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BTO Research Report No. 179

Winter Distribution and Disturbance of Wildfowl and Waders on Findhorn Bay

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Executive summary

1. **The objectives of the study were: a) to establish which areas within Findhorn Bay are important for feeding and roosting waterbirds at different times of the winter tidal cycle between October 1996 and March 1997, b) to identify when and where these coincided with human recreational disturbance and, c) to suggest conservation management objectives to minimise any disturbance to wintering birds. The study used methodology designed to be repeatable for future work, and complemented the summer work of Patterson and Boyle (1996).**

2. **The fieldwork was carried out in three visits, two within the wildfowling season and one after the wildfowling season had finished. Each tidal cycle was divided into high, falling, low and rising tides. During each visit, counts were made over two complete tidal cycles during both weekdays and weekends, thus giving a total of 48 counts for the winter period. Dawn counts of the roosting geese were also made during each of the three visits. These covered both weekdays and weekends giving a total of 14 counts.**

3. **During each count, the numbers and distribution of all waterfowl species on the estuary were mapped and the types and distribution of human activity around the estuary recorded. Special attention was paid to recording any interactions between human activities and the waterfowl.**

4. **Most recreational activity took place at weekends, with walkers and dog-walkers accounting for most of the observations. Wildfowling activity was recorded daily during the season, with the exception of Sundays, when shooting non-game species is prohibited in Scotland. Most activity was at dawn, and was concentrated in the southern and south-western parts of the estuary. There was little watersport activity compared to the summer months. A total of 115 disturbance events involving 10 types of recreational activity, were noted during the visits. This excludes the daily shooting activities of the wildfowlers, which accounted for an additional 7 recorded disturbance events.**

5. **Generally, recreational interactions with waterfowl were found to cause more disturbance at high tide than at low tide. The low tide feeding distribution of most of the waterfowl kept them separated from most recreational activities. Disturbed birds could usually find alternative, less disturbed parts of the estuary. There is a suggestion that the high levels of recreational activity around the north-eastern part of the estuary (around the village) keeps feeding waterfowl away from this otherwise exploitable area. High tide disturbance frequently involved birds flying around for several minutes, often relocating to the opposite end of the estuary, or occasionally leaving the estuary altogether.**

6. **There are indications that wildfowling has widespread effects on the waterfowl on the Findhorn. During the wildfowling season, most waterfowl appeared to be disturbed at a greater distance, and to fly for a greater distance than during the post-wildfowling season. The use of the southern and south-western saltmarsh areas of the estuary by waterfowl at all stages of the tidal cycle increased after the wildfowling season ended. The roosting geese had earlier mean departure times,**

relative to sunrise, during the wildfowling season than post-season.

7. **Waterborne recreational activity produced higher levels of disturbance, but at lower frequency, than land-based activity. Roosting waterfowl were disturbed on several occasions by boats and windsurfers approaching the shoreline too closely. A marked increase in the winter activity of windsurfers is identified as likely to become of increasing concern in the future.**

8. **Recommendations on containing and reducing the recreational interactions between waterfowl and people on the estuary are suggested.**

1. PROJECT AIMS, BACKGROUND AND METHODS

1.1 Project Aims

a) To establish which areas within Findhorn Bay are important for feeding and roosting waterbirds at different times of the winter tidal cycle between October 1996 and March 1997.

b) To identify when and where these coincide with human recreational disturbance.

c) To suggest conservation management objectives to minimise any disturbance to wintering birds.

1.2 Project Background

The United Kingdom is a key wintering area for many species of waterfowl in NW Europe. The entire breeding population of Icelandic Greylag Goose, Icelandic/Greenlandic Pink-footed Goose and Svalbard Barnacle Goose winter in the UK. Other important wildfowl species, with 50% and over of the north-west European population wintering in the UK, include light and dark-bellied Brent Goose and Gadwall. Among the waders, 69% of the East Atlantic Flyway population of Redshank, 66% of Turnstone and 65% of the *islandica* race of Knot all winter in the UK. Overall there are 26 species of waterfowl whose UK wintering populations comprise 25% or more of the known international population.

Findhorn Bay is part of the Culbin Sands, Culbin Forest and Findhorn Bay SSSI and the proposed Moray Firth Basin SPA and is shortly to be designated as a local nature reserve. The bay provides important feeding and roosting habitats for passage and wintering waterfowl, as well as being an integral part of the wider Moray Basin system. The latter regularly supports over 20,000 wintering waterfowl with internationally important populations of nine waterfowl species and has been proposed as a Special Protection Area (SPA) and Ramsar site. These comprise Icelandic/Greenlandic Pink-footed Goose (4% of the total population, all of which winters in GB), Icelandic Greylag Goose (14% of the total population, all of which winters in GB), Wigeon (5% of NW European population, 12% of GB), Red-breasted Merganser (2% of NW European, 19% of GB), Oystercatcher (1% of East Atlantic Flyway population, 3% of GB), Bar-tailed Godwit (3% of East Atlantic Flyway population, 7% of GB), Curlew (1% of East Atlantic Flyway, 4% of GB), and Redshank (5% of East Atlantic Flyway, 4% of GB) (Johnson & Mudge 1995).

The Moray Basin also holds the largest concentration of seaduck in Britain, with nationally important populations of the three regular species of diver, Scaup, Eider, Long-tailed Duck, Common Scoter, Velvet Scoter, Goldeneye, Red-breasted Merganser and Goosander.

Several other species of waterfowl winter in nationally important numbers on the Moray Basin, including Mute Swan, Shelduck, Pintail, Tufted Duck, Ringed Plover, Knot, and Dunlin. During spells of severe winter weather the Moray Basin assumes even greater international importance as a cold weather waterfowl refuge. Waterfowl from other parts of Europe concentrate in the basin, attracted by the relatively mild climate and the abundance of available food (Johnson & Mudge 1995).

During the summer months the Moray Basin and more especially Findhorn and Spey Bays are important as a feeding area for large numbers of Ospreys (an Annex 1 species). Until recently, locally important numbers of Shelduck bred at Findhorn Bay but these have declined in recent years, possibly as a result of increased human disturbance. It has been of local concern that rising levels of recreational activity in Findhorn Bay are causing increased disturbance to waterfowl, in both the winter and summer months.

A study of the numbers and distribution of both waterfowl and recreational activities on Findhorn Bay was undertaken between April and September 1995 (Patterson & Boyle 1996), when all interactions between waterfowl and recreation were recorded. That survey found that most birds were present in Findhorn Bay during the spring and autumn passage periods, but the greatest human activity was concentrated in the summer when bird numbers were lower. The study also found that birds and people tended to use different parts of the Bay at any given tidal phase. The majority of people were found in the north-eastern part of the estuary around Findhorn Village, with the bulk of the waterfowl feeding in the central, southern and south-western areas, and roosting mainly along the south and south-west shores. The spatial separation of waterfowl and human activity was thought to have been the main reason for the relatively low number of incidents of disturbance of waterfowl by human recreational activity (23 in total). Only 31 breeding pairs of waterfowl were found around the Bay.

During the 1995 study, boating was found to be the commonest activity on the estuary, but caused lower levels of disturbance than expected. This was apparently explained as boating took place mainly in the northern part of the estuary at high tide, when most of the of the waterfowl were roosting in the southern and south-western saltmarshes. However, it was thought that the most disturbance to waterfowl, especially those breeding and roosting, was caused by walkers and dog-walkers using the south and south-west parts of the estuary.

Similar methods were used to undertake a survey over the 1996/97 winter encompassing the wildfowling season. With many more waterfowl present on the estuary in the winter, there was an increased likelihood of recreational disturbance.

1.3 Methods

The study was carried out over a five-month period between November 1996 and March 1997. A total of three visits was made within the period (16 November - 2 December 1996, 18 January - 3 February 1997 and 22 February - 11 March 1997). Two of these visits were within the wildfowling season (1 September - 20 February) and one was post wildfowling season. Each visit comprised of counts over two complete tidal cycles during weekdays and two at weekends, thus producing data for a total of 12 complete tidal cycles for the winter period. During each count, the numbers and distribution of the waterfowl on the estuary were mapped and the types and distribution of human activity around the estuary recorded. Special attention was paid to recording any interactions between human activities and the waterfowl.

The estuary was sub-divided into 22 count sections (Figure 1.3.1) based on a combination of habitat and easily recognisable permanent features. The sections and methods used were designed to be repeatable in the future.

Each tidal cycle was divided into four sections corresponding to low, rising, high and falling tides. The estuary was counted from seven viewing points on the southern and eastern sides (Figure 1.3.1). These were broadly similar to those used during the 1995 summer work. Each circuit of the day took between 2.5 and 3 hours depending on the state of the tide. During each circuit, all the waterfowl, people and interactions between birds and people were plotted on a large-scale map. The distribution of any water in each section was mapped before it was counted as waterfowl were counted on both land and water. A distinction between feeding, roosting and "loafing" (wildfowl only) behaviour was made, and indicated on the maps.

Dawn counts of the roosting geese were made during each of the three visits giving a total of 14 over the winter. These covered both weekdays and weekends, and allowed comparison between wildfowling and post-wildfowling periods.

Between counting circuits of the estuary further observations of recreational activities and interaction with the waterfowl were made from the various vantage points. All incidents where waterfowl were disturbed were noted on specially designed forms. Each incident recorded included data on the type of disturbance, the distance of the source of disturbance from the bird, the distance walked or flown, the time spent moving and the time to resume prior activities after cessation of the disturbance. Flights of birds without any apparent cause of disturbance were also noted.

Human recreational activity and other disturbance was divided into the following categories:

Boating (powered and unpowered and canoes)
Windsurfing
Fishing (from the shore)
Bait digging
Motor vehicles
Walkers (including birdwatchers)
Dog walkers
Wildfowling
Aircraft (jets, turbo-props, gliders and microlights)
Raptors

2. RESULTS

2.1 Waterfowl Distribution: Waders

The average number of waterfowl on each of the 22 count sections was totalled for each counting circuit and tabulated against the tidal phase, weekend/weekday and wildfowling/post-wildfowling season.

Figures 2.1.1 - 2.1.8 show the distribution and the mean numbers of waders over the tidal cycle on weekdays and weekends for wildfowling and non-wildfowling periods combined.

The distribution of waders on the estuary at high tide was broadly similar during both weekdays and weekends for wildfowling and non-wildfowling seasons combined (Figures 2.1.1 & 2.1.2). As most of the estuary was covered by the tide, the waders tend to concentrate in the peripheral parts of the estuary. The saltmarsh areas of 8, 11, 14, 17 and 20 were used mostly for roosting, although there were normally a few feeding Curlew and Redshank. On spring tides, when the saltmarsh areas were often partially flooded, greater numbers of waders, especially Curlew, fed during high tide. Neap tides occasionally allowed use of peripheral mudflats, such as 9, 12 and 22, by feeding and roosting waders. There was more use made of mudflat 13 at weekends than weekdays.

Figures 2.1.3 and 2.1.4 show the distribution of waders on falling tides on weekdays and weekends for wildfowling and non-wildfowling seasons combined. There was a general movement from the peripheral mudflats and saltmarsh areas into the central mudflats of the estuary, as the waders fed along the receding tideline.

The distribution of waders over low tide on weekdays and weekends for the wildfowling and non-wildfowling seasons combined is shown in figures 2.1.5 and 2.1.6. The distribution is broadly similar to that at falling tide, but more waders fed in section 5 as it became uncovered. Fewer birds were recorded in section 3 (mainly used as a roosting area) as they moved further into the estuary to feed.

Figures 2.1.7 and 2.1.8 show the distribution of waders on the rising tide on weekdays and weekends for the wildfowling and non-wildfowling seasons combined. The birds are well distributed within the estuary, using most of the sections. The pattern of distribution is similar to that of low tide, but with fewer birds in sections 5 and 16 (in the central part of the estuary) as it becomes covered, and an increase in the numbers in the south-western corner (sections 19 and 20).

There were several changes shown in the wildfowling and post-wildfowling weekday distribution of high tide roosting waders (Figures 2.1.9 & 2.1.10). During the post-wildfowling season, the waders were spread over fewer sections than during the wildfowling season. There was also a marked decrease in the mean numbers of waders roosting in section 3 at the mouth of the estuary and an increase in the mean number of roosting birds in the saltmarsh section 20 in the south-western part of the estuary. The increase in the wader numbers in section 20 appears to be a direct result of a re-distribution of birds within the estuary rather than a change in the overall numbers using the estuary. The majority of the waders involved were Oystercatchers, which had regularly roosted at the mouth of the estuary for much of the winter. Duck shooting is a

regular event on these saltmarshes during the season and might explain the post-wildfowl increase in roosting birds once regular disturbance had ceased. There was no apparent increase in other disturbance activity in section 3 to explain the mean decrease in roosting waders. It is also possible that some of the roosting Oystercatchers began to move up river back towards their breeding sites from late February. The mean number of roosting waders in sections 9 and 12 (eastern side of the estuary) decreased sharply post-wildfowling season. Some of these birds may have switched to sections 21 and 22 at the southern end of the estuary (Figure 2.1.10) as there was a small post-wildfowling increase in mean numbers. Curlew is one such species likely to have shown this shift.

The weekend, post-wildfowling high tide distribution was broadly similar to the weekday post-wildfowling distribution (Figure 2.1.9). There was a marked increase in the mean number of waders using the south-western saltmarsh when compared to the weekend wildfowling high tide distribution (Figures 2.1.11 & 2.1.12). There was also an increase in mean bird numbers in sections 21 and 22 in the south-eastern part of the estuary, an area very disturbed during the wildfowling season. There was a decrease in the mean number of waders along the eastern side of the estuary post-wildfowling season, but some of these birds might have been responsible for the increases in the south-eastern sections of the estuary.

The weekday mean wader distribution on falling tides (Figures 2.1.13 & 2.1.14) shows a post-wildfowling increase in numbers in sections 1 and 4 at the eastern side of the mouth and a decrease along the eastern sections in the middle of the estuary (sections 8, 9 and 12). The post-wildfowling decrease in the section 3 (western side of the mouth) is likely to be related to the switch of roosting birds to the south-western part of the estuary or possibly to sections 1-4 on the eastern side of the mouth.

The weekend mean wader distribution on falling tides post-wildfowling (Figure 2.1.16) is very similar to the weekend distribution during the wildfowling season (Figure 2.1.15). There were, however, decreases along the eastern side of the estuary. There was also a marked post-wildfowling decrease in numbers in section 3 (western side of the mouth), possibly offset by increases in section 16 in the central part of the estuary.

The weekday post-wildfowling distribution of waders over low tide was broadly similar to the distribution within the wildfowling season (Figures 2.1.17 & 2.1.18), but with a mean decrease in numbers in the eastern and southern sections of the estuary (especially sections 4, 10 and 13). Some of these waders may have switched to adjacent sections as both sections 5 and 16 in the middle of the estuary both held higher mean numbers post-wildfowling season. A possible explanation for these changes is availability of food supply, which is likely to become depleted in the favoured feeding areas as the winter progresses.

The post-wildfowling distribution of waders at low tide at weekends was generally similar to the low tide distribution within the wildfowling season (Figures 2.1.19 & 2.1.20). There were post-wildfowling decreases in sections 5 and 16, but increased numbers in sections 10 and 13. Generally, there was a post-wildfowling increase in wader numbers in the southern half of the estuary, with the greatest single increase recorded from section 10. The post-wildfowling declines on some of the northern sections of the estuary is likely to be explained by the birds spending more time in these southern sections.
The weekday post-wildfowling distribution of waders on the rising tide showed a marked

increase in the use made of the saltmarsh in the south-western part of the estuary compared to the mean distribution during the wildfowling season (Figures 2.1.21 & 2.1.22). The cessation of wildfowling, and more especially duck shooting, is likely to be a major factor in this switch although, unlike the post-wildfowling high tide distribution, the mean numbers of waders around the estuary mouth were very similar both during and after the wildfowling season. There was a small increase in the post-wildfowling use of section 22 at the southern end of the estuary.

The weekend post-wildfowling distribution of waders on a rising tide showed a similar trend to the weekend wildfowling distribution, with an increase in mean numbers in sections in the south-western part of the estuary (Figures 2.1.23 & 2.1.24). Elsewhere, mean wader numbers declined in section 5 and along the eastern edge of the estuary in the post-wildfowling season. Increases in mean numbers occurred in section 16.

Overall, in the post-wildfowling season, there was an increase in wader numbers in the south-western part of the estuary, and a decrease in numbers in the north-western sections of the estuary. The main species involved was Oystercatcher with, to a lesser extent, Curlew and Redshank.

2.2 Waterfowl Distribution: Wildfowl

The mean numbers and distribution of wildfowl on weekdays over the tidal cycle showed several differences between the wildfowling and post-wildfowling seasons. During three of the four states of the tide (rising tide being the exception), there were increases in the mean numbers of wildfowl using the south-western part of the estuary in the post-wildfowling season. Wigeon were the most numerous species of wildfowl during the day. The geese used the estuary for roosting most of the time. Geese are dealt with in more detail under the section on wildfowling (Section 2.3).

The weekday post-wildfowling high tide distribution of wildfowl showed mean decreases in virtually all of the northern and eastern sections of the estuary compared to the weekday distribution within the wildfowling season (Figures 2.2.1 & 2.2.2). It is possible that some of these "missing" birds were actually in the extensive saltmarsh in the south-western part of the estuary (section 20). Due to the network of hidden creeks, it proved impossible to accurately count birds in the saltmarsh except as they entered or left it, and it is likely that mean high tide numbers of wildfowl in this area were under-estimated. The apparent mean decrease in wildfowl using sections 17 and 18 between the wildfowling and post-wildfowling seasons might well be explained by the birds moving into the saltmarsh proper, and therefore missed during the counts. The cessation of shooting within the saltmarsh is likely to have been a contributory factor in the mean increase in numbers in section 20.

The weekend high tide distributions of wildfowl mirror the weekday trends fairly closely (Figures 2.2.3 & 2.2.4). There was a mean decrease in the numbers of wildfowl in the northern and central sections of the estuary after the end of the wildfowling season, with an increase in the saltmarsh sections within the southern and south-western parts of the estuary. The decrease in numbers in section 19 (south-western corner) during the post-wildfowling season may be as a result of the wildfowl feeding in the saltmarsh of section 20, and therefore remaining out of sight. The factors affecting the weekday count, outlined above, are equally applicable for the weekend counts.

The weekday distributions of wildfowl over the falling tide show a similar pattern to the high tide counts (Figures 2.2.5 & 2.2.6). There was a marked increase in the mean numbers of wildfowl in the south-western part of the estuary compared to the wildfowling season. As the tide falls, the wildfowl tend to move up the estuary, and therefore become easier to count as they leave the creeks of the saltmarsh. There was also a detectable increase in wildfowl using the south-eastern part of the estuary after the end of the wildfowling season (sections 13 and 21 in particular). This is again likely to be related to a lack of shooting disturbance.

The weekend distribution of wildfowl on falling tides during the post-wildfowling season was similar to the weekday post-wildfowling season (Figures 2.2.7 & 2.2.8). There was an increase in wildfowl in the south-western corner of the estuary and decreases on all of the northern sections in the post-wildfowling season.

The weekday post-wildfowling distribution of wildfowl at low tide also showed an increase in the mean numbers using the southern and south-western sections of the estuary compared to their distribution within the wildfowling season (Figures 2.2.9 & 2.2.10). The mean numbers in the northern sections of the estuary showed little change between wildfowling and post-wildfowling seasons.

The weekend post-wildfowling mean distribution of wildfowl at low tide was similar to that of the weekday post-wildfowling distribution. There was a marked increase in the use made of the south-western part of the estuary during weekends post-wildfowling season, with birds remaining adjacent to the saltmarsh, and a small number feeding in the saltmarsh of sections 20 and 21 (Figures 2.2.11 & 2.2.12). It is likely that these figures are underestimates as birds can remain undetected within the creek systems. It is likely that a proportion of the birds "missing" from the northern sections of the estuary between the wildfowling and post-wildfowling seasons were spending a greater amount of time at the southern end of the estuary, with the lack of shooting disturbance.

The weekday post-wildfowling distribution of wildfowl on rising tides revealed a broadly similar pattern of distribution within the estuary between the two periods but, in many sections, a reduction occurred in the mean numbers in the post-wildfowling period (Figures 2.2.13 & 2.2.14). There were a few more birds on the saltmarsh of sections 9, 10, 20 and 21, compared to the wildfowling season.

The weekend distribution of wildfowl on rising tides also showed a broadly similar distribution between the two (Figures 2.2.15 & 2.2.16). Post-wildfowling, there was a reduction in the mean numbers of wildfowl on all of the northern sections of the estuary, but relatively little difference in the mean numbers in the southern and south-western sections of the estuary. The only exception to this trend was on sections 21 and 22 in the south-eastern part, where there was an increase in the mean numbers post-wildfowling season.

Overall, in the post-wildfowling season, there was an increase in the wildfowl numbers in the southern and south-western parts of the estuary, and a decrease in numbers in the northern sections of the estuary during most of the tidal cycle. Rising tides were the one exception to this trend. The greatest difference in wildfowling and post-wildfowling

distribution was noted on falling tides. The main species involved was Wigeon, with a greater proportion of birds remaining in or close to the salt marsh areas of the estuary post-wildfowling season.

The mean numbers for each species of waterfowl on each estuary section at each stage of the tidal cycle are summarised in Appendix 1.1 - 1.18.

2.3 Goose Roost Counts

A total of 14 dawn visits were made to:

a) map the distribution of the roosting geese on the estuary

b) obtain data on the species and numbers using the estuary

c) record the interactions between the wildfowlers and geese

The visits were divided between wildfowling (nine counts) and post-wildfowling seasons (five counts). This made it possible to monitor any changes in goose behaviour between the seasons. Several visits were made at dusk to monitor the arrival of the geese onto the estuary, but were found to be of limited usefulness as the birds tended to arrive after dark which meant that counting was inaccurate and species identification made that much more difficult. The geese never appeared to leave the estuary before dawn (on most occasions, the early morning observations began well before dawn so as to avoid missing the first geese leaving). Even at dawn, it was not always easy to obtain ideal counting conditions. On wildfowling days, the departure of the geese tended to be triggered and governed by the activities of the wildfowlers, and more especially by the number of shots fired. Thus, on occasions, hundreds of geese would take off simultaneously from different parts of the estuary and fly off in totally different directions.

The count data are summarised in Table 2.3.1. Only two species of goose were noted on the estuary during the winter (Greylag and Pink-footed Goose). Overall, during the wildfowling period between November and early February, Greylags were present in far greater numbers than Pink-footed Geese. The one exception to this was in late January when slightly more Pink-footed Geese were recorded. The highest count of Greylags was 2776 on 22 January. The numbers tended to fluctuate at the end of January/beginning of February. There is at least one other roosting site in the area (Loch Spynie) where there is no shooting, and it is possible that there is some interaction between the two sites. The numbers of Pink-footed Geese on the estuary in most of November were very low (between 20 and 70, but picked up at the end of November (970 on November 30) before peaking in late January at 1169 and again in March (2513). This species too showed marked fluctuations in the numbers on the estuary. There is some evidence to suggest that numbers of Pink-footed Geese fly onto the estuary at dawn to "loaf", their length of stay governed by the levels of wildfowling. Once disturbed they would fly off for the day, presumably to feed in the surrounding fields. However, Pink-footed Geese certainly used the estuary as a roosting area as well.

The five counts made in the post-wildfowling period (Table 2.3.1) revealed a large decline in the numbers of Greylag Goose (a maximum of 173 counted between February 23 and

March 10), and a steady increase in the numbers of Pink-footed Geese, peaking at 2513 on the final count of March 10. It is possible that the prolonged spell of mild weather throughout much of February and early March encouraged the wintering Greylags to begin the movement back to their breeding grounds a little earlier than usual. The same also accounts for the steady increase in the numbers of Pink-footed Geese; birds beginning to move northwards and using the estuary as a staging point. It is also possible that the lack of shooting encouraged more of the "local" Pink-footed Geese to use the estuary.

The position of the roosting goose flocks was mapped during each count (Figures 2.3.1 & 2.3.2). There were several differences between the wildfowling and post-wildfowling seasons. However, the reduced post-wildfowling sample size both in the number of roost counts made and the depleted numbers of geese (especially Greylag) will have influenced the results to some extent. During the wildfowling season, the main roost of Greylag was along the channel in sections 10, 13 and 16. The Pink-footed Geese favoured the mudflats adjacent to the rifle butts, straddling sections 13 and 16. Very occasionally, small numbers of Pink-feet were noted a short distance away from the main roost, by the channel in section 13. In November, on two occasions, a mixed flock of Greylag and Pink-feet were recorded roosting in the western part of section 16, well away from the more usual areas (Figure 2.3.1).

Post-wildfowling, the few Greylag still roosting on the estuary were occupying the same general area around the channel in sections 10 and 13, but tended to be closer to the edge of the estuary (Figure 2.3.2). They also fed and "loafed" soon after dawn on the saltmarsh in section 11. The roosting Pink-footed Geese also showed a modified distribution (Figure 2.3.2). There was still a roost adjacent to the rifle butts, but much closer to the saltmarsh, in sections 13 and 22. A lot of Pink-footed Geese also "loafed" and fed after dawn in a new area to the east of the rifle butts straddling sections 13, 21 and 22. This actually brought them into the saltmarsh.

The departure time from the estuary of each group of geese was recorded during every roost count. The average departure time for the geese was calculated for each count and the data plotted as mean departure in minutes either side of sunrise (Figure 2.3.3). The data for the wildfowling season indicate earlier mean departure times than during the post-wildfowling period. During the wildfowling season, the majority of the geese leave no later than 10 minutes after sunrise. The one exception to this occurred on January 23, when the average departure time was 20 minutes after sunrise. The weather was probably a major factor in this apparent anomaly; it had rained overnight and was still very overcast and misty at dawn, effectively adding a few minutes to the time. The mean departure time for the post-wildfowling season shows a trend towards a later time. The early departure time of February 24 is hard to explain. There were fewer geese recorded roosting on the estuary than on any other date during the 14 counts (Table 2.3.1).

From the data available, it is clear that the geese altered their behaviour patterns during the wildfowling season. From observations made during the regular tidal counts during the post-wildfowling season, there were many more geese feeding on the estuary (mostly in the saltmarsh areas in south) than during the wildfowling season. It is possible that the other local sources of food for these birds had become depleted towards the end of the winter, forcing the birds to move to new areas. Passage birds, not familiar with the winter wildfowling on the estuary, might spend a few days feeding before moving on, choosing to

feed in the previously disturbed areas of the estuary. Further research on the staging activities on the Findhorn estuary may be required.

2.4 Recreational Activity

There was generally some form of recreational activity taking place during most of the survey days, with by far the greatest activity at weekends, and then especially in late February and early March. The bulk of the land-based recreation took place along the eastern side of the estuary, especially concentrated in the north-eastern area around Findhorn village. The weather and the time of the day, rather than the state of the tide, exerted the greatest influence over the frequency of most of the land-based recreation. Fishing and bait-digging were exceptions, influenced by the state of the tide rather than the weather.

Walking and dog-walking were by far the two most common recreational activities. Of the two, walkers used more of the estuary (recorded in 16 sections) than dog-walkers (recorded from nine sections) (Figures 2.4.1 & 2.4.2). The 10 observations of birdwatchers (mostly at weekends and mostly at the southern end of the estuary) are included in the overall walkers total. The bulk of the dog-walking in section 1 was done at high tide (35 out of a total of 59 weekend observations). Conversely, none of the 10 observations of dog-walkers in section 4 were at high tide (Figure 2.4.2). The beach of section 4 is normally covered at high tide whilst the top of section 1 is usually uncovered. A similar situation was noted for walkers, with the majority in section 1 recorded at either high tide or falling tide at the weekend (Figure 2.4.1).

The bulk of the bait-digging took place at weekends and was concentrated along the narrow shore of section 4, with two observations from sections 10 and 16 respectively (Figure 2.4.3). All the bait-digging took place over the low tide period. Fishing was only observed on a single occasion, (Figure 2.4.3), adjacent to Findhorn village, and over low tide (the channel had water in it).

Motor vehicles were noted in sections 1, 4, 7, 11, 12, and 17 (Figure 2.4.4). The majority of these were a single observation; tractors moving boats (section 1), an excavator moving shingle (section 4), a pick-up truck repairing a fence (section 7) or gathering driftwood (sections 12 and 13). The six observations from the saltmarsh of section 17 involved birdwatchers who sat in their cars overlooking the estuary from the rough track from Netherton cottages. Wildfowlers also parked their vehicles in this area but left soon after dawn.

The wildfowling was concentrated in the south-eastern corner (for geese), whilst some duck shooting took place in the saltmarsh in the south-west corner (presumably for ducks). Those visits made during the season recorded wildfowling daily except Sundays. For the most part, the wildfowlers kept to the saltmarsh but were observed on several occasions looking for "pricked" geese on the mudflats of sections 13 and 16.

There was very little boating activity, and most of this was at weekends (Figure 2.4.5) and centred around the village in the northern half of the estuary over the high tide period. The bulk of the observations involved a Humber craft moored in the village, which mostly operated within sections 1 and 4. Only one speedboat was observed and this soon left the

estuary. Only two canoes (in section 4) were recorded over the winter.

Windsurfing was popular at weekends when a combination of tide (two hours either side of high tide) and wind conditions were suitable. The majority of participants appeared to be from a local club, with their equipment stored adjacent to the village jetties. However, several observations were made of "visiting" windsurfers who arrived with their boards in the car. All the windsurfers launched themselves from section 4, with the bulk of activity within sections 4 and 10 (Figure 2.4.6). The more adventurous proceeded into the centre of the estuary (sections 10 and 16), with occasional activity on very high tides at the extreme southern end of the estuary (sections 13 and 22).

2.5 Disturbance

2.5.1 Findhorn studies

For the purposes of the current study, the impact of each disturbance incident was graded into three categories;

low: **where waterfowl remain alert/stop feeding for <10 seconds and/or move <10 m.**

medium: **where waterfowl remain alert/stop feeding >10 seconds, or walk between 10 m and 50 m, or fly between 10 and 50 m.**

high: **where waterfowl walk > 50 m, or fly >50 m.**

These divisions were chosen to be practical and repeatable and allow comparison between the degree of disruption caused to the routine of a bird by a particular disturbance incident. It is virtually impossible to assign an individual disturbance "score" to a particular disturbance activity. The degree of severity of a particular incident might be influenced by its frequency, and by other factors pertaining at the time (*i.e.* the weather, time of the year and potentially disturbing events in the vicinity. At first sight, a "low" level of disturbance, for example where a bird either stops feeding for 8 seconds and/or moves 8 m, is not likely to be important as an isolated incident. However, if the same level of disturbance affected the same individual several times an hour, several hours a day, the long-term effects (reduced feeding/increased stress levels) might assume greater importance than one or two "high" level disturbance incidents, where birds move >50 m. It is all these unknown factors that make the assessment of disturbance so subjective, with the long-term effects possibly taking weeks to reveal themselves (*e.g.* birds not attaining breeding condition the same year).

2.5.2 Distribution of disturbance events

It is the actual number of disturbance events rather than the actual number of disturbance sources that are recorded. For example, a single disturbing source, such as a windsurfer, may produce several independent disturbance events during the course of moving around in the estuary, and it is these events that are analysed in the report.

Figures 2.5.2.1 - 2.5.2.7 show the distribution of disturbance events by estuary section. In view of the fact that most of the recreational activities on the estuary were recorded at weekends, it was to be expected that the bulk of the instances of disturbance would also occur at weekends (wildfowling disturbance was the exception to this, but the main direct effects are dealt with under the goose roost Section 2.3).

The actual number of disturbance observations involving walkers and dog walkers is relatively small even in sections 1 and 4 (Figures 2.5.2.1 & 2.5.2.2) which were very popular with these groups. A likely explanation is that waterfowl habitually avoided section 1 altogether as it was walked so regularly. The estuary count data tend to support this view, with a few Oystercatcher and Turnstone being the main species recorded, and usually on the falling tide. Section 4 was also popular with walkers, especially the area around the village proper. The main waterfowl species in this part of the section were the odd Curlew and several Turnstone. These individuals (of both species) had become much more tolerant of recreational activities, and so were apparently disturbed much less than might otherwise be expected in view of the levels of recreational activities taking place on the section.

There were two observations of disturbance by bait diggers (Figure 2.5.2.3), both adjacent to the "Pink House", both caused as they walked to new digging areas. A small number of Knot flew to new feeding areas.

The disturbance by wildfowlers relates to individuals walking to and from cars at the start or finish of the session (sections 11, 20 and 21), or walking onto the mud to look for "pricked" geese (sections 13 and 16). The number of such disturbance incidents were equally divided between weekdays and weekends, and were infrequent. The effect of wildfowling on the geese in general is discussed in Section 2.3

Aircraft disturbance (Figure 2.5.2.4) was limited to the southern part of the estuary, and mostly involved Nimrod aircraft taking off. When this occurred soon after dawn it was particularly disturbing to roosting geese.

Raptor disturbance was spread over nine sections of the estuary (Figure 2.5.2.5), and showed a weekday bias. It is possible that the increase in general recreational activities at weekends meant raptors were less active, preferring to keep away. The majority of the disturbance observations involved a pair of Peregrine Falcons, semi-resident for much of the winter in the saltmarsh of section 20. Raptor activity caused intense disturbance whenever it occurred (Section 2.5.8.2).

Boating disturbance was mostly at weekends and confined to the northern sections of the estuary (Figure 2.5.2.6). Roosting waders were disturbed from section 4 as a result of the close proximity of a boat as it moved down the estuary. The majority of boating disturbances affected wildfowl on the water, often resulting in birds taking off and flying elsewhere within the estuary.

Windsurfing was confined to weekends (Figure 2.5.2.7) and disturbed wildfowl actually on the water and roosting waders in the southern part of the estuary.

There were several disturbance observations with an unknown cause, all of which occurred

at weekends. These were in the north-western and south-eastern parts of the estuary. It is possible that those on the western side of the estuary towards the mouth were caused by walkers, and those in the south-western part of the estuary caused by raptors.

2.5.3 Disturbance to specific groups

If all the disturbance events that were recorded as affecting waders over the winter are summarised, a mean disturbance distance of 42 m and a mean flight distance of 497 m is found (Table 2.5.3.1) for wildfowl. The respective figures are 89 m and 871 m for wildfowl This indicates that wildfowl responded to disturbance from a greater distance, and fly for a greater distance, than waders on Findhorn. However, wildfowl tend to have a shorter average recovery time (a measure of the time taken for the bird to resume pre-disturbance activity) than waders after the disturbance event is over (2 seconds versus 14 seconds).

2.5.4 Disturbance to species

Disturbance observations (excluding disturbance caused by the actual shooting of the "quarry" species) were made on 10 species of wildfowl as opposed to seven species of waders (Table 2.5.4.1). The most commonly disturbed species overall were Oystercatcher (23 observations) and Turnstone (14 observations). The wildfowl species with the most disturbance observations were Wigeon (9), Pink-footed Goose (8) and Long-tailed Duck (7) It is noticeable that the four main "quarry" species of the wildfowlers (Greylag and Pink-footed Geese, Mallard and Wigeon) were all disturbed at a greater mean distance than other waterfowl species with the exception of Dunlin. The bulk of the Dunlin tended to feed in the southern part of the estuary, and therefore were relatively close to the wildfowling areas. This may have made them more susceptible to disturbance than would otherwise have been the case. The four species of waterfowl that showed the greatest average flight distances were all wildfowl (Greylag Goose, Mallard, Wigeon and Red-breasted Merganser), with Curlew and Dunlin showing the greatest mean flight distances amongst the waders. The greatest mean flight time on the estuary in response to disturbance was recorded for Mallard (92 seconds) with Bar-tailed Godwit the wader species with the greatest mean flight time in response to a disturbance (56 seconds). Where birds were disturbed and flew out of the estuary, the total flight time is unknown, so only the actual time within the estuary was noted. The mean recovery time after a disturbance was shorter for wildfowl than for waders. Oystercatcher (at 35 seconds) had the longest mean recovery time of all the waterfowl on the estuary.

2.5.5 Frequency of the recorded disturbances

Table 2.5.5.1 shows the total number of recorded disturbance observations for the eleven categories of disturbance recorded over the winter. The top four most commonly observed disturbance events on the estuary were raptors (22 observations), dog-walkers (21 observations), walkers (17 observations) and windsurfers (15 observations). Overall, land-based disturbance produced a total of 52 disturbance observations. Water-based disturbance (windsurfing and boats combined) produced a total of 26 disturbance observations. The water-based disturbance also caused the disturbed waterfowl to fly considerably greater distances (1007 m for windsurfing and 1405 m for boats) than land-based disturbances. The greatest mean disturbance distance was recorded for wildfowlers (walking onto the estuary towards the end of a shooting session presumably when the

waterfowl were more likely to have a lower disturbance threshold).

Table 2.5.5.2 shows the total number of each type of disturbance that affected each species of waterfowl. Aircraft were the commonest source of disturbance for Pink-footed Geese (six instances noted), and overall caused more of a disturbance to wildfowl than waders.

Boats on the estuary disturbed more wildfowl than waders, with Red-breasted Merganser the most disturbed species (four occurrences). Roosting Oystercatchers in section 3 were disturbed on two occasions as a boat passed too close to the shore. The disturbed waders flew 2000 m to the southern end of the estuary. Four of the five species recorded as being disturbed by boats flew more than 1000 m as a result.

Windsurfing activity was observed to disturb a total of eight species, second only to dog-walking. Considering that it only took place at weekends, in certain weather conditions, involved relatively few people at any one time, and was restricted by the state of the tide, it proved to be an important disturbance activity on the estuary, and needs to be monitored carefully in the future. Long-tailed Duck was the most commonly disturbed species (five observations). Perhaps surprisingly, windsurfing disturbed a total of five wader species, mostly at roost, but also around the launching point for the windsurfers in the village. The displaced roosting waders flew considerable distances (2500 m in the case of Dunlin).

A total of nine species were disturbed by dog-walkers (six waders and three wildfowl). Turnstone and Oystercatcher were the two most commonly disturbed species with six and four observations respectively. The Turnstone were mostly disturbed in section 4, and were generally used to human activity as shown by the average disturbance distance of 4 m, and the relatively short flight distance of 24 m.

Walkers disturbed five species, fewer than dog-walkers. Curlew and Turnstone were the species most regularly involved (five disturbance observations each), with most of the incidents occurring in section 4. The mean disturbance distance for Turnstone at 14 m was greater than for dog-walkers within the same section, as was the average flight distance of 164 m. Oystercatchers were disturbed only slightly less with four observations. Wildfowlers walking about the saltmarsh or onto the mudflats disturbed a total of four species, with Dunlin the most commonly affected species (three observations).

Bait-diggers, fishermen and motor vehicles were only occasionally present on the estuary and caused little disturbance.

2.5.6 Tidal state and degree of disturbance

Table 2.5.6.1 shows the individual disturbance incidents for each species for the different states of the tide. The number of disturbance events in relation to the state of the tide was as follows; low tide - 30, high tide - 42 and rising/falling tide - 43.

Species such as Curlew and Oystercatcher, were disturbed at a greater distance by walkers and dog-walkers at high tide than at other states of the tide. The mean flight distances in response to disturbance at high tide were also greater. In the case of Curlew, the mean flight distance at low tide in response to walkers and dog-walkers was 120 m, compared to 1438 m at high tide with the same number of observations. Raptor disturbance at high tide

caused Dunlin to fly greater mean distances than at low tide (1200 m as opposed to 500 m). Conversely, Redshank flew greater distances when disturbed by raptors at low and medium tides rather than at high tide. However, the birds took longer to recover from the disturbance at high tide. Turnstone were almost solely disturbed on rising/falling tides (11 out of a total of 14 disturbance incidents). The disturbance distances were less at high tide than over the medium tides, but the Turnstone flew further when disturbed at high tide.

Overall, the majority of disturbance observations were at high tide or on the falling/rising tides, often closer to high tide than low tide. Only Mute Swan and Shelduck suffered disturbance purely over low tide, with a single observation for each species, whilst Bar-tailed Godwit recorded single disturbance incidents at every stage of the tidal cycle.

2.5.7 Differences in disturbance reactions between wildfowling and post-wildfowling seasons

Table 2.5.7.1 summarises the mean disturbance reactions of waterfowl in the wildfowling and post-wildfowling seasons. Fewer disturbance observations were made during the post-wildfowling period, as two out of the three periods of winter fieldwork were made during the wildfowling season. To allow a meaningful comparison, ideally the data ought to be balanced, requiring similar types of disturbance over the two seasons, and observations made at similar stages of the tidal cycle. In many cases, it is not possible to make very meaningful statistical comparisons because of the small number of observations made during the course of this study. However, within these limitations, there are indications that waterfowl were more prone to disturbance, and moved further during the wildfowling season than during the post-wildfowling season. For several species, similar disturbance observations were made at the same state of the tide both during and post-wildfowling season.

Dunlin were apparently disturbed at similar distances by raptors in both seasons, but flew slightly further during the wildfowling season (1200 m or 600 m compared to 400 m).

Oystercatcher appeared to react to disturbance by walkers and dog-walkers at low tide at a similar average distance in the wildfowling season and the post-wildfowling seasons (24 m compared to 21 m), but flew further (77 m compared to 321 m). A similar situation appear to prevail for raptor disturbance, with the mean disturbance distance at low tide during the wildfowling season being 28 m compared to 24 m during the post-wildfowling season. It would appear that humans and raptors cause obvious disturbance at similar distances (between 21 - 28 m) during the low tide period. The actual levels of disturbance caused by a hunting raptor may well be higher than disturbance by humans, with individual waders being pursued over considerable distances. In many instances, waders disturbed feeding at low tide by human activity can relocate in a relatively short time and resume feeding. or less evenly distributed between wildfowling and post-wildfowling parts of the season.

Aircraft disturbance to Pink-footed Geese appeared to cause them to fly greater distances during the wildfowling season than post-wildfowling season (mean distance of 297 m compared to 72 m.

Turnstone generally followed the trend shown by the other wader species. Walkers and dog-walkers apparently caused the birds to fly further during the wildfowling season

although the actual flight times were considerably greater in the post-wildfowling season.

Although the tidal states are not strictly comparable, Wigeon were apparently disturbed by raptors at closer distances in the post-wildfowling season, but flew further during the wildfowling season (mean flight distances of 1500 m compared to 298 m). Aircraft disturbance, conversely, appeared to affect the birds more in the post-wildfowling season than in the wildfowling season, with greater disturbance distances, and distances flown.

2.5.8 Actual examples of disturbance observations made at Findhorn

From the variety of observations made over the winter period, the following are "case studies" that resulted in high levels of waterbird disturbance. The majority of disturbance events involving the recreational activities detailed below did not normally lead to such high levels of disturbance.

2.5.8.1 Windsurfing

On March 9 there were up to six windsurfers operating on the estuary between 10:40 and 13:55 (over the entire high tide period). Most windsurfing activity is usually confined to the northern and central sections of the estuary. On this occasion, it was a particularly high tide, and quite windy. A single windsurfer decided to head down to the southern end of the estuary, keeping more or less to the central sections as he did so. At the time, section 22 was entirely covered except for a small "saltmarsh island" with roosting waders, and the tide was already well advanced onto the saltmarsh section of 21. Waders were roosting on this section too.

Initially, the windsurfer disturbed a group of five Long-tailed Duck from section 13. They flew for *c*. 350 m and landed again in section 16. The next species to be flushed off the water was a Goldeneye, which headed up the estuary from section 13 and also landed in section 16 after flying 400 m. The windsurfer "coasted" slowly towards the wader roost on the saltmarsh island in section 21, as if he wanted to get a closer look. At a range of *c*. 80 m from the roosting waders, he turned round to head back up the estuary. However, it was too late by then, as two Dunlin flew out of the saltmarsh, and up the estuary. This precipitated a "ripple effect", and several groups of Oystercatcher and 20 Curlew took off from section 21, and began circling over sections 21 and 22. After some 10 seconds, the Curlew flew for 650 m and landed adjacent to the rifle butts in section 21, and settled down fairly quickly (4/5 seconds). The Oystercatcher split up, with a group of six flying to roost in the saltmarsh of section 20 (a flight of 2500 m), whilst 20 headed up the estuary to join a roosting group on the saltmarsh of section 8 (involving a flying time of 30 seconds and covering *c*.2500). The remaining 20 Oystercatcher from the disturbed roost continued to circle over sections 21 and 22 for 20 seconds and eventually returned to their original roosting spot on the saltmarsh "island" in section 22. Thus, a single windsurfer caused disturbance to a total of 74 birds (5 species) over 120 seconds on both land and water at, arguably, the stage of the tidal cycle when waterfowl are most susceptible.

On this particular day, a repeat episode was noted some 56 minutes later, when a different windsurfer coasted onto the flooded saltmarsh of 21, flushing some of the previously disturbed Curlew. The alarm calls of these birds as they moved westwards in turn

disturbed another 35 roosting Curlew that were not originally affected by the windsurfer. All the birds circled for 65-70 seconds, before 30 returned to roost by the rifle butts again, and 30 continued flying westwards into the saltmarsh of section 20 (and out of sight of the observer).

2.5.8.2 Raptors

In early March, at low tide, a hunting Peregrine headed north up the estuary from the vicinity of the "Pink House" (sections 4/10/16). The exact starting point of this hunting flight was not observed, but a large group of waterfowl were "pushed "up the estuary in section 5 ahead of the falcon. A conservative estimate was of 300 Wigeon, 250 Oystercatcher and 250 Dunlin. As these birds flew over sections 4 and 5, they flushed other birds, such as Redshank, and further Wigeon and Oystercatcher. The falcon disappeared after 5 seconds, apparently chasing a single wader south down the estuary. The disturbed waterfowl continued to circle and alarm over sections 4 and 5 adjacent to Findhorn village for approximately 25 seconds. The Wigeon were the first species to land after flying 125 m, they landed in a channel at the centre of the estuary in section 5, and remained in an alert state for some time as they "loafed". The Oystercatchers landed on a sandy area of section 5 and rested. After 12 minutes or so, 30 Oystercatchers left the roost and flew south and out of sight behind the "Pink House", probably their original feeding area before the disturbance.

The Dunlin flock, accompanied by 20 Redshank, landed in section 4 by the village and remained alert. This was the only occasion over the winter that Dunlin were observed in this part of the estuary. Most of the birds remained motionless, almost in a state of shock, whilst one or two birds made half-hearted attempts to feed in the sandy and gravelly substrate. A flock of 150 Dunlin flew north back up the estuary 10 minutes after the falcon disturbance began. The remaining 100 Dunlin eventually stayed in section 4 and roosted there. It was unusual to observe Dunlin roosting at low tide on the estuary.

Thus, the effects of this particular raptor disturbance included the redistribution of some of the feeding waterfowl for a part of the tidal cycle.

A little later that afternoon (35 minutes after the first raptor disturbance), the same individual Peregrine was once again active in the vicinity of the "Pink House", causing the waterfowl on sections 10 and 16 to fly around for 15-20 seconds, with Oystercatchers landing again in section 16 after 15 seconds, and Dunlin and Redshank flying down the estuary to the southern end and out of view. As waterfowl tend to feed more on a falling tide than over low tide (in most cases), these types of repeated interruptions might not be too serious if they are not a daily occurrence and the birds are not struggling to maintain their body weight in cold weather and/or other poor feeding conditions.

2.5.8.3 Boats

A small speedboat entered the estuary at high tide, and followed the navigation markers along the eastern channel down the estuary. It continued slowly (within the likely official limits for craft using the estuary) as far as the junction of sections 10, 13 and 16 (*i.e.* about two thirds of the way down the estuary). At this point, it turned around and slowly retraced its steps. It was probably in the estuary for a total of five minutes. Despite the

leisurely nature of this "excursion", waterbirds were disturbed all along the route.

A "loafing" flock of six Red-breasted Mergansers were flushed at a range of *c.*65 m from section 5 as the boat moved down the estuary. They flew *c.*1500 m to the western side of section 16 and continued "loafing" once again. On the way back to the mouth, even more birds were disturbed, possibly as they had been displaced in some way as the boat originally moved down the estuary. A single Red-breasted Merganser was "pushed" ahead of the boat in section 5, eventually flying as far as the estuary mouth, and possibly away altogether (it was out of view by then). At the southern end of section 2, opposite the village, a further group of three Red-breasted Mergansers took flight at a range of 55 m. They flew north to the mouth, and out of the estuary altogether. Finally, as the boat was close to leaving the estuary, it disturbed a feeding flock of seven Long-tailed Duck at 40 m range. They flew down the estuary for 500 m, eventually resuming feeding in the eastern part of section 5 opposite the village.

2.5.8.4 Dog-walkers

There was relatively little recreational activity recorded along the western sections of the estuary, opposite Findhorn village, primarily due to access difficulties. There were even fewer disturbance observations from these sections (3 and 6). Perhaps because of this, the area was important as a roosting site for waders (especially Oystercatcher) and a low-tide feeding and "loafing" area for waterfowl (more especially Wigeon and Oystercatcher). On a single occasion, a dog-walker chose to walk along most of the shoreline of sections 3, 6 and 7 at high tide, moving south to north, towards the estuary mouth.

The first in a sequence of disturbance events involving several species began in the northern part of section 6, when a mixed roosting flock of duck were disturbed at a range of *c.*150 m. Five Mallard flew towards the "Pink House" and landed in section 5, a flight of *c.*700 m. The remaining four Mallard and two Wigeon from the disturbed flock initially swam out from the shore, but after 8 seconds, flew south down the estuary for 500 m and landed in section 5.

The next "loafing" flock to be disturbed comprising 55 Wigeon and 20 Mallard took off at 200 m range. The flock flew right down the estuary, with the Wigeon peeling off to head for the south-western saltmarsh (section 20), and the Mallard heading for the south-eastern corner of the estuary. A Red-breasted Merganser was disturbed from section 5 as the ducks flew over, and also headed south down the estuary. The Wigeon and Mallard had flown at least 1500 m to reach the southern part of the estuary.

The dog ran ahead of the owner and, at 150 m range, flushed a mixed roosting flock of 50 Bar-tailed Godwit and 40 Dunlin from section 6. The godwits circled sections 3 and 6 for 60 seconds and then landed in section 3 at the end of the large Oystercatcher roost. The Dunlin chose to leave the area entirely, and flew to the southern end of the estuary, and out of sight, probably to roost in the saltmarsh of sections 20 or 21.

The dog ran into section 3 and flushed the roost of 600 Oystercatcher (and the 50 displaced Bar-tailed Godwit) at 150 m range. The flock circled over the estuary for up to 180 seconds. Around 120 Oystercatcher returned to section 3 and landed behind the dog-walker after circling for 90 seconds. Another 390 birds circled for a further 90 seconds and

then rejoined the group already down in section 3. Within 90-120 seconds, the majority of these birds had resumed roosting. A small contingent of 90 Oystercatchers from the flock of 600 decided to fly to the mouth of the estuary on the western side, and they landed in the northernmost part of section 3. After a few minutes, the dog-walker flushed these 90 birds and they flew south to rejoin the main roost in the southern part of section 3. At the time of the disturbance to the roost, another dog-walker was wandering along the eastern side of the estuary mouth, so the Oystercatchers were unable to settle in that part of the estuary.

The 50 Bar-tailed Godwit flew down the estuary and behind the "Pink House", probably to roost on the saltmarsh of section 8.

2.5.8.5 Wildfowling

The activities of the wildfowlers could affect the waterfowl on the estuary in a number of ways other than the most obvious one of disturbing geese and apparently altering the distribution of roosting birds (sections 2.1 & 2.2). On occasions it appeared that the noise of the guns and the disturbance caused as the roosting geese were disturbed from the estuary temporarily altered the preferred feeding distribution of some of the other waterfowl on the estuary.

One such apparent instance was noted on a falling tide in early February. The tide was beginning to recede from the southern parts of the estuary, and under normal circumstances, sections 12, 13 and 22 (in the south-eastern corner of the estuary) would support large numbers of feeding waterfowl. However, these sections are adjacent to the main part of the estuary used by the wildfowlers, and on this particular occasion, were devoid of any waterfowl except the remaining roosting geese. There was a concentration of *c*.100 feeding Redshank in a relatively small area around the main channel in section 16. From observations made during the course of the winter, this was not the normal feeding area for Redshank at this state of the tide in this part of the estuary. Normally, the birds would be generally distributed within section 13, with feeding groups in sections 12 and 22 (close to the saltmarsh). Within 20 minutes of the last shot being fired, small numbers of feeding waders of three species (Oystercatcher, Curlew and Redshank) began to return to section 13. The numbers continued to increase over the next 15 minutes, despite the fact that the tide was still falling.

The disturbance of the quarry species by the wildfowlers can in turn disturb other species of waterfowl on the estuary. An example of one such event occurred when *c*.1000 Greylag Geese suddenly took flight from their roosting area on section 13 in response to several gunshots. The geese flushed a feeding flock of *c*.1000 Dunlin, which were also in the northern part of section 13. The geese headed south-east and out of the estuary. The waders flew around for some 13 seconds before landing 250 m away, still within section 13, and resumed feeding almost immediately.

3. DISCUSSION

3.1 Background to Disturbance Measurements

Disturbance to waterfowl, defined here as a human-induced activity, can affect breeding, roosting and feeding behaviour (Owen 1972; Prins & Ydenberg 1985; Mitchell, Moser & Kirby 1988; Davidson & Rothwell 1993). Disturbance may lead to differences in the day and night distributions of waterfowl (Rehfisch *et al.* 1991) and may lead to the avoidance of heavily disturbed areas (Holloway *et al.* 1992), although the distribution may revert to the pre-disturbance state once the disturbance ceases (Toomer *et al.* 1995).

As yet, most calculations of the cost of disturbance have been theoretical (*e.g.* Piersma 1994). Relatively little work has been done to quantify disturbance. Data can be collected by measuring the distance of the disturbance to the disrupted waterfowl, the distance moved (if at all) by the birds, and the length of time taken to resume pre-disturbance activity. These sorts of data allow comparisons between the effects of different types of disturbance to be made. Studies of the effects of wildfowling on waterbirds in Denmark (Madsen 1985; Madsen 1988; Madsen & Fox 1995) showed Brent and Pink-footed Geese took flight at greater distances during the wildfowling season than during the closed season. However, the type and scale of response by different waterfowl to disturbance is very variable. The same species of bird may react in different ways at different times on different estuaries. On some estuaries, the constituent waterfowl population may become used to regular disturbance, whilst "visiting" individuals of the same species may react in a totally different manner (Davidson & Rothwell 1993). There are many factors likely to influence the way a bird reacts to disturbance including the time of the year, time of the tide, weather conditions, flock size, success of feeding, the type of disturbance and the history of disturbance (Madsen 1985; Keller 1989; Smit & Visser 1993).

Disturbance in itself is not necessarily a serious problem to the birds in the short-term. Many waterfowl are able to compensate for disruptions to their regular behaviour patterns in a number of ways. Some species may not normally utilise all the available feeding time during a tidal cycle. These birds may be able to extend their period of feeding to compensate for time lost through disturbance. In areas where food is abundant and easily obtainable, it might be feasible for a bird to increase its feeding rate to compensate for time lost feeding. Thus, apparently high levels of disturbance might not lead to an overall reduction in the food intake or in the overall usage of feeding areas (Davidson & Rothwell 1993). However, on the same feeding area, some affected species will be unable to compensate as effectively as others *e.g.* Wigeon. Thus, when assessing the significance of disturbance to estuarine waterfowl, their ability to adapt feeding regimes to allow for disruption to their normal feeding regimes should be taken into account. A net reduction in energy balance is likely to lead to a reduction in survival rate. Factors such as the carrying capacity of an area, the nutritional state and requirements of the birds, and the actual feeding rates in relation to the potential maxima will influence the effects of disturbance on waterfowl. This information is often unavailable, and generally very hard to establish, so assessments of disturbance need to be based on more limited information available.

Individual disturbance events may not be critical to a bird's survival but may cumulatively lead to reductions in energy intake rates (Bélanger & Bedard 1990; Burger & Gochfield

1991) and even reduced survival (Stroud *et al.* 1990). In northern temperate estuaries, this reduction in the energy intake rate may be particularly critical in winter when the metabolic requirements of waterfowl are high (Piersma 1994). The ability of waterbirds to compensate for lost foraging time depends on the energetic cost incurred by the disturbance, measured in terms of the increased flight time and the disturbance period, as well as feeding strategy of the species. If a species needs to feed for a long time to fulfil its daily energy requirements, then it is unlikely to be able to fully compensate for feeding disruption (Madsen & Fox 1995). It may, therefore, be desirable to control the levels of disturbance to waterfowl by the creation of protected areas. In many situations, there is likely to be a trade-off between use of a food resource (including feeding areas) and the risk of disturbance (Gill *et al*. 1996).

It has been shown that human disturbance on estuaries adds to a baseline of disturbance from natural causes such as birds of prey or the rising tide forcing birds to abandon feeding grounds (Davidson & Rothwell 1993). The effects of such additional disturbances are likely to be most serious at times when birds have difficulty in finding sufficient food for their needs even under natural, undisturbed conditions. This is most likely to occur in severe weather during the winter months. In northern temperate regions most waterfowl accumulate energy reserves during the early part of the winter, with a peak in late December to late January (depending on the species) broadly coinciding with the time when severe weather occurs most often (Davidson & Rothwell 1993). Thus, waterfowl are particularly susceptible to periods of severe weather which occur outside the mid-winter period, either as fat stores are being laid down, or in the late winter/early spring when stores are likely to be much depleted. In order for a bird to gain weight the daily intake of food must exceed the daily need, and disturbance in the early part of the season may have no obvious impact at the time, it may however delay the timing of the energy store gain, so increasing the vulnerability of the bird to later periods of severe weather.

Some species of bird appear to be more "nervous" than others, with Bar-tailed Godwit, Curlew and Redshank more susceptible to disturbance than species such as Oystercatcher, Dunlin and Turnstone. Smit & Visser (1993) found that a single person on a mudflat can cause surprisingly widespread disturbance with, for example, cessation of feeding by Dunlin within a 13 ha area and Curlew within a 50 ha area. In a "worse-case" situation, shy species such as Curlew, might be prevented from feeding on more than 1000 ha of estuary by as few as 20 evenly distributed people walking over the mudflats (Davidson & Rothwell 1993). In the open tidal environment dog walkers generally create worse disturbance than more static people. An approach from water to a feeding or roosting area will generally cause major disturbance, and this often worse than a similar approach made from the landward side.

Several studies examining the disturbance effects of wildfowling on wetlands (*e.g.* Madsen & Fox 1995; Madsen 1995), have concluded that it can alter the diurnal patterns of waterfowl and cause an increase in the flight distances. It can also displace waterbirds from their preferred feeding and roosting habitats at both local and regional levels, and increase the turnover at the site. It is likely that sites with regular wildfowling disturbance support lower numbers of waterbirds than would be the case if there was no wildfowling. In Britain large increases in wildfowl numbers were found in five out of nine sites examined following restrictions or prohibition of hunting; in the four remaining sites there were no obvious effects observed (Owen & Salmon 1984).

The consequence of long escape flight distances and/or increased wariness such as that induced by hunting disturbance may restrict local site use, with a drop in the time spent feeding (Madsen 1985). In such cases, it might be possible for the disturbed waterfowl to compensate and use the previously unexploited resource during the times of the 24 hour cycle when human activity has ceased or is at depressed levels, or at other times of the season (Owens 1977).

Wigeon have been shown to react badly to a single disturbance incident at the wrong time which can deter birds from feeding until the next tidal cycle (Fox *et al.* 1993) . The feeding behaviour of dabbling ducks, such as Wigeon, may be modified by shooting activities. In British refuge areas Wigeon tend to be diurnal feeders, but convert to nocturnal feeding on most sites outside the refuges (Owen & Williams 1976). A similar pattern was found in the Danish Wadden Sea, where the Wigeon feed by day on the protected foreshore, but become more nocturnal when forced to move to the unprotected areas as a result of dwindling food supplies. After the end of the wildfowling season, the Wigeon returned to diurnal feeding in the non-protected areas (Madsen 1988). Studies in Denmark indicated that Wigeon regularly disturbed by wildfowling were unlikely to compensate for lost feeding time within the same day (Madsen 1993).

In Sweden, an experiment examined the disturbance effects of limited wildfowling on a single day of the week only. The numbers of wildfowl increased during the six days with no wildfowling, but it took more than a week for the numbers to recover to the levels recorded when shooting was fully banned (Anderson 1977). An experiment on a lake in Germany where the shooting of Mallard was performed once a month during the autumn showed a marked reduction of 60-70% on the days after shooting. It took nearly three weeks before peak numbers had been reached again (Jettka 1986).

Experiments with night shooting showed that serious disruption to the feeding activities of Wigeon ensued, but the birds did not move from the site so long as the shooting was carried out on isolated nights only (Mudge 1989). Between 1991 and 1994 an extensive marsh area adjacent to a reserve adopted a shooting regime of four consecutive days of wildfowling followed by three days of no wildfowling. Prior to this, wildfowling had taken place seven days a week. However, the intermittent regime did not result in an increase in the number of staging geese, while the numbers of roosting dabbling duck increased during the days with no shooting, but sharply decreased during the four days of consecutive shooting.

In Britain, it has been shown that numbers of dabbling duck increased significantly over a 23- year period in refuge areas but not in those areas where wildfowling took place (Owen & Salmon 1984). Additionally, it was noted that Wigeon numbers had increased markedly on the reserves and decreased outside, indicating a shift in distribution. Outside the wildfowling season these differences were not as marked, suggesting that disturbance rather than real habitat differences was the underlying cause. In Italy, all geese are protected, but tend to concentrate in those areas which are protected from hunting. It is thought that the disturbance in relation to the legal shooting of other species of waterfowl is the main reason for their limited distribution (Perco 1991).

Meltofte (1981) found that in Denmark, staging waders such as Golden Plover and Curlew were differently distributed in spring compared to autumn. In the autumn proportionately

fewer birds occurred in the areas with high levels of shooting compared to those areas with no or moderate shooting intensity. Curlew, in particular, were found to be very restricted in their use of sites in the autumn compared to their spring distribution at sites.

Several studies (*e.g.* Smit & Visser 1993; Stock 1993; Koolhaas *et al.* 1993) have shown that aircraft can cause widespread and long-lasting disturbance, with turbo-prop aircraft and helicopters being worse than jets. The relative slowness of propeller aircraft (and also microlights) appear to unsettle the waterfowl more than the fast-moving jets. Waterfowl habitually feeding adjacent to airfields learn to mostly ignore jet disturbance (pers. obs.)

The degree of disturbance is also likely to be influenced by the size of the area available to the birds. On a small estuary, there may be very few alternative areas for disturbed waterfowl to move to, and it is possible that these alternative areas might themselves be affected by disturbance. In this situation, some species might leave an estuary altogether.

3.2 The Findhorn Observations

The number of waterfowl using the estuary over the winter period is much higher than during the summer (<200 individuals; Patterson & Boyle 1996), with an increased likelihood of disturbance in certain sections. In total, 115 disturbance events (excluding actual wildfowling) were recorded during the three periods of winter fieldwork compared to 52 during the prolonged summer study, when there was more recreation taking place around the estuary. During both the winter and summer periods, there was more recreational activity and disturbance recorded at weekends than during the week (excluding wildfowling). If each of the 115 winter disturbance events are graded from low to high in their severity (see section 2.5), then 103 were high, 10 were medium and two were low. It is possible that some low disturbance events are missed, as they might merely involve a bird changing its behaviour in a very subtle manner.

The amount of data collected makes for a very limited sample size, especially of post-wildfowling data. Thus, the results and the conclusions drawn are subject to all the usual provisos, but hopefully will act as a baseline for future work. Apart from a cold spell prior to Christmas and again over New Year, the 1996/97 winter was very mild. This may have left the majority of the waterfowl in a better physical condition to withstand disturbance than would have been the case during a protracted cold winter, when any loss of feeding time/area due to disturbance might have been crucial to the welfare of the bird.

Disturbance over high tide, when most waterfowl were roosting on the estuary, was likely to have caused higher levels of disruption (in the short-term at least) than disturbance over the other parts of the tidal cycle. Birds disturbed at roost may not be able to find suitable alternative areas within the estuary, due to other recreational pressures around the estuary, and/or the degree of tidal cover. In these instances, birds might leave the estuary altogether (Bar-tailed Godwits were observed adopting this strategy at Findhorn). At low tide, disrupted waterfowl should normally be able to move from disturbed areas to undisturbed areas within the estuary. This may lead to a reduction in food intake, but at least they can continue to feed, perhaps returning to their original preferred feeding area(s) when the disturbance event has finished. At Findhorn, no waterfowl were observed leaving the estuary as a result of low tide disturbance, apart from geese and a few wildfowl disturbed from channels. At low tide many waterfowl roosted or "loafed" on the mudflats,

indicative that they had managed to feed enough during the preceding falling tide.

From the limited data collected, it is likely that at present and in the future, the most important recreational activities on the estuary with respect to disturbance appear to be water-based recreation and wildfowling. This assumes that the levels and the distribution of other forms of recreation such as walking remain at current levels.

Wildfowling activities took place six days a week, and were mostly confined to within an hour or two of dawn. There was arguably extra "pressure" put on the Findhorn geese in the second half of January by virtue of the wildfowling ban imposed in England in response to the severe winter weather over the New Year period. This may have encouraged even greater numbers of visiting wildfowlers from over the border to try their luck on the Findhorn. One minibus from Yorkshire held 10 wildfowlers, spending a long weekend in the area. There have already apparently been problems with visiting wildfowlers at Findhorn (George 1997) Shooting of wildfowl, such as Wigeon, in the south-western saltmarsh apparently occurs overnight on occasions (pers. comm.), and sometimes during the day (pers. obs.). On occasions

Apart from the instant effect of guns discharging, wildfowling produced some less obvious effects, such as the apparent long-term modification to the distribution of several species of waterfowl within the estuary during the wildfowling season. From observations made at the dawn goose roost counts, very few waterfowl, other than the geese, actually take off in response to the gunshots. However, when the wildfowling was taking place during low tide, it was noticeable that there were always relatively low numbers of other waterfowl species within several hundred metres of the area occupied by the wildfowlers. These "deserted areas" (mainly sections 12 and 13) were regularly used at low tide later in the day, when the wildfowlers had left. There was a general impression that waterfowl were more abundant on the mudflats at the southern end of the estuary after the end of the wildfowling season.
The comparison of wildfowling season and post-wildfowling season waterfowl counts suggest that Wigeon, in particular, refrained from spending time in the south-western saltmarsh area during the wildfowling period. It seems likely that geese would use the estuary, and the southern saltmarshes in particular, to a greater degree during the day if there was no wildfowling. The saltmarsh of section 20 was used far more as a regular roosting site for Oystercatcher and Curlew once the wildfowling season had finished. The numbers of roosting Curlew also increased in section 21, an area of saltmarsh at the southern end of the estuary.

Analyses of the disturbance data suggest that several species of waterfowl were disturbed to a greater degree during the wildfowling season than during the post-wildfowling season. This obviously has potential ramifications for the other potentially disturbing activities on the estuary, which may have a disproportionate large effect on waterfowl already disrupted by wildfowling. The growth of wildfowling needs to be monitored closely, especially the activities of visiting wildfowlers.

Considering the numbers and the distribution of walkers and dog-walkers within the estuary, there were relatively few cases of disturbance observed from these sources. There are several explanations for this; the most heavily walked sections of the estuary around Findhorn village are generally not used much by waterfowl, and those individuals that are

present may have become accustomed to human activity. The Turnstone and Curlew usually present in section 4 adjacent to the village are a case in point. It is likely that regular recreational disturbance along the north-eastern part of the estuary has led to a marked decrease in its use by waterfowl at all states of the tide. There were very few instances of walkers and dog-walkers disturbing waterfowl roosts, but the potential for such disturbance in sections 3 and 5 is clearly present (and one such episode was observed). Disturbance to the roosts in the saltmarsh at the southern end of the estuary is less likely as access is made more difficult over high tide due to the water-filled creeks. At low tide, virtually all walking/dog-walking activity was at the edge of the estuary, so there was very little interaction between birds and man. This is certainly the case in the south-eastern part of the estuary where a combined total of 30 walkers and dog-walkers resulted in a total of only three disturbance observations. Clearly, if the numbers of walkers and dog-walkers increased dramatically, with a shift to the areas used at high tide, then the situation could deteriorate markedly. There may be times when the presence of walkers and dog-walkers is likely to have a disproportionately disturbing impact on the waterfowl at times and locations where they are already "sensitised" to avoid wildfowlers.

The activities of fisherman and bait-diggers were not significant, and at current winter levels are unlikely to have a major impact on the waterfowl.

Disturbance from water-based activities appears to have a greater effect on waterfowl than land-based disturbance; the birds tend to flush at a greater distance and disturbed wildfowl will often fly considerable distances from even slow-moving craft (Davidson & Rothwell 1993; pers. obs.). Over the winter period there were relatively few observations of boats on the estuary (nine in total), but 10 resulting observations of disturbance incidents. Generally, the boating activity was confined to the northern part of the estuary, especially around the village. A few Red-breasted Merganser or Long-tailed Duck were usually disturbed by any boat in this area. A local took his small boat across the estuary to the jetty in section 7 on a couple of occasions, but the bulk of the activity was from a Humber boat, training would-be sailors during some weekends. Although the boating activity was mostly in the middle of the estuary over high tide, and therefore not likely to affect most of the birds on the estuary, roosting waterfowl were disturbed on one occasion by a boat passing too close to section 4. The potential for this to happen more frequently is fairly high if the number of craft increase and their distribution within the estuary changes. There was clearly much more boating activity during the summer months, but fewer waterfowl to disturb.

Windsurfing activity was also much more limited over the winter than during the summer, only taking place at weekends. The effects of windsurfing on the waterfowl on the estuary appeared to be partially dependent on the gaudiness of the sail, the number of windsurfers operating and their distance apart on the estuary (Davidson & Rothwell 1993; pers. obs.). From observations made over several weekends, wildfowl tended to flush more readily if the sail was a vibrant colour, rather than one of more muted tones. The greater the number of windsurfers out on the estuary at any one time, the greater the disturbance to wildfowl, some leaving the estuary altogether. The disturbance effect is compounded by the fact that the majority of windsurfers fall into the water several times during each session, with the ensuing sudden movements involved in righting the board. There is potential for further disturbance as the windsurfers enter and leave the water. On average, each surfer appeared to come ashore every 20 minutes or so. If a session lasts two hours or

more, it will involve a fair amount of coming and going, especially if six or seven windsurfers are operating simultaneously on the estuary.

Most windsurfing took place in the northern half of the estuary, and mostly adjacent to the village. However, several windsurfers reached the southern end of the estuary during some of the higher tides, and caused considerable disturbance to waterfowl roosts by approaching far too closely. These excursions into the southern part of the estuary also led to windsurfers coming ashore to either have a rest or effect repairs to their board. The southern part of section 4 (adjacent to the "Pink House"), and section 8 (adjacent to the landing lights) were two of the areas with such observations. With many windsurfers operating at the same time, there is potential for simultaneous disturbance to several parts of the estuary over the high tide roosting period. This could develop into a serious long-term disturbance problem, which should be addressed in the near future.

4. RECOMMENDATIONS

1. Wildfowling could be restricted to just one part of the estuary (perhaps the south-eastern corner). This would allow waterfowl displaced by the wildfowling activities to utilise the southern and south-western parts of the estuary for both feeding and roosting. The majority of geese leaving the morning roost on the estuary fly over the south-eastern area of the estuary (and therefore over the proposed wildfowling area). If wildfowling was more limited in extent than is currently the case, it might allow the departing wildfowl a greater degree of freedom to alter their flightlines. The local club should limit the numbers of wildfowlers operating on the estuary at any one time. This might especially apply to visiting wildfowlers, particularly if the numbers are swelled due to a cold weather ban south of the border. The behaviour of all wildfowlers should follow the BASC code of conduct, and once again, perhaps the local club could ensure that greater emphasis is placed upon it. Important issues that need to be addressed (and possibly controlled) include the discharge of guns to "spook" the roosting geese into flight, ensuring that the quarry distances are within the recommended range of the guns, and possibly the frequency of wildfowling on the estuary. During the season, excepting Sundays, wildfowling appeared to take place on a daily basis.

2. Windsurfing is likely to grow in popularity, so it is important to try and contain any potential increase in disturbance before it actually happens. Windsurfers should not approach a waterfowl roost any closer than 500 m. This should avoid the sort of roost disturbance observed in the southern sections of the estuary due to windsurfers entering the flooded saltmarsh. Ideally, windsurfing would be restricted to the northern and central parts of the estuary (Figure 4.3.1). This would limit disturbance to one waterfowl roost, (in section 3). If there is no code of practice for windsurfers, then perhaps one should be written and distributed to the local clubs. It would need to emphasise the problems of approaching too close to wildfowl on the water and more especially, to roosts of waterfowl, with an advisory minimum approach distance to ensure minimal disturbance to the latter.

3. A similar policy for boats using the estuary would require that they did not approach roosting waterfowl closer than 500 m (except where this was unavoidable when following a navigation channel within the estuary). Speed limits for boats using the estuary would be enforced. Although no water-skiing was observed to have taken place over the winter period, it is likely to increase in popularity during the summer months, and it might be desirable to restrict these activities to certain areas of the estuary (*e.g.* the northern half).

4. Whilst walking and dog-walking are the commonest forms of recreation on the estuary over the winter, they caused relatively few cases of disturbance, and generally are not perceived as being a problem at present. However, it would be advantageous to restrict access along the western side of the estuary mouth, especially at high tide.

The saltmarsh area in the south-eastern part of the estuary appeared to be used as a roosting area by the majority of the wintering Dunlin on the estuary and also by smaller numbers of species such as Curlew and Redshank. It might prove disturbing to the roosts if access across the saltmarsh was improved at high tide by

the possible construction of footbridges across several of the drains. However, the establishment of roosting refuges on saltmarsh elsewhere within the southern part of the estuary could help offset the possible disturbance to other roost sites.

5. **Special measures to protect all or part of the main waterfowl roosting areas on the estuary, currently in the sections 3, 8, 21, 17 and 20 could be introduced (Figure 4.1.1). The majority of these are in the saltmarsh in the southern half of the estuary, which ideally would become a conservation zone, with limited or zero access over high tide. This would allow for increased recreation in the northern half of the section to "displace" waterfowl into the relatively undisturbed southern section. The ideal, perhaps, might be to create a refuge in the south-western part of the estuary. Observations on disturbance to the roosts in section 3, towards the estuary mouth, have indicated a willingness of the displaced birds to move to the southern saltmarshes. Indeed, with the cessation of wildfowling, there was a general increase in the use made of the southern sections of the estuary, both for feeding and roosting. Hides giving views of some of the roosting areas could be installed to offset the loss of access.**

6. **All of the recommendations will require much consultation and discussion at a local level. Advisory signs, education, information leaflets and visits to some of the clubs with recreational interests on the estuary might help. A greater ranger presence might also be of help.**

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Interpretation of the Disturbance Tables

The following codes and abbreviations have been used in the disturbance tables.

Species codes:

MS	**=**	**Mute Swan**
PG	**=**	**Pink-footed Goose**
GJ	**=**	**Greylag Goose**
SU	**=**	**Shelduck**
WN	**=**	**Wigeon**
MA	**=**	**Mallard**
LN	**=**	**Long-tailed Duck**
GN	**=**	**Goldeneye**
E	**=**	**Eider**
RM	**=**	**Red-breasted Merganser**
OC	**=**	**Oystercatcher**
RP	**=**	**Ringed Plover**
KN	**=**	**Knot**
GP	**=**	**Golden Plover**
GV	**=**	**Grey Plover**
L	**=**	**Lapwing**
DN	**=**	**Dunlin**
BA	**=**	**Bar-tailed Godwit**
CU	**=**	**Curlew**
RK	**=**	**Redshank**

Wader = A combination of all the listed species of waders.
Wildfowl = A combination of all the listed species of wildfowl.

Disturbance Type

AC	**=**	**Aircraft**
BD	**=**	**Baitdigger**
BT	**=**	**Boat**
DW	**=**	**Dog-walker**
FM	**=**	**Fisherman**
MV	**=**	**Motor Vehicle**
NK	**=**	**Unknown Source**
RA	**=**	**Raptor**
WF	**=**	**Wildfowling**
WK	**=**	**Walker**
WS	**=**	**Windsurfing**

For some analyses, similar types of disturbance have been lumped together and given a letter.

Disturbance Group (Disgroup)

A = Aircraft
B = Walkers, Dog-walkers, Fishermen and Baitdiggers
C = Raptors
D = Windsurfing
E = Boats

Distevnt = Distance of disturbance incident from the disturbed waterfowl

Distwalk = the distance walked (if at all) by the disturbed waterfowl

Timewalk = the time spent walking (if any) by the disturbed waterfowl

distflew = the distance flown (if at all) by the disturbed waterfowl

Timeflew = the time spent flying (if any) by the disturbed waterfowl

Timercvr = the time that the disturbed waterfowl took to resume their pre-disturbance activities once the disturbance event has finished.

Obs = the total number of observations

WILDFOWLING SEASON										POST-WILDFOWLING SEASON				
Species	**20/11/96**	**SAT 23/11/96**	**SUN 24/11/96**	**SAT 30/11/96**	**22/1/97**	**23/1/97**	**SAT 25/1/97**	**28/1/97**	**SAT 1/2/97**	**SUN 23/2/97**	**24/2/97**	**27/2/97**	**5/3/97**	**10/3/97**
Greylag Goose	**2345**	**1374**	**1317**	**1594**	**2776**	**2316**	**1774**	**872**	**1759**	**100**	**125**	**170**	**151**	**173**
Pink-footed Goose	**71**	**20**	**30**	**970**	**662**	**1169**	**398**	**970**	**800**	**350**	**300**	**670**	**1669**	**2513**
Total no. geese	**2416**	**1394**	**1347**	**2564**	**3438**	**3485**	**2172**	**1822**	**2559**	**450**	**425**	**840**	**1820**	**2686**
No. of wildfowlers counted	**10+**	**15+**	**0**	**15+**	**6+**	**8+**	**12+**	**8+**	**12**	**0**	**0**	**0**	**0**	**0**

Table 2.3.1. **The total number of geese counted during dawn roost counts at Findhorn. The numbers of wildfowlers are the minimum numbers observed.**

Type of species	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations
Waders	**42**	**29**	**20**	**497**	**30**	**14**	**74**
Wildfowl	**89**	**35**	**10**	**871**	**42**	**5**	**41**

Table 2.5.3.1 **The mean values of disturbance measurement for species groups for wildfowling and post-wildfowling seasons combined.**

Species	Distance of disturbance[1] (m)	Distance walked[2] (m)	Time walking[3] (s)	Distance flown[4] (m)	Time flying[5] (s)	Time to resume activities[6] (s)	No. of observations
Bar-tailed Godwit	77	.	.	601	56	5	4
Curlew	60	20	70	818	26	4	11
Dunlin	92	.	.	639	40	3	10
Eider	30	.	.	100	20	.	1
Greylag Goose	92	.	.	1450	20	1	2
Goldeneye	58	.	.	950	26	.	2
Knot	45	.	.	250	18	1	1
Long-tailed Duck	57	.	.	475	16	2	7
Mallard	90	.	.	1470	92	.	5
Mute Swan	4	35	10	.	.	.	1
Oystercatcher	39	58	12	578	36	35	23
Pink-footed Goose	156	.	.	319	42	7	8
Redshank	25	.	.	322	14	5	11
Red-breasted Merganser	69	.	.	1460	35	2	5
Shelduck	35	.	.	80	8	4	1
Turnstone	10	6	3	118	23	5	14
Wigeon	91	.	.	1036	53	7	9

[1]Distance of disturbance incident from the disturbed waterfowl
[2]Distance walked (if at all) by the disturbed waterfowl
[3]Time spent walking (if any) by the disturbed waterfowl
[4]Distance flown (if at all) by the disturbed waterfowl
[5]Time spent flying (if any) by the disturbed waterfowl
[6]Time that the disturbed waterfowl took to resume their pre-disturbance activities once the disturbance event had finished

Table 2.5.4.1 The mean values of disturbance measurement for each species for the wildfowling and post-wildfowling seasons combined.

Species are arranged alphabetically.

Type of Disturbance	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations
Aircraft	**65**	**.**	**.**	**465**	**34**	**5**	**14**
Baitdigger	**45**	**.**	**.**	**250**	**18**	**1**	**1**
Boat	**69**	**.**	**.**	**1405**	**61**	**137**	**11**
Dog-walker	**61**	**17**	**22**	**503**	**54**	**6**	**21**
Fisherman	**35**	**.**	**.**	**130**	**20**	**2**	**3**
Motor vehicle	**34**	**65**	**8**	**575**	**21**	**1**	**3**
Unknown source	**30**	**.**	**.**	**100**	**20**	**.**	**1**
Raptor	**12**	**.**	**.**	**519**	**27**	**6**	**22**
Wildfowling	**237**	**.**	**.**	**391**	**21**	**2**	**7**
Walker	**32**	**50**	**16**	**467**	**26**	**3**	**17**
Windsurfing	**59**	**.**	**.**	**1007**	**31**	**3**	**15**

Table 2.5.5.1 **The mean values of each type of disturbance for all species of waterfowl combined over the wildfowling and post-wildfowling seasons combined.**

Disturbance Type	Species	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations
Aircraft	Dunlin	52	0.00	0.00	188	34	1	2
	Greylag Goose	92	0.00	0.00	1450	20	1	2
	Mallard	40	0.00	0.00	350	10	0.00	1
	Pink-footed Goose	74	0.00	0.00	243	46	7	6
	Shelduck	35	0.00	0.00	80	8	4	1
	Wigeon	50	0.00	0.00	675	29	6	2
Baitdigger	Knot	45	0.00	0.00	250	18	1	1
Boat	Long-tailed Duck	70	0.00	0.00	425	14	4	2
	Mallard	65	0.00	0.00	1400	105	0.00	2
	Oystercatcher	42	0.00	0.00	2000	75	540	2
	Red-breasted Merganser	83	0.00	0.00	1450	25	2	4
	Wigeon	90	0.00	0.00	2000	190	0.00	1
Dog-walker	Bar-tailed Godwit	150	0.00	0.00	80	60	3	1
	Curlew	40	20	70	225	6	4	2
	Dunlin	150	0.00	0.00	60	90	0.00	1
	Mallard	140	0.00	0.00	2100	120	0.00	2
	Mute Swan	4	35	10	0.00	0.00	0.00	1
	Oystercatcher	48	0.00	0.00	259	57	6	5
	Redshank	48	0.00	0.00	238	9	4	2
	Turnstone	4	6	3	80	24	7	6
	Wigeon	250	0.00	0.00	900	120	0.00	1
Fisherman	Oystercatcher	80	0.00	0.00	140	38	4	1
	Turnstone	12	0.00	0.00	125	11	1	2
Motor vehicle	Curlew	7	0.00	0.00	800	30	0.00	1
	Oystercatcher	47	65	8	0.00	0.00	1	1
	Redshank	47	0.00	0.00	350	11	0.00	1
Unknown source	Eider	30	0.00	0.00	100	20	0.00	1

Disturbance Type	Species	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations

Table 2.5.5.2 **The mean values of each type of disturbance by species for the wildfowling and post-wildfowling seasons combined.**

Species are arranged alphabetically.

Raptor	Bar-tailed Godwit	4	0.00	0.00	775	54	7	3
	Dunlin	4	0.00	0.00	733	41	10	3
	Oystercatcher	15	0.00	0.00	346	22	6	8
	Redshank	10	0.00	0.00	408	15	6	5
	Wigeon	17	0.00	0.00	698	23	8	3
Wildfowling	Curlew	150	0.00	0.00	110	5	1	1
	Dunlin	162	0.00	0.00	417	20	2	3
	Pink-footed Goose	400	0.00	0.00	550	30	0.00	2
	Wigeon	225	0.00	0.00	275	20	0.00	1
Walker	Curlew	59	0.00	0.00	878	25	3	5
	Oystercatcher	31	50	16	78	12	3	4
	Redshank	29	0.00	0.00	262	20	3	2
	Red-breasted Merganser	25	0.00	0.00	1500	75	0.00	1
	Turnstone	14	0.00	0.00	164	28	2	5
Windsurfing	Curlew	67	0.00	0.00	1325	50	7	2
	Dunlin	80	0.00	0.00	2500	60	0.00	1
	Goldeneye	58	0.00	0.00	950	26	0.00	2
	Long-tailed Duck	52	0.00	0.00	495	17	2	5
	Oystercatcher	80	0.00	0.00	1850	50	0.00	2
	Redshank	15	0.00	0.00	150	10	0.00	1
	Turnstone	20	0.00	0.00	30	0.00	0.00	1
	Wigeon	100	0.00	0.00	1700	20	0.00	1

Table 2.5.5.2 **The mean values of each type of disturbance by species for the wildfowling and post-wildfowling seasons combined.**

Species are arranged alphabetically.

Species	Tide[1]	Group[2]	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations
Bar-tailed Godwit	HT	B	150	0.00	0.00	80	60	3	1
	LT	C	0.00	0.00	0.00	413	68	7	2
	MT	C	4	0.00	0.00	1500	26	0.00	1
Curlew	HT	B	53	0.00	0.00	1438	28	6	2
	HT	D	67	0.00	0.00	1325	50	7	2
	LT	B	38	20	70	120	10	1	2
	LT	C	150	0.00	0.00	110	5	1	1
	MT	B	68	0.00	0.00	540	21	4	3
	MT	F	7	0.00	0.00	800	30	0.00	1
Dunlin	HT	B	150	0.00	0.00	60	90	0.00	1
	HT	C	4	0.00	0.00	1200	30	0.00	1
	HT	D	80	0.00	0.00	2500	60	0.00	1
	LT	A	52	0.00	0.00	188	34	1	2
	LT	C	3	0.00	0.00	500	47	10	2
	MT	C	162	0.00	0.00	417	20	2	3
Eider	HT		30	0.00	0.00	100	20	0.00	1
Greylag Goose	HT	A	150	0.00	0.00	900	20	1	1
	MT	A	34	0.00	0.00	2000	0.00	0.00	1
Goldeneye	HT	D	58	0.00	0.00	950	26	0.00	2
Knot	MT	B	45	0.00	0.00	250	18	1	1
Long-tailed Duck	HT	D	52	0.00	0.00	495	17	2	5
	HT	E	70	0.00	0.00	425	14	4	2
Mallard	HT	B	140	0.00	0.00	2100	120	0.00	2
	HT	E	65	0.00	0.00	1400	105	0.00	2
	MT	A	40	0.00	0.00	350	10	0.00	1
Mute Swan	LT	B	4	35	10	0.00	0.00	0.00	1

Table 2.5.6.1 **The mean disturbance values by species for each disturbance type at the different stages of the tidal cycle for wildfowling and post-wildfowling seasons combined.**

Species are arranged alphabetically.

Oystercatcher	HT	B	150	0.00	0.00	300	180	4	1

Species	Tide[1]	Group[2]	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations
	HT	C	5	0.00	0.00	225	13	6	2
	HT	D	80	0.00	0.00	1850	50	0.00	2
	HT	E	30	0.00	0.00	2500	80	540	1
	LT	B	22	50	16	199	15	5	7
	LT	C	25	0.00	0.00	443	28	7	5
	LT	F	47	65	8	0.00	0.00	1	1
	MT	B	70	0.00	0.00	88	24	2	2
	MT	C	4	0.00	0.00	100	12	2	1
	MT	E	53	0.00	0.00	1500	70	0.00	1
Pink-footed Goose	HT	A	55	0.00	0.00	100	95	6	1
	MT	A	78	0.00	0.00	271	36	8	5
	MT	C	400	0.00	0.00	550	30	0.00	2
Redshank	HT	B	45	0.00	0.00	225	6	4	1
	HT	C	5	0.00	0.00	250	10	7	1
	LT	C	16	0.00	0.00	480	18	6	3
	LT	F	47	0.00	0.00	350	11	0.00	1
	MT	B	36	0.00	0.00	258	17	3	3
	MT	C	4	0.00	0.00	350	10	4	1
	MT	D	15	0.00	0.00	150	10	0.00	1
Red-breasted Merganser	HT	B	25	0.00	0.00	1500	75	0.00	1
	HT	E	60	0.00	0.00	1667	28	2	3
	MT	E	130	0.00	0.00	800	15	0.00	1
Shelduck	LT	A	35	0.00	0.00	80	8	4	1
Turnstone	HT	B	5	0.00	0.00	190	30	2	3
	MT	B	10	6	3	103	21		610
	MT	D	20	0.00	0.00	30	0.00	0.00	1

Table 2.5.6.1 **The mean disturbance values by species for each disturbance type at the different stages of the tidal cycle for wildfowling and post-wildfowling seasons combined.**

Species are arranged alphabetically.

Wigeon	HT	B	250	0.00	0.00	1900	120	0.00	1

Species	Tide[1]	Group[2]	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations
	HT	D	100	0.00	0.00	1700	20	0.00	1
	HT	E	90	0.00	0.00	2000	190	0.00	1
	LT	C	24	0.00	0.00	298	19	8	2
	MT	A	50	0.00	0.00	675	29	6	2
	MT	C	4	0.00	0.00	1500	30	0.00	1
	MT	C	225	0.00	0.00	275	20	0.00	1

[1]Level of tide (HT = High Tide, LT = Low Tide, MT = Mid Tide - rising and falling)
[2]Grouping of disturbance type (A = Aircraft, B = Walkers, Dog-walkers, Fishermen & Baitdiggers, C = Raptors, D = Windsurfing, E = Boats)

Table 2.5.6.1 **The mean disturbance values by species for each disturbance type at the different stages of the tidal cycle for wildfowling and post-wildfowling seasons combined.**

Species are arranged alphabetically.

Species	Tide [1]	Group [2]	Season [3]	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations
Bar-tailed Godwit	HT	B	W	150	0.00	0.00	80	60	3	1
	LT	C	W	0.00	0.00	0.00	413	68	7	2
	MT	C	W	4	0.00	0.00	1500	26	0.00	1
Curlew	HT	B	W	53	0.00	0.00	1438	28	6	2
	HT	D	NW	67	0.00	0.00	1325	50	7	2
	LT	B	NW	38	20	70	120	10	1	2
	LT	G	W	150	0.00	0.00	110	5	1	1
	MT	B	W	68	0.00	0.00	540	21	4	3
	MT	F	W	7	0.00	0.00	800	30	0.00	1
Dunlin	HT	B	W	150	0.00	0.00	60	90	0.00	1
	HT	C	W	4	0.00	0.00	1200	30	0.00	1
	HT	D	NW	80	0.00	0.00	2500	60	0.00	1
	LT	A	NW	55	0.00	0.00	275	60	1	1
	LT	A	W	48	0.00	0.00	100	7	1	1
	LT	C	NW	3	0.00	0.00	400	28	10	1
	LT	C	W	0.00	0.00	0.00	600	65	0.00	1
	MT	C	W	162	0.00	0.00	417	20	2	3
Eider	HT		NW	30	0.00	0.00	100	20	0.00	1
Greylag Goose	HT	A	W	150	0.00	0.00	900	20	1	1
	MT	A	W	34	0.00	0.00	2000	0.00	0.00	1
Goldeneye	HT	D	NW	58	0.00	0.00	950	26	0.00	2
Knot	MT	B	W	45	0.00	0.00	250	18	1	1
Long-tailed Duck	HT	D	NW	52	0.00	0.00	495	17	2	5
	HT	E	W	70	0.00	0.00	425	14	4	2
Mallard	HT	B	W	140	0.00	0.00	2100	120	0.00	2
	HT	E	W	65	0.00	0.00	1400	105	0.00	2
	MT	A	W	40	0.00	0.00	350	10	0.00	1
Mute Swan	LT	B	W	4	35	10	0.00	0.00	0.00	1

Table 2.5.7.1 **The mean disturbance values by species for each disturbance group at different stages of the tidal cycle during the wildfowling and post-wildfowling seasons.**

Species	Tide [1]	Group [2]	Season [3]	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations
Species are arranged alphabetically.										
Oystercatcher	HT	B	W	150	0.00	0.00	300	180	4	1
	HT	C	W	5	0.00	0.00	225	13	6	2
	HT	D	NW	80	0.00	0.00	1850	50	0.00	2
	HT	E	W	30	0.00	0.00	2500	80	540	1
	LT	B	NW	21	50	16	77	10	5	4
	LT	B	W	24	0.00	0.00	321	22	6	3
	LT	C	NW	24	0.00	0.00	438	26	8	2
	LT	C	W	28	0.00	0.00	447	29	6	3
	LT	F	W	47	65	8	0.00	0.00	1	1
	MT	B	W	70	0.00	0.00	88	24	2	2
	MT	C	W	4	0.00	0.00	100	12	2	1
	MT	E	W	53	0.00	0.00	1500	70	0.00	1
Pink-footed Goose	HT	A	NW	55	0.00	0.00	100	95	6	1
	MT	A	NW	75	0.00	0.00	89	36	8	4
	MT	A	W	90	0.00	0.00	1000	35	0.00	1
	MT	C	W	400	0.00	0.00	550	30	0.00	2
Redshank	HT	B	W	45	0.00	0.00	225	6	4	1
	HT	C	W	5	0.00	0.00	250	10	7	1
	LT	C	NW	3	0.00	0.00	400	28	10	1
	LT	C	W	28	0.00	0.00	520	14	5	2
	LT	F	W	47	0.00	0.00	350	11	0.00	1
	MT	B	NW	36	0.00	0.00	258	17	3	3
	MT	C	W	4	0.00	0.00	350	10	4	1
	MT	D	NW	15	0.00	0.00	150	10	0.00	1
Red-breasted Merganser	HT	B	NW	25	0.00	0.00	1500	75	0.00	1
	HT	E	W	60	0.00	0.00	1667	28	2	3
	MT	E	W	130	0.00	0.00	800	15	0.00	1
Shelduck	LT	A	W	35	0.00	0.00	80	8	4	1

Species	Tide [1]	Group [2]	Season [3]	Distance of disturbance (m)	Distance walked (m)	Time walking (s)	Distance flown (m)	Time flying (s)	Time to resume activities (s)	No. of observations

Table 2.5.7.1 **The mean disturbance values by species for each disturbance group at different stages of the tidal cycle during the wildfowling and post-wildfowling seasons. Species are arranged alphabetically.**

Turnstone	**HT**	**B**	**NW**	**5**	**0.00**	**0.00**	**110**	**40**	**3**	**2**
	HT	**B**	**W**	**6**	**0.00**	**0.00**	**350**	**10**	**1**	**1**
	MT	**B**	**NW**	**14**	**0.00**	**0.00**	**111**	**28**	**3**	**5**
	MT	**B**	**W**	**6**	**6**	**3**	**88**	**8**	**7**	**5**
	MT	**D**	**NW**	**20**	**0.00**	**0.00**	**30**	**0.00**	**0.00**	**1**
Wigeon	**HT**	**B**	**W**	**250**	**0.00**	**0.00**	**1900**	**120**	**0.00**	**1**
	HT	**D**	**NW**	**100**	**0.00**	**0.00**	**1700**	**20**	**0.00**	**1**
	HT	**E**	**W**	**90**	**0.00**	**0.00**	**2000**	**190**	**0.00**	**1**
	LT	**C**	**NW**	**24**	**0.00**	**0.00**	**298**	**19**	**8**	**2**
	MT	**A**	**NW**	**60**	**0.00**	**0.00**	**1000**	**47**	**6**	**1**
	MT	**A**	**W**	**40**	**0.00**	**0.00**	**350**	**10**	**0.00**	**1**
	MT	**C**	**W**	**4**	**0.00**	**0.00**	**1500**	**30**	**0.00**	**1**
	MT	**C**	**NW**	**225**	**0.00**	**0.00**	**275**	**20**	**0.00**	**1**

[1]Level of tide (HT = High Tide, LT = Low Tide, MT = Mid Tide - rising and falling)
[2]Grouping of disturbance type (A = Aircraft, B = Walkers, Dog-walkers, Fishermen & Baitdiggers, C = Raptors, D = Windsurfing, E = Boats)
[3]Season (W = Wildfowling Season, NW = Post-wildfowling Season)

Table 2.5.7.1 **The mean disturbance values by species for each disturbance group at different stages of the tidal cycle during the wildfowling and post-wildfowling seasons.**

Species are arranged alphabetically.