with strong winds when water sports and sailing are likely to take place;
- Any particular events that were known the be taking place, and;
- A range of tide states.

Data analyses and presentation

2.26 The data collected was analysed using R and Minitab statistical software packages, with graphs and tables produced using both R and Microsoft Excel. The graphs include examples of stacked barplots, histograms, and box and whisker plots. The latter graph type depicts a range of information in a single plot, including the median value (represented by a thickened central line within the box), the interquartile range (the distribution of 25% to 75% of the data) of the dataset (the box itself), the range of the dataset (the 'whiskers'), and any outlier values (represented as standalone points).

2.27 As in the 2011/12 study, descriptive statistics (mean values within categories, etc) are used to summarise the dataset. The output from basic statistical tests (e.g. Chi-squared, Mann-Whitney U tests, and Pearson's Correlation coefficients) are also used to identify significant differences within the dataset, where relevant.

3. Results

Standard Watches

Categories, levels, and distribution of human activities

3.1 A total of 5,358 individual activity events were recorded within 39 categories across the survey period, including trains, aircraft, and predator activity (see Table 1). Taking into account group size[4], and excluding predator activity, this gives a total of 5,320 human activity event observations involving at least 10,246 people. A total of 1,690 dog observations were made, comprising 1,310 animals off lead and 380 on the lead. In total, 315 hours of fieldwork were undertaken across the 15 survey locations. Therefore, we calculate the average hourly rate of visitor activity across all surveyed locations to be at least 32.5 people and 5.4 dogs.

3.2 Walking without a dog was the most commonly recorded activity, accounting for 32% of observations, with dog walking a close second (31% of records). Cycling (14%) and jogging (12%) were also commonly recorded. With the exceptions of trains (3%) and birdwatching (2%), all other human activity types comprised 1% or less of overall observations. Amongst the recorded intertidal and/or water-based activity types, RIBs were the most common (although still comprising 1% or less of all records).

3.3 The overwhelming majority (95%) of activity events occurred on or above the shoreline, with those carried out on the intertidal area or water each comprising 5% of observations. Amongst the four most commonly recorded activity types the percentage of observed events taking place on the shoreline ranged from 99% (walking and dog walking) to 100% (cycling and jogging). 7% of dog walkers, compared to 4% of walkers, were observed using the intertidal area, with smaller numbers of both (<2%) also accessing the water.

[4] Note that aircraft and larger watercraft were automatically assigned a group size of 1 for the purposes of the analysis.

Table 1: Type and distribution of recorded activities across the coastal gradient. Note that a single activity event (e.g. a dog playing on the beach and then entering the water) would be recorded in multiple location categories, hence the three location columns do not necessarily total the number of observed events in the final column. Note also that row/column percentages have been rounded up to the nearest whole number, and that predator activity is also included in the table.

Activity type	Number (%) records on shoreline	Number (%) records on intertidal area	Number (%) records on water	Total number (%) of records
Walking	1,672 (99%)	56 (4%)	8 (1%)	**1,690 (32%)**
Dog walking	1,636 (99%)	115 (7%)	31 (2%)	**1,652 (31%)**
Cycling	736 (100%)	2 (1%)	0 (0%)	**736 (14%)**
Jogging	594 (100%)	0 (0%)	0 (0%)	**594 (12%)**
Train	144 (92%)	0 (0%)	0 (0%)	**157 (3%)**
Birdwatching	63 (100%)	1 (2%)	0 (0%)	**63 (2%)**
Predator	23 (61%)	9 (24%)	2 (6%)	**38 (1%)**
RIB or similar fast small boat	1 (3%)	1 (3%)	38 (100%)	**38 (1%)**
Large motorboat with inboard engine > 10m	0 (0%)	0 (0%)	37 (100%)	**37 (1%)**
Motor vehicle	33 (95%)	1 (3%)	0 (0%)	**35 (1%)**
Person accessing boat or water	29 (86%)	11 (33%)	5 (15%)	**34 (1%)**
Kitesurfer on water	10 (36%)	10 (36%)	27 (97%)	**28 (1%)**
Resident activity	28 (100%)	0 (0%)	0 (0%)	**28 (1%)**
Windsurfer on water	4 (15%)	6 (23%)	27 (100%)	**27 (1%)**
Mobility scooter	22 (100%)	0 (0%)	0 (0%)	**22 (1%)**
Other	14 (67%)	1 (5%)	3 (15%)	**21 (1%)**
Canoe on water	1 (6%)	1 (6%)	16 (95%)	**17 (1%)**
Pump scoop dredging	0 (0%)	0 (0%)	15 (100%)	**15 (1%)**
Sitting on beach/bench	14 (94%)	0 (0%)	0 (0%)	**15 (1%)**
Person working on boat	6 (47%)	1 (8%)	7 (54%)	**13 (1%)**
Photography	11 (100%)	3 (28%)	0 (0%)	**11 (1%)**
Rowing boat	0 (0%)	0 (0%)	11 (100%)	**11 (1%)**
Airborne	0 (0%)	0 (0%)	0 (0%)	**9 (1%)**
Fishing	8 (100%)	1 (13%)	0 (0%)	**8 (1%)**
Bait harvesting or similar from boat	0 (0%)	0 (0%)	7 (100%)	**7 (1%)**
Litter picking	7 (100%)	1 (15%)	0 (0%)	**7 (1%)**
Paddleboarding	1 (15%)	1 (15%)	6 (86%)	**7 (1%)**
Rollerskating/ skateboarding	6 (100%)	0 (0%)	0 (0%)	**6 (1%)**
Wildfowling	5 (84%)	3 (50%)	2 (34%)	**6 (1%)**
Bait digging	4 (80%)	5 (100%)	0 (0%)	**5 (1%)**

Activity type	Number (%) records on shoreline	Number (%) records on intertidal area	Number (%) records on water	Total number (%) of records
Picnicking	4 (100%)	0 (0%)	0 (0%)	**4 (1%)**
Swimming	2 (50%)	1 (25%)	4 (100%)	**4 (1%)**
Unaccompanied dog off lead	3 (100%)	1 (34%)	0 (0%)	**3 (1%)**
Moderate to large sailing boat, not running motor	0 (0%)	0 (0%)	3 (100%)	**3 (1%)**
Horse riding	2 (100%)	0 (0%)	0 (0%)	**2 (1%)**
Jet ski on water	0 (0%)	0 (0%)	2 (100%)	**2 (1%)**
Cockle-raking	1 (100%)	1 (100%)	0 (0%)	**1 (1%)**
Kids playing	1 (100%)	0 (0%)	0 (0%)	**1 (1%)**
Metal detecting	1 (100%)	1 (100%)	0 (0%)	**1 (1%)**
Total	**5,086 (95%)**	**233 (5%)**	**251 (5%)**	**5,358 (100%)**

3.4 65 individual dog walking observations (4% of the total) comprised individuals/groups carrying out a secondary activity (see Table 2). Jogging was most frequently observed (67% of secondary observations), with cycling, birdwatching, and rollerskating/skateboarding also recorded.

Table 2: Number (%) of secondary activities recorded amongst dog walkers across all survey locations. Note that column percentages have been rounded up to the nearest whole number.

Secondary activity type	Number (%) records
Jogging	43 (67%)
Cycling	8 (13%)
Birdwatching	6 (10%)
Sitting on beach/bench	4 (7%)
Mobility scooter	3 (5%)
Rollerskating/skateboarding	1 (2%)
Total	**65 (100%)**

3.5 Figure 1 includes images that show examples of some of the terrestrial and water-based activities recorded from different survey locations across the survey period.

Figure 1: Examples of recorded activity types; (a) paddleboarding in Bramble Bush Bay, (b) kitesurfing at Whitley Lake, (c) walking at Upton Country Park (Holes Bay), and (d) litter picking at Blue Lagoon.

3.6 The relative composition and frequency of observed activities differed between the 15 survey locations, with Figure 2 summarising the number of groups undertaking each activity type at each locality. The activity levels at each location were significantly different: (X^2_{14} = 10,711.2; p<0.001), with some locations much busier than others.

3.7 Parkstone Bay (Survey Point 5) was by far the busiest survey location, with Whitley Lake (Survey Point 7) in second place (albeit with fewer than half the number of groups observed at the previous locality). Middle Beach (Survey Point 11) and three of the Holes Bay survey locations (Survey Points 3, 4, and 14, respectively) all recorded approximately half to two thirds of the number of observations made at Whitley lake. Cleaval Point (Survey Point 12),

Lytchett Fields (Survey Point 16), and Brands Bay (Survey point 10) were the least busy locations, in ascending order of observations; each reporting a tiny number of observations relative to most of the other survey localities.

3.8 The large number and variety of activities recorded across the different locations make it difficult to spatially present all of the observations made. Map 4 depicts the relative proportion of each of the 6 activity types, recorded on at least 40 occasions across all survey locations combined over the entire survey period, at each survey point.

3.9 Walking and dog walking were the most frequently recorded activities at the majority (11) of the survey locations. Nevertheless, cycling (followed by walking) was the most commonly observed activity at both Holes Bay North and South (Survey Points 3 and 4, respectively), and passing trains were the dominant activity type at Holton Lee (Survey Point 1). Perhaps unsurprisingly, birdwatching was by far the most commonly observed activity type at Lytchett Fields RSPB Reserve (Survey Point 16).

3.10 Map 5 depicts the distribution of the recorded activity types across the coastal gradient at each survey location. With the exception of Holton Lee (Survey Point 1), the majority of observations at every locality occurred on the shoreline, with a significant difference between the number of water-based activities and those carried out on the (combined) shoreline/intertidal areas ($X^2_{14} = 310.6$; $p<0.001$). The largest proportion of water-based activities were recorded at Holton Lee, followed by Bramble Bush Bay (Survey point 9), and Arne/Shipstal (Survey point 13). The largest proportion of intertidal activities were recorded at Lytchett Fields (Survey Point 16), with marginally smaller proportions recorded at Lytchett Bay (Survey Point 2), Blue Lagoon (Survey Point 6), Brands Bay (survey point 10), and Arne/Shipstal.

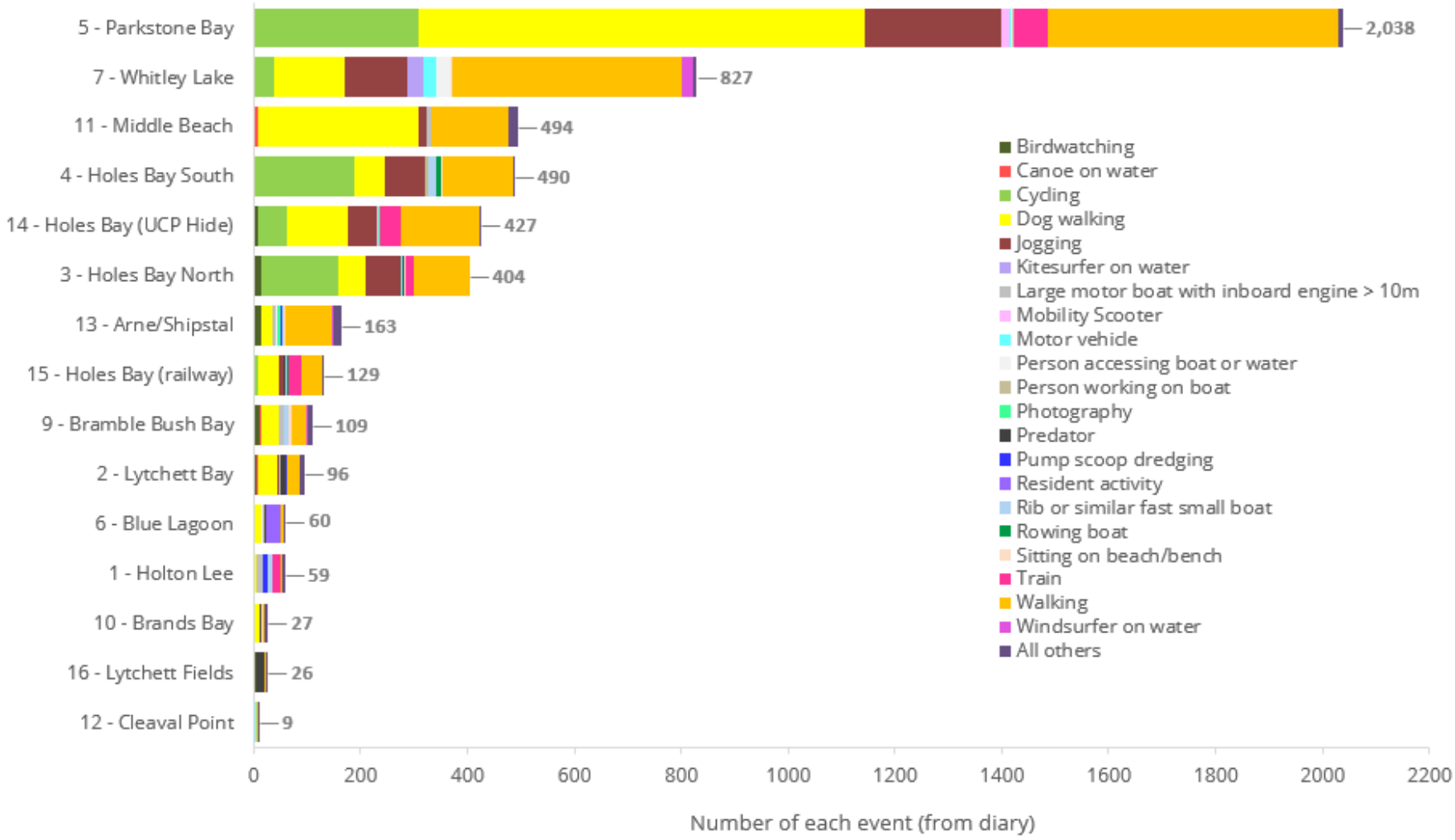
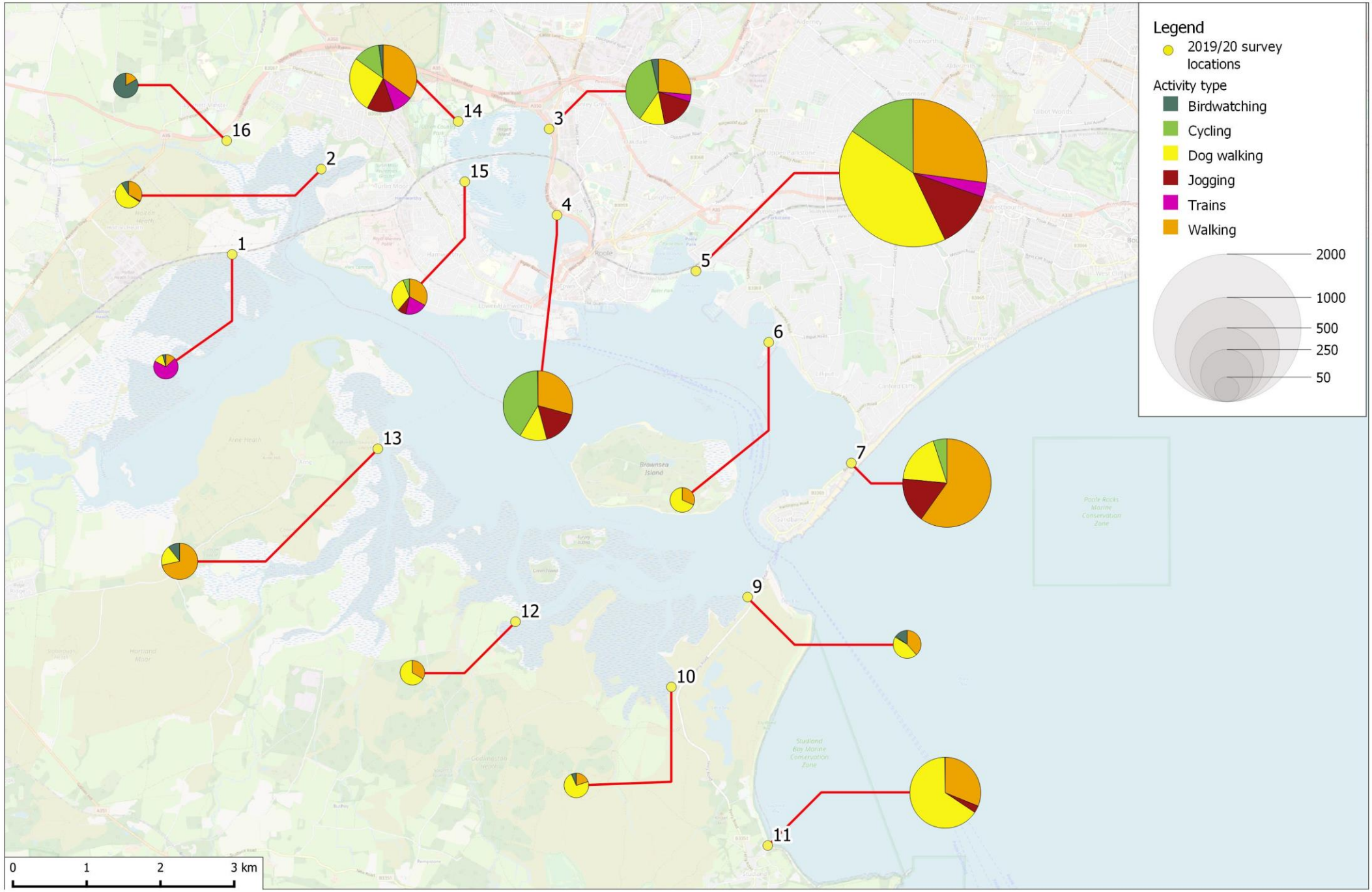
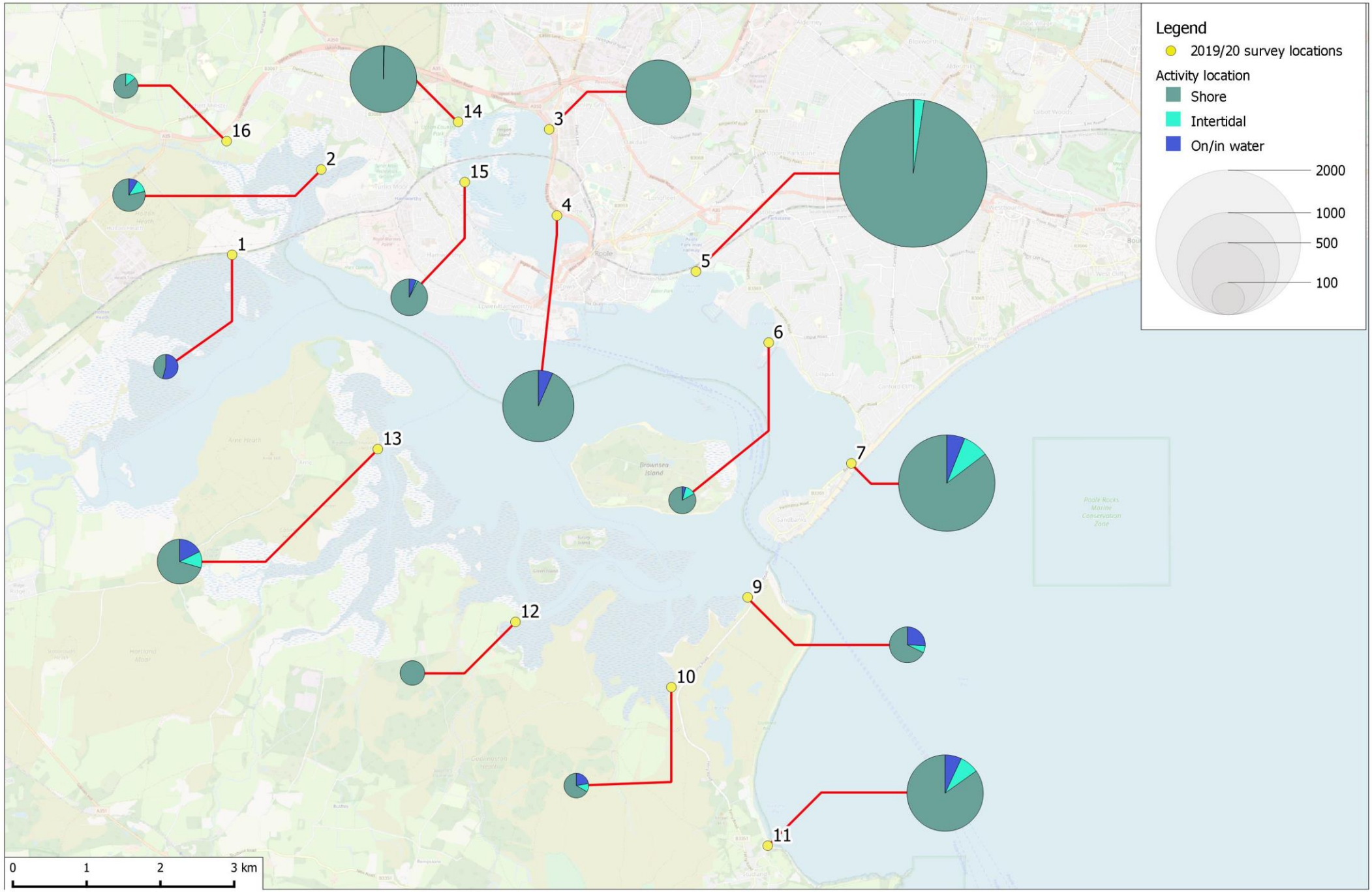


Figure 2: Total number of records (labelled at the end of each bar) per activity type recorded from each survey point. Only those activities with a minimum of 10 observations across all survey points are individually identified, with the remainder of activities (plus those not specifically categorised) included under "all others".

Map 4: Number and types of activity recorded on 40 or more occasions across all survey locations (chart sizes scaled relative to the total number of observations within the relevant categories at each locality)



Map 5: Number of activity records (from diary) recorded on the shore, intertidal area, and on/in the water at each survey location



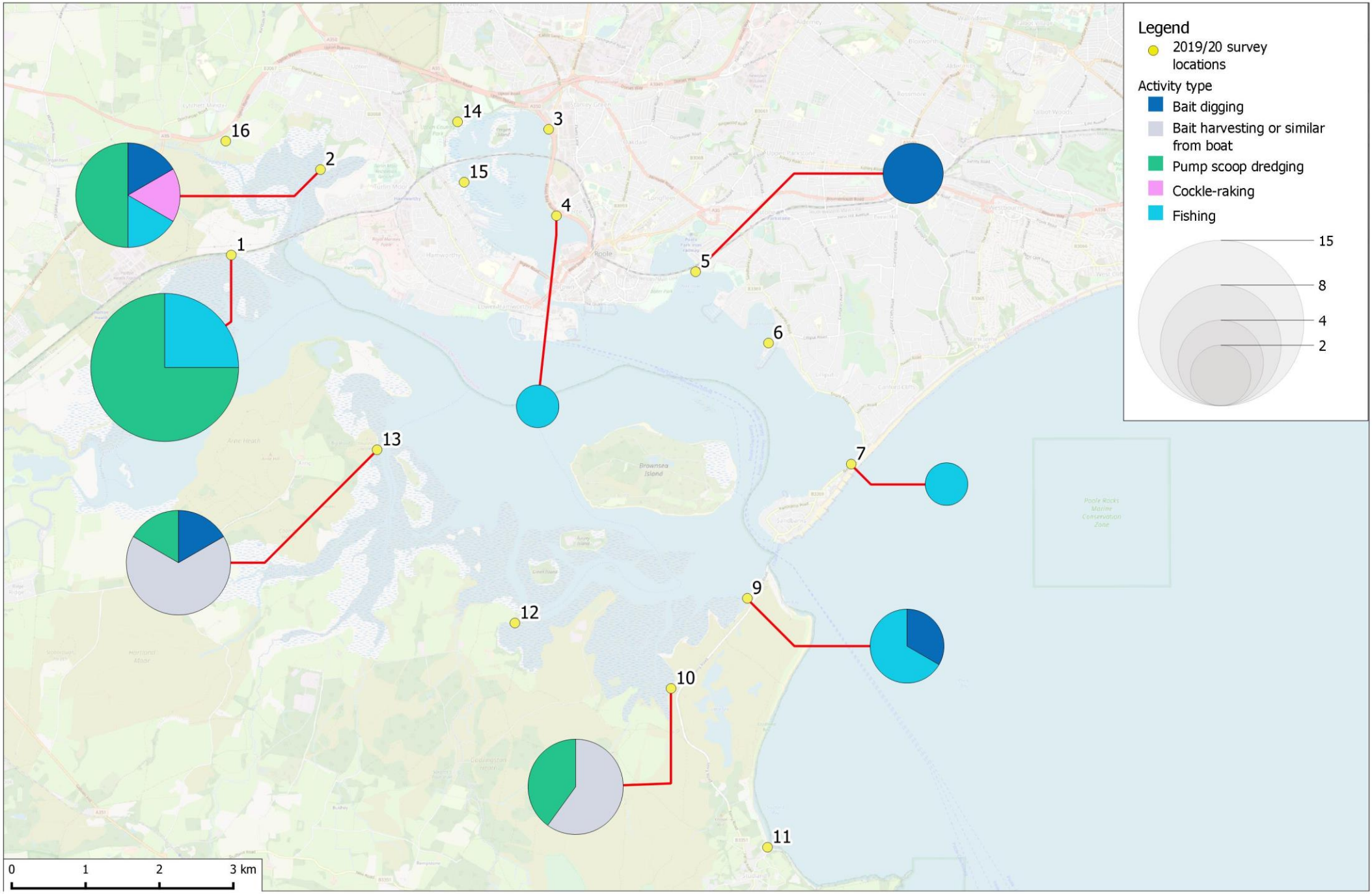
3.11 Map 6 depicts the spatial distribution of all observed harvesting activity (I.e. bait digging, cockle raking, pump scoop dredging, and fishing) across the survey locations recorded during the Standard Watch surveys. Pump scoop dredging is unique to Poole Harbour and uses a water pump to filter clams from underlying sediments using a boat-towed dredge. The largest number of harvesting observations (12) were made at Holton Lee (Survey Point 1) where pump scoop dredging was proportionally by far the most dominant harvesting activity type. Pump scoop dredgers were also observed at Lytchett Bay (Survey Point 2), Brands Bay (Survey Point 10), and Arne/Shipstal (Survey Point 13), although boat-based bait harvesting was the dominant harvesting type observed at the latter two locations.

3.12 Fishing (angling) was the dominant harvesting activity type at Holes Bay South (Survey Point 4), Whitley Lake (Survey Point 7), and Bramble Bush Bay (Survey Point 9), and was also recorded at Holton Lee and Lytchett Bay. Bait digging was observed at four locations (Lytchett Bay, Parkstone Bay (Survey Point 5), Bramble Bush Bay (Survey Point 9), and Arne/Shipstal), whilst cockle raking was only recorded at Lytchett Bay. No harvesting activities were recorded at Holes Bay North (Survey Point 3), Blue Lagoon (Survey Point 6), Middle Beach (Survey Point 11), Cleaval Point (Survey Point 12), Holes Bay (UCP Hide) (Survey Point 14), Holes Bay (railway) (Survey Point 15), or Lytchett Fields (Survey Point 16).

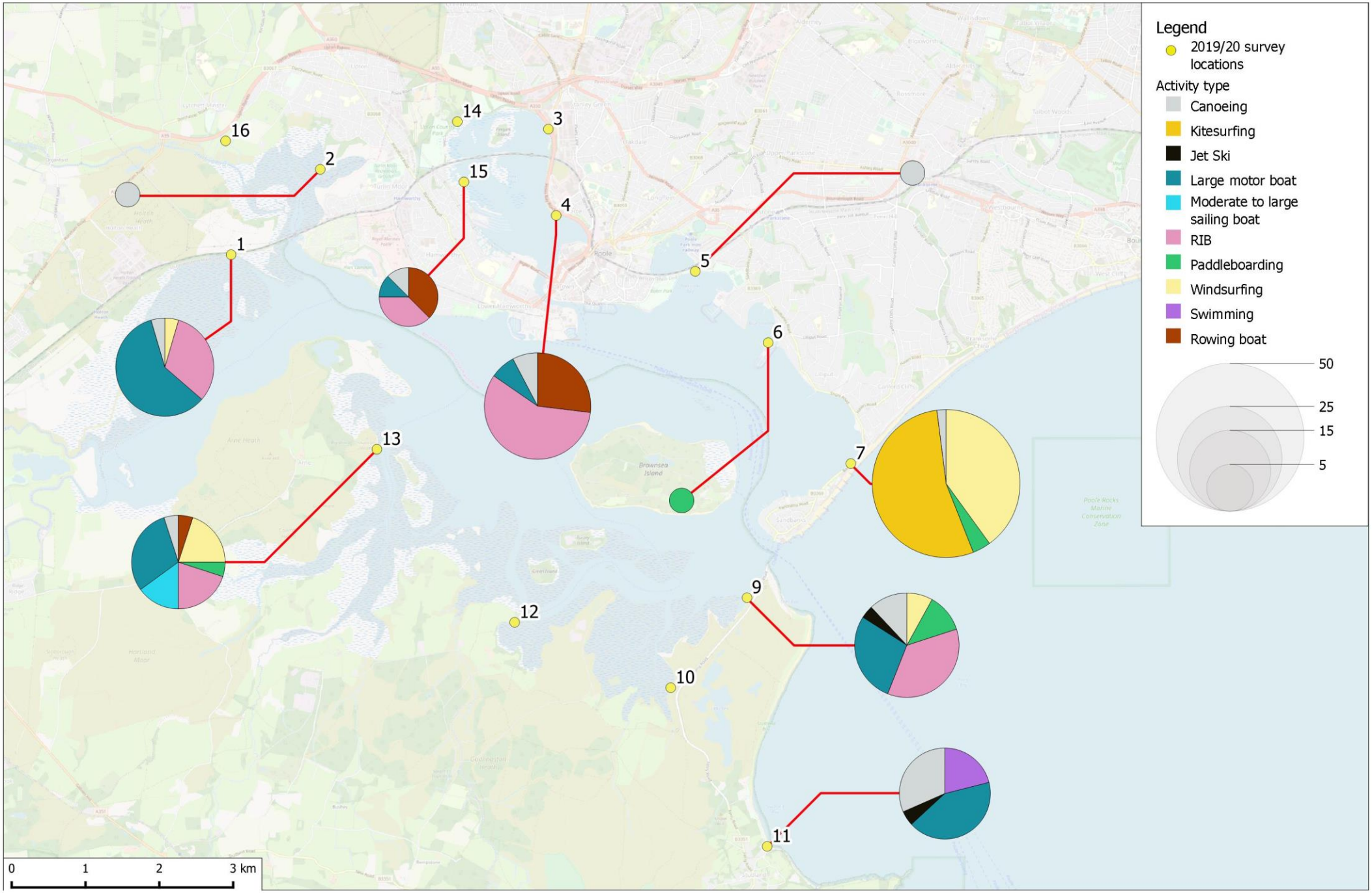
3.13 Map 6 shows the distribution and observation frequency of recreational water-based activities across all survey locations. The largest number of observations (50) were made at Whitley Lake, with approximately half the number of observations made there recorded at Holton Lee, Holes Bay South, Bramble Bush Bay, Middle Beach, and Arne/Shipstal. A small number of observations were made at Lytchett Bay, Parkstone Bay, Blue Lagoon, and Holes Bay (railway), and none were made at Holes Bay North, Brands Bay, Cleaval Point, Holes Bay (UCP Hide), or Lytchett Fields.

3.14 Kite and windsurfing were the dominant water-based recreational activities at Whitley Lake, but were otherwise only recorded in relatively small proportions from Bramble Bush Bay, Arne/Shipstal, and Holton Lee. RIBs, or similar craft, were the most commonly recorded activity type at Holes Bay South and Bramble Bush Bay, with large motorboats most frequent at Holton Lee, Middle Beach, and Arne/Shipstal. The largest number of relevant activity types (7) were recorded from Arne/Shipstal, with only single types recorded at Lytchett Bay, Parkstone Bay, and Blue Lagoon.

Map 6: Number of diary records of fishing, bait, and cockle collection at each survey location (chart sizes scaled relative to the total number of observations within the relevant categories at each locality). Note that no relevant activities were recorded from survey locations 3, 6, 11, 12, 14, 15, and 16



Map 7: Number and type of water-based activities recorded at each survey location (chart sizes scaled relative to the total number of observations within the relevant categories at each locality). Note that no relevant activities were recorded from survey locations 3, 10, 12, 14, and 16

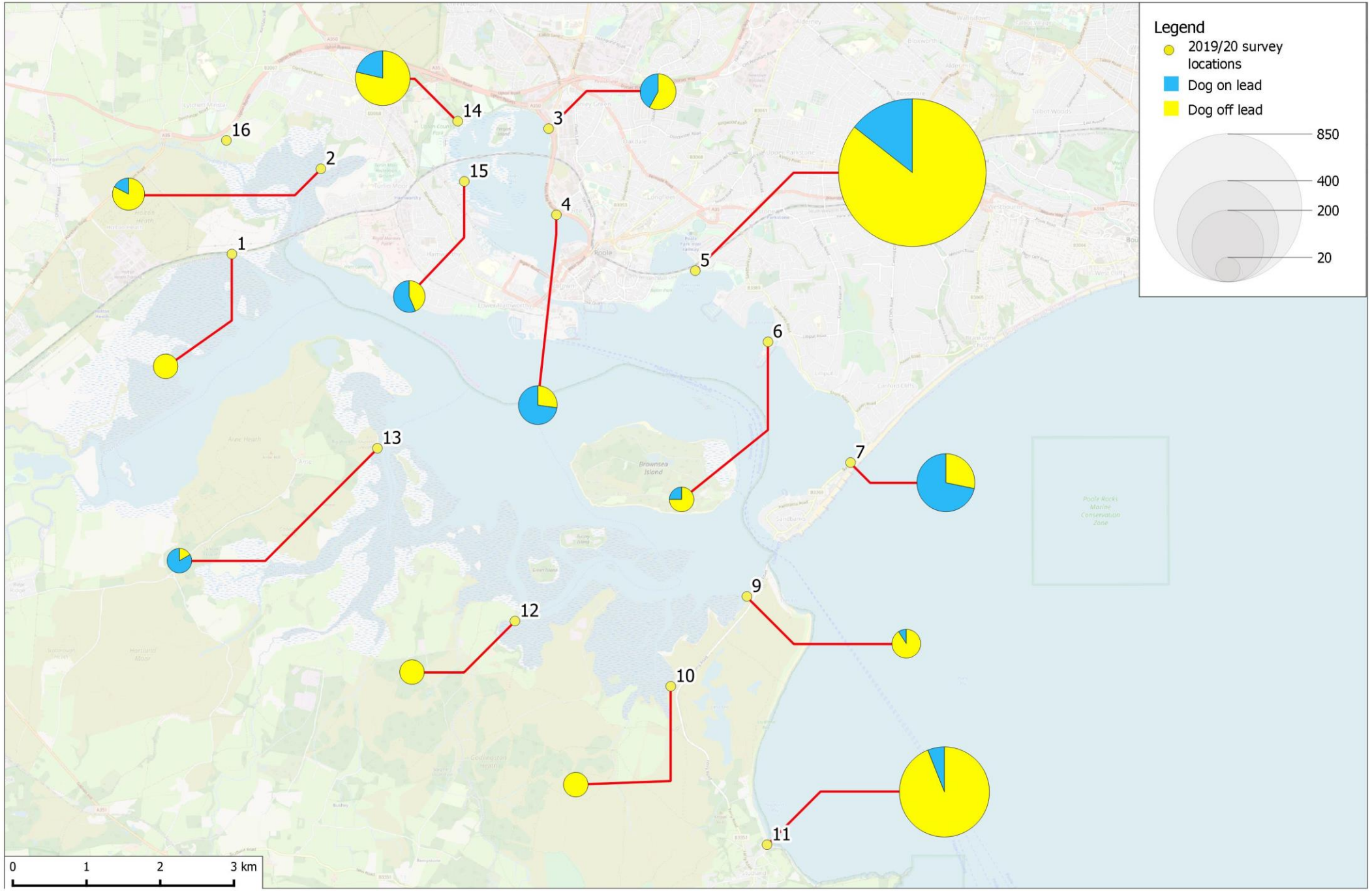


3.15 1,690 dogs were recorded in total (see Table 3), with animals observed at every survey location (with the exception of Lytchett Fields; see Map 8). The largest number of dogs were recorded at Parkstone Bay (50% of all observations), with the smallest number (excluding Lytchett Fields) recorded at Cleaval Point. The second largest number of records (19% of the total) came from Middle Beach. The majority of dogs across all survey locations (78%) were recorded off the lead, although this trend was bucked at Holes Bay South, Whitley Lake, Arne/Shipstal, and Holes Bay (railway). Both Holes Bay South and Whitley Lake are however adjacent to busy main roads.

Table 3: Number (%) of dogs observed on and off lead at each survey location over the entire survey period, with the larger proportion per survey location highlighted in grey. Note that row percentages have been rounded up to the nearest whole number.

Survey location	Number (%) dogs on lead	Number (%) dogs off lead	Total number (%) of dogs observed
5 - Parkstone Bay	122 (15%)	725 (86%)	847 (100%)
11 - Middle Beach	19 (7%)	297 (94%)	316 (100%)
7 - Whitley Lake	94 (72%)	37 (29%)	131 (100%)
14 - Holes Bay (UCP Hide)	25 (22%)	92 (79%)	117 (100%)
4 – Holes Bay South	43 (73%)	16 (28%)	59 (100%)
3 - Holes Bay North	21 (42%)	29 (58%)	50 (100%)
2 - Lytchett Bay	7 (18%)	33 (83%)	40 (100%)
15 - Holes Bay (railway)	22 (57%)	17 (44%)	39 (100%)
9 - Bramble Bush Bay	3 (10%)	30 (91%)	33 (100%)
13 – Arne/Shipstal	20 (84%)	4 (17%)	24 (100%)
6 - Blue Lagoon	4 (25%)	12 (75%)	16 (100%)
10 - Brands Bay	0 (0%)	12 (100%)	12 (100%)
1 - Holton Lee	0 (0%)	3 (100%)	3 (100%)
12 - Cleaval Point	0 (0%)	3 (100%)	3 (100%)
16 - Lytchett Fields	0 (0%)	0 (0%)	0 (0%)
Total	**380 (23%)**	**1,310 (78%)**	**1,690 (100%)**

Map 8: Number of dogs recorded on and off lead at each survey location (chart sizes scaled relative to the total number of observations within the relevant category at each locality). Note that no relevant activities were recorded from survey location 16



Bird Counts

3.16 A total of 47 species, excluding gulls, were recorded during the Standard Watches carried out at the 15 survey locations over the entire survey period (see Table 4). These comprised 17 species of wader, 16 species of wildfowl, and 14 other waterbird species. No survey location recorded all species, with the largest species totals, of 28 and 27 species respectively, recorded at Holes Bay (railway) (Survey Point 15) and Brands Bay (Survey Point 10). The smallest number of species (9) were recorded at both Whitley Lake (Survey Point 7) and Middle Beach (Survey point 11).

3.17 The most widespread wader species were Curlew *Numenius arquata*, Oystercatcher *Haematopus ostralegus*, and Redshank *Tringa totanus* (each recorded from 14 survey locations), whilst Green Sandpiper *T. ochropus*, Knot *Calidris canutus*, Sanderling *C. alba*, and Spotted Redshank *T. erythropus* were all recorded from single sites only. Mallard was the most commonly recorded wildfowl species (13 locations), with three other species (Greylag Goose *Anser anser*, Common Scoter *Melanitta nigra*, and Scaup *Aythya marila*) recorded from single sites. Amongst the other waterbird species, Cormorant *Phalacrocorax carbo* was most widespread, being recorded at 15 survey locations, whilst Coot *Fulica atra*, Moorhen *Gallinula chloropus*, and Great White Egret *Ardea alba* were each only recorded at individual sites.

3.18 The maximum counts of wader and wildfowl species at each of the survey locations are summarised in Maps 9 and 10, respectively. The distribution and abundance of each species varied dramatically between the different survey points. The largest numbers of waders were concentrated in the north of Holes Bay and within Brands Bay, whilst much smaller numbers were recorded from survey sites in the immediate proximity of Poole and Studland (e.g. Parkstone Bay, Whitley Lake, and Middle Beach). This distribution was mirrored by wildfowl species, although maximum counts were even lower from those locations in proximity to Poole and Studland.

3.19 Black-tailed Godwit were the most abundant wader species at five sites across the survey area, although large numbers of Dunlin *C. alpina* were also recorded in Holes and Brands Bays. Avocet were also relatively abundant within Holes and Lytchett Bays. Nevertheless, there was still much inter-site variation, with Oystercatcher the dominant species at Arne/Shipstal, Middle Beach, and Parkstone Bay; Bar-tailed Godwits *Limosa lapponica* at Whitley Lake; Curlew at Holton Lee; and Lapwing *Vanellus vanellus* at Lytchett Fields.

3.20 Wigeon *Mareca penelope*, Teal *Anas crecca*, and/or Shelduck were the dominant wildfowl species, in terms of maximum counts, across the northern survey locations, with relatively large numbers of Wigeon also recorded at Arne/Shipstal and Brands Bay. Nevertheless, with the exception of the latter survey location, Dark-bellied Brent Geese *Branta bernicla bernicla* were the most abundant wildfowl species across the southern and eastern survey points.

Table 4: Summary of species recorded from within Standard Watch focal areas across all survey visits, using all count data (i.e. two counts per visit). Qualifying species specifically named on the Poole Harbour SPA citation are indicated in bold, with named component species of the qualifying waterfowl assemblage italicised. Note that all other wader and waterfowl species in the table are considered part of the SPA qualifying assemblage, however. The largest and second largest counts per row are highlighted in dark and light grey, respectively.

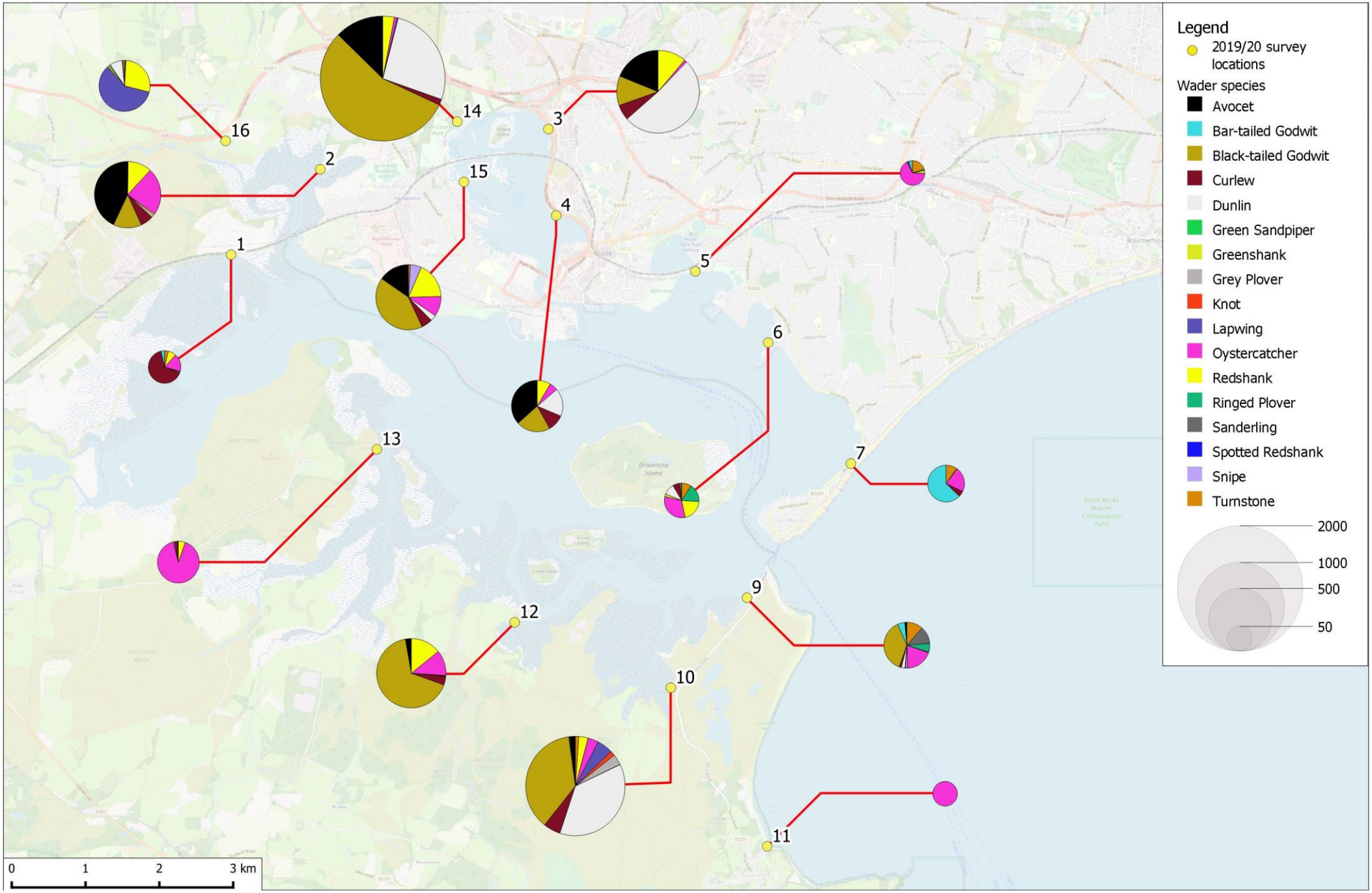
Species group	Species	Total no. locations recorded	Maximum single count per Survey Point														
			1 – Holton Lee	2 – Lytchett Bay	3 – Holes Bay North	4 – Holes Bay South	5 – Parkstone Bay	6 – Blue Lagoon	7 – Whitley Lake	9 – Bramble Bush Bay	10 – Brands Bay	11 – Middle Beach	12 – Cleaval Point	13 – Arne/ Shipstal	14 – Holes Bay (UCP Hide)	15 – Holes Bay (railway)	16 – Lytchett Fields
Waders	**Avocet**	9	0	243	165	125	0	1	0	4	24	0	17	0	251	83	0
	Bar-tailed Godwit	7	5	0	0	0	3	2	110	14	3	0	0	1	0	0	0
	Black-tailed Godwit	9	0	78	101	73	0	0	0	103	470	0	410	0	1,100	225	4
	Curlew	14	89	36	53	36	1	10	9	4	71	0	25	6	30	30	1
	Dunlin	10	1	5	450	60	0	16	0	7	470	0	0	0	525	16	27
	Green Sandpiper	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Greenshank	7	1	5	0	0	0	4	0	1	1	0	1	0	0	0	4
	Grey Plover	4	0	0	0	0	0	0	0	4	44	0	1	2	0	0	0
	Knot	1	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0
	Lapwing	3	0	0	0	0	0	0	0	0	65	0	0	0	5	0	200
	Oystercatcher	14	24	131	9	18	37	49	38	52	44	18	73	204	15	54	0
	Redshank	14	11	66	97	29	2	32	1	1	38	0	87	12	59	98	94
	Ringed Plover	3	0	0	0	0	1	26	0	17	0	0	0	0	0	0	0
	Sanderling	1	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0

Species group	Species	Total no. locations recorded	Maximum single count per Survey Point													
			1 – Holton Lee	2 – Lytchett Bay	3 – Holes Bay North	4 – Holes Bay South	5 – Parkstone Bay	6 – Blue Lagoon	7 – Whitley Lake	9 – Bramble Bush Bay	10 – Brands Bay	11 – Middle Beach	12 – Cleaval Point	13 – Arne/ Shipstal	14 – Holes Bay (UCP Hide)	15 – Holes Bay (railway)	16 – Lytchett Fields
	Snipe	3	0	1	0	0	0	0	0	0	0	0	0	0	0	30	2
	Spotted Redshank	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Turnstone	7	5	0	0	0	11	14	17	31	14	0	0	0	0	5	0
Wildfowl	Canada Goose	8	2	2	14	0	0	1	0	0	18	0	0	2	11	38	0
	Common Scoter	1	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
	Dark-bellied Brent Goose	9	0	40	0	0	109	185	29	24	140	11	368	113	0	0	0
	Gadwall	4	0	16	0	0	0	0	0	0	5	0	0	0	11	6	0
	Goldeneye	7	2	0	2	1	4	0	0	0	0	0	1	1	0	1	0
	Greylag Goose	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Mallard	13	12	3	4	2	4	14	0	2	2	0	18	17	10	2	4
	Mute Swan	9	0	27	66	16	0	2	0	0	2	0	2	2	11	44	0
	Pintail	5	0	0	3	0	0	0	0	0	75	0	28	0	44	1	0
	Red-breasted Merganser	12	6	9	0	6	10	14	5	10	4	1	4	13	0	5	0
	Scaup	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
	Shelduck	12	125	23	25	58	0	21	0	7	90	0	64	11	56	99	21
	Shoveler	5	1	0	0	0	0	0	0	0	10	0	4	0	105	4	0
	Teal	9	2	165	290	19	0	0	0	0	146	0	95	0	270	68	79

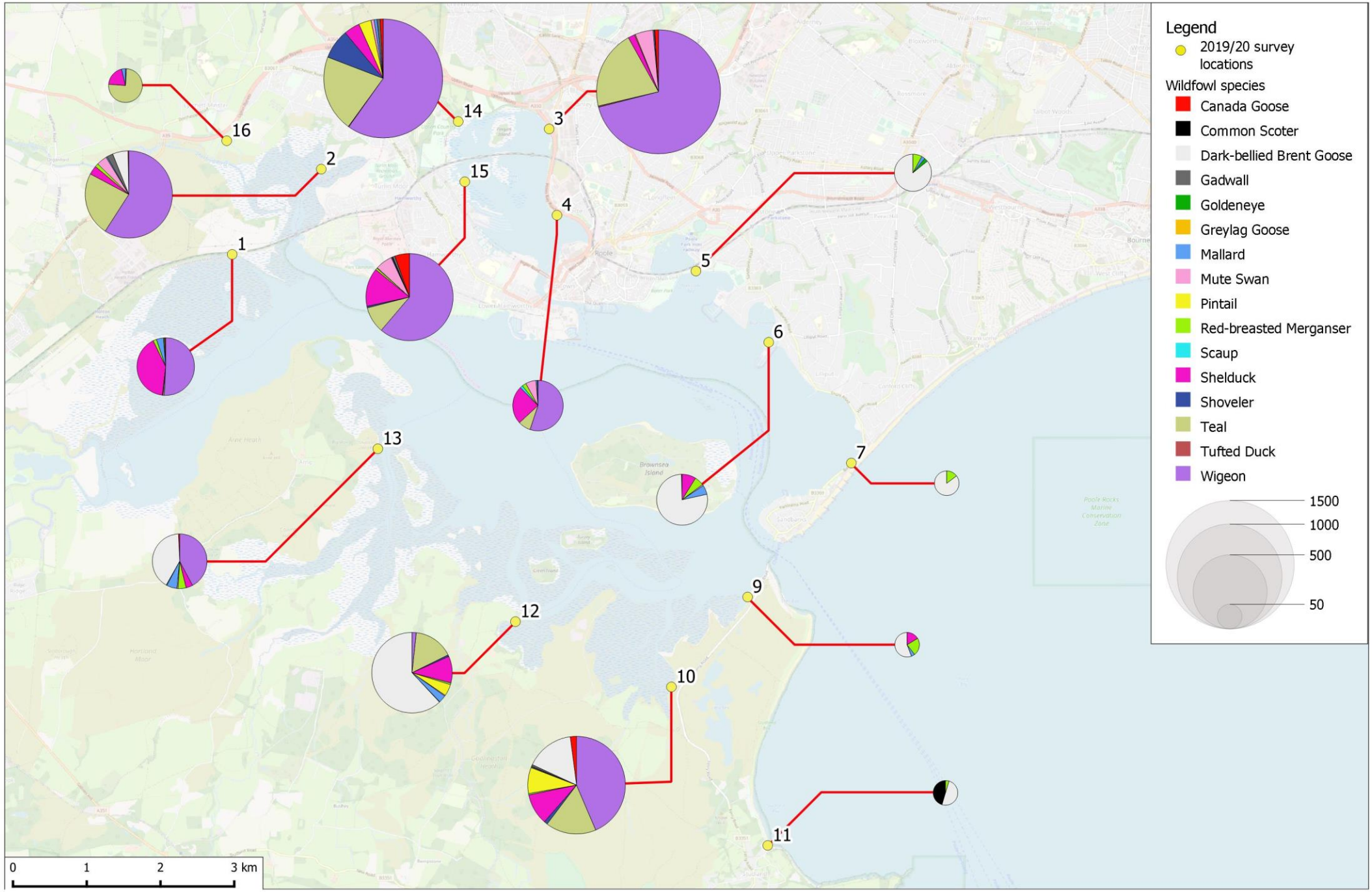
Species group	Species	Total no. locations recorded	Maximum single count per Survey Point													
			1 – Holton Lee	2 – Lytchett Bay	3 – Holes Bay North	4 – Holes Bay South	5 – Parkstone Bay	6 – Blue Lagoon	7 – Whitley Lake	9 – Bramble Bush Bay	10 – Brands Bay	11 – Middle Beach	12 – Cleaval Point	13 – Arne/ Shipstal	14 – Holes Bay (UCP Hide)	15 – Holes Bay (railway)	16 – Lytchett Fields
	Tufted Duck	2	0	0	4	0	0	0	0	0	0	0	0	0	2	0	0
	Wigeon	10	155	412	1,000	130	0	0	0	0	380	0	10	116	775	425	1
Other	Black-necked Grebe	4	0	0	0	0	2	0	0	2	0	5	0	1	0	0	0
	Coot	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
	Cormorant	15	1	5	4	3	2	2	1	2	1	1	1	3	4	4	2
	Great Crested Grebe	14	3	2	2	5	6	1	2	4	2	5	2	7	1	5	0
	Great Northern Diver	7	0	0	0	1	1	0	0	2	1	0	1	2	0	1	0
	Great White Egret	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Grey Heron	7	0	1	6	1	0	0	0	3	0	0	0	0	1	4	1
	Little Egret	14	1	2	3	2	1	1	0	1	2	1	3	2	2	2	4
	Little Grebe	4	0	0	0	0	1	0	0	0	0	0	0	2	7	8	0
	Moorhen	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Sandwich Tern	2	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
	Shag	6	0	0	0	1	2	1	0	1	0	1	0	0	0	1	0
	Slavonian Grebe	4	3	0	0	0	1	0	0	2	0	0	3	0	0	0	0

Species group	Species	Total no. locations recorded	Maximum single count per Survey Point													
			1 – Holton Lee	2 – Lytchett Bay	3 – Holes Bay North	4 – Holes Bay South	5 – Parkstone Bay	6 – Blue Lagoon	7 – Whitley Lake	9 – Bramble Bush Bay	10 – Brands Bay	11 – Middle Beach	12 – Cleaval Point	13 – Arne/ Shipstal	14 – Holes Bay (UCP Hide)	15 – Holes Bay (railway)	16 – Lytchett Fields
	Spoonbill	3	2	0	0	0	0	0	0	0	0	0	3	9	0	0	0
Total no. species recorded			**18**	**21**	**20**	**20**	**18**	**20**	**9**	**25**	**27**	**9**	**24**	**20**	**22**	**28**	**16**

Map 9: Maximum count of waders at each survey location (chart sizes scaled relative to the total number of observations at each locality)



Map 10: Maximum count of wildfowl at each survey location (chart sizes scaled relative to the total number of observations at each locality)



Effect of people on bird numbers and distribution

3.21 In order to investigate the effect of human activity, and any associated disturbance, upon the distribution of birds across the wider study area we calculated the density of birds at each survey location, using the maximum count of each species and the extent of the focal area at each location. We also calculated the number of activity events at each survey location across the entire survey period and divided it by the total number of survey hours to produce an event rate.

3.22 Survey locations which exhibited a larger number of activity events (per hour of survey) generally supported a lower density of both waders and wildfowl within their focal areas, although this pattern was not as apparent for non-wader/wildfowl species (see Figure 3). Parkstone Bay (Survey Point 5) recorded the largest number of activity events across the survey period and supported obviously lower wader and wildfowl densities. Nevertheless, several other survey localities also supported lower bird densities (e.g. Middle Beach – Survey Point 11) despite comprising quieter sites. Those sites with the highest densities, and lowest levels of disturbance, were generally in the Holes or Brands Bay areas.

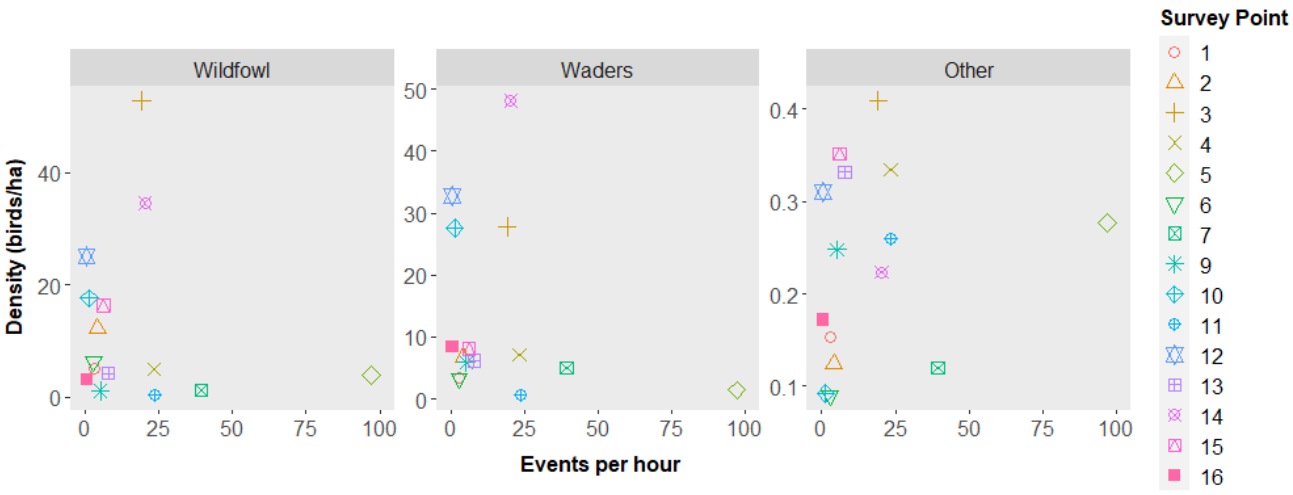


Figure 3: Bird densities (calculated using maximum count across all survey visits divided by the focal area at each survey point) in relation to disturbance levels (calculated by dividing total groups across all survey visits by total survey hours) at each survey location.

3.23 The patterns shown in Figure 3 are even more readily apparent in Figure 4, which depicts the number of birds present at the end of each standard watch, during each survey visit, in relation to the total number of groups of people observed during the same visit. This data is stratified by both survey location (top row) and tide state (bottom row).

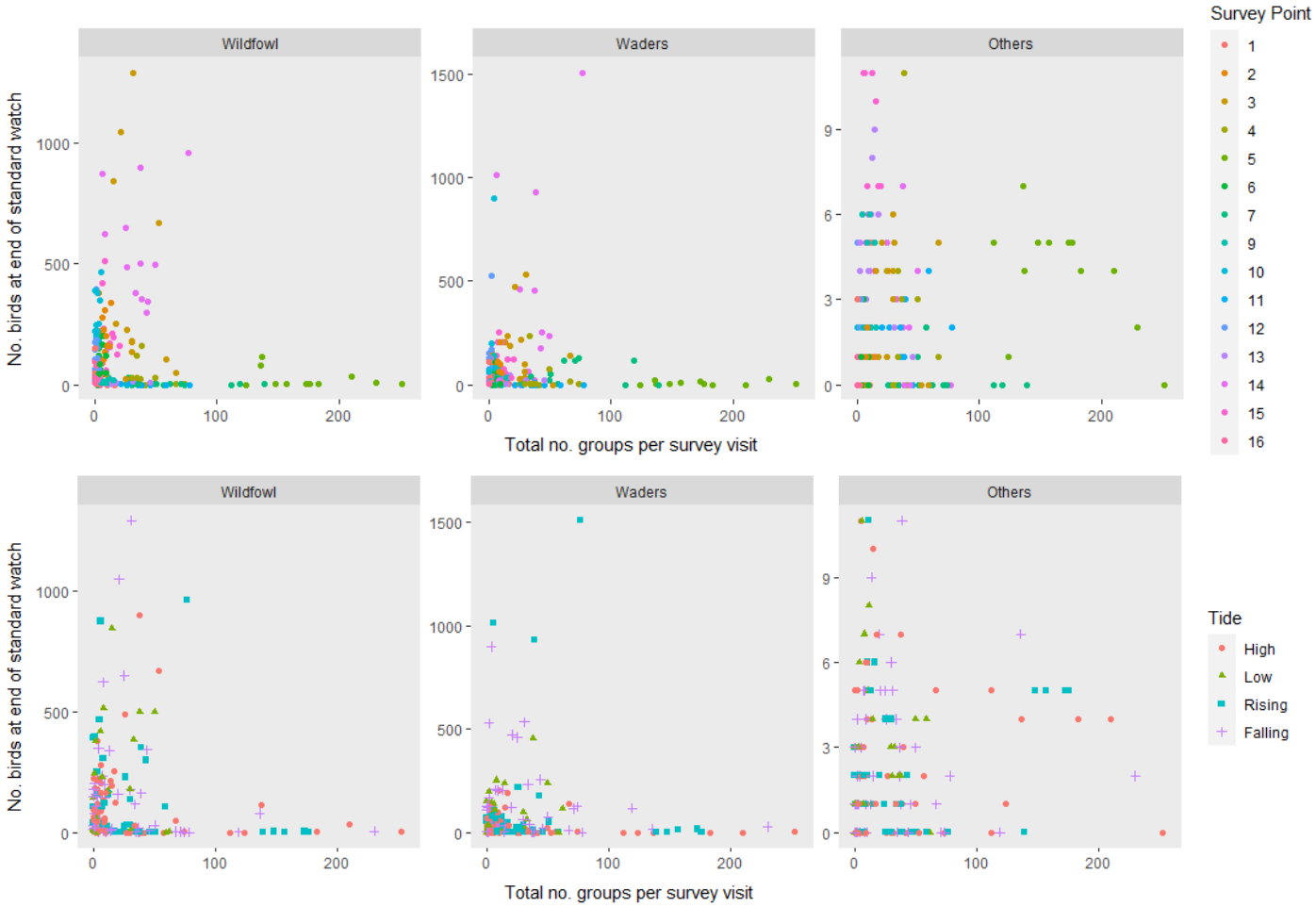


Figure 4: Number of birds present at the end of each standard watch survey (n=180) in relation to the total number of groups observed during the same survey, stratified by Survey Point (top row) and tide state (bottom row).

3.24 The coloured points in the top row of plots are generally clustered, indicating that the majority of survey locations consistently supported a similar number of species at the end of each standard watch, and were subject to a similar level of human disturbance. This pattern is again readily apparent for both waders and wildfowl, but it is less clear cut for other species.

3.25 The effect of the tide on bird numbers at the survey locations (bottom row of plots) is apparently more complex and will be potentially compounded by

other factors (including disturbance/activity levels). Nevertheless, the data suggests that larger numbers of both waders and wildfowl were observed on low, rising, and falling tides. Furthermore, the presence of larger numbers of other species (e.g. grebes and divers) at Parkstone Bay (Survey Point 5) in particular, may be due to the prevalence of surveys carried out there on high and rising tides.

Behavioural responses

3.26 Of the 5,358 individual activity events recorded across the entire survey period, 3,725 (70%) comprised potential disturbance events. A potential disturbance event occurred when birds were present within the focal area during a standard watch, and an activity was carried out within 200m of them (or when an activity was carried out >200m distant but had an obvious disturbance effect).

3.27 Across all survey locations, the 3,725 potential disturbance events observed generated a total of 9,708 species-specific behavioural observations (see Table 5). Of these, 8,994 (93%) resulted in no visible change to the birds' behaviour or any direct response. 12% of potential disturbance events therefore generated a behavioural response, with 5% leading to a major flight.

Table 5: Summary of response data across all survey locations (note that each potential disturbance event within the diary is treated as a unique event, and any event resulting in >1 response type is allocated to the most extreme (e.g. an event causing some birds to become alert, and others to take a short flight, would be classified as inducing a short flight response). Note that percentages have been rounded up to the nearest whole number.

Response	Number (%) of potential disturbance events	Number (%) of observations
No response	3,255 (88%)	8,994 (93%)
Alert	118 (4%)	188 (2%)
Walk/Swim	123 (4%)	174 (2%)
Short flight	73 (2%)	100 (2%)
Major flight	156 (5%)	252 (3%)
Total	**3,725 (100%)**	**9,708 (100%)**

3.28 Using these figures, we can calculate that there were, on average, 11.8 potential disturbance events/hour across all survey locations over the entire survey period. These events caused, on average, a single species response 2.3 times/hour during the same period, with a flight response (short or major) occurring approximately once an hour.

3.29 These response rates varied considerably between survey locations however (see Table 6), with Parkstone Bay (Survey Point 5) recording 81.7 potential disturbance events/hour compared to 0.2 events/hour at Cleaval Point (Survey Point 12). Whitley Lake (Survey Point 7) recorded the highest rate of single species responses (8.1 responses/hour) whereas Cleaval Point recorded only 0.3 responses/hour. Whitley Lake also recorded the highest rate of flight responses (2.3 responses/hour), followed closely by Holes Bay (UCP Hide) (Survey Point 14) with 2.2 responses/hour. Conversely, Holes Bay South (Survey Point 4) only recorded a flight response rate of 0.2 responses/hour across the length of the survey period.

Table 6: Hourly rates of potential disturbance and singles species/flight responses at each of the survey locations across the entire survey period. The largest value in each column is highlighted dark grey, the second largest in light grey, and the lowest is boldly italicised.

Survey location	Potential disturbance events/hr of survey	Single species response/hr of survey	Flight response/hr of survey
1 - Holton Lee	0.9	0.8	0.6
2 - Lytchett Bay	2.6	2.4	1.6
3 - Holes Bay North	15.6	5.3	1.5
4 - Holes Bay South	17.3	0.7	***0.2***
5 - Parkstone Bay	81.7	2.0	0.6
6 - Blue Lagoon	2.5	3.3	1.6
7 - Whitley Lake	24.7	8.1	2.3
9 - Bramble Bush Bay	2.6	2.2	1.8
10 - Brands Bay	0.6	0.7	0.6
11 - Middle Beach	0.5	0.4	0.3
12 - Cleaval Point	***0.2***	***0.3***	0.3
13 - Arne/Shipstal	3.2	1.6	1.0
14 - Holes Bay (UCP Hide)	18.3	3.5	2.2
15 - Holes Bay (railway)	5.6	0.8	0.8
16 - Lytchett Fields	1.1	1.9	1.4
Mean	**11.8**	**2.3**	**1.1**

3.30 Despite a larger number of responses being recorded In January, the proportion of each response recorded varied little between the three months of the survey (see Table 7), with a similar ratio to that observed in the combined dataset. Similarly, day type appeared to have little effect on the proportion of response types observed (see Table 8), with a similar number of responses recorded on weekdays and at the weekend.

Table 7: Summary of response data by month. Note that percentages have been rounded up to the nearest whole number.

Month	No response	Alert	Walk/Swim	Short flight	Major flight	Total
December	2,039 (92%)	30 (2%)	51 (3%)	22 (1%)	88 (4%)	**2,230 (100%)**
January	3,968 (94%)	109 (3%)	37 (1%)	40 (1%)	79 (2%)	**4,233 (100%)**
February	2,987 (93%)	49 (2%)	86 (3%)	38 (2%)	85 (3%)	**3,245 (100%)**
Total	**8,994 (93%)**	**188 (2%)**	**174 (2%)**	**100 (2%)**	**252 (3%)**	**9,708 (100%)**

Table 8: Summary of response data by day type. Note that percentages have been rounded up to the nearest whole number.

Day type	No response	Alert	Walk/Swim	Short flight	Major flight	Total
Weekday	4,649 (93%)	82 (2%)	110 (3%)	62 (2%)	118 (3%)	**5,021 (100%)**
Weekend	4,345 (93%)	106 (3%)	64 (2%)	38 (1%)	134 (3%)	**4,687 (100%)**
Total	**8,994 (93%)**	**188 (2%)**	**174 (2%)**	**100 (2%)**	**252 (3%)**	**9,708 (100%)**

Responses to activity types

3.31 The 9,708 species specific response observations are summarised by activity type in Figure 5, with activities organised in decreasing number of observations. Those activities with shorter green bars led to a higher proportion of disturbance responses, although the small sample size of many of the activities should nevertheless be noted.

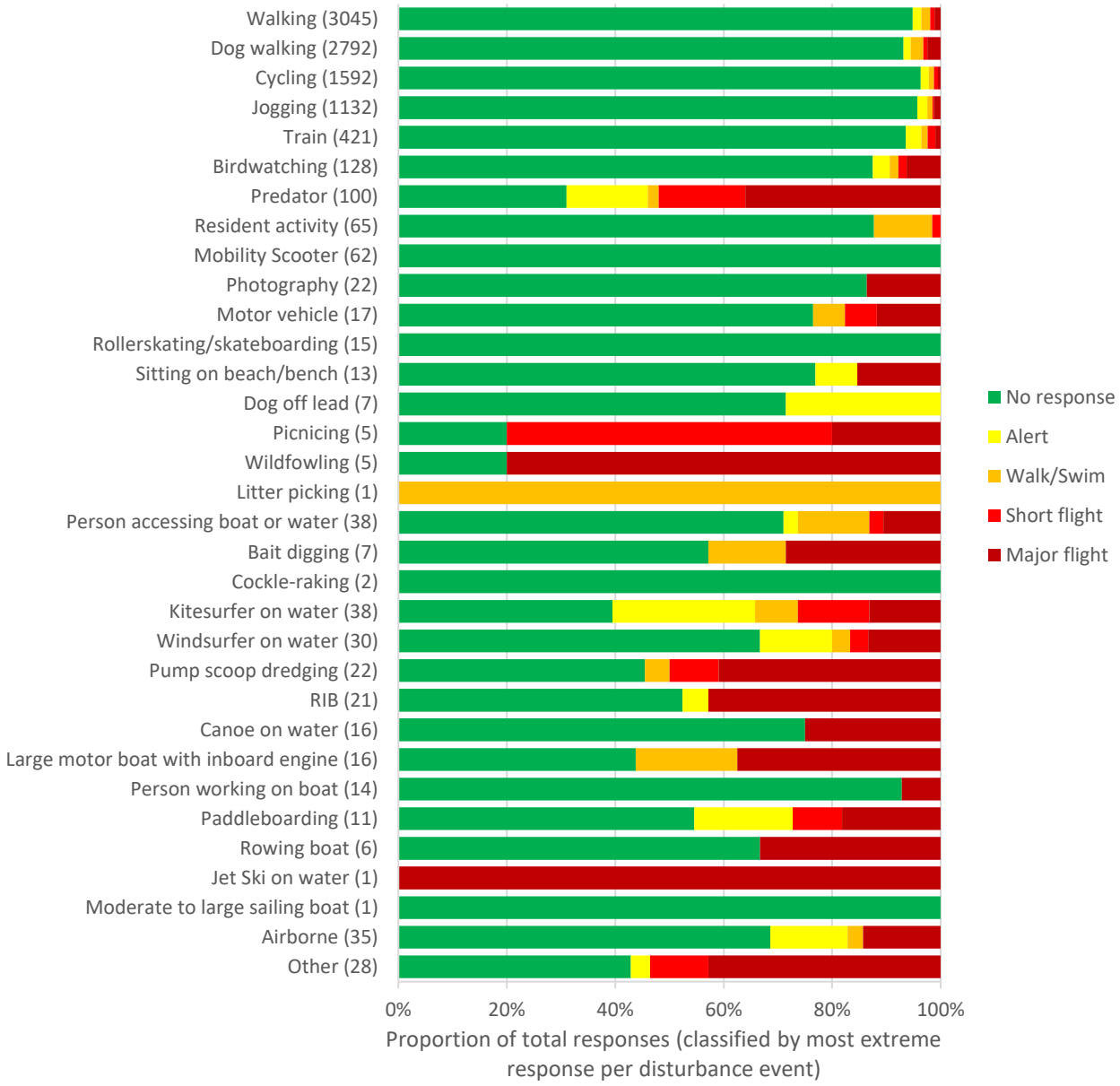


Figure 5: Responses of birds to differing activity types (all species across all locations). Activities are grouped into those which are predominantly based on the shoreline, then those on the intertidal area, water-based activities, airborne activities, and 'other'. The different activities are ranked by sample size (i.e. the number of species-specific observations) within each of the three categories (with sample size per activity type identified in parentheses).

3.32 For the most frequently recorded activities (walking, dog walking, cycling, and jogging) a relatively small proportion of potential disturbance events triggered a response from the birds. It is nevertheless important to recognise that walking, for example, still caused 157 species-specific disturbance events. It is furthermore evident that water-based activities, and those that included loud noises (e.g. wildfowling or aircraft), more frequently triggered

a behavioural response from any birds present. The proportion of extreme (flight) responses to predator presence are also interesting to contrast with the anthropogenic activities in the figure.

3.33 Table 9 provides a summary of observed flight events, including the total number of times that birds were flushed (i.e. combined short and major flights), stratified by activity type. The number of potential disturbance events indicates the frequency with which the activity was recorded. If all activities were similar in the responses they caused, then both the percentages of times birds were flushed and the percentage of times a major flight was recorded would be expected to be broadly similar to the percentage of potential disturbance events.

3.34 Walking accounted for 32% of potential disturbance events but accounted for only 22% of birds flushed and 14% of major flights. This indicates that each walking event caused disproportionately less flushing than might be expected. By contrast, dog walking led to the largest number of both major and combined flights (28% and 26% of the respective totals), which is broadly in line with the relative proportion potential disturbance events caused by dog walkers (29%). Notably also, dog walking only resulted in 9% of the total birds flushed.

3.35 Despite forming a relatively a low proportion of the activities recorded overall (1% or less), the following activities flushed a disproportionately large number of birds: airborne activity (6% of all birds flushed), canoeing (4%), kitesurfing (5%), people accessing boats or the water (3%), and 'other' activity (13%). The latter category includes birds flushed due to an unseen/unidentified agent, loud noises or gunfire, and workmen.

3.36 A similarly small number of infrequently recorded activities overall resulted in a higher observed frequency of major flight events. These comprised large motorboats (3% of major flights overall), pump scoop dredging (4%), RIBs (4%), and 'other' activities (5%).

3.37 The presence of predators was also a notable high impact activity type overall, in terms of both flush frequency (15% of major flights) and the number of birds flushed (24% of the birds observed flushed), despite predators accounting for only 2% of potential disturbance events overall.

Table 9: Summary of activity events resulting in potential disturbance events within focal areas, the total number of birds flushed, and the frequency of any flush event (included combined totals for short and major flights). The largest and second largest % values per row are highlighted in dark and light grey, respectively (rows with equal percentages are not marked). Note that percentages have been rounded up to the nearest whole number.

Activity type	Total number (%) birds flushed	Number (%) of times major flight recorded	Total number (%) of times birds flushed	Total number (%) of potential disturbance events
Airborne	492 (6%)	5 (2%)	5 (2%)	35 (1%)
Bait digging	7 (1%)	2 (1%)	2 (1%)	7 (1%)
Birdwatching	80 (1%)	8 (4%)	10 (3%)	128 (2%)
Canoe on water	288 (4%)	4 (2%)	4 (2%)	16 (1%)
Cockle-raking	0 (0%)	0 (0%)	0 (0%)	2 (1%)
Cycling	644 (7%)	8 (4%)	20 (6%)	1,592 (17%)
Dog walking	806 (9%)	69 (28%)	89 (26%)	2,792 (29%)
Jet ski on water	2 (1%)	1 (1%)	1 (1%)	1 (1%)
Jogging	301 (4%)	14 (6%)	17 (5%)	1,132 (12%)
Kitesurfer on water	378 (5%)	5 (2%)	10 (3%)	38 (1%)
Large motorboat with inboard engine > 10m	101 (2%)	6 (3%)	6 (2%)	16 (1%)
Litter picking	0 (0%)	0 (0%)	0 (0%)	1 (1%)
Mobility scooter	0 (0%)	0 (0%)	0 (0%)	62 (1%)
Moderate to large sailing boat, not running motor	0 (0%)	0 (0%)	0 (0%)	1 (1%)
Motor vehicle	15 (1%)	2 (1%)	3 (1%)	17 (1%)
Paddleboarding	11 (1%)	2 (1%)	3 (1%)	11 (1%)
Person accessing boat or water	232 (3%)	4 (2%)	5 (2%)	38 (1%)
Person working on boat	1 (1%)	1 (1%)	1 (1%)	14 (1%)
Photography	10 (1%)	3 (2%)	3 (1%)	22 (1%)
Picnicking	55 (1%)	1 (1%)	4 (2%)	5 (1%)
Predator	2,177 (24%)	36 (15%)	52 (15%)	100 (2%)
Pump scoop dredging	87 (1%)	9 (4%)	11 (4%)	22 (1%)
Resident activity	1 (1%)	0 (0%)	1 (1%)	65 (1%)

Activity type	Total number (%) birds flushed	Number (%) of times major flight recorded	Total number (%) of times birds flushed	Total number (%) of potential disturbance events
RIB or similar fast small boat	115 (2%)	9 (4%)	9 (3%)	21 (1%)
Rollerskating/ skateboarding	0 (0%)	0 (0%)	0 (0%)	15 (1%)
Rowing boat	4 (1%)	2 (1%)	2 (1%)	6 (1%)
Sitting on beach/bench	39 (1%)	2 (1%)	2 (1%)	13 (1%)
Train	146 (2%)	4 (2%)	10 (3%)	421 (5%)
Unaccompanied dog off lead	0 (0%)	0 (0%)	0 (0%)	7 (1%)
Walking	1,942 (22%)	35 (14%)	58 (17%)	3,045 (32%)
Wildfowling	66 (1%)	4 (2%)	4 (2%)	5 (1%)
Windsurfer on water	44 (1%)	4 (2%)	5 (2%)	30 (1%)
Other	1,181 (13%)	12 (5%)	15 (5%)	28 (1%)
Total	**9,225 (100%)**	**252 (100%)**	**352 (100%)**	**9,708 (100%)**

Variation between sites

3.38 The number of potential disturbance events, and the resultant response of birds present, varied between survey location (see Figure 6, Map 11, and Table 10). Some localities recorded relatively few potential disturbance events, with Holton Lee (Survey Point 1), Brands Bay (Survey Point 2), and Cleaval Point (Survey Point 12) recording 26, 22, and 9 events respectively.

3.39 Survey locations with a higher number of potential disturbance events (such as those within Parkstone and Holes Bay), tended to have a much lower proportion of bird responses, in comparison to those sites with fewer event observations. Southern sites in particular (e.g. those around the Studland coast) had a much larger number of flight responses proportional to the number of potential disturbance events observed there than at other locations within the wider survey area.

3.40 The observed differences between the responses of birds at the different survey locations is significant, when contrasting the proportion of all birds disturbed (i.e. combined response categories) against the proportion

showing no response ($X^2_{10} = 1652.9$; $p<0.001$). Note that data from Survey Points 1 and 10 to 12 have been omitted due to their small sample sizes.

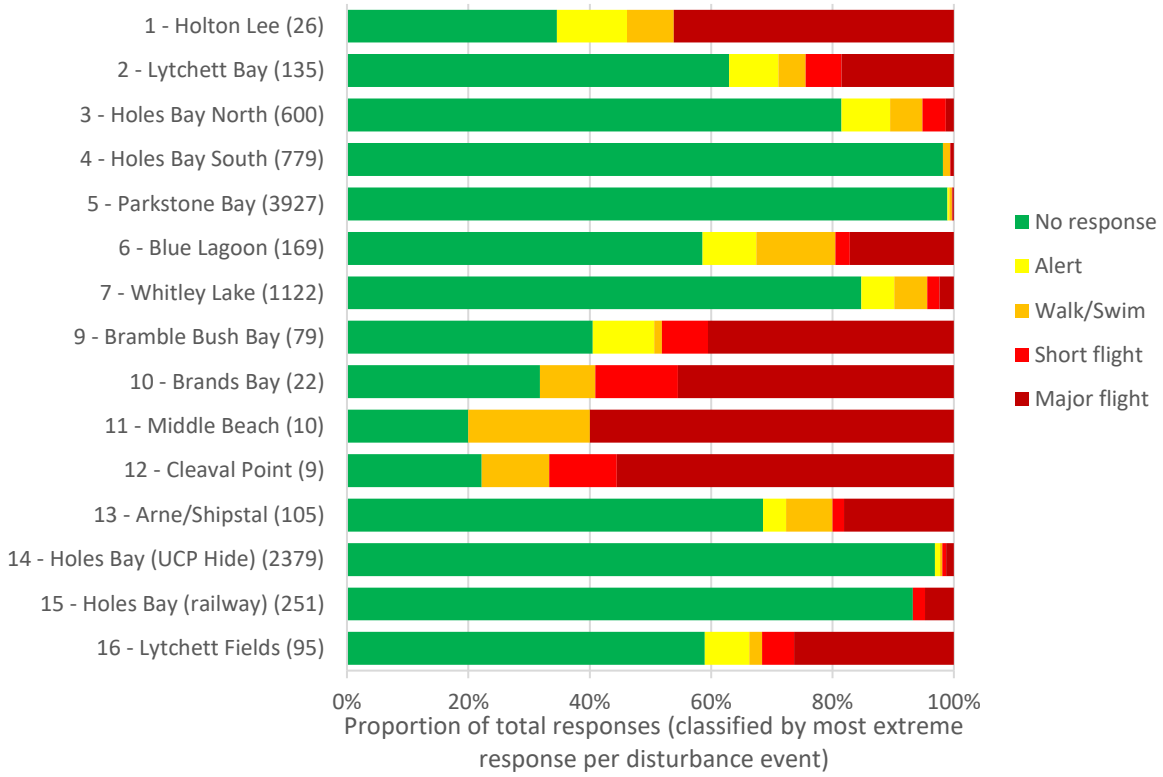


Figure 6: Responses of birds at each survey location (all species across all activity types). Sample sizes at each survey point are identified in parentheses.

Map 11: Bird responses at each survey location, plotted as responses per hour (chart sizes scaled relative to the cumulative number of responses per hour across all categories at each locality)

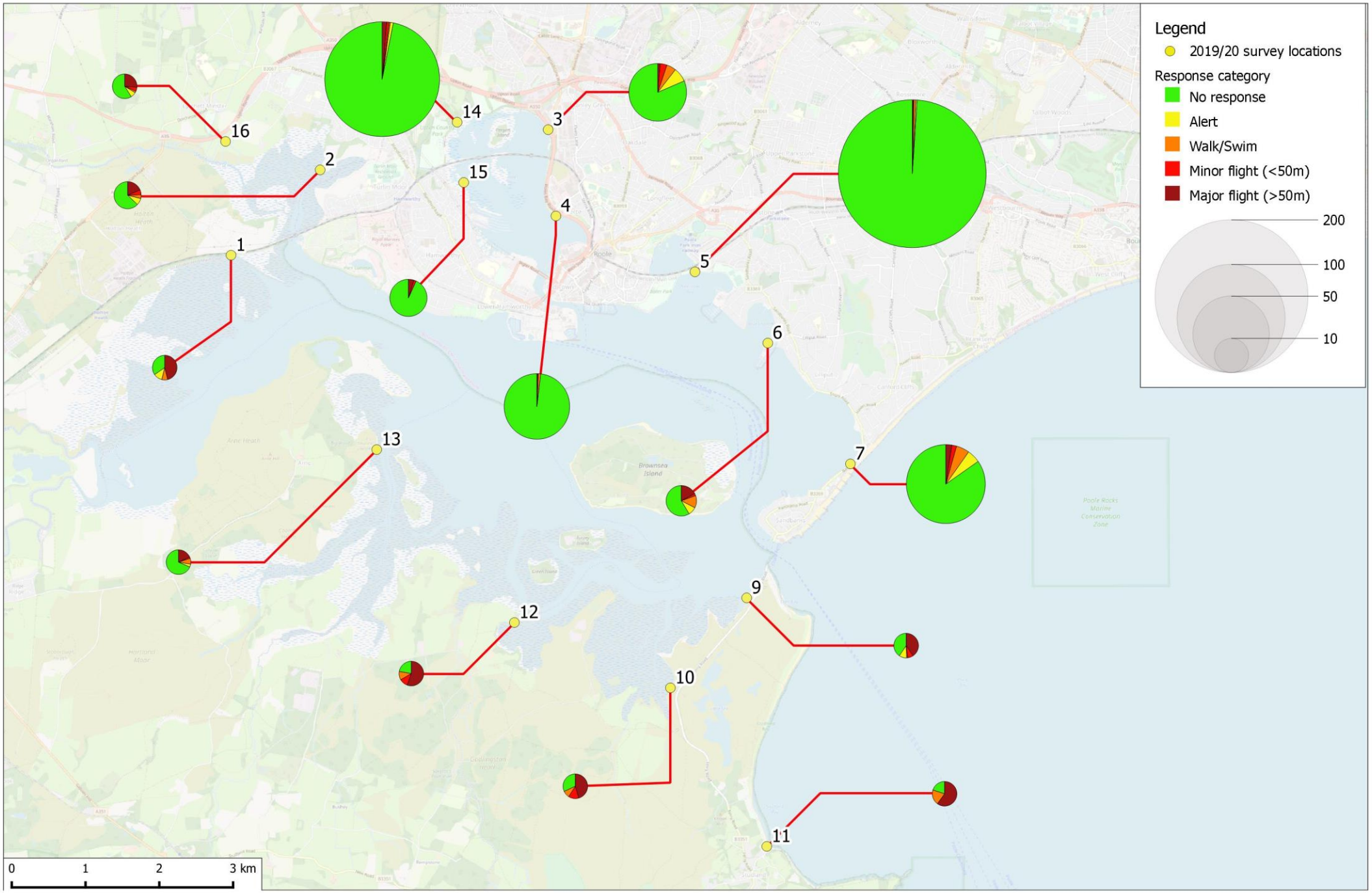


Table 10: Summary of responses by survey location. Column percentage is shown for total number of flights. Note that percentages have been rounded up to the nearest whole number.

Survey location	No response	Alert	Walk/Swim	Short flight	Major flight	Total	Total number of flights	Flights per hour of survey (21hrs for all locations)
1 - Holton Lee	9 (35%)	3 (12%)	2 (8%)	0 (0%)	12 (47%)	26 (100%)	12 (4%)	0.57
2 - Lytchett Bay	85 (63%)	11 (9%)	6 (5%)	8 (6%)	25 (19%)	135 (100%)	33 (10%)	1.57
3 - Holes Bay North	489 (82%)	48 (8%)	32 (6%)	23 (4%)	8 (2%)	600 (100%)	31 (9%)	1.48
4 - Holes Bay South	765 (99%)	0 (0%)	9 (2%)	1 (1%)	4 (1%)	779 (100%)	5 (2%)	0.24
5 - Parkstone Bay	3,886 (99%)	11 (1%)	18 (1%)	4 (1%)	8 (1%)	3,927 (100%)	12 (4%)	0.57
6 - Blue Lagoon	99 (59%)	15 (9%)	22 (14%)	4 (3%)	29 (18%)	169 (100%)	33 (10%)	1.57
7 - Whitley Lake	951 (85%)	61 (6%)	61 (6%)	22 (2%)	27 (3%)	1122 (100%)	49 (14%)	2.33
9 - Bramble Bush Bay	32 (41%)	8 (11%)	1 (2%)	6 (8%)	32 (41%)	79 (100%)	38 (11%)	1.81
10 - Brands Bay	7 (32%)	0 (0%)	2 (10%)	3 (14%)	10 (46%)	22 (100%)	13 (4%)	0.62
11 - Middle Beach	2 (20%)	0 (0%)	2 (20%)	0 (0%)	6 (60%)	10 (100%)	6 (2%)	0.29
12 - Cleaval Point	2 (23%)	0 (0%)	1 (12%)	1 (12%)	5 (56%)	9 (100%)	6 (2%)	0.29
13 - Arne/Shipstal	72 (69%)	4 (4%)	8 (8%)	2 (2%)	19 (19%)	105 (100%)	21 (6%)	1.00
14 - Holes Bay (UCP Hide)	2,305 (97%)	20 (1%)	8 (1%)	16 (1%)	30 (2%)	2,379 (100%)	46 (14%)	2.19
15 - Holes Bay (railway)	234 (94%)	0 (0%)	0 (0%)	5 (2%)	12 (5%)	251 (100%)	17 (5%)	0.81
16 - Lytchett Fields	56 (59%)	7 (8%)	2 (3%)	5 (6%)	25 (27%)	95 (100%)	30 (9%)	1.43
Total	**8,994 (93%)**	**188 (2%)**	**174 (2%)**	**100 (2%)**	**252 (3%)**	**9,708 (100%)**	**352 (100%)**	**16.76**

3.42 We summarise major flight responses by activity in Table 11. The grey coloured values highlight localities at which at least 10 instances of the respective activity were recorded. For several of the survey locations where frequent occurrences of a particular activity were observed relatively few of them resulted in a major flight (e.g. cyclists, joggers, and windsurfers).

3.43 Nevertheless, several other activities, either consistently or at specific survey locations, resulted in a proportionately larger number of major flight events:

- Airborne activity at Lytchett Fields (Survey point 16: 10% of observations, all of which comprised either coastguard or military helicopter activity);
- Birdwatchers at Bramble Bush Bay (Survey Point 9: 30% of observations) and Lytchett Fields (11% of observations);
- Dog walkers at many sites, including at Blue Lagoon (Survey Point 6: 41% of observations), Bramble Bush Bay (44% of observations), Brands Bay (Survey Point 10: 20% of observations), and Arne/Shipstal (Survey Point 13: 14% of observations);
- Kitesurfers and people accessing the water at Whitley Lake (Survey Point 7: both 13% of respective observations);
- Pump scoop dredgers in Lytchett Bay (Survey Point 2: 42% of observations), and;
- Walkers in Lytchett and Bramble Bush Bays (13% and 50% of observations, respectively).

3.44 Contextually, predator presence also caused a high proportion of major flush responses at all sites where it was recorded.

Table 11: Percentage of potential disturbance events at each survey location resulting in a major flight across all species, organised by activity type. Activities which did not result in any major flight responses are excluded, and grey shading indicates those localities with at least 10 observations of the relevant activity type and boldly italicised figures indicate values of 50% or more for the given combination of activity type and survey location.

Activity type	Percentage of potential disturbance events at each Survey Point resulting in a major flight															Total potential disturbance events
	1 – Holton Lee	2 – Lytchett Bay	3 – Holes Bay North	4 – Holes Bay South	5 – Parkstone Bay	6 – Blue Lagoon	7 – Whitley Lake	9 – Bramble Bush Bay	10 – Brands Bay	11 – Middle Beach	12 – Cleaval Point	13 – Arne/ Shipstal	14 – Holes Bay (UCP Hide)	15 – Holes Bay (railway)	16 – Lytchett Fields	
Airborne		25													10	35
Bait digging					***50***											7
Birdwatching		33						30				7			11	128
Canoe on water							33					***100***				16
Cycling			<0.5	<0.5				***50***					2			1,592
Dog walker	33	9	2		<0.5	41	4	44	20	***75***		14	1	4		2,792
Jet ski on water								***100***								1
Jogging				1			1						4			1,132
Kitesurfer on water							13									38
Large motorboat with inboard engine	***60***							***67***				25				16
Motor vehicle						29										17
Paddleboard												***100***				11
Person accessing boat or water							13									38

Activity type	Percentage of potential disturbance events at each Survey Point resulting in a major flight															Total potential disturbance events
	1 – Holton Lee	2 – Lytchett Bay	3 – Holes Bay North	4 – Holes Bay South	5 – Parkstone Bay	6 – Blue Lagoon	7 – Whitley Lake	9 – Bramble Bush Bay	10 – Brands Bay	11 – Middle Beach	12 – Cleaval Point	13 – Arne/ Shipstal	14 – Holes Bay (UCP Hide)	15 – Holes Bay (railway)	16 – Lytchett Fields	
Person working on boat				***50***												14
Photography												38				22
Picnicking								25								5
Predator		18	33			27					***75***		***60***		49	100
Pump scoop dredging	***57***	42														22
RIB or similar fast small boat	***100***							25				***83***		***50***		21
Rowing boat														33		6
Sitting on beach/bench									***100***							13
Train													1	2		421
Walking		13	3	<0.5	<0.5		1	***50***		***100***		4	<0.5	7		3,045
Wildfowling		***80***														5
Windsurfer on water	***100***						4									30
Other								***100***	***100***	***100***	***100***		13			28

3.45 Figure 7 shows the amount of behavioural responses observed at different locations in relation to the amount of access recorded. The plots separately depict the relationship between the flush rate (i.e. the number of birds caused to fly per hour) and the percentage of potential disturbance events causing birds to take flight against both the number of groups and the number of potential disturbance events per hour, with each point corresponding to a single survey point. The relationship between flush rate and both depicted access/disturbance metrics was non-significant. A significant relationship was however identified between the percentage number of potential disturbance events resulting in a flight response and both number of groups and potential disturbance events per hour ($S = 950.1$, p-value = <0.01 and $S = 1105.5$, p-value = <0.01, respectively).

3.46 This indicates that at the locations with higher levels of activity taking place (e.g. Survey Point 5 - Parkstone Bay and Survey Point 14 - Holes Bay (UCP Hide)), the proportion of events causing birds to take flight was lower. This could potentially be due to a range of factors as, for example, busier locations tended to be characterised by particular types of (mainly shore-based) activity, and the numbers of birds were often low and the species involved varied.

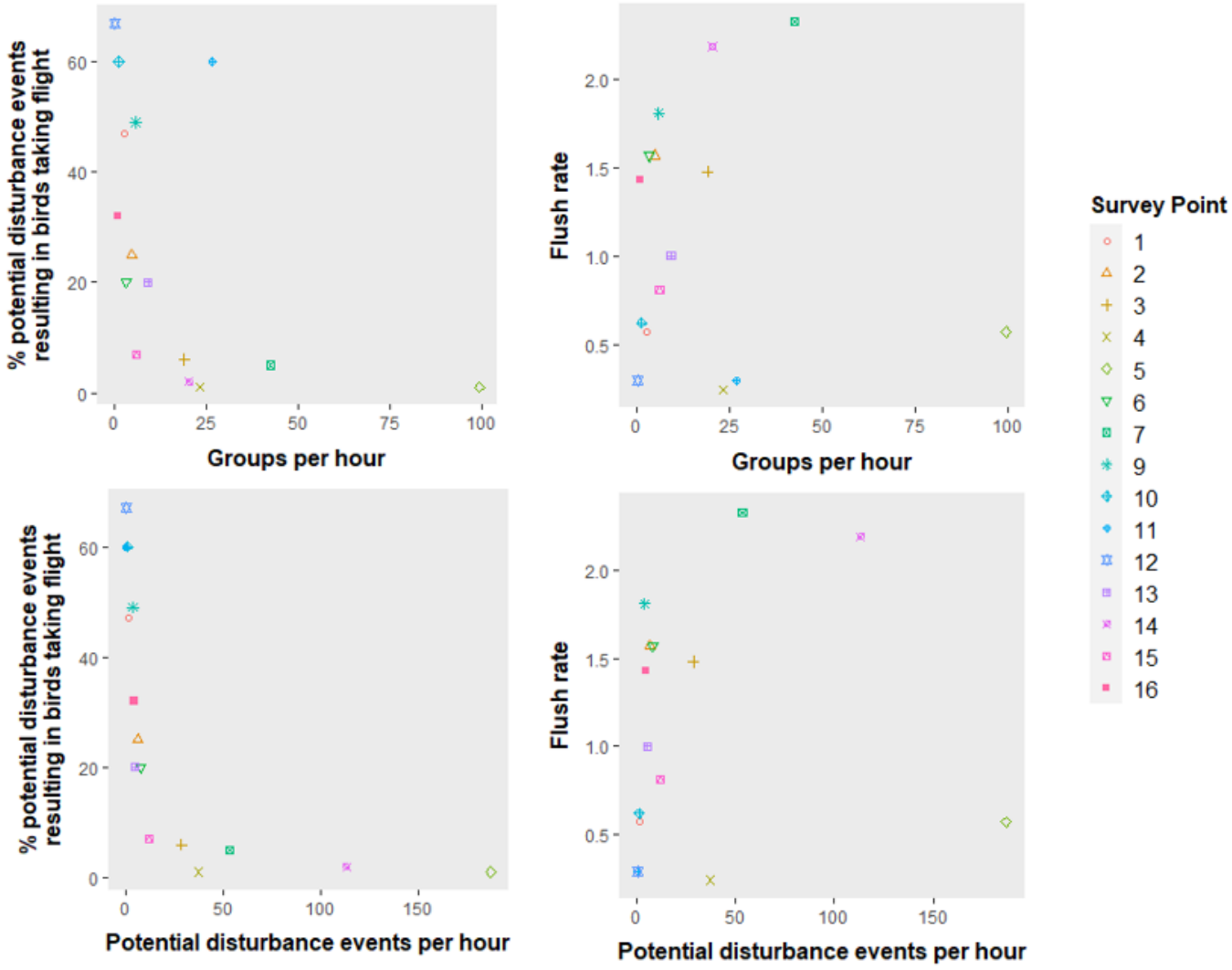


Figure 7: Disturbance in relation to access levels, using % of potential disturbance events resulting in birds taking flight and flush rate (number of flights per hour) as metrics. The response of the two metrics is shown for both the number of groups per hour and the total number of potential events per hour at each survey location.

Response by species

3.47 Figure 8 summarises the proportional response by those species with at least 25 observations to all potential disturbance events across the entire survey period. All of the species exhibited a disturbance response to <80% of potential disturbance events. Wigeon exhibited the largest proportion of responses overall (18%), with Oystercatcher (11%), Curlew (11%), Turnstone *Arenaria interpres* (11%), and Dunlin (10%) exhibiting a slightly lower proportion of responses. The largest proportional flush response (both short and major flights) was shown by Dunlin (10%), Turnstone (7%), and

Greenshank *Tringa nebularia* (7%). Goldeneye *Bucephala clangula* (<0.5%), Shoveler *Anas clypeata* (2%), and Pintail *A. acuta* (2%) exhibited the lowest relative proportional responses overall, with neither Tufted duck nor Canada Goose *Branta canadensis* showing any responses whatsoever.

3.48 Map 12 depicts the hourly flush rate per species at each survey location across the entire survey period (including those caused by predators), allowing for direct comparison between sites (i.e. the larger the pie chart, the more individuals were flushed). It shows that by far the largest number of birds overall were flushed from Holes Bay (UCP Hide) (Survey Point 14) with other large flush rates seen at Whitley lake (Survey Point 7), Brands Bay (Survey Point 10), and Lytchett Fields (Survey Point 16). Relatively small numbers of birds were flushed from Holes Bay South (Survey Point 4), Parkstone Bay (Survey Point 5), and Middle Beach (Survey Point 11).

3.49 Furthermore, there was a large degree of variation in the proportion of each species flushed at each survey location, with Black-tailed Godwit dominant at Holes Bay (UCP Hide), and Wigeon at Holton Lee (Survey Point 1), Lytchett Bay (Survey Point 2), and Brands Bay (Survey Point 10). Dark-bellied Brent Goose comprised the largest proportion of flushes at Blue Lagoon (Survey Point 6), Cleaval Point (Survey Point 12), and Arne/Shipstal (Survey Point 13), whereas Oystercatcher did at Parkstone Bay, Bramble Bush Bay (Survey Point 9), and Middle Beach. Bar-tailed Godwit was the main species flushed at Whitley Lake (Survey Point 7), and Lapwing at Lytchett Fields, with proportionately large numbers of Teal also flushed at Holton Lee, Holes Bay South, Cleaval Point, and Arne/Shipstal.

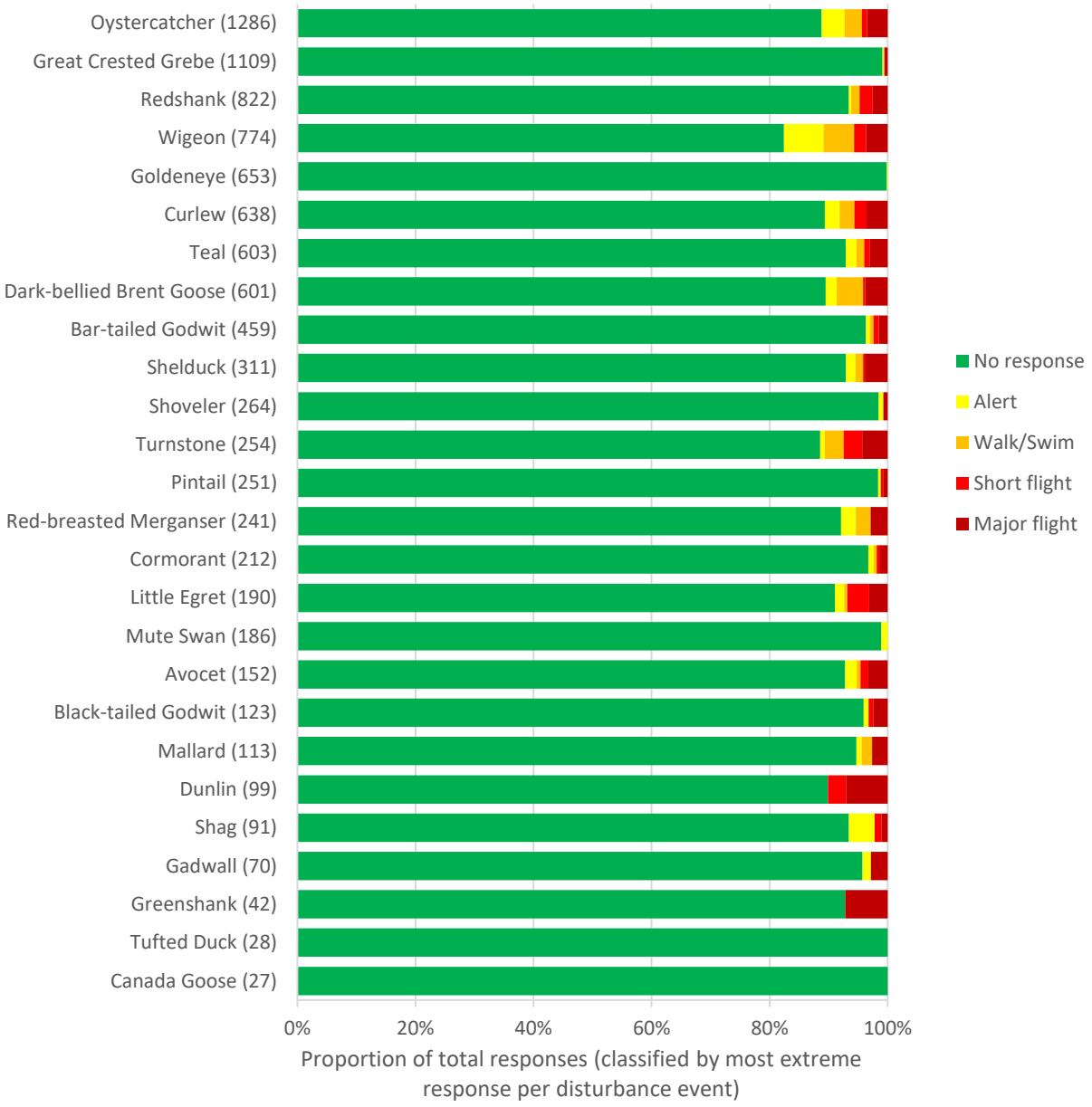
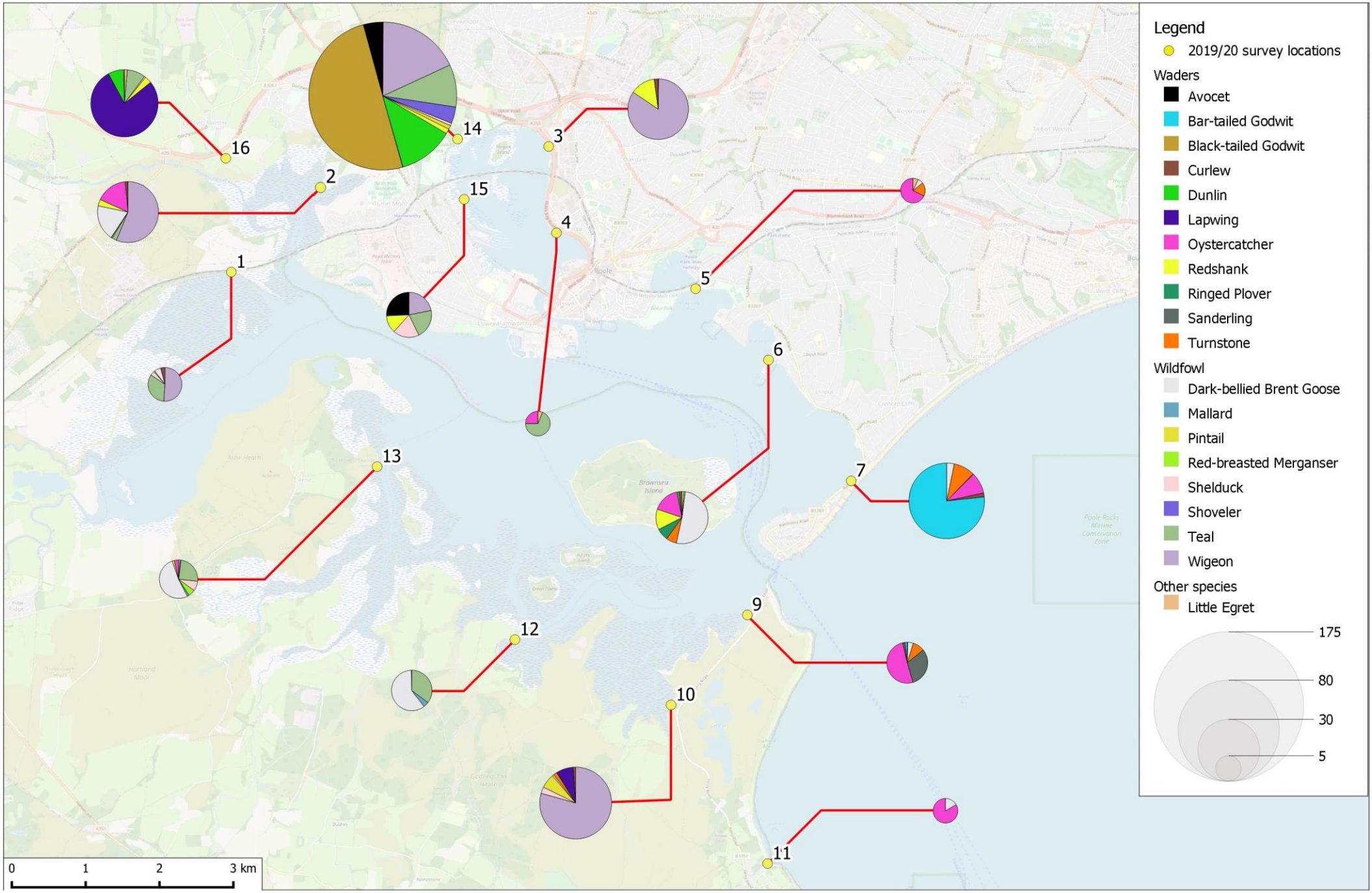


Figure 8: Response to disturbance events by individual species across all survey locations. Only species with 25+ response observations are shown, and percentage responses are calculated using the total number of potential disturbance events recorded for each.

Map 12: Number of birds flushed per hour across all survey visits at each survey location (only species with at least 10 individuals observed flushed on at least 1 survey visit are depicted)



Distances displaced and time lost

3.50 Of the potential disturbance events recorded across all survey locations, 261 resulted in a major flight response (involving 7,146 individual birds). The distance that the birds were displaced (i.e. moved away from their original position) was estimated for 224 of these observations. The mean displacement distance across the 224 distances recorded was 286.9m. Birds were seen to fly out of view as a result of several of the major flights observed, and the displacement distance for these observations could not be assessed. Similarly, due to the distances involved, a proportion of the distance estimates consisted of distance bands. The midpoint of any distance band estimate has therefore been used in subsequent analyses and data presentation.

3.51 The recorded distances are displayed by species in Figure 9. Median displacement distance ranged from 50m for Spotted Redshank to 650m for Shoveler (although both based on very small samples). For those species for which >10 observations were made, displacement distance ranged from 100m for Redshank to 375m for Dark-bellied Brent Goose. Dark-bellied Brent Goose, Oystercatcher, and Turnstone were all seen to be displaced by 1km on at least a single occasion, with a single displacement of Curlew by 1400m comprising the largest observed distance in the dataset.

3.52 Displacement distances also varied between survey location (see Figure 10). Holton Lee (Survey Point 1), Parkstone Bay (Survey Point 5), and Holes Bay (railway) (Survey Point 15) shared the largest median displacement distances of 500m, whilst Lytchett Fields (Survey Point 16) recorded the smallest at 100m. Across all displacements recorded, Holton Lee recorded the greatest distance of 1400m, whereas Brands Bay (Survey Point 10) and Cleaval Point (Survey Point 12) both recorded major flight events which resulted in no displacement whatsoever. Lytchett Bay (Survey Point 2) and Whitley Lake (Survey Point 7) also both recorded displacements of 1000m on at least a single occasion.

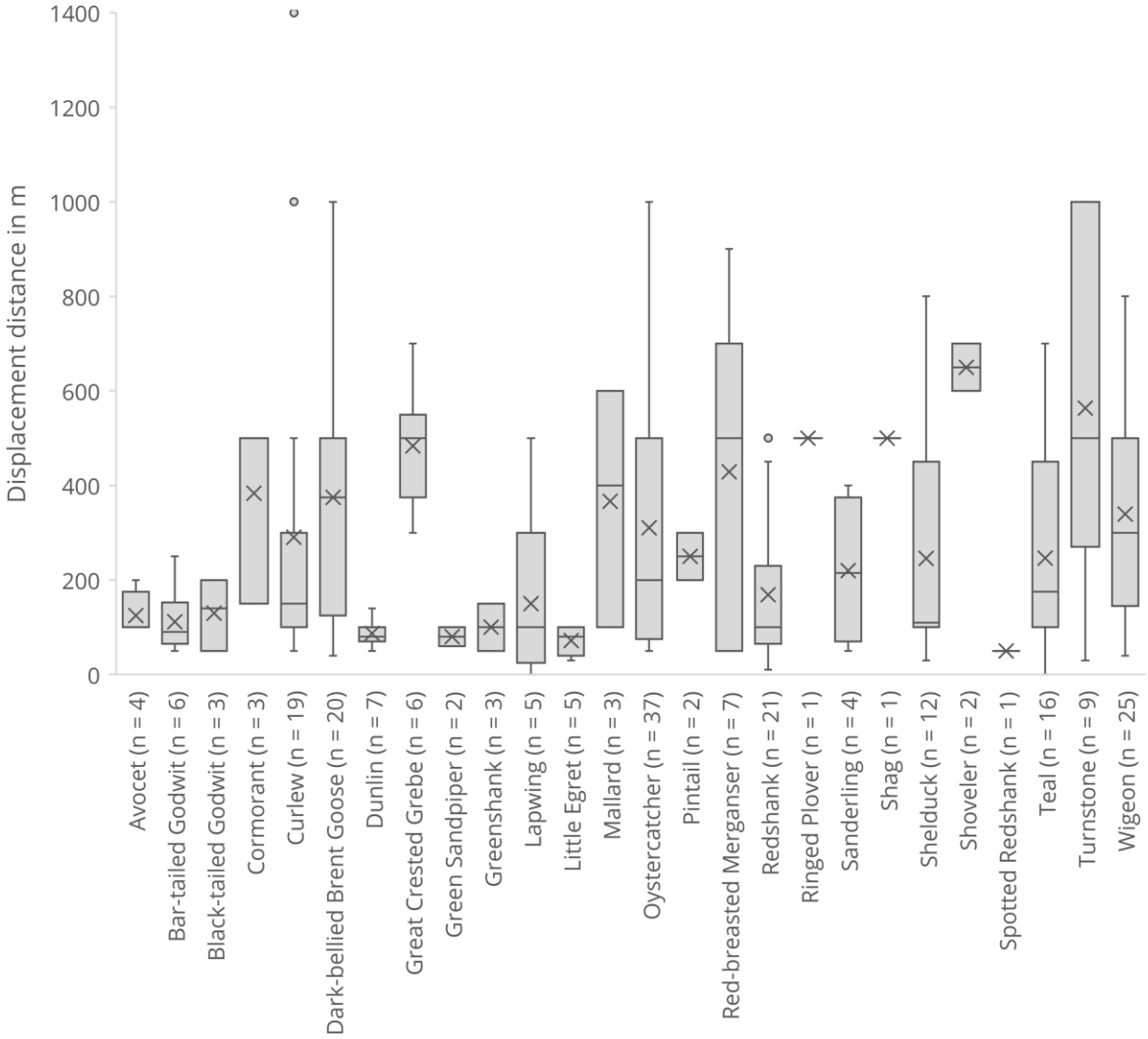


Figure 9: Variation in displacement after a major flight event for all species for which distances were recorded across all survey locations (number of observations per species provided in parentheses). Note that some extreme displacements (whereby birds were flushed out of view of the surveyor) will not be included in the dataset. Median values are indicated by a solid line, mean values by a cross, and outlier values by isolated points.

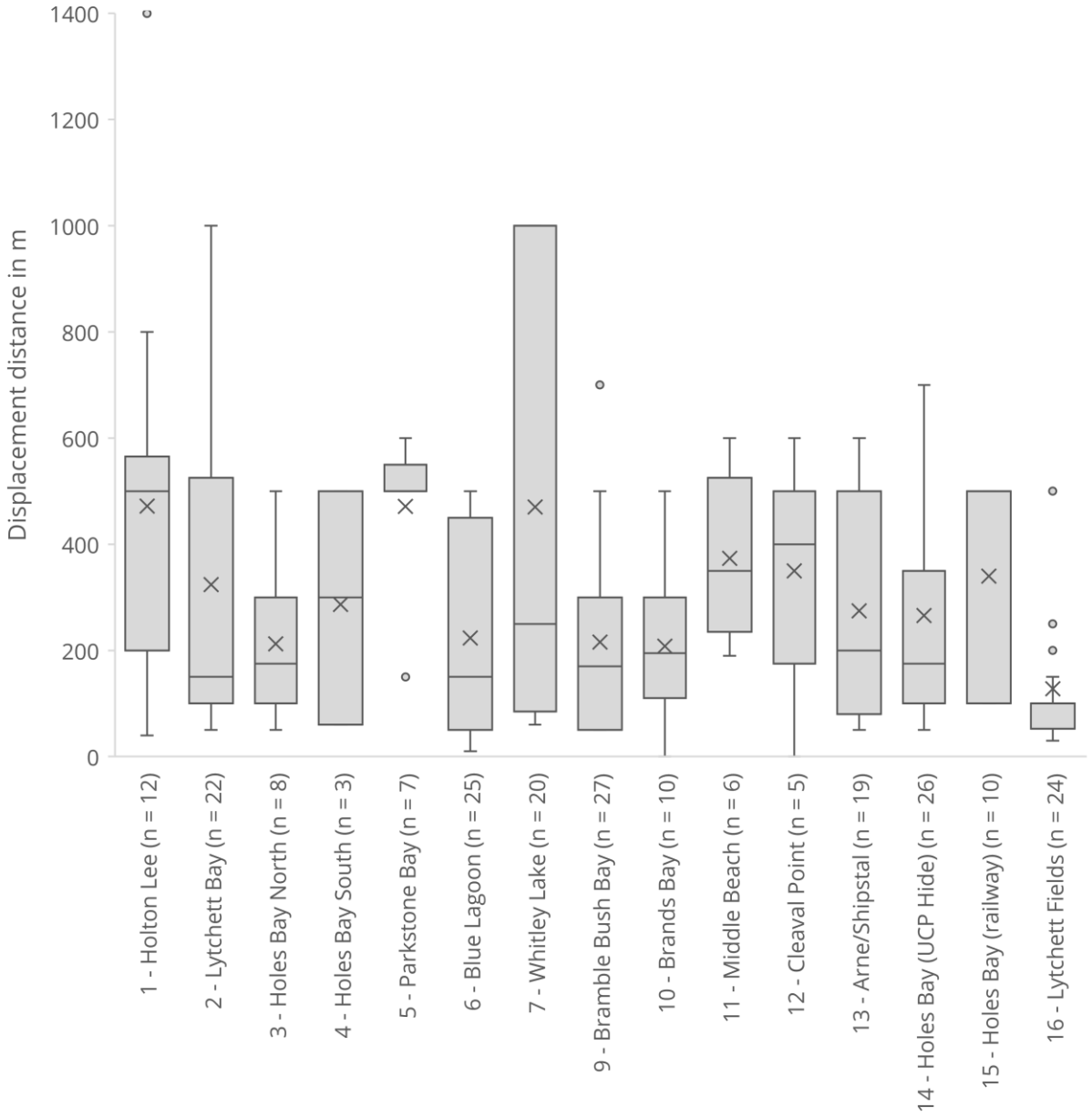


Figure 10: Variation in displacement between survey locations for all species after a major flight for which distances were recorded (number of observations per location provided in parentheses). Note that some extreme displacements (whereby birds were flushed out of view of the surveyor) will not be included in the dataset. Median values are indicated by a solid line, mean values by a cross, and outlier values by isolated points.

3.53 The distances birds were displaced following a major flight also varied between broad activity categories. Figure 11 displays these distances, with trains, aircraft, non-assigned activity types ("other"), and predator presence classified separately. It is important to note that the broad categories do not necessarily represent the exact location of the individual activity upon the coastal gradient (i.e. on the shoreline, intertidal area, or water) at the time of the potential disturbance event.

3.54 Aircraft and watersports activities displaced birds the greatest distance (both with median distances of 500m), whereas trains induced the shortest displacement (median distance of 90m). Within the broad groupings, dog walking and walking (the two most commonly recorded activity types in the diary dataset) exhibited median displacement distances of 190m and 300m, respectively. Low sample sizes are nevertheless prevalent across the broad categories, and this may signify that birds frequently flew out of view.

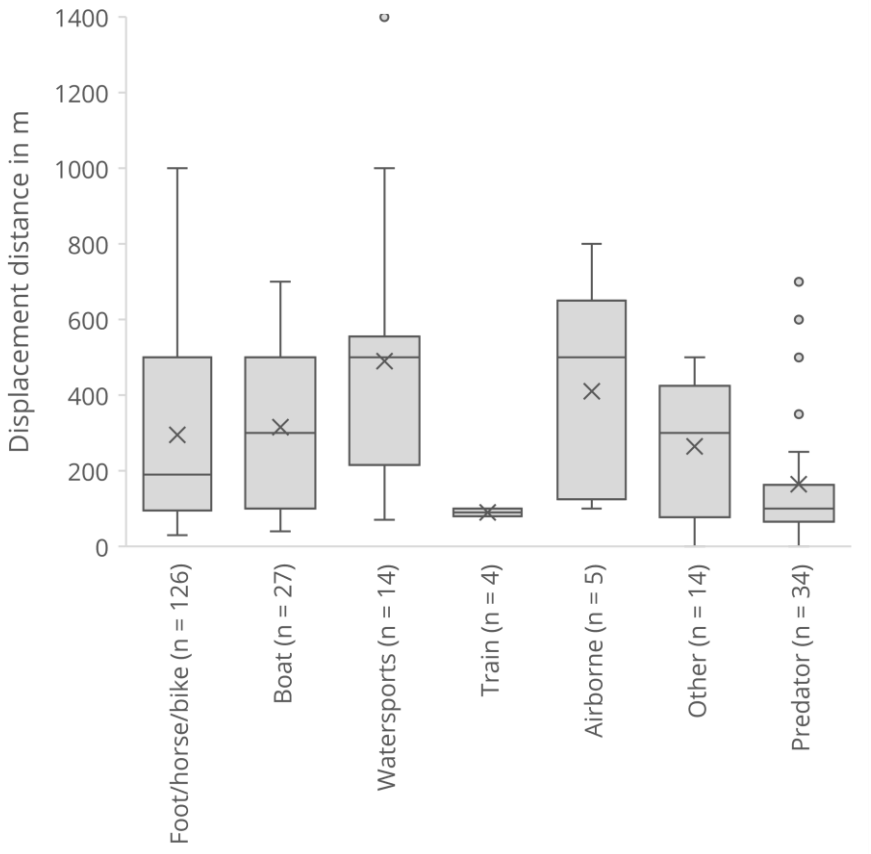


Figure 11: Variation in displacement between broad activity category for all species after a major flight for locations for which distances were recorded (number of observations per broad activity grouping in parentheses). Note that some extreme displacements (whereby birds were flushed out of view of the surveyor) will not be included in the dataset. Median values are indicated by a solid line, mean values by a cross, and outlier values by isolated points.

3.55 Difficulties associated with the non-return of flushed birds, and in identifying those individual returning birds/flocks that did, means that establishing the amount of time lost to birds by a major flight is not straightforward. Nevertheless, it was possible to record the amount of time taken for normal behaviour to resume for birds identified during 149 separate major flight events, comprising 5,549 individuals (see Figure 12). This ranged from 10 seconds to 13 minutes, with the birds in 91% of observations taking less than two minutes to resume normal behaviour.

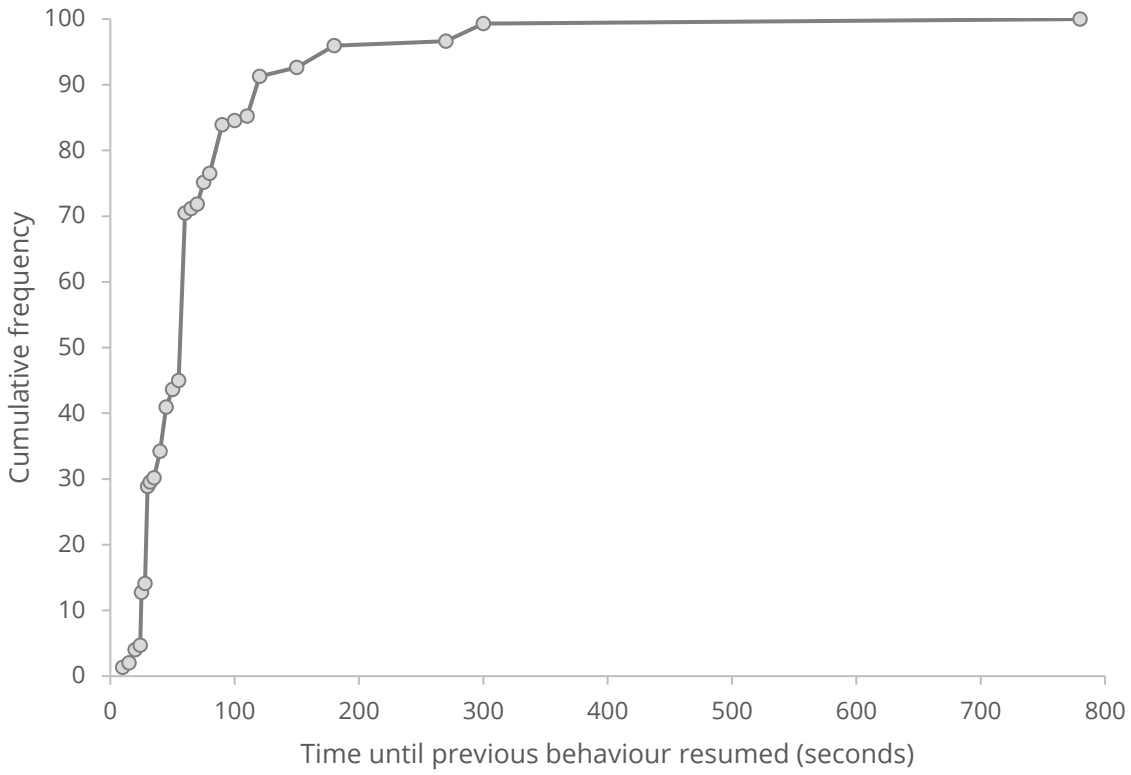


Figure 12: Time taken for birds to resume their previous behaviour after a major flight, using data from 149 individual observations and expressed as a cumulative percentage.

Wider Area Counts

Bird distribution

3.56 Maps 13a to 13e depict the results of the Wider Area Counts carried out at the end of each Standard Watch. Maps 13a and 13b display the distributions of the grebe species observed, Maps 13c to 13e show the locations of duck

species, and Map 13f depicts the localities at which divers and auks were noted.

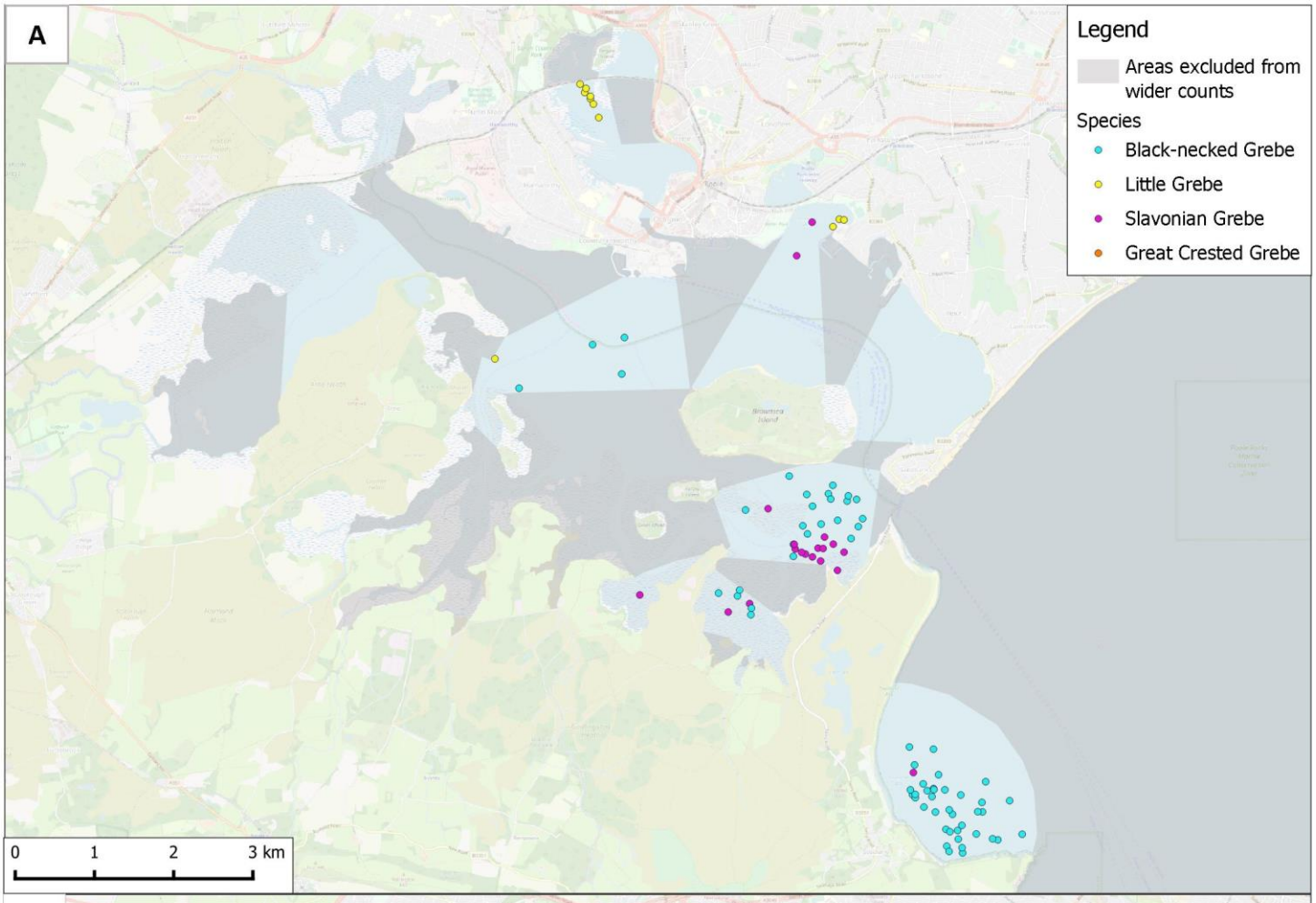
3.57 Great Crested Grebe *Podiceps cristatus* was the most commonly observed grebe species, recorded across the majority of the Wider Area Count survey areas. Black-necked Grebes *P. nigricollis* were concentrated in Studland Bay and between Bramble Bush Bay and the southern side of Brownsea Island, with a smaller number of observations from Brands Bay and the central harbour area. Slavonian Grebes *P. auritus* were also most frequently observed between Bramble Bush Bay and Brownsea Island, with a smaller number of records from Parkstone, Brands, Studland, and Newton Bays. Observations of Little Grebe *Tachybaptus ruficollis* were concentrated along the north-western edge of Holes Bay and in Parkstone Bay.

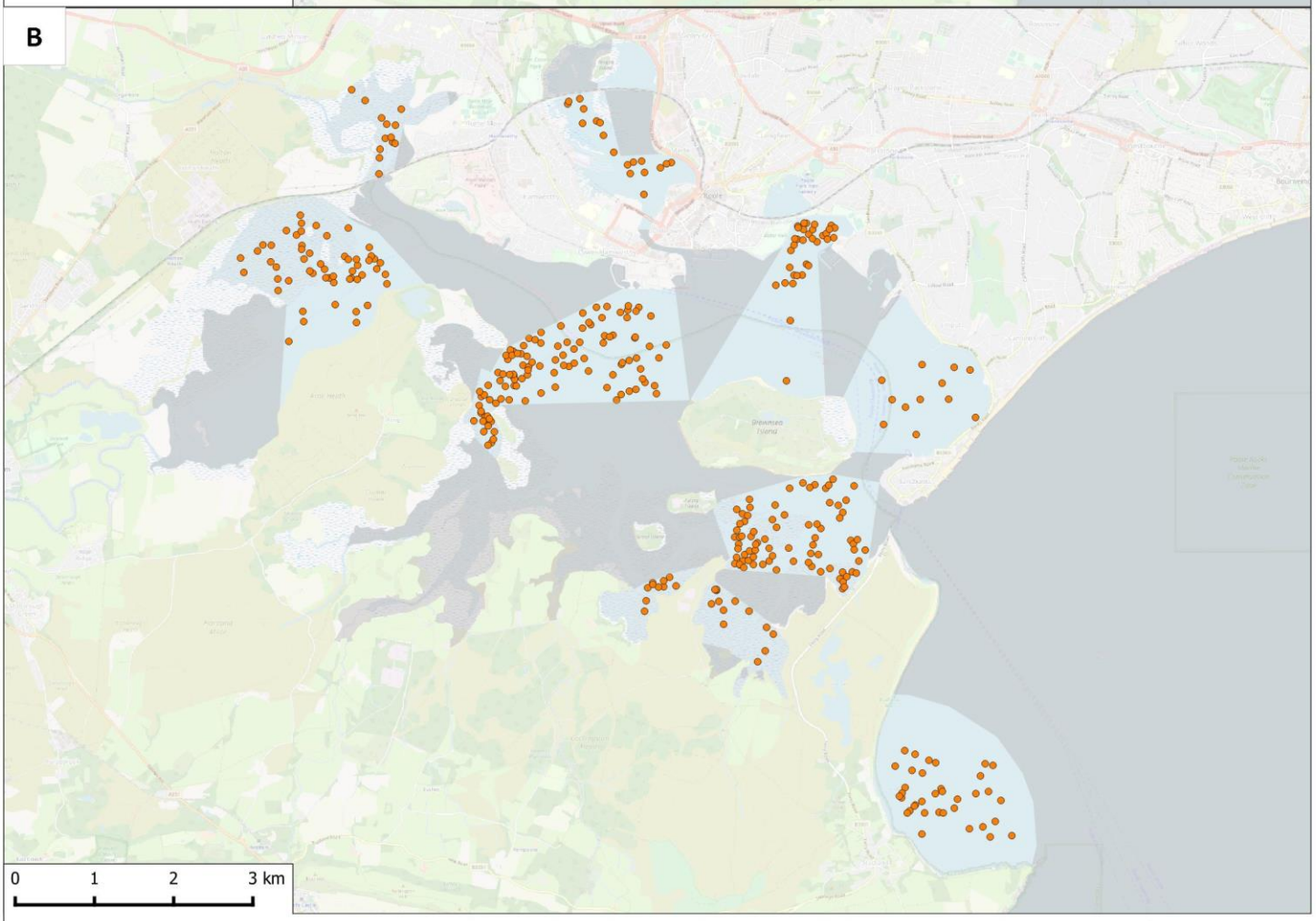
3.58 Red-breasted Merganser were widely and regularly recorded across the majority of the Wider Area Count survey areas, whereas Goldeneye were much less frequently observed. The latter species was most commonly recorded from within the central harbour area, in Bramble Bush, Brands, and Parkstone Bays, and off the mouth of the Wareham Channel. Of the scarcer duck species record, Scaup and Long-tailed Duck *Clangula hyemalis* were restricted to a handful of observations in Holes and Bramble Bush Bays, respectively. Common Scoter were also recorded from the Bramble Bush/Brands Bay area, although the species was far more frequently observed in Studland Bay.

3.59 Great Northern Diver *Gavia immer* was the only diver species recorded during the 2019/20 surveys and was recorded in small numbers across the majority of the Wider Area Count survey area. Concentrations of observations were however apparent in the Bramble Bush/Brands Bay area, and within Parkstone and (the southern part) of Holes Bays. A single record of Razorbill *Alca torda* was made from Studland Bay.

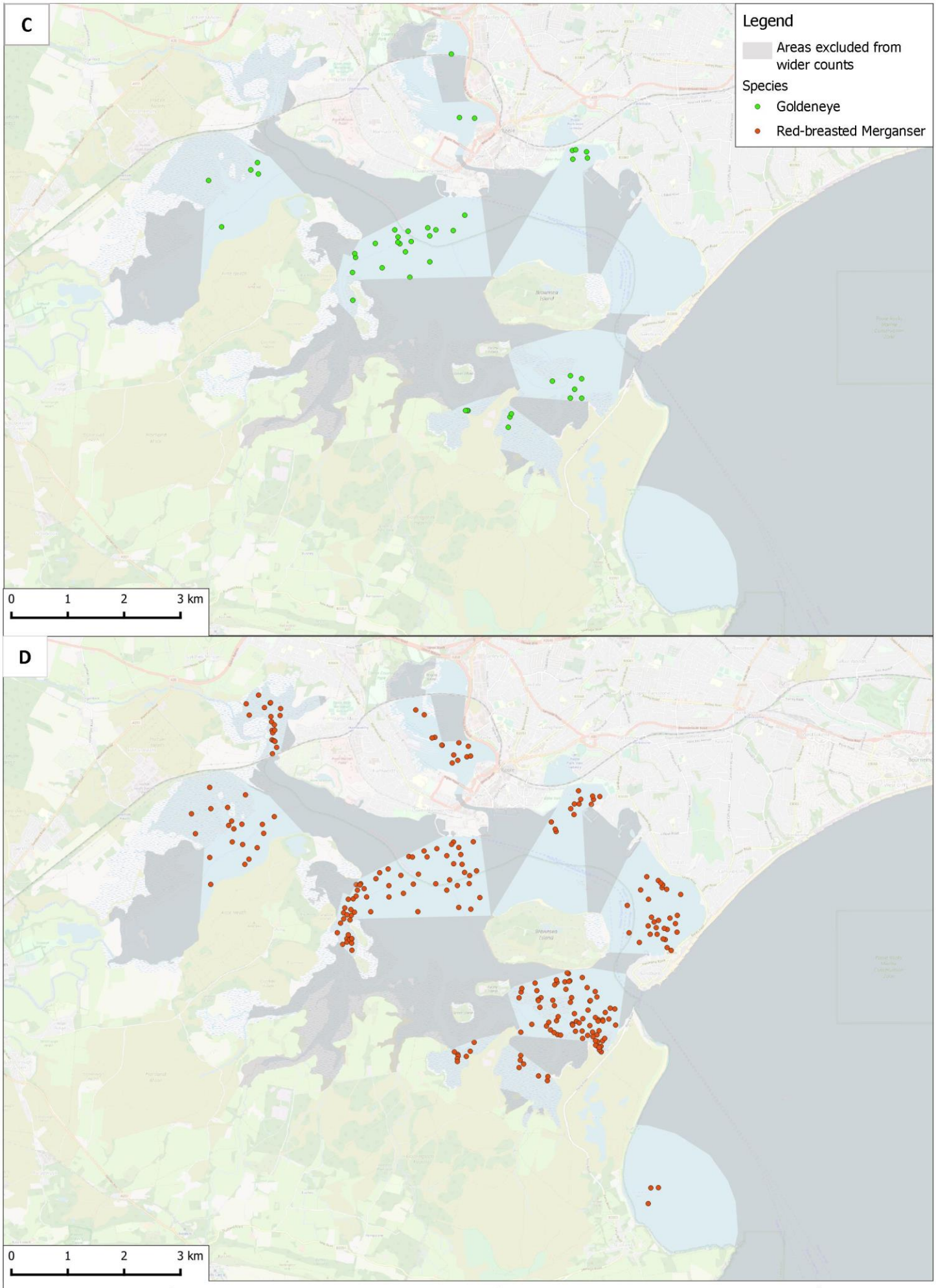
3.60 The distributions of the species recorded from the Wider Area Counts is likely informed by both their ecological/dietary requirements, the tidal state at the time of the count, and the presence of any potentially disturbing activities (human or otherwise). There is nevertheless some indication within the maps presented that the species depicted may be avoiding the area of the harbour between the mouth of Parkstone Bay and the northern shore of Brownsea Island.

Map 13a&b: Wider area bird counts - Grebes

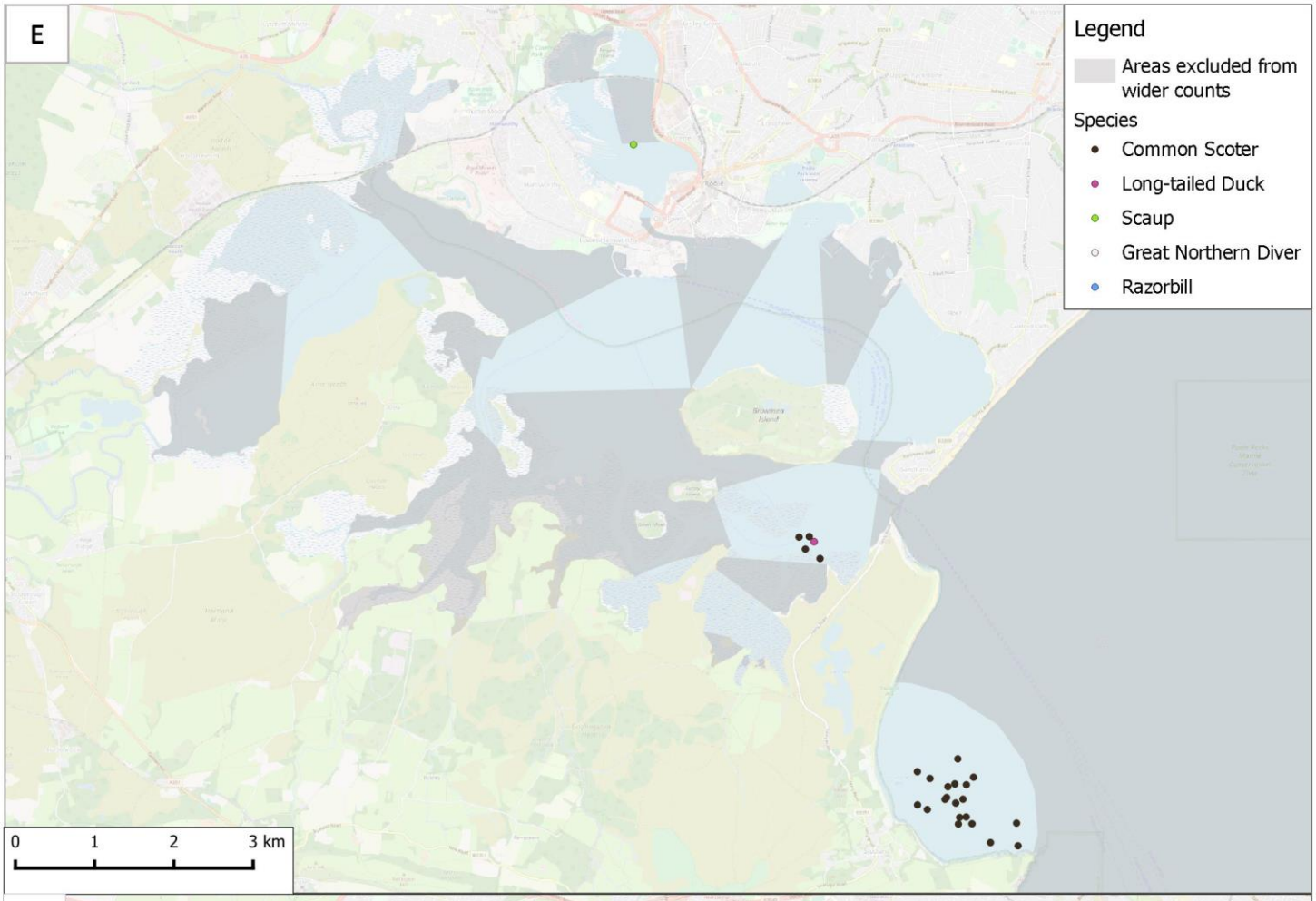


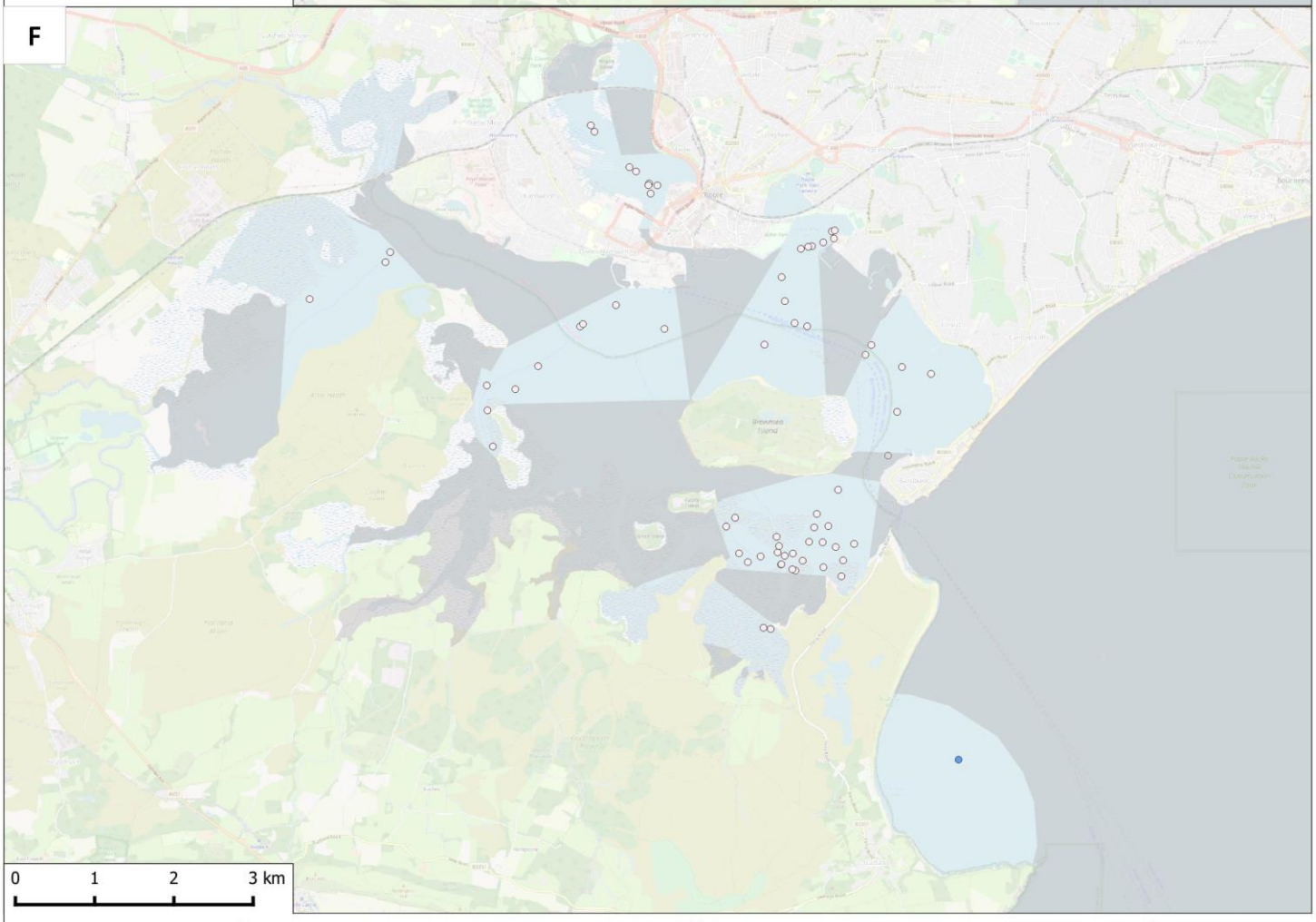


Map 13c&d: Wider area bird counts - Goldeneye and Red-breasted Merganser

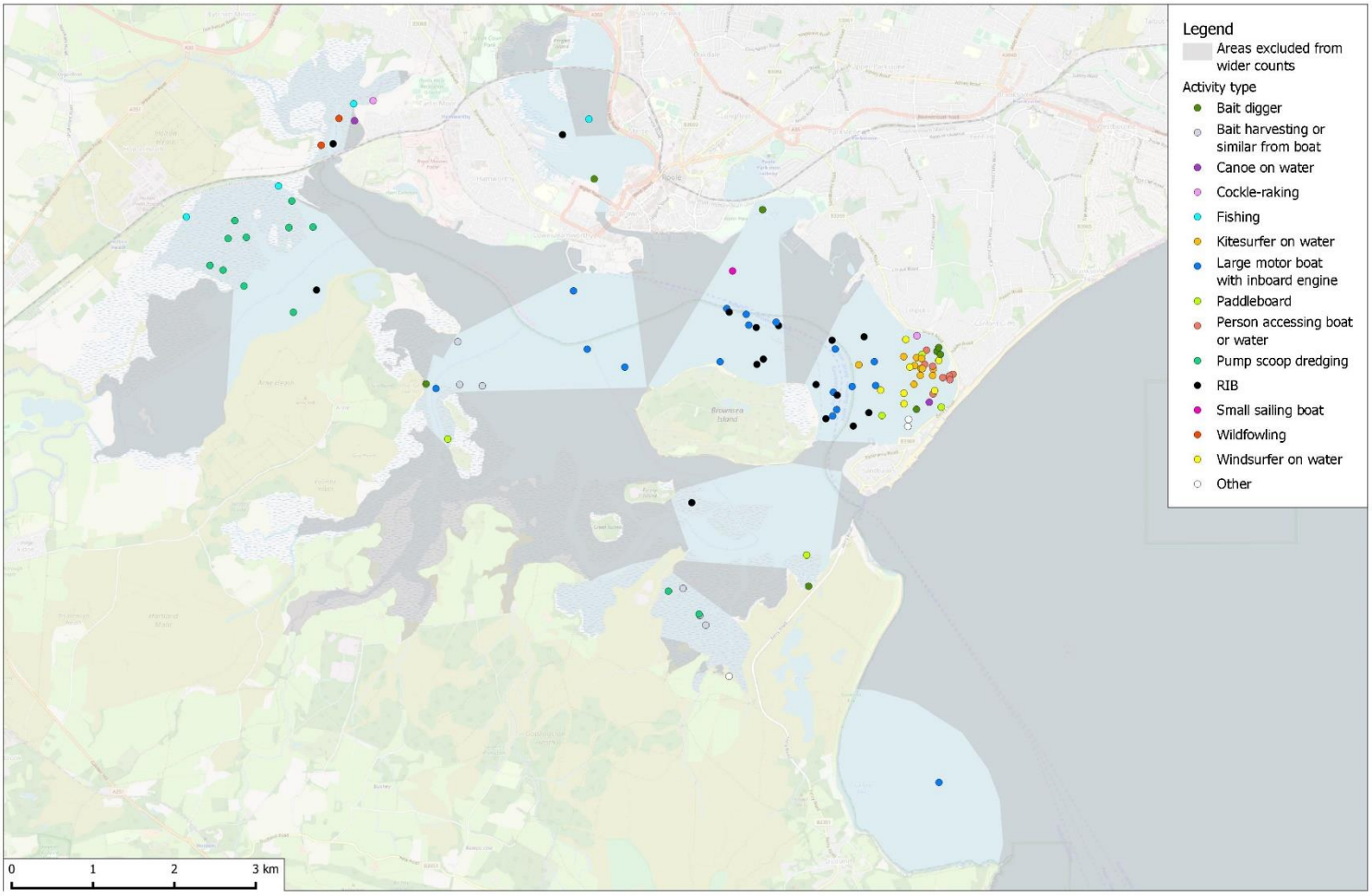


Map 13d&e: Wider area bird counts - scarcer wildfowl, divers, and auks





Map 14: Wider area activity counts (terrestrial activities excluded)



Distribution of activities

3.61 Map 14 depicts the distribution of the non-terrestrial activities recorded during the Wider Area Counts. It excludes numerous observations of dog walkers/walkers along the Studland Bay beaches, for example, in order to focus upon those activity types considered potentially more disturbing to the harbour's deeper water foraging bird species.

3.62 The most frequently recorded activities comprised a range of watersports types, RIBs (or similar small craft), large motorboats, and pump scoop dredgers. Watersports activities were concentrated at Whitley Lake and off Sandbanks, whereas pump scoop dredging was most frequently observed in the Wareham Channel and Brands Bay. The latter site also frequently recorded boat-based bait harvesting activity.

3.63 RIB and large motorboat observations were concentrated in the shipping lane bounded by Sandbanks to the south-east and Poole Quay to the north-west. These observations potentially help to explain the apparent avoidance of this area by waterfowl (although this part of the harbour is also deep and/or dredged, potentially making it less suitable for forage-diving species). The observations of wildfowling within Lytchett Bay are also noteworthy.

4. Comparison with the previous Poole Harbour Disturbance Study

4.1 Further analyses were carried out in order to try and identify any apparent changes in the Standard Watch data which have occurred between the current study and the first Poole Harbour Disturbance Study carried out in 2011/12. These analyses focussed upon the comparison of the levels of use by people, the bird numbers present, and the proportion of extreme responses to any disturbance behaviour observed.

4.2 In order to make comparisons robust, only data from those survey locations which were subject to the same level of survey effort during both studies were used. This resulted in 12 survey locations being included in the comparison dataset, with the following localities excluded from further analyses:

- Pilot Point (Survey Point 8 - 2011/12 study only);
- Holes Bay (UCP Hide) (Survey Point 14);
- Holes Bay (railway) (Survey Point 15), and;
- Lytchett Fields (Survey Point 16 - current study only).

Levels of use

4.3 The combined level of use across all 12 of the survey locations (measured via the number of groups observed across all activity types) has increased between the current study and the last (see Figure 13). Site-level increases in the number of groups recorded at the majority of survey locations are also apparent, with the exception of Holton Lee (Survey Point 1), Brands Bay (Survey Point 10), and Cleaval Point (Survey Point 12).

4.4 These increases are statistically significant across all sites combined ($W = 36918$, p-value = 0.03), as well as for Lytchett Bay (Survey Point 2: $W = 27$, p-value = 0.01), Parkstone Bay (Survey Point 5: $W = 18$, p-value = <0.01), Whitley Lake (Survey Point 7: $W = 37$, p-value = <0.05), and Middle Beach (Survey Point 11: $W = 32$, p-value = 0.02) at the site-level.

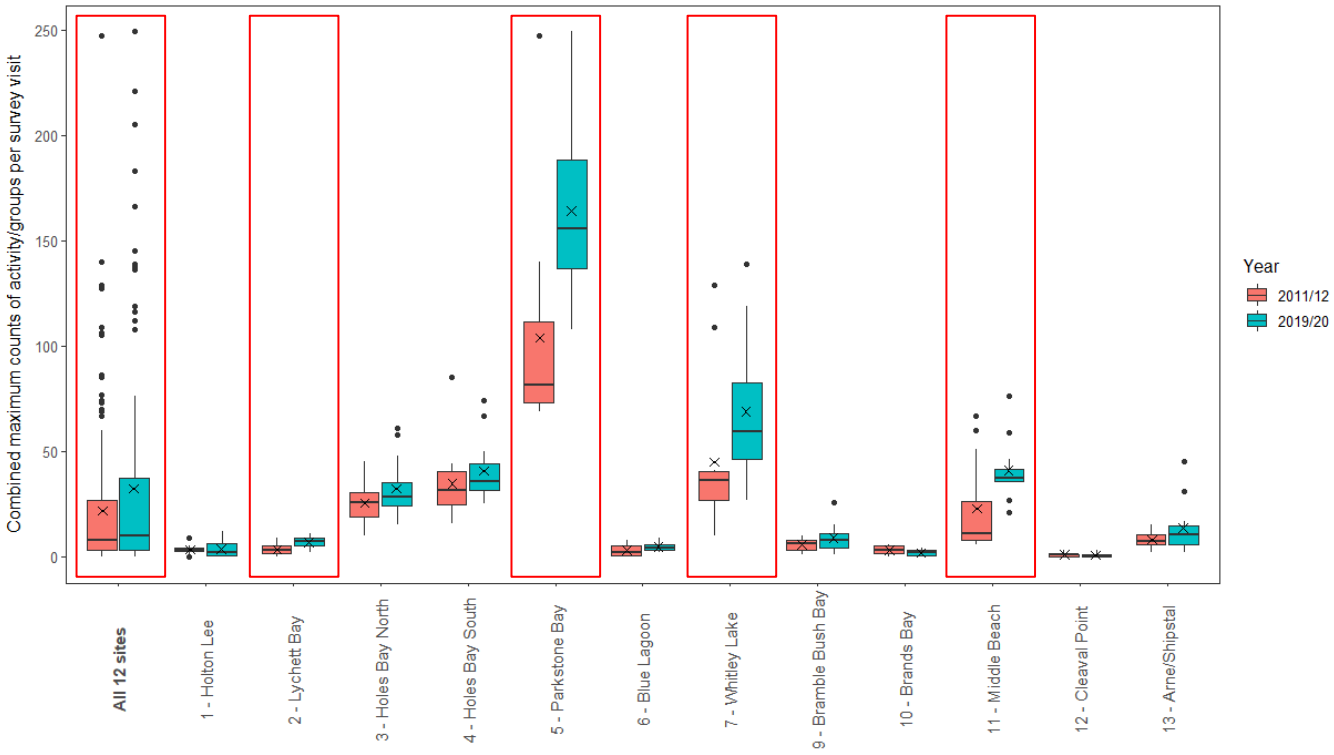


Figure 13: Comparison between number of groups (across all activity types) recorded per survey visit (1) across all 12 survey points subject to the same level of survey effort during both the 2011/12 and 2019/20 Poole Harbour disturbance studies, and (2) at each of the 12 survey points. Median values are indicated by a solid line, mean values by a cross, and outlier values by isolated points. Red boxes highlight those survey points for which a statistically significant difference was found between the paired counts.

4.5 The increases in the level of recreational use, both across all survey locations combined and at the site-level for one third of the locations analysed, are noteworthy. Nevertheless, despite both studies extending the same level of survey effort to each of the 12 survey locations assessed, the ratio of weekend to weekday survey days differs between the two as a result of the shorter overall survey period during the 2019/20 study when compared to the 2011/12 study (three months versus four months, respectively).

4.6 In order to assess whether the larger proportion of weekend survey days within the 2019/20 study dataset was the reason for the observed increases in levels of use, separate weekday and weekend visit rates (expressed as groups per hour) were calculated for both of the study datasets (see Table 12). The ratio of weekend to weekday visit rate for each of the two studies was then calculated. The 2019/20 visit rate ratio (1.17) is smaller than that for 2011/12 (1.63) which indicates that weekend survey dates accounted for fewer observations than weekday survey dates in 2019/20, despite the larger

number of weekend survey days during the current study. This supports the assumption that increased weekend survey effort is not driving the observed increases in some survey metrics.

Table 12: Comparison between weekday and weekend survey effort and visit rate (expressed as groups per hour) across the 12 survey points subject to the same level of survey effort overall during both the 2011/12 and 2019/20 Poole Harbour disturbance studies.

Survey year	Day type	Total groups	Total survey hours	Visit rate (groups/hour)	Ratio of weekend to weekday visit rate
2019/20	Weekday	2,196	126	17.4	**1.17**
	Weekend	2,575	126	20.4	
2011/12	Weekday	1,735	168	10.3	**1.63**
	Weekend	1,410	84	16.8	

Activity types

4.7 The number of overall records of each activity from the 12 comparable survey points varies between the two study periods. Figure 14 shows the percentage (and actual numerical) change in each activity type between the 2011/12 and 2019/20 studies combined across the relevant survey locations. Records of picnicking and resident activity show the largest percentage increases (300% and 170%, respectively), although they both comprise activity types with a relatively small number of observations during the 2011/12 study.

4.8 More significantly, the number of records of both dog walkers has more than doubled (112% increase), and the number of jogger and walker records have increased by 83% and 33%, respectively. These increases comprise 791 additional observations of dog walkers, 368 of walkers, and 239 of joggers in the 2019/20 study. There was also a 22% increase in the number of cyclists recorded, equating to 118 additional observations.

4.9 Also noteworthy is the decrease in the number of records of most water-based and harvesting activities. Fishing decreasing by 82% (35 fewer records) and observations of RIBs and small sailing boats decreasing by 34% and 100%, respectively. Nevertheless, the appearance of a small number of paddleboarding records, comprising a newly recorded activity during the 2019/20 study, is of interest.

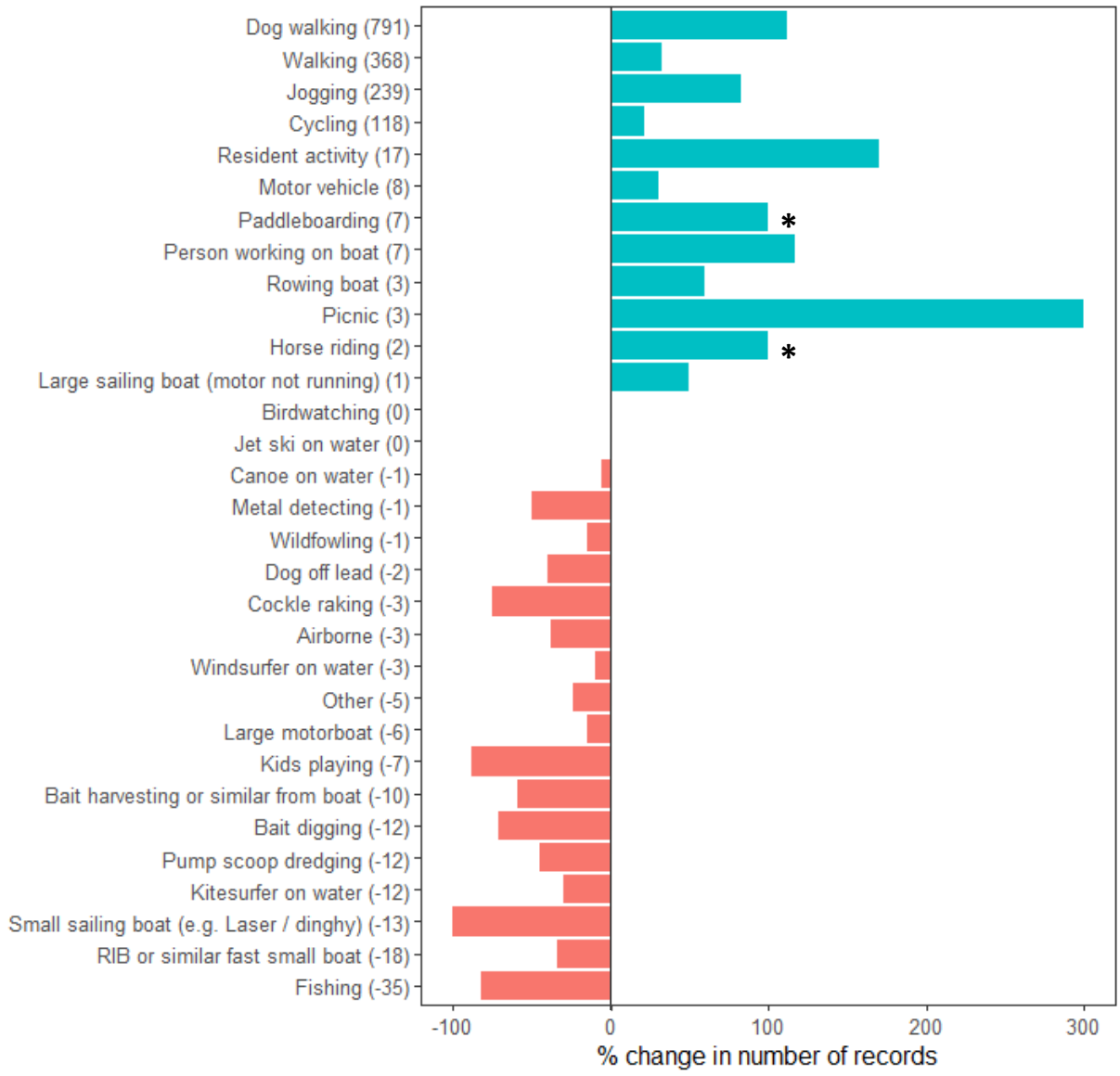


Figure 14: Percentage change in the number of records of each activity type observed across the 12 survey points subject to the same level of survey effort overall during both the 2011/12 and 2019/20 Poole Harbour disturbance studies. Activities are depicted in descending order of actual numerical change (with between-study numerical change per activity provided in parentheses). Asterisks identify those activity types which were not recorded from the 12 survey points during the 2011/12 study.

4.10 In addition to those identified in Figure 14, the following activity types (amalgamated into other activities during the 2011/12 study, e.g. litter picking within walking) were recorded separately from the 12 survey points during the 2019/20 study:

- Litter picking (7 records);
- Person on a mobility scooter (20 records);
- Person accessing boat or water (34 records);
- Photography (9 records);
- Rollerskating/skateboarding (6 records);
- People sitting on the beach/a bench (15 records), and;
- Swimming (4 records).

Bird numbers

4.11 Overall wader and wildfowl numbers across all 12 survey points combined, and at the site-level for the majority of survey locations, remained similar between the two study periods (see Figure 15).A possible decline in numbers was noted at Holes Bay North (Survey Point 3), although this was statistically non-significant. Nevertheless, statistically significant declines in bird numbers were identified between the two studies at Middle Beach (Survey Point 11: W = 108, p-value = 0.04), Cleaval Point (Survey Point 12: W = 113, p-value = 0.02), and Arne/Shipstal (Survey Point 13: W = 108.5, p-value = 0.04).

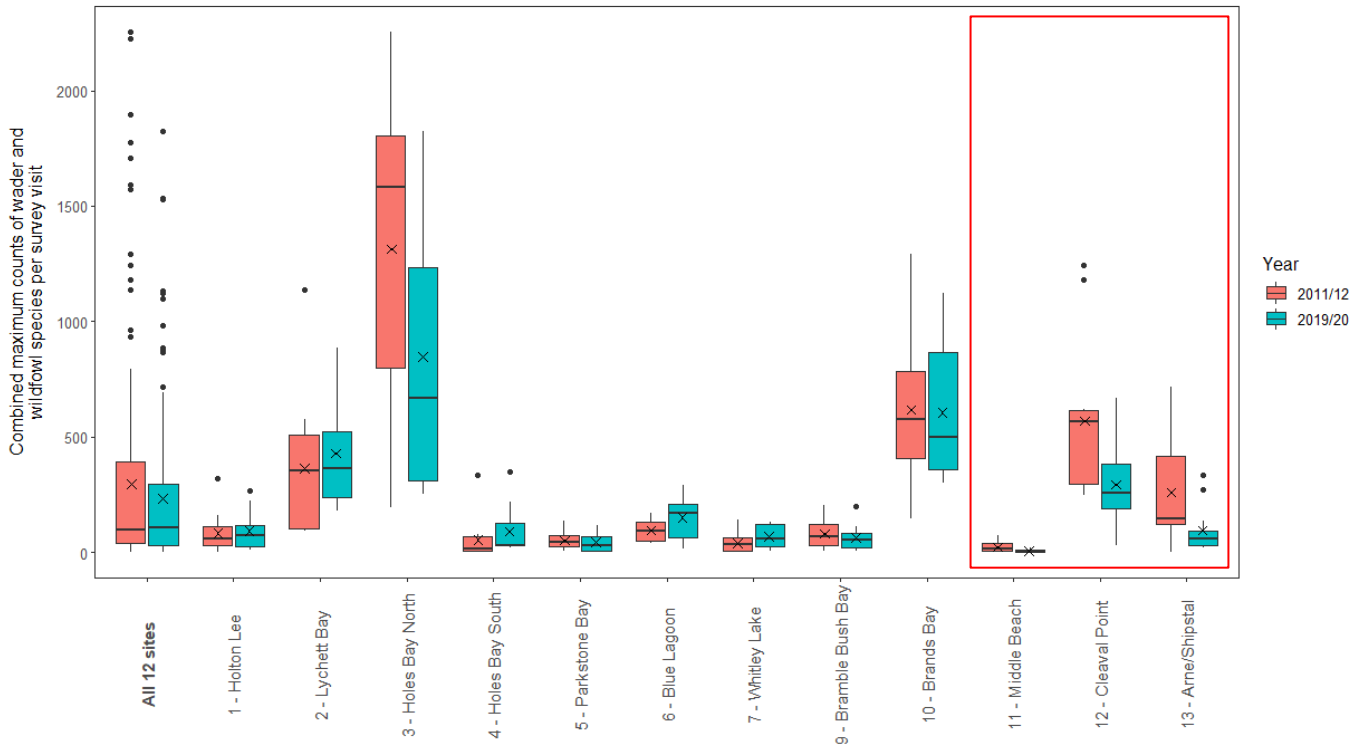


Figure 15: Comparison between maximum wader and waterfowl counts per survey visit (1) across all 12 survey points subject to the same level of survey effort during both the 2011/12 and 2019/20 Poole Harbour disturbance studies, and (2) at each of the 12 survey points. Median values are indicated by a solid line, mean values by a cross, and outlier values by isolated points. Red boxes highlight those survey points for which a statistically significant difference was found between the paired counts.

Bird responses

4.12 Extreme bird responses to disturbance events (as measured using the number of observed short and major flights) have remained similar across all 12 survey locations combined, and at the majority of individual survey localities, between the study periods (see Figure 16). Nevertheless, the number of extreme responses has significantly increased at both Lytchett Bay (Survey Point 2: W = 34, p-value = 0.02) and Whitley Lake (Survey Point 7: W = 22.5, p-value = <0.01), and significantly decreased at Middle Beach (Survey Point 11: W = 107, p-value = 0.03) during the same period.

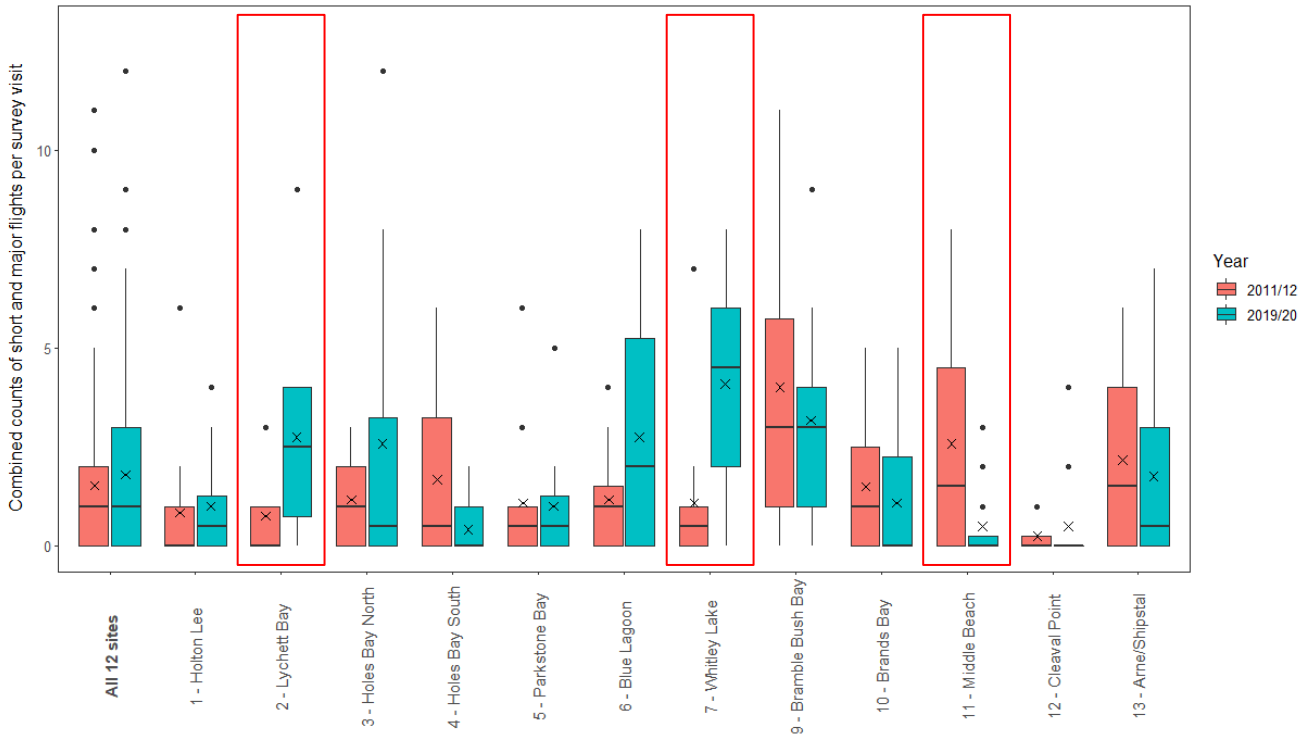


Figure 16: Comparison between the total number of flush events (short and major flights) observed per survey visit (1) across all 12 survey points subject to the same level of survey effort during both the 2011/12 and 2019/20 Poole Harbour disturbance studies, and (2) at each of the 12 survey points. Median values are indicated by a solid line, mean values by a cross, and outlier values by isolated points. Red boxes highlight those survey points for which a statistically significant difference was found between the paired counts.

5. Discussion

5.1 The limitations that applied in 2011/12 also apply to the current study. These are discussed in more detail in Liley & Fearnley (2012a), but namely comprise the fact that:

- The study does not consider disturbance in relation to prey distribution and/or abundance, nor make any predications of the population consequences for the bird species present;
- Survey points were non-randomly distributed across the study area, but do provide a good geographic spread, covering a range of different habitats and parts of the Harbour;
- There was an uneven distribution of surveys across the tidal range, and;
- All surveys were carried out in daylight hours, potentially under/over-recording certain activities (for example wildfowling may be under-recorded) and nocturnal bird distributions.

5.2 The previous study also provides detailed references concerning research carried out on the distribution of benthic invertebrates within the Harbour, and the ecological effects of disturbance on waders, in particular, and it should be referred to in combination with this report.

5.3 Nevertheless, the findings of the current study are robust, and its' key findings largely mirror those of the previous 2011/12 disturbance study. A wide range of activities were recorded, varying in both their distribution and intensity, across the Poole Harbour study area. Disturbance levels appear to affect the distribution of birds within the Harbour, although most individual activity events do not cause an observable disturbance effect. Busier sites (exemplified by Parkstone Bay) tended to hold fewer birds and also tended to exhibit fewer extreme disturbance responses from the birds present.

5.4 It should be noted though that the surveys at each location were focussed on a particular recording area. It would have been impossible for the surveyors to cover a wider geographic area or view in multiple directions simultaneously. As such, the data does not relate to all activities and interactions between birds and people at a particular locality. A prime example of this is the presence of a high tide roost/foraging area, used by Oystercatchers and Dark-bellied Brent Geese in particular, on grassy amenity areas located well above the high-water mark at Baiter, adjacent to the Parkstone Bay survey point. Surveyors noted that birds which used these areas were regularly chased and/or flushed by dogs off the lead, although

these observations were outside of the recording area and therefore were not systematically logged.

5.5 Dog walking and walking remain the most commonly recorded activity types across the harbour study area, although water-based activities were more likely to result in a behavioural response than those activities based on the shoreline or intertidal areas. Nevertheless, dog walking and walking still account for both the largest numbers of birds flushed and the largest number of flush events across the entire study period (excluding predator behaviour).

5.6 The number of activity events has significantly increased across the entire study area since the previous study, with the observed increases in activity levels statistically significant for Lytchett Bay, Parkstone Bay, Whitley Lake, and Middle Beach. Dog walking observations more than doubled across the entire survey area, for example, with jogging increasing by more than 80%, and walking by a third. Increases in the number of dog walkers are particularly noticeable at both Parkstone Bay and Middle Beach, where records doubled and tripled, respectively, between the two study periods.

5.7 Considering that dog walkers alone accounted for 69% of the observed disturbance responses at Parkstone Bay, and 44% of those at Middle Beach, it is interesting that there hasn't been an obvious corresponding decrease in the number of waders and wildfowl recorded across the entire study area. Parkstone Bay, Whitley Lake, and Middle Beach have however all consistently supported smaller numbers of waders and wildfowl in comparison to other sites, and it is therefore potentially more difficult to identify any declining trend at these locations.

5.8 It would seem, nevertheless, that there are areas with very high levels of recreational use which support relatively few birds. In other areas of the Harbour, where there are lower levels of recreational use, larger numbers of birds occur and these locations are therefore, perhaps, the ones where more behavioural responses might be expected. Conversely, those locations where recreational use is erratic, and varies in time and space, are perhaps those where behavioural responses are to be expected.

5.9 Statistically significant decreases in observed bird numbers do appear to have occurred at Middle Beach, Cleaval Point, and Arne/Shipstal. The decline in bird numbers at Cleaval Point and Arne/Shipstal are not easy to explain, given the apparent absence of any corresponding increase in activity levels or major disturbance events at these sites. The observed declines could

simply comprise further evidence of the decreasing numbers of waders and wildfowl wintering in the south-west due to climate change (eg. Austin & Rehfisch, 2005; Maclean et al., 2008).

5.10 Nevertheless, WeBS data[5] do not suggest that marked declines in wetland bird numbers have taken place across the Harbour. The BTO data indicate that in 2011/12 the site maxima for Poole Harbour were 21,830 birds and in 2012/13 23,432 birds, while more recent data indicate totals of over 24,000 birds (e.g. 25,688 in 2018/19). Such totals may be reflective of recent changes in survey effort but provide little evidence of a decline in overall bird numbers over the period. Alternatively, any declines within specific parts of the Harbour may indicate displacement following inter-study period changes in food abundance and/or distribution.

5.11 The large increase in activity levels at Middle Beach, in association with a statistically significant decline in wader and waterfowl numbers, follows on from observations made in 2011/12 study, which highlighted the effects of dog walkers (in particular) at this locality. The location is second only to Parkstone Bay in the number of off-lead dogs recorded during the current study and supports an impoverished wader and wildfowl community. While clearly functionally linked to the Poole Harbour SPA, it should be noted however that this location is outside the SPA boundary. The intertidal habitat here is also quite sandy, and as such it is hard to draw direct comparisons with areas within the Harbour which hold softer sediments supporting higher prey biomass. The statistically significant decrease in the number of major disturbance events at Middle Beach is almost certainly linked to the dwindling numbers of birds present in the face of increasing amenity use.

5.12 As a counterpoint to the situation observed at Middle Beach, the survey location at Lytchett Fields RSPB Reserve (which was not surveyed previously) was shown in the current study to be effectively free of dog walking activity. This was the only location in the wider survey area where no dog walking was recorded at all, during any visit. The provision of an area of Suitable Alternative Natural Greenspace (SANG) immediately adjacent to the site, and its promotion amongst the dog walking community alongside informative signage from the RSPB, appear to have been effective so far in shielding this location from any of the potentially negative effects associated with the presence of dogs off the lead.

[5] See BTO online reporting, data accessed 20th April 2020

5.13 Both Lytchett Bay and Whitley Lake reported statistically significant increases in the number of flush events between the two study periods. Dog walkers and walkers were responsible for the largest relative proportion of human-related disturbance responses recorded at these two localities during the current study, and there were large increases in both activity types in the intervening period. Observations of dog walkers more than tripled at Lytchett Bay, for example, and records of both dog walkers and joggers more than doubled at Whitley Lake. Observations of walkers also increased by nearly half at the latter location. Although the two sites have not shown significant declines in the number of birds recorded, they are important locations for Black-tailed and Bar-tailed Godwits, respectively, and any increase in disturbance could therefore potentially lead to negative impacts on the populations of the two species.

5.14 At Whitley Lake there is a dedicated Windsurfing Zone which is well used by kitesurfers and windsurfers, in the right wind conditions. The same area is a key part of the Harbour for Bar-tailed Godwit, and on surveys carried out during rising/falling tides they were notable in gathering within the Zone (as this is the last/first part of the intertidal habitat to be exposed). On a number of occasions Bar-tailed Godwits, Oystercatchers, and Curlew were observed congregating in very small areas where sediments were exposed, distancing themselves from the watersports activity. Kitesurfing was responsible for 13% of the observed disturbance responses at Whitley Lake during the current study, and any further spreading by these activities is therefore likely to make the area unusable for the birds during these tide states.

5.15 It is important to note that the current study incorporates within in its dataset a small number of emerging recreational activities (i.e. not recorded during the previous 2011/12 study) which are not easily classifiable. An example of this is the “parkrun” event held at Upton Country Park, the route of which runs alongside the Holes Bay (UCP) survey point. This large-scale event was witnessed on a small number of occasions during the course of the 2019/20 study period and was subsequently classified as ‘jogging’ for the purposes of analyses. It is however possible that the ‘parkrun’ phenomenon in itself comprises a separate activity event/potential disturbance trigger due to the large numbers of participants and the extended temporal period over which it occurs.

5.16 In comparing the changes in recreation use it is also important to note that the surveys in 2019/20 coincided with a very wet and stormy winter, with a succession of storms taking place (see Appendix 5). As such, many water-

based activities may have occurred at lower levels than might have been expected had conditions been more favourable. Any comparison is further complicated by those activities which are more likely to take place during particular weather conditions, or tide states that cannot be controlled for.

5.17 Comparison of the totals of particular intertidal/water-based activities across all survey points does not indicate a consistent pattern, with kitesurfing recorded on 40 occasions in 2011/12 and 28 in the current study, windsurfing on 30 and 27 occasions, canoeing on 17 and 16 occasions, respectively. Paddleboarding is nevertheless perhaps particularly worthy of comment, as this activity was not recorded at all during the previous study, and the 7 observations made in the current study are exemplative of what appears to be a watersport which is rapidly growing in popularity.

Recommendations

5.18 It is important to highlight that, in general, compliance with the guidance on activities permitted in bird sensitive areas within the Harbour[6] (within intertidal areas and on the water, at least) appears to be relatively high, based upon the results of the current study. This would suggest this is working well. Nevertheless, the recommendations made in the 2011/12 study, with respect to potential forms of mitigation and user engagement/education, are still valid, and Middle Beach in particular risks completely losing what intertidal bird interest remains, in the absence of some form of ongoing mitigation/engagement.

5.19 There has been an extremely large increase in the number of dog walkers observed (the majority of whom walk their animals off-lead) across the Harbour and adjoining areas. This has been largely bolstered by the massive proportional increase in the numbers observed at Parkstone Bay, Whitley Lake, and Middle Beach. Dog walking continues to be one of the most disturbing activities to birds within the Harbour and, if the observed increasing trend carries on, has obvious potential to negatively impact upon the qualifying features of the SPA/Ramsar site.

5.20 The instigation and/or continuation of regular and frequent dog walker engagement and awareness raising outreach activities at locations around the Harbour during the winter months is likely to be essential in the short

[6] Poole Harbour Commissioners – Poole Harbour sensitive areas map

term. This can build upon the work already carried out by Dorset Dogs[7], and increase the impact of signage already in place at localities such as Baiter/Parkstone Bay. At locations with high levels of use and lower bird numbers (such as Parkstone Bay and Middle Beach, and potentially other sections of shoreline too), bird use is only likely to be restored if the numbers of people accessing them can be reduced or if specific areas of shoreline are kept free of people.

5.21 National surveys show that use of the countryside for recreation is increasing, with people tending to visit more frequently than they used to (O'Neill, 2019). It is likely that the increases observed in the number of dog walkers, as well as joggers, walkers, and cyclists, is also linked to increases in local housing and the increase in local population since the previous disturbance study was undertaken. As such, any future mitigation package to resolve impacts from housing growth will need to consider long-term growth projections and provide a range of solutions that allow for a certain level of future-proofing. Lytchett Fields provides an example of a location which is close to local housing and new housing development, yet where there appears to be little or no issues with recreational use. Here a no-dogs policy appears to work, and it is noteworthy that there is also a dedicated area for recreation – a SANG – adjacent to the site, but removed from sensitive areas of the SPA/Ramsar site, where dogs are encouraged.

5.22 Whitley Lake and the Sandbanks area are important locations for both watersports enthusiasts and for some of the scarcer/more localised wader and waterbird species within the Harbour (e.g. Bar-tailed Godwit). Furthermore, the current study has identified the fact that watersports enthusiasts (including those on the water and accessing it across the intertidal area) are negatively impacting the availability of intertidal roosting and foraging habitat at the site. The increasing spread of watersport use in this area, particularly people setting up and walking out across the intertidal area, could essentially result in it becoming unusable for birds, at least during intermediate tide states. There is scope in this area, however, to create a refuge area, potentially demarked with buoys, which is kept free of such access and available for sole use by the birds. Large areas of the beach and intertidal area would still remain publicly accessible under this scenario

[7] Dorset Dogs website

and would be promoted for use by watersports enthusiasts via signage and/or outreach material.

5.23 The historic loss of the Pilot Point wader roost, and the continuing decline in the numbers of waders and wildfowl using Middle Beach's intertidal areas, are indicative of increased levels of recreational pressure on the shoreline of the Studland peninsula. The survey results indicate marked increases in use at Middle Beach, highlighting the pressure this part of the study area is under from growing recreational use. All three of the Studland survey points (Brands and Bramble Bush Bays and Middle Beach) recorded much higher proportional disturbance responses than those areas of the Harbour located in proximity to areas of higher population density. Although not significant, there are also indications that activity levels have increased, and bird numbers decreased, in Bramble Bush Bay at least (alongside the previously identified significant changes observed at Middle Beach).

5.24 Bramble Bush Bay holds wader roosts and is an important feeding area for some species and, further along the shore, the roost site at Sandy Point is becoming increasingly important as a roost for Oystercatcher and Turnstone (Morrison, 2019). Any increase in terrestrial activity/disturbance levels in Bramble Bush Bay, in particular, also has the potential to spill over onto the contiguous shoreline of Brands Bay, and consequently impact the latter sites important wintering bird populations. There is relatively little access infrastructure in terms of signage, paths etc. in this area currently, and it is therefore vulnerable to increasing levels of recreational disturbance.

5.25 Finally, it is recommended that the disturbance studies carried out in the winters of 2011/12 and 2019/20 are repeated during the winter of 2027/28 in order to maintain monitoring frequency. This will also allow any changes in activity levels and bird numbers/distributions arising from mitigation enacted in the inter-study period to be evaluated.

References

Austin, G. E., & Rehfisch, M. M. (2005). Shifting nonbreeding distributions of migratory fauna in relation to climatic change. *Global Change Biology*, *11*(1), 31–38. doi: doi:10.1111/j.1529-8817.2003.00876.x

Bright, A., Reynolds, G. R., Innes, J., & Waas, J. R. (2003). Effects of motorised boat passes on the time budgets of New Zealand dabchick, Poliocephalus rufopectus. *Wildl. Res.*, *30*(3), 237–244.

Burton, N. H. K., Armitage, M. J. S., Musgrove, A. J., & Rehfisch, M. M. (2002). Impacts of man-made landscape features on numbers of estuarine waterbirds at low tide. *Environ. Manage.*, *30*(6), 857–864.

Burton, N. H., Rehfisch, M. M., & Clark, N. A. (2002). Impacts of disturbance from construction work on the densities and feeding behavior of waterbirds using the intertidal mudflats of Cardiff Bay, UK. *Environ Manage*, *30*(6), 865–871.

Clarke, R. T., Sharp, J., & Liley, D. (2008). *Access patterns in south-east Dorset. The Dorset household survey: Consequences for future housing and greenspace provision.* Footprint Ecology / Poole Borough Council. Retrieved from Footprint Ecology / Poole Borough Council website: internal-pdf://Household Survey Part II, Footprint Ecology, 9 Dec 08-3502160128/Household Survey Part II, Footprint Ecology, 9 Dec 08.pdf

Coyle, M., & Wiggins, S. (2010). *European Marine Site Risk Review* (Natural England Research Report No. NERR038). Natural England.

Cryer, M., Linley, N. W., Ward, R. M., Stratford, J. O., & Randerson, P. F. (1987). Disturbance of overwintering wildfowl by anglers at two reservoir sites in South Wales. *Bird Study*, *34*(3), 191–199.

Fitzpatrick, S., & Bouchez, B. (1998). Effects of recreational disturbance on the foraging behaviour of waders on a rocky beach. *Bird Study*, *45*(Pt2), 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.

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

Liley, D. (2008). *Development and the North Norfolk Coast: Scoping document on the issues relating to access*. Footprint Ecology / RSPB / Norfolk Coast Partnership. Retrieved from Footprint Ecology / RSPB / Norfolk Coast Partnership website: internal-pdf://Footprint Ecology North Norfolk Coast scoping July 08-1042652161/Footprint Ecology North Norfolk Coast scoping July 08.pdf

Liley, D., & Fearnley, H. (2012a). *Poole Harbour Disturbance Study*. Footprint Ecology / Natural England.

Liley, D., & Fearnley, H. (2012b). *Poole Harbour Disturbance Study—Map Annex*. Footprint Ecology / Natural England.

Liley, Durwyn, & Sutherland, W. J. (2007). Predicting the population consequences of human disturbance for Ringed Plovers Charadrius hiaticula: A game theory approach. *Ibis*, *149*(s1), 82–94. doi: doi:10.1111/j.1474-919X.2007.00664.x

Maclean, I. M. D., Austin, G. E., Rehfisch, M. M., Blew, J., Crowe, O., Delany, S., … Wahl, J. (2008). Climate change causes rapid changes in the distribution and site

abundance of birds in winter. *Global Change Biology*, *14*(11), 2489–2500. doi: 10.1111/j.1365-2486.2008.01666.x

Morrison, S. (2019). *Wader and Seafowl Roost Survey of Poole Harbour, Dorset—Winter 2018/19*. unpublished report for the Poole Harbour Commissioners.

Nolet, B. A., Bevan, R. M., Klaassen, M., Langevoord, O., & Van der Heijden, Y. (2002). Habitat switching by Bewick's swans: Maximization of average long-term energy gain? *J. Anim. Ecol.*, *71*(6), 979–993.

O'Neill, R. (2019). *Monitor of Engagement with the Natural Environment – The national survey on people and the natural environment. Headline report 2019* (NECR No. 275). Natural England and the Office for National Statistics. Retrieved from Natural England and the Office for National Statistics website: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/828552/Monitor_Engagement_Natural_Environment_2018_2019_v2.pdf

Randall, R. E. (2004). Management of coastal vegetated shingle in the United Kingdom. *Journal of Coastal Conservation*, *10*(1), 159–168. doi: DOI: 10.1652/1400-0350(2004)010[0159:MOCVSI]2.0.CO;2

Regel, J., & Putz, K. (1997). Effect of human disturbance on body temperature and energy expenditure in penguins. *Polar Biology*, *18*(4), 246–253.

Ross, K., Liley, D., Austin, G., Clarke, R. T., Burton, N. H., Stillman, R. A., … Underhill-Day, J. (2014). *Housing development and estuaries in England: Developing methodologies for assessing the impacts of disturbance to non-breeding waterfowl*. Footprint Ecology, unpublished report for Natural England.

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. Retrieved from UK CEED & Bournemouth University website: file:///S:/reports%20%26%20pdfs/Papers%20linked%20to%20Endnote/CEED%20recreation%20marine%20sites.pdf

Stillman, R. A., Cox, J., Liley, D., Ravenscroft, N., Sharp, J., & Wells, M. (2009). *Solent disturbance and mitigation project: Phase I report*. Footprint Ecology / Solent Forum. Retrieved from Footprint Ecology / Solent Forum website: http://www.solentforum.org/resources/pdf/natconsv/solent_disturbance_phase1.pdf

Stillman, R. A., & Goss-Custard, J. D. (2002). Seasonal changes in the response of oystercatchers Haematopus ostralegus to human disturbance. *J. Avian Biol.*, *33*(4), 358–365.

Stock, M., & Hofeditz, F. (1997). Compensatory limits: Energy budgets of Brent Geese, Branta b- bernicla, the influence of human disturbance. *Journal Fur Ornithologie*, *138*(4), 387–411.

Thiel, D., Jenni-Eiermann, S., Palme, R., & Jenni, L. (2011). Winter tourism increases stress hormone levels in the Capercaillie Tetrao urogallus. *Ibis*, *153*(1), 122–133. doi: 10.1111/j.1474-919X.2010.01083.x

Thomas, K., Kvitek, R. G., & Bretz, C. (2003). Effects of human activity on the foraging behavior of sanderlings Calidris alba. *Biological Conservation*, *109*(1), 67–71. doi: 10.1016/S0006-3207(02)00137-4

Underhill-Day, J. C. (2005). *A literature review of urban effects on lowland heaths and their wildlife*. Peterborough: English Nature. Retrieved from English Nature website: internal-pdf://EN RR 623, John Day literature review of urban effects-3794804480/EN RR 623, John Day literature review of urban effects.pdf

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*(1), 146–154.

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*(Pt 4), 475–483.

Yasué, M. (2005). The effects of human presence, flock size and prey density on shorebird foraging rates. *Journal of Ethology*, *23*(2), 199–204. doi: 10.1007/s10164-005-0152-8

Appendix 1: Location of Survey Points

Survey Point	Location	Description of location
1	Holton Lee	From top of beach below railway bridge. Railway bridge access had been rescinded on final visit, via installation of a locked gate, so survey was carried out from adjacent hillside.
2	Lytchett Bay	End of spit into saltmarsh. Accessed with care to limit disturbing birds.
3	Holes Bay North	Opposite Macdonalds & southern end of car park, & northern end of gap in scrub. On concrete path.
4	Holes Bay South	First bench by beginning of scrub (heading east from opposite the Mercedes garage).
5	Parkstone Bay	Bob Willmore bench (first bench heading east from sign about outflow east of Baiter car park).
6	Blue Lagoon	At/just below gate through from block of flats. No view onto shore outside Blue Lagoon. Access provided by Salterns Marina.
7	Whitley Lake	On foreshore below litter bin, c.50m east of slipway, below house no. 59 (tall white building with balconies, etc).
9	Bramble Bush Bay	Just above houseboats, on grass above beach, overlooking Bramble Bush Bay.
10	Brands Bay	National Trust Bird Hide overlooking Brands Bay.
11	Middle Beach (Studland)	From National Trust car park, viewing area with fence, etc, above café.
12	Cleaval Point	On beach, just by track to pumping station. Access provided by Rempstone Estate.
13	Arne/Shipstal	On beach, just round from RSPB sign and picnic bench.
14	Holes Bay (UCP Hide)	Former location of bird hide in Upton Country Park (now a fenced viewpoint).
15	Holes Bay (railway)	At eastern end of wooded spit.
16	Lytchett Fields RSPB	From RSPB viewpoint at end of access path.

Appendix 2: Activity codes

Activity type	Code	Activity type	Code
Airborne	AB	Paddleboard	Pb
Bait digger	BD	Person accessing boat or water	BW
Bait harvesting or similar from boat	BDD	Person working on boat	B
Birdwatching	BR	Photography	Ph
Canoe on water	Ca	Picnic	P
Cockle-raking	CR	Predator	PR
Cycling	C	Pump scoop dredging	PSD
Dog walking	DW	Resident activity in nearby garden	Rs
Fishing (from shore)	F	RIB or similar fast small boat	SMb
Horse riding	HR	Rollerskating/skateboarding	RSK
Jet ski on water	JS	Rowing boat	RB
Jogging (without dogs)	J	Sitting on beach/bench	Sit
Kids playing	KP	Swimming	Sw
Kitesurfer on water	KS	Train	Tr
Large motorboat with inboard engine > 10m	LMb	Unaccompanied dog off lead	DX
Litter picking	LP	Walking/rambling (without dogs)	W
Metal detecting	MD	Wildfowling	WF
Mobility scooter	Msc	Windsurfer on water	WS
Moderate to large sailing boat, not running motor	LS	Other	O
Motor vehicle	MV		

Appendix 3: Response codes

Response	Description	Code
No response	No change in behaviour/position	NR
Alert	Heads up/responsive, but no change in birds' position	A
Walk/Swim	Birds walked/swam a short distance prior to resuming previous behaviour	W
Short flight	Birds flew a short distance (<50m) and resumed previous behaviour in general area	f
Major flight	Birds took flight and flew >50m	F

Appendix 4: Survey dates and times

Survey location	Survey details			
	Day	Date	Start time	Finish time
16 - Lytchett Fields	Thu	05/12/2019	08:47	10:32
2 - Lytchett Bay	Thu	05/12/2019	11:48	13:33
14 - Holes Bay Hide	Thu	05/12/2019	14:24	16:09
1 - Holton Lee	Sat	07/12/2019	14:15	16:00
4 - Holes Bay South	Sat	07/12/2019	08:45	10:30
3 - Holes Bay North	Sat	07/12/2019	11:25	13:10
15 - Holes Bay (railway)	Sat	07/12/2019	14:10	15:55
12 - Cleaval Point	Sat	07/12/2019	11:30	13:15
13 - Arne/Shipstal	Sat	07/12/2019	08:30	10:15
2 - Lytchett Bay	Mon	09/12/2019	11:45	13:30
14 - Holes Bay Hide	Mon	09/12/2019	08:30	10:15
6 - Blue Lagoon	Mon	09/12/2019	11:25	13:10
5 - Parkstone Bay	Mon	09/12/2019	08:22	10:07
7 - Whitley Lake	Mon	09/12/2019	14:10	15:55
9 - Bramble Bush Bay	Fri	13/12/2019	10:30	12:15
3 - Holes Bay North	Fri	13/12/2019	08:20	10:05
15 - Holes Bay (railway)	Fri	13/12/2019	10:50	11:35
4 - Holes Bay South	Fri	13/12/2019	14:25	16:10
7 - Whitley Lake	Fri	13/12/2019	08:25	10:10
6 - Blue Lagoon	Fri	13/12/2019	11:27	13:12
5 - Parkstone Bay	Fri	13/12/2019	14:05	15:50
14 - Holes Bay Hide	Sat	14/12/2019	08:27	10:12
16 - Lytchett Fields	Sat	14/12/2019	11:28	13:13
2 - Lytchett Bay	Sat	14/12/2019	14:15	16:00
11 - Middle Beach	Sun	15/12/2019	08:20	10:05
5 - Parkstone Bay	Sun	15/12/2019	08:14	09:59
6 - Blue Lagoon	Sun	15/12/2019	11:28	13:13
7 - Whitley Lake	Sun	15/12/2019	13:58	15:43
9 - Bramble Bush Bay	Sun	15/12/2019	10:40	12:25
10 - Brands Bay	Sun	15/12/2019	13:05	14:50
1 - Holton Lee	Mon	16/12/2019	09:30	11:15
13 - Arne/Shipstal	Mon	16/12/2019	12:20	14:05
11 - Middle Beach	Tue	17/12/2019	13:00	14:45

Survey location	Survey details			
	Day	Date	Start time	Finish time
12 - Cleaval Point	Tue	17/12/2019	08:35	10:20
10 - Brands Bay	Tue	17/12/2019	10:50	12:35
13 - Arne/Shipstal	Tue	17/12/2019	12:50	14:35
16 - Lytchett Fields	Wed	18/12/2019	09:45	11:30
9 - Bramble Bush Bay	Wed	18/12/2019	09:05	10:50
10 - Brands Bay	Wed	18/12/2019	11:30	13:15
1 - Holton Lee	Wed	18/12/2019	11:00	12:45
3 - Holes Bay North	Thu	19/12/2019	08:20	10:05
4 - Holes Bay South	Fri	20/12/2019	08:30	10:15
15 - Holes Bay (railway)	Fri	20/12/2019	10:55	12:40
11 - Middle Beach	Fri	20/12/2019	14:00	15:45
7 - Whitley Lake	Sat	21/12/2019	08:30	10:15
15 - Holes Bay (railway)	Sat	21/12/2019	08:25	10:10
3 - Holes Bay North	Sat	21/12/2019	11:10	12:55
9 - Bramble Bush Bay	Sat	21/12/2019	10:45	12:30
4 - Holes Bay South	Sat	21/12/2019	14:05	15:50
11 - Middle Beach	Sat	21/12/2019	08:20	10:05
12 - Cleaval Point	Sat	21/12/2019	13:15	15:00
5 - Parkstone Bay	Sun	22/12/2019	08:55	10:40
6 - Blue Lagoon	Sun	22/12/2019	12:05	13:50
14 - Holes Bay Hide	Sun	22/12/2019	08:28	10:13
2 - Lytchett Bay	Sun	22/12/2019	11:23	13:08
16 - Lytchett Fields	Sun	22/12/2019	14:11	15:56
10 - Brands Bay	Sun	22/12/2019	08:30	10:15
1 - Holton Lee	Sun	22/12/2019	11:10	12:55
13 - Arne/Shipstal	Sun	22/12/2019	13:45	15:30
12 - Cleaval Point	Mon	23/12/2019	13:45	15:30
16 - Lytchett Fields	Fri	10/01/2020	13:43	15:28
6 - Blue Lagoon	Fri	10/01/2020	12:06	13:51
7 - Whitley Lake	Fri	10/01/2020	14:39	16:24
15 - Holes Bay (railway)	Fri	10/01/2020	09:05	10:50
3 - Holes Bay North	Fri	10/01/2020	11:50	13:35
4 - Holes Bay South	Fri	10/01/2020	14:15	16:00
9 - Bramble Bush Bay	Fri	10/01/2020	13:10	14:55
13 - Arne/Shipstal	Sat	11/01/2020	08:45	10:30
12 - Cleaval Point	Sat	11/01/2020	11:40	13:25

Survey location	Survey details			
	Day	Date	Start time	Finish time
1 - Holton Lee	Sat	11/01/2020	14:15	16:00
2 - Lytchett Bay	Wed	15/01/2020	10:25	12:05
5 - Parkstone Bay	Thu	16/01/2020	08:20	10:05
3 - Holes Bay North	Thu	16/01/2020	08:20	10:05
16 - Lytchett Fields	Fri	17/01/2020	11:47	13:32
2 - Lytchett Bay	Fri	17/01/2020	14:32	16:17
15 - Holes Bay (railway)	Fri	17/01/2020	08:25	10:10
4 - Holes Bay South	Fri	17/01/2020	10:50	12:35
14 - Holes Bay Hide	Fri	17/01/2020	08:42	10:27
7 - Whitley Lake	Sat	18/01/2020	11:00	12:45
6 - Blue Lagoon	Sat	18/01/2020	13:15	15:00
4 - Holes Bay South	Sat	18/01/2020	08:20	10:05
3 - Holes Bay North	Sat	18/01/2020	11:05	12:50
15 - Holes Bay (railway)	Sat	18/01/2020	13:25	15:10
13 - Arne/Shipstal	Sat	18/01/2020	09:00	10:45
2 - Lytchett Bay	Sat	18/01/2020	08:34	10:19
14 - Holes Bay Hide	Sat	18/01/2020	12:10	13:55
16 - Lytchett Fields	Sat	18/01/2020	14:55	16:40
1 - Holton Lee	Sun	19/01/2020	10:40	12:25
9 - Bramble Bush Bay	Sun	19/01/2020	13:40	15:25
14 - Holes Bay Hide	Mon	20/01/2020	12:00	13:45
12 - Cleaval Point	Mon	20/01/2020	11:30	13:15
13 - Arne/Shipstal	Mon	20/01/2020	14:15	16:00
12 - Cleaval Point	Tue	21/01/2020	10:00	11:45
10 - Brands Bay	Tue	21/01/2020	12:45	14:30
9 - Bramble Bush Bay	Wed	22/01/2020	13:30	15:15
11 - Middle Beach	Thu	23/01/2020	14:10	15:55
13 - Arne/Shipstal	Fri	24/01/2020	13:45	15:30
3 - Holes Bay North	Sat	25/01/2020	08:15	10:00
4 - Holes Bay South	Sat	25/01/2020	10:50	12:35
15 - Holes Bay (railway)	Sat	25/01/2020	13:30	15:15
11 - Middle Beach	Sat	25/01/2020	08:00	09:45
9 - Bramble Bush Bay	Sat	25/01/2020	10:15	12:00
10 - Brands Bay	Sat	25/01/2020	12:50	14:35
7 - Whitley Lake	Sat	25/01/2020	08:30	10:15
6 - Blue Lagoon	Sat	25/01/2020	11:40	13:25

Survey location	Survey details			
	Day	Date	Start time	Finish time
5 - Parkstone Bay	Sat	25/01/2020	14:30	16:15
5 - Parkstone Bay	Sun	26/01/2020	09:22	11:02
16 - Lytchett Fields	Sun	26/01/2020	11:21	13:06
14 - Holes Bay Hide	Sun	26/01/2020	14:30	16:15
2 - Lytchett Bay	Sun	26/01/2020	08:40	10:25
12 - Cleaval Point	Sun	26/01/2020	08:15	10:00
11 - Middle Beach	Sun	26/01/2020	08:00	09:45
10 - Brands Bay	Sun	26/01/2020	10:30	12:15
1 - Holton Lee	Mon	27/01/2020	08:30	10:15
1 - Holton Lee	Wed	29/01/2020	12:10	13:55
7 - Whitley Lake	Wed	29/01/2020	08:11	09:56
5 - Parkstone Bay	Wed	29/01/2020	11:52	13:37
6 - Blue Lagoon	Wed	29/01/2020	15:05	16:50
11 - Middle Beach	Thu	30/01/2020	10:05	11:50
10 - Brands Bay	Thu	30/01/2020	08:00	09:45
16 - Lytchett Fields	Wed	05/02/2020	12:55	14:40
10 - Brands Bay	Wed	05/02/2020	11:55	13:40
9 - Bramble Bush Bay	Wed	05/02/2020	14:15	16:00
12 - Cleaval Point	Thu	06/02/2020	10:20	12:05
1 - Holton Lee	Thu	06/02/2020	13:20	15:05
2 - Lytchett Bay	Sat	08/02/2020	09:14	10:59
7 - Whitley Lake	Sat	08/02/2020	12:49	14:34
9 - Bramble Bush Bay	Sat	08/02/2020	08:40	10:25
13 - Arne/Shipstal	Sat	08/02/2020	11:45	13:30
4 - Holes Bay South	Wed	12/02/2020	15:20	17:05
10 - Brands Bay	Wed	12/02/2020	12:40	14:25
11 - Middle Beach	Wed	12/02/2020	14:50	16:35
3 - Holes Bay North	Wed	12/02/2020	08:25	10:10
15 - Holes Bay (railway)	Wed	12/02/2020	11:00	12:45
5 - Parkstone Bay	Fri	14/02/2020	08:17	10:02
6 - Blue Lagoon	Fri	14/02/2020	11:52	13:37
10 - Brands Bay	Sat	15/02/2020	09:50	11:35
14 - Holes Bay Hide	Sat	15/02/2020	09:53	11:38
11 - Middle Beach	Sat	15/02/2020	07:35	09:20
6 - Blue Lagoon	Mon	17/02/2020	12:12	13:57
2 - Lytchett Bay	Mon	17/02/2020	11:20	13:05

Survey location	Survey details			
	Day	Date	Start time	Finish time
7 - Whitley Lake	Mon	17/02/2020	08:47	10:32
13 - Arne/Shipstal	Tue	18/02/2020	11:25	13:20
15 - Holes Bay (railway)	Tue	18/02/2020	12:50	14:35
14 - Holes Bay Hide	Tue	18/02/2020	11:45	13:30
12 - Cleaval Point	Wed	19/02/2020	11:20	13:05
16 - Lytchett Fields	Wed	19/02/2020	12:40	14:25
14 - Holes Bay Hide	Wed	19/02/2020	15:30	17:15
2 - Lytchett Bay	Thu	20/02/2020	15:07	16:52
1 - Holton Lee	Thu	20/02/2020	13:15	15:00
3 - Holes Bay North	Fri	21/02/2020	12:50	14:35
4 - Holes Bay South	Fri	21/02/2020	15:40	17:25
7 - Whitley Lake	Fri	21/02/2020	12:25	14:10
5 - Parkstone Bay	Fri	21/02/2020	15:35	17:20
6 - Blue Lagoon	Sat	22/02/2020	11:05	12:50
5 - Parkstone Bay	Sat	22/02/2020	08:30	10:15
4 - Holes Bay South	Sat	22/02/2020	09:30	11:15
12 - Cleaval Point	Sat	22/02/2020	07:35	09:20
3 - Holes Bay North	Sat	22/02/2020	15:10	16:55
14 - Holes Bay Hide	Sat	22/02/2020	09:00	10:45
2 - Lytchett Bay	Sat	22/02/2020	15:02	16:47
1 - Holton Lee	Sat	22/02/2020	12:15	14:00
10 - Brands Bay	Sat	22/02/2020	14:55	16:40
15 - Holes Bay (railway)	Sat	22/02/2020	12:35	14:20
16 - Lytchett Fields	Sat	22/02/2020	12:17	14:02
15 - Holes Bay (railway)	Sun	23/02/2020	09:10	10:55
4 - Holes Bay South	Sun	23/02/2020	11:30	13:15
7 - Whitley Lake	Sun	23/02/2020	13:25	15:10
13 - Arne/Shipstal	Sun	23/02/2020	10:20	12:05
9 - Bramble Bush Bay	Sun	23/02/2020	13:15	15:00
12 - Cleaval Point	Sun	23/02/2020	15:45	17:30
13 - Arne/Shipstal	Tue	25/02/2020	10:40	12:25
11 - Middle Beach	Wed	26/02/2020	07:50	09:35
9 - Bramble Bush Bay	Wed	26/02/2020	10:20	12:05
3 - Holes Bay North	Sat	29/02/2020	08:15	10:00
6 - Blue Lagoon	Sat	29/02/2020	11:40	13:25
16 - Lytchett Fields	Sat	29/02/2020	14:37	16:22

Survey location	Survey details			
	Day	Date	Start time	Finish time
5 - Parkstone Bay	Sat	29/02/2020	07:58	09:43
11 - Middle Beach	Sat	29/02/2020	08:10	09:55
1 - Holton Lee	Sat	29/02/2020	10:45	12:30

Appendix 5: Survey conditions

Weather conditions

The majority of survey visits (68%) were carried on rainless days (see Figure A5), although it rained for at least one quarter of the total survey time on 23% of survey visits, and for more than half the total survey time on 2% of visits. There was a high frequency of wet, and often extreme stormy, weather during the winter of 2019/20, which commonly peaked during the weekend (e.g. Storms Ciara and Dennis in February).

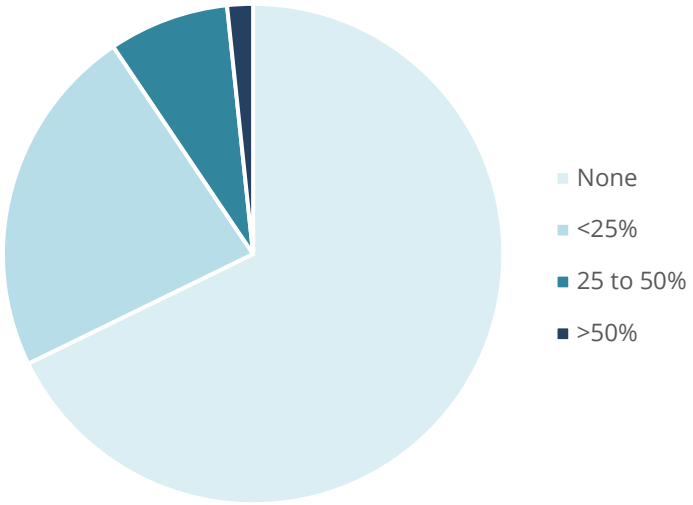


Figure A5: Percentage of rainfall time during each survey visit, across all survey locations (N=180).

Tidal coverage

Overall, a relatively even spread of coverage was applied to each of the four tidal states (falling, high, low, and rising) across the entire survey period (See Table A5). Approximately one quarter of all surveys were carried out on both rising and falling tides, with approximately a third of survey visits undertaken over high tide. A smaller number (15%) of surveys overall were carried out during low tide. A large proportion of low tides occurred during the hours of darkness over the study period, however, and extreme weather conditions precluded carrying out surveys on some otherwise suitable low tide dates.

The spread of tidal coverage at each of the survey locations varied, with several sites (e.g. Brands Bay, Middle Beach, and Cleaval Point) subject to an equal (or approximately

equal) number of surveys across all four tidal states. Nevertheless, low tide coverage was lower or lacking at several locations (e.g. Holes Bay South, Parkstone Bay, and Blue Lagoon), with surveys carried out on high or falling tides prevalent at many of the localities.

Table A5: Summary of tidal states during each survey visit (number/row percentage) across entire study period, stratified by survey location. Values of 50% or more are highlighted in grey, and those of 10% or less are boldly italicised.

Survey location	Tide state				Total
	Falling	High	Low	Rising	
1 - Holton Lee	4 (34%)	4 (34%)	2 (17%)	2 (17%)	**12 (100%)**
2 - Lytchett Bay	2 (17%)	6 (50%)	***1 (9%)***	3 (25%)	**12 (100%)**
3 - Holes Bay North	3 (25%)	3 (25%)	2 (17%)	4 (34%)	**12 (100%)**
4 - Holes Bay South	6 (50%)	5 (42%)	***0 (0%)***	***1 (9%)***	**12 (100%)**
5 - Parkstone Bay	2 (17%)	6 (50%)	***0 (0%)***	4 (34%)	**12 (100%)**
6 - Blue Lagoon	2 (17%)	8 (67%)	***0 (0%)***	2 (17%)	**12 (100%)**
7 - Whitley Lake	4 (34%)	4 (34%)	***1 (9%)***	3 (25%)	**12 (100%)**
9 - Bramble Bush Bay	3 (25%)	4 (34%)	2 (17%)	3 (25%)	**12 (100%)**
10 - Brands Bay	3 (25%)	3 (25%)	3 (25%)	3 (25%)	**12 (100%)**
11 - Middle Beach	3 (25%)	3 (25%)	2 (17%)	4 (34%)	**12 (100%)**
12 - Cleaval Point	3 (25%)	3 (25%)	3 (25%)	3 (25%)	**12 (100%)**
13 - Arne/Shipstal	4 (34%)	4 (34%)	2 (17%)	2 (17%)	**12 (100%)**
14 - Holes Bay (UCP Hide)	3 (25%)	2 (17%)	3 (25%)	4 (34%)	**12 (100%)**
15 - Holes Bay (railway)	2 (17%)	6 (50%)	3 (25%)	***1 (9%)***	**12 (100%)**
16 - Lytchett Fields	5 (42%)	3 (25%)	2 (17%)	2 (17%)	**12 (100%)**
Total	**49 (28%)**	**64 (36%)**	**26 (15%)**	**41 (23%)**	**180 (100%)**