BTO Research Report No. 178

Counting Waterfowl on Large Estuaries at Low Tide

Authors

A.J. Musgrove & S.J. Holloway

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to the WeBS partners

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BTO, National Centre for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU
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British Trust for Ornithology

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ABSTRACT

The WeBS Low Tide Count scheme aims to investigate the relative importance of different areas within estuaries for non-breeding waterfowl. However, the largest estuaries in the UK, which hold a large proportion of the total number of birds, are difficult to survey at low tide by standard methods. The estuaries in question are the Wash, Morecambe Bay, the Ribble Estuary, the Thames Estuary and the Solway Firth. Additionally, parts of the Severn Estuary, the Humber Estuary and Lough Foyle may also require specialised counting techniques.

A literature search was undertaken to investigate how birds have been surveyed on large estuaries in the past and elsewhere in the world. A number of case studies are discussed and then the pros and cons of land-based, boat-based and aerial counts are listed.

In addition, fieldwork was carried out at four sites around the Wash. At these four sites (Snettisham Scalp, Nene Mouth, Holbeach St Matthew and Wrangle Flats), counts were undertaken at low tide to try to assess the likely accuracy of such counts and also to look for any other problems which could be encountered.

A series of aerial counts which had been carried out by English Nature at the Wash in 1994-95 are discussed, and the totals of some species recorded on these aerial surveys are compared with WeBS Core counts. From the costs involved with these counts, approximate costings are made for both aerial and land-based counts of the large estuaries.

The main conclusions of the report are that any attempt to count large estuaries at low tide from the shore is likely to result in significant underestimates being made. Counts can be improved by having observers walk out onto the mudflats but as this can often be hazardous, volunteers should not be encouraged to do so. Although professional counters could be employed to walk out onto wide mudflats to improve the counts, there would still be a potential problem with safety. Additionally, there are some parts of the largest estuaries that are not possible to reach on foot at all. Aerial surveys are another way to survey these larger sites. However, there are likely to be problems with count accuracy and identification of birds from the air.

1. INTRODUCTION

1.1 The WeBS Low Tide Count Scheme

The Wetland Bird Survey (WeBS) Low Tide Count Scheme has been running since the winter of 1992-93, and aims to complement the even longer-running WeBS Core Counts (previously the National Wildfowl Counts and the Birds of Estuaries Enquiry). WeBS is organised and funded jointly by the British Trust for Ornithology (BTO), The Wildfowl and Wetlands Trust (WWT), the Royal Society for the Protection of Birds (RSPB) and the Joint Nature Conservation Committee (JNCC). The Core Counts aim to record all of the non-breeding waterfowl in the United Kingdom (although the majority of non-estuarine coastal habitats are not covered), and thus provide information about overall population sizes, population trends between years and the relative importance of different sites. The most important sites for waterfowl tend to be estuaries where the Core Counts usually take place at high tide, since the birds then become more concentrated and are thus easier to count.

One disadvantage of these high-tide counts is that they do not provide any information about where the birds are feeding within the estuary when the tide goes out. WeBS Low Tide Counts aim to provide this information. As well as being of considerable academic interest in itself, knowledge of the low tide distribution of waterfowl within estuaries is of vital importance for their effective conservation. Estuaries are under constant pressure from development, recreation and pollution, and knowledge of exactly where the birds are feeding enables a sensible strategy for the conservation management of an estuary to be made.

WeBS Low Tide Counts take place through the winter from November to February, with counters requested to make monthly counts between two hours before and two hours after low tide. The estuary is divided up into recognisable smaller areas, loosely termed “mudflats”, and on each count date, a counter records all of the birds using the mudflat. The division of the site into mudflats, although overseen and approved by the national organiser, is largely undertaken by the counters themselves, using their local knowledge of an area. Most counters are volunteers, and their efforts are co-ordinated at a local level by a local organiser, who has a good knowledge of the site and the counters. Local organisers are sometimes volunteers, but more often are professionals such as reserve wardens whose reserves take in part of sites.

1.2 Coverage of UK Estuaries by the WeBS Low Tide Count Scheme

Over the five winters since the WeBS Low Tide Count Scheme began, counts (either complete or partial) have been carried out at 45 sites around the UK. These sites are listed in Table 1.2.1 along with their mean overall waterfowl numbers (calculated as average winter maxima over the five-year period 1990-91 to 1994-95). Additionally, the species present in internationally important numbers on that estuary are listed. Note that two sites, the Inner Thames and Findhorn Bay, are not listed in Table 1.2.1. This is because they are generally treated as sub-sections of much larger sites (i.e. the Thames and the Inner Moray Firth respectively).

Similarly, the most important estuaries (those holding a mean of over 5,000 waterfowl) which have not yet been counted as part of the scheme are listed in Table 1.2.2. It is very noticeable that for the most part, the estuaries holding the highest numbers of waterfowl have not yet been counted at low tide. This is unfortunate since these sites are, by definition, the most important sites for non-breeding waterfowl. Although the UK’s estuaries between them hold about three

million birds, approximately half of that total is found on just the eight most important sites.

On large estuaries, WeBS Low Tide Counts should therefore be carried out. However, there are two principal problems with these sites which have to date precluded such counts being undertaken. Firstly, the physical size of these estuaries means that the usual counting methods will not necessarily produce accurate data. This is because the greater the distance over which birds are counted, the more difficult is the identification of the species and the counting or estimation of flock sizes. Secondly, large estuaries are dangerous places and it is unreasonable to send volunteers out onto hazardous mudflats where they might be cut off by tidal movements. Because of these problems, low tide counts of the larger estuaries have stalled.

1.3 Large Estuaries

There are five principal estuaries which are uncountable by normal WeBS Low Tide Count methods. These are the Wash, Morecambe Bay, the Ribble Estuary, the Thames Estuary and the Solway Firth. In addition, parts of the Severn Estuary, the Humber Estuary and Lough Foyle also contain wide mudflats which would ideally be counted by specialised methods. These eight sites, which between them hold approximately 1.4 million non-breeding waterfowl, are illustrated in Figure 1.3.

The Wash is the single most important site for non-breeding waterfowl in the UK. The area of intertidal substrate is almost 30,000 ha and mudflats extend up to 9 km from the shore. Of the species wintering on the Wash, 11 are present in internationally important numbers. The Wash is the most important site in the country for Brent Geese, Shelducks, Grey Plovers and Knots, the second most important for Lapwings and Bar-tailed Godwits and the third most important for Dunlins.

The Ribble Estuary, with an intertidal area of over 10,000 ha, is the second most important site in the UK on average, although numbers of waterfowl there in the winter of 1994-95 were greater than those on the Wash. This was largely due to the huge counts of Wigeons, of which up to 110,000 were present, easily the highest numbers of this species anywhere in the UK. The Ribble Estuary is also the most important site in the UK for Sanderlings and Bar-tailed Godwits, the second most important site for Teals and (as part of south-west Lancashire) Pink-footed Geese, and the third most important site for Lapwings, Knots and (with nearby Martin Mere) Bewick's Swans. Although the inner part of the estuary is narrow, counting it is difficult due to extensive areas of saltmarsh. Added to this, towards the mouth of the estuary the mudflats extend up to 6 km from the shore.

To the north of the Ribble Estuary is the vast expanse of Morecambe Bay, with an intertidal area of over 33,000 ha. This is probably the most difficult estuary to count at low tide, with mudflats extending up to 10 km from the shore. The Bay is the third most important site overall for waterfowl in the UK, and it holds the highest numbers of Oystercatchers, Dunlins and Turnstones in the country. It is also the second most important site for Redshanks and the third most important for Pintails.

The Thames Estuary is a complex area, with a number of sites which could perhaps be considered part of the "Greater Thames" area already covered by the WeBS Low Tide Counts. On the north shore, areas of the Essex coast from the Crouch Estuary northwards have been already covered whilst on the south shore, the Medway and Swale have both been counted

separately. Additionally, the Inner Thames, downstream as far as Tilbury, has also been counted at low tide. The remainder of the area, especially the extensive flats of Maplin Sands and Foulness Sands (extending up to 8 km offshore), as well as the north shore of the Isle of Grain, north shore of the Isle of Sheppey and the Southend area, an area of some 15,000 ha, have not yet been counted. The Thames Estuary is the fifth most important estuary in the UK for waterfowl and in particular, is the most important site for Ringed Plovers, the second most important for Brent Geese, Grey Plovers and Knots, and the third most important for Bar-tailed Godwits.

Finally, the Solway Firth, with an intertidal area of over 27,000 ha, is the sixth most important waterfowl site in the UK. Although the inner section is likely to be straightforward to count at low tide, towards the mouth of the estuary (to the north and west of Silloth) mudflats extend about 8 km from the shore. The Solway Firth is of prime importance, holding essentially the entire Svalbard breeding population of Barnacle Geese and by far the largest concentration of Scaups in the UK. The Firth is also the second most important wintering site for Oystercatchers and Curlews in the UK.

Three other sites are likely to be difficult to survey fully at low tide. The Humber Estuary, the fourth most important waterfowl site in Britain, has only relatively narrow mudflats along most of its length. However, the flats to the west of Spurn Point are approximately 4 km across. The Humber Estuary is by far the most important wintering site for Golden Plovers in the UK and is also the third most important site for Redshanks.

Similarly, most of the Severn Estuary is fairly easy to count at low tide. However, the mudflats known as the Welsh Grounds are up to 4 km from the shore, and the Middle Grounds, up to 6 km from the shore, are islands. Berrow and Stert Flats in Bridgwater Bay are also fairly extensive. The Severn Estuary is the second most important wintering site for Dunlins in the UK.

Lough Foyle is the second most important estuary in Northern Ireland for wintering wildfowl, and is the second most important site in Northern Ireland for Pale-bellied Brent Geese. Although it is not quite so large as some of the other estuaries discussed above, the mudflats do attain a width of 3 km and the relatively remote nature of much of the estuary, with a corresponding small number of available observers, make this estuary a candidate for special consideration. It should be noted that the western shore of the Lough is in the Irish Republic and this would require co-operation from the I-WeBS counters. There may be difficulties connected with security arrangements in the area.

1.4 Aims of the Report

Since the larger estuaries hold such important wintering populations of waterfowl, yet cannot be easily surveyed as part of the WeBS Low Tide Count Scheme, specialised techniques should be developed to cover these sites. To this end, a literature review has been undertaken to assess if and where such problems have been encountered and by what means they have been tackled. In addition to this, fieldwork has been carried out on the Wash with the express intention of fully determining at first hand all of the problems involved with low tide counts of large estuaries.

The report will summarise the findings of the literature review and will detail the fieldwork undertaken. The conclusions drawn will be of value in determining the best way to proceed with low tide counts of the Wash, Morecambe Bay, the Ribble Estuary, the Thames Estuary, the Solway Firth, the Humber Estuary, the Severn Estuary and Lough Foyle. In addition, any

lessons learnt will be applicable to other estuaries which have already been counted as part of the WeBS Low Tide Count Scheme, when repeat counts are made in the future. Sites such as the Dee Estuary, the Tay Estuary, the Burry Inlet and Lavan Sands will probably benefit from improved counting techniques for wider mudflats.

2. COUNTING WATERFOWL ON LARGE ESTUARIES: A LITERATURE REVIEW

The problems of surveying waterfowl usage of large estuaries has been encountered throughout the world wherever large scale surveys have been attempted. Additionally, similar problems are encountered when trying to count waterfowl along long stretches of coast, or whilst surveying birds at sea. Count methods can be classified as land-based, boat-based or aerial, and the techniques, advantages and disadvantages are described below. However, in many cases (especially in Britain), a combination of techniques is likely to be of most use.

2.1 Land-Based Counts

Clark & Pr_s-Jones (1994) described a low tide survey of the whole of the Severn Estuary. This was covered on foot, and mostly used volunteers who, for safety reasons, were asked to count from the high tide mark. In a number of cases, professional ornithologists from the Institute of Terrestrial Ecology carried out similar counts to double-check the count accuracy of the volunteers. However, the professional counters walked out onto the mudflats. In general, there was good agreement between the two sets of counts except for when the overall number of birds present was low. In such cases, the ITE counters recorded higher totals than the volunteers as a result of being closer to the birds.

The Wash has also been counted at low tide by professional counters. Goss-Custard *et al.* (1977) described the distribution of feeding waders in the Wash in the winters of 1972/73 and 1973/74, but only on the inner banks. It was noted that since the mudflats were so large, many places could only be visited occasionally within the time available. There was also a problem of the mud forming ridges and runnels, which effectively hid many birds. Most of the intertidal flats were visited at least twice, and all of the inner shore was surveyed at least six times.

A further study of the Wash at low tide, described by Goss-Custard *et al.* (1988), took place during the winters of 1985/86 (west side) and 1986/87 (east side). Additionally, the outer banks (islands of intertidal substrate appearing at low tide) were studied by a single aerial survey in December 1987 (see below). Initial land-based counts were along routes which, from prior scanning with a telescope, would keep disturbance to a minimum. Any subsequent surveys of the same areas followed the same routes, except for minor deviations to avoid flocks. The position of any birds counted was recorded using a compass, with cross-bearings to at least two reference points. Adjacent areas were counted on consecutive days, allowing the distribution of the birds noted on the previous day to be checked. In addition, a total of 11 areas were revisited at a later date using the same routes and survey methods, making it possible to see how representative the results of the survey were.

In areas of the Wash where there were many ridges and runnels, transects were walked. These were spaced approximately 400 m apart and aligned along the length of the runnels. Birds were counted ahead of the observer, and only those flying up within 25 m either side were recorded. The numbers from these transects were used to estimate the total number using the area in question. Care was taken to note where the birds were flying to, so as not to double-count them.

Bibby *et al.* (1992) suggested that for low tide counts, poles could be positioned in the mudflats to accurately mark count areas. Whilst this may be useful in smaller sections of an estuary, the size of these larger sites means that this technique is unlikely to be useful overall; the strength of

the tides will result in a rapid loss of poles from mudflats.

2.2 Boat-Based Counts

Boat-based counts have been regularly used to reach areas of estuarine habitats which cannot easily be accessed on foot (Parish *et al.* 1987; Smit 1982). Examples of such areas are coasts lined with mangrove swamps and complexes of islands within larger estuarine systems. Much work has also been done on counting birds on the open sea from boats (Komdeur *et al.* 1992), although the transect methods used have limited relevance to estuarine birds. Although it may sometimes be difficult to count from a boat, in many cases the boat may be used simply as transport to an otherwise inaccessible location, and the observer may then get out of the boat and count as for land-based surveys.

2.3 Aerial Counts

Aerial surveys of birds on estuaries have been used in many parts of the world already. In Britain, an aircraft was used to estimate the numbers of birds feeding on the outer banks of the Wash in 1987 (Goss-Custard *et al.* 1988). A series of 600 m wide transects, aligned at right angles to the longest axis of the bank, were flown in a light, high-wing aircraft, at a height of 80 m and ground speed of around 80 knots. The birds were counted as they were disturbed by the aircraft and later the numbers were corrected for the proportion of the area covered. During the flight, counts from land were made of parts of the inner banks which had already been counted, as a check on the accuracy of the aerial counts. The results showed that about half of the Bar-tailed Godwits on the Wash were feeding on the outer banks, as were about 20% of the Oystercatchers.

Elsewhere, aerial surveys of waterbirds have been carried out in Europe (Smit 1982, Komdeur *et al.* 1992), south-east Asia (Parish *et al.* 1987; Edwards & Parish 1988), Australia (Lane *et al.* 1983; Parish *et al.* 1987), North America (Dunne *et al.* 1982; Stenzel & Page 1988), Mexico (Harrington 1993) and South America (Morrison 1983). Much of what has been written about aerial surveys is covered in an excellent manual by Komdeur *et al.* (1992) which is an invaluable guide to carrying out aerial surveys. The main points are as follows.

When preparing a map of the area to be counted from the air, it is important to try to use well-defined natural features as boundaries. If count areas can't be easily defined, forcing the counter to rely upon the use of navigational equipment, it is advantageous to make the areas larger to reduce inaccuracies. Otherwise, smaller areas are preferable. This is partly because a better resolution of bird distribution can be achieved, and partly because less data will be lost if the plane has to return to base early (because of the weather, for example).

In choosing a plane, it is important to have good views from all observation seats, and so high-winged planes are recommended. Single-engined planes are satisfactory for inshore waters although twin-engined planes are safer when surveying offshore (in case one engine fails). Four-seater planes are usually needed, since there are usually at least two observers (plus the pilot). The Cessna 172 and Cessna 182 are suggested by Komdeur *et al.* (1992) as suitable models; these planes fly at 110-145 km/h. If a single observer is counting, a two-seater plane is probably satisfactory, and will be able to fly at a slower speed, which makes counting easier. However, the plane will not be able to fly so far without needing to be refuelled. Komdeur *et al.* (1992) recommended the Piper-cub.

The pilot should be experienced in low-altitude flying. The pilot is not an observer, and should not be spoken to during the flight unless this is necessary to confirm the route. The pilot should be aware of any military air activity in the area. It is also important to make sure that the plane carries safety equipment such as life jackets and, preferably, an emergency radio transmitter. A careful eye should be kept on the weather, and if this is not suitable, the count should be called off. The ideal weather is with low winds and complete high altitude cloud cover. Bright sunshine should be avoided.

The observers should ideally be accustomed to aerial surveying. However, such people are rare and as a second choice, preference should be given to observers who regularly count migrating birds (i.e. seawatchers), who are used to identifying flying birds rapidly. It should be noted that all observers are likely to be prone to airsickness to some extent. Counting should ideally be done with the naked eye, with binoculars (preferably small and light ones) used only for identification, since they restrict the field of view. Observations should be recorded on a dictaphone if possible, and should be transcribed as soon as possible after completing the count. Small dictaphones can be fragile so it is worth taking a spare.

In most cases, more than one person is involved with recording the birds. There may be one person counting, one estimating proportions of species and another keeping track of the locations, directions and times of observations. If a plane flies a pre-selected course, passing set locations at known times, then it should be fairly easy to calculate the positions of flocks of birds later. In some cases, it may be useful to photograph flocks of birds to count later (or to double-check estimates against). Also, Komdeur *et al.* (1992) suggest that it is useful to record as much additional information as possible from the air, such as the presence of bait-diggers.

Most surveys have been flown at an altitude of 40-50 m. At lower altitudes, the amount of disturbance increases, as does the danger of bird-strikes. The higher one gets, however, the greater the difficulties with identification. Additionally, the slower the aircraft travels, the more accurate the data are likely to be. Both light aircraft and helicopters have been used. Koolhaas *et al.* (1993) studied the responses of Knots to activity by jet fighters and light aircraft. It was concluded that on days on which aircraft were flying, Knot numbers were rarely large, birds were less approachable and were more restless. Light aircraft appeared to cause very strong disturbance even when flying at altitudes of over 100 m.

All of the aerial surveys reported upon have emphasised the difficulty of identification of species, and birds sometimes have to be classified in categories (e.g. small, medium and large). The more boldly patterned birds such as Oystercatchers, Stilts and Godwits are readily identified, but the smaller species are less easily distinguished. In Britain, problems are perhaps likely with Dunlins, Ringed Plovers, Knots and Grey Plovers. Many dabbling duck may prove difficult unless seen in flight. Curlews are apparently seriously underestimated because the species is very wary and leaves an area before it can be counted. In some cases, aerial surveys, although not providing particularly good data on numbers and species, may be useful in determining where to target foot or boat-based surveying later. Counters improve their accuracy only with a good deal of experience; therefore, if aerial surveys of many estuaries were to be carried out, the same team of observers would ideally be involved throughout. Specific identification tips are discussed by Komdeur *et al.* (1992).

The use of video from planes is likely to be very difficult, due to the vibrations of the plane and

focusing problems. The technology does exist for excellent resolution aerial photography, but unfortunately is confined to use by the military. Although this is probably simply wishful thinking, if one had the right connections it might just be possible to convince the air-force that aerial photography of estuarine birds would be a good training exercise! Many estuaries (including the Wash) are already regularly overflown by military aircraft and so this would not cause a great increase in disturbance.

2.4 Advantages and Disadvantages of Different Methods of Counting Waterfowl at Low Tide on Large Estuaries

Land-based counts

Advantages:

- Consistency with other low tide surveys.
- Simple methodology.
- Inexpensive.
- Identification and counting are likely to be more accurate from land, so long as visibility factors (including distance) are not restrictive.

Disadvantages:

- May be dangerous on wide expanses of intertidal substrate. Using large numbers of volunteers would reduce the control over safety measures in such areas.
- If counters do count only from the high-water mark, more distant birds may be missed, miscounted or misidentified. This is more likely when the intertidal terrain is not flat.
- Requires a large amount of manpower in comparison to aerial counts.
- Counters walking out onto the mud may disturb birds which are closer in to the shore, thus creating a false pattern of distribution. This may also lead to double-counting.
- The wider the mudflat, the faster the tide will move across it. Therefore, tideline feeders will also move a great deal with the ebb and flow. Since land-based counts may be rather slow compared to aerial counts, times and positions of birds need to be recorded accurately to reduce the likelihood of double-counts.
- The lack of reference points when out on a large area of mudflat may make it difficult to judge exactly which subsection of an estuary birds are on. Although the bearing to a flock of birds can be determined by use of a compass, it is very difficult to judge distance on a featureless expanse.

Boat-based counts

Advantages:

- Allows access to areas difficult (or impossible) to reach on foot.
- Relatively fast means of transport which allows large areas to be covered faster than on foot.
- Compared to aerial surveys, boats are inexpensive and are able to come closer to the birds, thus usually enabling more accurate identification and counting.
- Boats have already been used successfully on some WeBS Low Tide Counts.

Disadvantages:

- Can be hampered by bad weather e.g. strong winds.
- Need trained staff and access to a boat.
- In many cases it may be difficult to count from a boat; in particular, it is usually not possible to use a telescope from a boat.
- A boat entering more remote parts of an estuary may cause a good deal of disturbance. The disturbance can be less than that caused by a plane, but it will almost certainly last longer.

Aerial counts

Advantages:

- Safer than walking out onto dangerous mudflats.
- Rapid surveying enables a more accurate "snap-shot" at a particular state of the tide.
- Good estimates of numbers can be obtained for some species.
- Large areas can be covered with a minimum of manpower.
- For some inaccessible areas, aerial surveys may be the only practical method of counting.

Disadvantages:

- Aircraft availability may be limited, reducing flexibility of when to carry out the counts.
- Can be expensive, although this should be weighed up against the costs of surveying by other methods (e.g. by employing professional counters).
- Can be hampered by poor weather.

- Specific identification often difficult at high speed and unfamiliar angle.
- Accurate estimation of numbers is difficult and requires counters experienced in this kind of survey (of whom there are very few).
- Disturbance of feeding flocks.
- Flying at low level over dense flocks of birds increases the danger of bird-strikes.
- Rarer species are unlikely to be recorded.

3. ASSESSING PROBLEMS ASSOCIATED WITH LOW TIDE COUNTS OF LARGE ESTUARIES: FIELDWORK ON THE WASH

In order to gain first-hand experience of the problems involved with counting a large estuary at low tide, fieldwork was carried out on four occasions over the winter of 1996-97. Although counts of birds were made, the main purpose of the fieldwork was to look for the difficulties associated with making those counts. Being based in Thetford, the obvious choice of study site was the Wash, which holds the largest numbers of waterfowl in the British Isles and has mudflats which are up to 9 km from the shore. Additionally, there are a number of large offshore islands.

Four observation points were chosen, two on the south shore and one on each of the east and west shores, as shown in Figure 3. The sites were largely selected on the basis of ease of access. Counts were made from the shore from all of these sites at low tide and any problems encountered were recorded. On the first two visits, two observers were present. Since this provided additional safety, it was possible to investigate the effect of walking out onto the mudflat to assess how this improved the count accuracy.

3.1 Snettisham Scalp

The area known as Snettisham Scalp was visited on 12/12/96 (Figure 3.1). The sector of mudflat which was counted was selected whilst at the site.

Counts were made from the shore at TF647336 independently from 13:30-13:50. The locations of the birds noted were mapped and the results are listed in Table 3.1. The counts agreed fairly closely with one another, although some differences were noted. This was perhaps partly due to differing estimation/counting techniques of the observers and partly due to the mobility of the birds themselves which meant that birds could move in or out of the count sector before being counted by one or other observer; this probably accounted for most of the difference in Dunlin counts. The differences in numbers of Mallards, Grey Plovers, Knots and Redshanks counted may have been due to these birds frequenting the area close to Wolferton creek and thus being obscured from view for part of the time.

The problem of identifying and counting birds at long range was effectively negated by the poor visibility; mist and heavy drizzle limited visibility to *ca* 1 km. It would have been possible to count birds at a greater distance had the visibility been better. The terrain was relatively flat and was not considered to hide many birds. At this point of the Wash, the mudflats do extend at least 3.5 km offshore with additional offshore islands also present even further out at low tide. Interestingly, about 2 km out from the shore the sandy-mud substrate inclines upwards towards the centre of the Wash. This obviously has important implications for safety since a fieldworker out on the mudflats could be cut off by the rising tide.

After carrying out the shore-based counts, SJH walked out *ca* 1.5 km onto the mudflats from 14:00-15:00. At this distance, the shoreline was obscured at times by the mist. Birds were again mapped and those additional to the ones mapped from the shoreline totalled 67 (compared with 401 from the shore), comprising 44 Dunlins, 17 Bar-tailed Godwits, four Knots, one Grey Plover and one Curlew. Many of these birds would probably have been visible from the shore had it not been for the mist. Similarly, had the visibility been better, SJH would presumably have been able to record many more birds whilst out on the mud. Although the substrate was fairly firm, in one area SJH sank in up to his ankles and found it difficult to extricate his waders from the sand.

This occurred in an apparently firm area. Whilst walking out onto the mudflats, it was necessary to cross Wolferton Creek, another fairly large creek and a much shallower creek. These were not dangerous at this state of the tide (approximately an hour before low tide) and the water reached about half-way up SJH's calves. However, it was apparent that a rising tide would fill these channels first and cut off a retreat to the shore.

3.2 Nene Mouth

The second study site, at the mouth of the River Nene just north of Sutton Bridge, was visited on 5/2/97 by AJM and M.M. Rehfisch (Figure 3.2). The shore-based observation point at TF496267 was reached at 10:50. The weather was excellent, bright and fairly windless with a little haze towards the tideline. Both observers counted birds within a selected sector of the mudflats independently and produced maps of bird distribution which were essentially similar, although the distance from the shore of the plotted birds varied between observers. Nearby birds (within about 1 km of the shore) were counted and identified relatively easily (although some may have been hidden in creeks, including Redshanks and some of the roosting Lapwings). Birds in the middle distance (approximately 2 km away) could be counted to what was probably a fair degree of accuracy but identification was more difficult. Estimates and identification of further birds (of up to 3 km away) were not considered to be reliable.

The totals of birds counted are listed in Table 3.2. The counts were rather similar for most species. The discrepancy in Lapwing totals was due to half of the flock flying out of the count sector before MMR had counted them. AJM's unidentified birds were thought to be mostly Knots (thus agreeing with MMR), with an unknown number of other species, particularly Dunlins, present.

Both observers then walked out over the saltmarsh and onto the mud, which was wet, becoming more so the further one went. This made walking difficult, especially when one had stopped for a while. There were numerous narrow rivulets, which not only made walking difficult but could well hide large numbers of birds from shore-based view. There was also a deeper channel which was more difficult to cross. Further observations were made after walking for seven minutes. A nearer flock of waders (which may have flown in, or may have appeared from out of a channel) could be seen much more clearly than from the shore and was made up of 50 Knots and 12 Dunlins. These Dunlins had not been separable from the Knots whilst viewing from the shore. A more distant flock contained *ca* 500 Knots/Dunlins (the proportions of which could not be accurately judged) and at least seven Oystercatchers. After walking for another five minutes, the mud became very difficult to walk through. At this stage, more Oystercatchers were visible, but the tideline birds were still too far away to count or identify accurately. Bearings were taken from this final position to establish position. After spending 10 minutes here, the route was retraced to the shore. The channels were again crossed with care and could be potentially dangerous on a fast-rising tide.

Bait-diggers were noted to the east of the study area but none were within it (perhaps due to the terrain?). Otherwise, the most noticeable disturbance was by low-flying military aircraft, although this may have disturbed the observers more than the birds. The movements of the observers did result in some redistribution of the birds, including *ca* 150 Shelducks.

3.3 Holbeach St Matthew

The study site is in the south-west corner of the Wash, just north of the village of Holbeach St Matthew (Figure 3.3). The site was visited by AJM on 20/2/97. The weather was good except for a very strong southerly wind which made counting difficult. In order to make any sort of

sensible count, a sheltered position had to be found. This meant, however, that the count may not have picked up quite so many birds as one would if standing on top of a bank.

The shape of the seawall at this part of the Wash meant that two counts could be made. The first, from the position TF409339, was made from 12:28-12:40. It appeared that the tide was not so far out as the mean low water mark on the Ordnance Survey map. It was, however, very difficult to determine distances on the mudflats. It was also very difficult at any distance to determine the difference between water and wet mud.

The limits to the count sector were decided upon whilst out at the site, although it was rather difficult to determine which distant buoy was which. During the initial count, from this position behind the saltmarsh, very few birds were identifiable. These were mostly Shelducks although many unidentified waders were present in the distance (see Table 3.3). Additionally, a flock of 600 Brent Geese flew in from the east and landed in the saltmarsh. Although these were strictly outside the count sector, the observation was of interest in that after landing, not a single goose was visible.

The second count was made from TF407346. This position was a sluice-gate/bridge over the outlet known as Lawyer's Creek; the construction of the bridge provided shelter from the wind. Since this counting point was some 700 m further north into the estuary it was hoped that this would enable more birds to be counted. The visible area of the mudflats was greater here than previously. A sector was counted (13:29-13:52) which approximated to that counted from the first viewpoint. Additionally, a sector to the west of this was also counted (12:54-13:29). Table 3.3 lists the birds counted in both of these sectors, as well as the birds counted in the east sector from the first viewpoint.

The numbers of Shelducks present in the east sector compared very well between the two counts, but all other species were undercounted (some grossly) when viewed from behind the saltmarsh. The mixed flock of Knots and Dunlins appeared to be present in proportions of roughly 50/50, but this could not be determined with any accuracy. It was felt that other species such as Grey or Ringed Plovers would be easily overlooked in such a flock at any greater distance. A mixed flock present just past the saltmarsh was difficult to separate into species even at fairly close range; this close flock may have been missed on the first count due to a relatively low vantage point. It could be, however, that the birds may have appeared between the two counts.

On the western sector, birds were mapped out to a distance of *ca* 3 km but in reality, it was impossible to be sure how far one could see. A flock of *ca* 1,300 Brent Geese were visible along the Welland about 4 km away. These birds were, however, mostly seen in flight and an unknown number may have been missed on the mud. The other 176 Brent Geese flew in during the count to the nearby saltmarsh. A flock of 80 Lapwings also flew over but did not land. It was again very difficult to estimate proportions of Knots and Dunlins in dense flocks, and it is likely that any less numerous waders at ranges of over 1 km were missed. Using a zoom eyepiece on a telescope was essentially useless given the strength of the wind, even from a relatively sheltered position.

There was little disturbance to the birds except for the ever-present military jets. On leaving the shore to return to the car, however, two wildfowlers were noted. Additionally, a Merlin was hunting the saltmarsh although it appeared to be concentrating on passerines.

3.4 Wrangle Flats

The fourth study site, Wrangle Flats, was visited by AJM on 21/2/97 (Figure 3.4). Access was by a minor road to "Sailors' Home" and from here it took about 10 minutes to walk to the seawall. The visibility was excellent, with the Norfolk coast visible across the Wash. Although it was sunny and dry, the strength of the southerly wind (now blowing across the mudflats towards the viewing positions) made counting extremely difficult.

The initial count was made from the position TF449489 on an embankment behind the saltmarsh. The wind was too strong to stand on top of the embankment and counting thus had to be done from a sitting position. The "island" at the mouth of the Nene was used as a landmark to determine the southern limit of the count sector with the corner of the embankment at TF451489 determining the northern limit of visibility. According to the Ordnance Survey map, the mean low water mark is *ca* 3.5 km away. The count was made from 13:40-14:10. It was again notable how difficult it was to judge distance. The area shown as Bar Sand on the Ordnance Survey map was not visible as such. It may not have been uncovered by the tide or it could be that it was not distinguishable.

Over 5,000 birds were estimated to be present in the sector, with an additional 3,400 Brent Geese in two flocks to the north and south but not in the count sector. The counts, summarised in Table 3.4, again showed that the best information concerning numbers and identification can be gathered closer to the shore. At a distance of about 1.5 km, the information gathered becomes less accurate, with identification becoming difficult. Only numbers of birds can be estimated on the shoreline and identification is no longer safe.

A second count was then attempted from TF454490. Viewing from here did not help the identification of distant birds. It was notable, however, that even over the period of *ca* 10 minutes between finishing counting at the first position and starting to view from the second, many birds had moved quite considerably. The wind was even stronger here and simply holding the recording map still was very difficult, so an exact count was abandoned.

The only potential disturbance at this site was from a male Hen Harrier hunting over the saltmarsh, two dog walkers and some bird-scaring guns over nearby fields; none of these appeared to have a noticeable impact on the birds on the estuarine mud.

Finally, an attempt was made to count from further south across Butterwick Low, from TF406434 and TF412435. However, since the Ordnance Survey map had been printed, some of the saltmarsh had been reclaimed and was in use as a prison farm. It also appeared that the saltmarsh had extended further into the estuary from the new seawall. The wind was also very strong here and the count was abandoned.

3.5 General Points Arising from the Fieldwork

Safety

Large estuaries can be hazardous. It is not at all sensible to ask volunteer counters to venture onto most wide mudflats. The consistency of the intertidal substrate can often alter without warning with the danger of leaving the counter stuck in the sediment. This can happen especially in areas in which bait-diggers have been operating recently (M. Yates pers. comm.) A pit dug by

bait-diggers will fill with finer substrate after a few tides, leaving a potentially hazardous area of mud.

The tide can come in at a very fast rate on parts of some estuaries. This could take an observer by surprise, especially if tide tables have been misinterpreted. Channels of water across the mudflats may seem shallow at low tide but are likely to fill up quickly as the tide rises, with the danger of leaving an observer cut off from the shore.

Ideally, venturing out onto the mudflats should only be undertaken by experienced, professional counters who are fully aware of the dangers posed by such an environment. In all cases, it should be strongly recommended that a counter out on the mud should carry a mobile phone to call for help if necessary. Ideally, if a counter has to venture onto the mudflats, he or she should be accompanied by another person who waits on the shore to call for assistance if necessary; this person would ideally be a volunteer counter.

Identification and Count Accuracy

Different species of waterfowl can be identified at different distances on a large estuary. Obviously, for the more distant parts of the larger estuaries, it will not be possible to identify any birds from the shore, no matter what species they are.

The most important wildfowl species on intertidal mudflats is usually the Shelduck, which can be easily picked out at long distances. At a very long range, however, these birds may be confused with gulls. Other ducks on estuaries can be difficult to distinguish at long distances, although they can often be separated by "jizz". Geese are easily identifiable as such, and on most estuaries, only one goose species tends to occur. This may not be the case on the Solway, but in any case, geese are unlikely to be feeding on distant mudflats at low tide.

Of the waders, Oystercatchers (and Avocets) are identifiable at long range but most other species are more camouflaged. Dunlins and Knots, although difficult to see at any range individually, are invariably present in large flocks which increases the chance of noticing the birds. However, in a mixed flock of these two species, it can be very difficult to separate the two at ranges of over 1 km. Sanderlings were not seen and although this species is probably difficult to identify at a long range because of its appearance, the greatest problem with counting it on large estuaries will be due to its tideline feeding habits. Grey Plovers are often to be seen in small numbers in flocks of *Calidris* waders if not too distant, but cannot be distinguished at a long range. Ringed Plovers were not noted during any of the fieldwork and are likely to be difficult to pick out on a wide mudflat. Despite being the largest wader species on British estuaries, Curlews can be surprisingly difficult to see at ranges of over *ca* 1 km, due to their cryptic plumage and because they are widely dispersed as single birds. The two species of Godwit are difficult to separate at distance, unless in flight. Redshank are also fairly featureless birds at long range, but the greatest problem in surveying this species is its habit of favouring areas around creeks, which will hide many birds from shore-based observation. Flocks of Lapwings and Golden Plovers were only seen roosting fairly close to the shore and so did not cause identification problems. Golden Plovers could be confused with Grey Plovers at long range but the former usually occurs in large flocks.

Although it is very difficult to determine the distance that birds are from the shore, a rough guide to count accuracy might be that *ca* 90% of birds within 1 km of the shore are counted, perhaps *ca*

50% of birds within 2 km of the shore and probably less than *ca* 10% of birds more than 2 km away from the shore are counted. These figures are no more than an educated guess (and would ideally be improved upon by further research) and will obviously vary depending upon such factors as the species present, the terrain and the weather. In the case of the Wash, rough calculations show that *ca* 15% of the intertidal substrate is within 1 km of the shore, *ca* 21% between 1-2 km of the shore and the remaining *ca* 64% at a distance of greater than 2 km from the shore. If one assumes that birds are spread evenly throughout the Wash, the estimates of count accuracy given above would result in just over 30% of the birds being counted. However, birds are not spread evenly across the mudflats, with many following the tide as it falls. It is likely, therefore, that a substantially lower proportion would be recorded.

Count Sector Boundaries

One of the main difficulties which came to light whilst engaged in fieldwork, but had not been fully appreciated beforehand, was the problem of orientation. Over a flat, featureless landscape such as a mudflat it is virtually impossible to estimate distances. Thus, mapping of birds involved a fair amount of guesswork. This would have consequences if one asked volunteers to count all of the birds within, say, 1 km of the shore, since different counters would count birds to different distances. Some sort of hand held trigonometrical marker might be possible?

In addition to distance, the left- and right-hand boundaries of a count sector would have to be carefully defined. Since there are few permanent markers out on a mudflat, it is useful to use more distant markers such as buoys. At the study site at Holbeach St Matthew, a distant power station near Boston was used as a marker. Ideally, however, a compass should be used to define count areas.

Weather

The weather can affect low tide counts on all estuaries, but the problems are exacerbated on large estuaries. Mist and rain can limit visibility, an on-shore wind is likely to be stronger over a wide expanse of mudflats and bright sunshine can make it difficult to differentiate between water and wet mud and may also make waders more difficult to see.

4. AERIAL COUNTS OF THE WASH BY ENGLISH NATURE

A series of aerial counts of waterfowl on the Wash was carried out by English Nature during 1994 and 1995. Some of the unpublished counts are briefly summarised below.

Methods

Four aerial counts were undertaken, on 12/2/94, 21/8/94, 9/10/94 and 19/3/95. The counts were made from a Partenavia Observer aircraft, which is well-suited to this type of work, being high-winged and having a see-through nose. A route had been pre-selected and had been discussed with the pilot. Each count was about 2.5 hours long, during which the whole of the intertidal area of the Wash was covered, in addition to a part of the north Norfolk coast (this does not include the time taken between the airfield and the Wash). Counts were made on spring low tides. However, the route had to be a little flexible since the exact position of the shoreline can vary greatly depending upon the exact state of the tide and also with the strength of the wind.

There were two observers, counting from opposite sides of the plane (mostly with the naked eye, although binoculars were used when flying over open sea looking for sea-duck). However, only one person recorded the counts, to reduce the chance of double-counting. A dictaphone was used for recording data, and headsets were very important for communication owing to the noise of the plane. It was found that a trial flight was vital to get used to the flying conditions, the use of the headphones and dictaphone, the unfamiliar bird-counting techniques required and the likelihood of airsickness. An important observation was that 2.5 hours of counting was extremely tiring to the counters. The diversion along the north Norfolk coast looking for sea-duck was helpful as a break from continuous counting.

Much of the navigation was left to the pilot, but the observers had to ensure that their position was known at all times and was recorded regularly. It was particularly important to note the points at which the plane crossed from one recording area to another. At the time of these aerial counts, GPS (Global Positioning System) was not widely available and so was not used for navigation. However, it would certainly be worth considering in the future.

The Civil Aviation Authority (CAA) required the plane to be twin-engined for safety reasons. This unfortunately means that the plane cannot travel quite so slowly as a single-engined plane. CAA rules require the plane to fly at an altitude of over 250 feet; the survey was mostly done between this altitude and 500 feet. The plane was travelling at 100-120 knots. It was left to the pilot to contact the CAA and make the necessary arrangements. The pilot also liased with the RAF, who limit flying on the Wash to the weekend. The CAA prefer there to be two pilots present for extra safety, although this is negotiable.

The weather can be a serious constraint when planning aerial surveys. As well as the obvious requirement of good visibility, the CAA will not allow flights if the cloud level is lower than 5000 feet. Additionally, a wind speed greater than force three makes it impractical to count from an aircraft. The limitations of weather and flying only at the weekend means that it is necessary to be very flexible when planning aerial survey dates.

Results

The counters at English Nature considered that the aerial counts were good for establishing the relative distribution of birds (which is the main purpose of the WeBS Low Tide Counts) but not for determining overall numbers of birds present (although this would improve with experience). No analysis of the data was made at the time. However, some results have now been extracted from the raw data. Table 4.1 lists, for eight key species, the totals counted from the air, totals counted on the WeBS core count nearest to the date of the aerial survey, and the percentage of the core total which was recorded from the air.

For these eight species, over all four counts, the overall proportion seen from the air was just 28%. The percentage varied greatly between species. Shelduck appeared to be best-represented by aerial counts, with an average of 61% of the core total picked up from the air. This is not surprising given that this species is large and boldly patterned, although even so, almost two-fifths of the birds were missed. Another boldly patterned species, the Oystercatcher, scored an average of only 30% which does seem surprisingly low. Only 28% of Brent Geese were counted from the air, although this is probably explained to a large extent by birds feeding in fields, which were not counted in the aerial survey. Of the other waders, about 50% of Knot were located but the other species were very poorly covered, i.e. 11% of Dunlin, 7% of Redshank, 5% of Grey Plover and only 3% of Curlew. Other observers have noted that Curlew are particularly wary and fly before an aircraft approaches closely enough to count them (Komdeur *et al.* 1992).

The purpose of the WeBS Low Tide Counts is not to produce accurate totals of each species, but to determine the relative importance of differing parts of an estuary for waterfowl, and so the above comparisons with the core count totals may not be considered important. However, with such low proportions for some of the species, it is questionable whether a reliable pattern of distribution could be determined. In the worst example, on 19/3/95, 17404 Grey Plovers were counted on the WeBS core counts. However, only 255 were noted from the air. It seems unacceptable to produce a map of relative density from a survey in which 99% of the birds were missed.

Costings

An invoice was provided by English Nature which they received from Airmark Aviation Services Ltd. for the aerial survey which was carried out on 12/2/94. The Partenavia aircraft had to be flown from East Midlands airport to Conington (25 mins), and from there the Wash survey flight took place (3 hrs 45 mins). The aircraft then had to be flown back to East Midlands, resulting in a total of 4 hrs 35 mins flying time at £140 per hour, i.e. £641.62. Because of the trips between East Midlands and Conington, three sets of landing fees had to be paid, totalling £70. The pilot's fees were £120 for the day. The total, including VAT, came to £977.15.

5. APPROXIMATE COSTS OF AERIAL SURVEYS *VS* LAND-BASED SURVEYS USING PROFESSIONAL COUNTERS

Aerial Surveys

The cost of English Nature's aerial survey of the Wash mentioned in Chapter 4 can be used to yield an approximate costing for aerial surveys for each of the five principal "megasites". It is assumed that four counts are to be carried out (as with the standard WeBS Low Tide Counts), although as mentioned earlier, there is likely to be a problem with the weather limiting the available flying days. It should be noted that although some of each estuary can be counted from the shore by volunteers, it would be necessary for an aerial survey to cover the whole of each site, due to the differences in results obtained from the ground and from the air.

The costings were worked out as follows:-

Plane = £140 per hour
Landing fee = £20 (assume only one landing fee necessary)
Pilot = £120 per flight (although note that CAA may insist on a second pilot being present).

VAT at 17.5% and 10% for inflation were added and the total was multiplied by four for the four counts.

An attempt has been made to scale the costs by altering the flying time in proportion to the intertidal area (A) of each site. The Wash, with an intertidal area of 30,000 ha. required a flying time of 3 hrs 45 mins. Thus, the approximate cost for each flight can be calculated as:-

$$\text{Cost} = 5.17 \times [(525A/30000) + 140]$$

The calculated flight costs for each site are listed in Table 5.1. Assuming two observers, of SO- and ASO-grade, take part in the 20 counts, at *ca* £200 and £150 per day respectively, this means that the overall cost of covering these five sites by aerial survey would be about £21,385.

Professional Land-based Counts Made on Foot

Unlike aerial surveys, using professionals to walk out onto wide expanses of mud to count birds could be easily combined with surveys by volunteers (although there could potentially be some resentment felt by volunteers that they themselves were not being paid.) It seems reasonable to expect that volunteers could count all parts of an estuary which were within 1 km of the shoreline, and to use professionals to cover areas further out. However, given the difficult walking conditions on intertidal surfaces, and the dangers of rapidly rising tides, it would not be safe to attempt to cover some of the intertidal areas furthest from the shore (especially seeing as some of these are offshore islands). Setting a limit of 3 km as the furthest point to send counters, and assuming that they could count a further 1 km from this point, the proportions of the five main sites which could still not be accessed on foot are listed in Table 5.2. As can be seen, foot-based counts would give adequate coverage for the Ribble (since the substrate here is mostly sandy, the remaining 4% could probably also be covered) but significant parts of the other four sites would remain unsurveyed. From maps of the sites the approximate number of counter-days required to cover the areas between 1 km and 4 km from the shore can be estimated roughly. These are multiplied by four and then by £150 per day for an ASO-grade counter; the resulting

costs are listed in Table 5.3. In addition to the calculated total of £58200, it is likely that additional funds would be required for training, safety equipment and travel / subsistence. Navigation on mudflats would be helped by use of GPS equipment which would also need to be purchased.

Summary

The above calculations are obviously very approximate but it appears that, on cost alone, aerial surveys would be cheaper, costing in the region of £21,000 for the five sites in total compared to about £58,000 for employing professional foot-based counters.

6. CONCLUSIONS AND RECOMMENDATIONS

The conclusions which can be drawn from the report are:

1. Counting waterfowl on a large estuary from the shore is likely to result in missing a large proportion of the birds.

2. For safety reasons, it is not advisable to send volunteers out onto wide mudflats to improve count accuracy on large estuaries.

3. Any surveys of large estuaries need to be thoroughly planned beforehand, particularly with respect to the definition of count sectors.

There are three options available to WeBS for counting large estuaries at low tide.

1. The largest estuaries could be omitted from the low tide scheme altogether. This would be unfortunate since about half of the birds wintering on UK estuaries are to be found on just the eight most important (and largest) sites. If these sites were to be excluded from the WeBS Low Tide Count Scheme, any requests for data on these sites would have to be limited to Core Counts or would require specific research projects to be undertaken. Data already exist for some large estuaries, but this information on the low tide distribution of birds is not necessarily in the same format as standard WeBS data, nor is it necessarily available to the WeBS partners (e.g. Wash data collected by I.T.E.)

2. Partial surveys of the estuaries could be carried out, with only the birds visible from the shore being counted. This would obviously not be ideal, but since many development pressures on estuaries are on the shore of the estuary, it may be that such limited surveys would provide useful data even if they did not make it possible to assess the proportion of birds feeding at low tide on the "shore strip". The exact limits of such a study would have to be carefully defined.

3. A total survey could be attempted, using non-standard methods. This would involve either employing trained, professional counters to go out on the mud, or carrying out aerial surveys of the sites. Both are likely to be costly, with preliminary estimates suggesting a figure in the region of £21,000 to cover the Wash, Morecambe Bay, the Ribble Estuary, the Solway Firth and the Thames Estuary, by aerial survey, compared to about £58,000 for corresponding foot-based counts. Both methods have their advantages and disadvantages. Land-based counts are likely to be more accurate and more comparable with low tide counts of other estuaries. However, they will take more time and can be dangerous for the counters. Also, there are some parts of the large estuaries which cannot be reached on foot. Aerial surveys would be preferable on safety grounds and cost and should be able to cover a large estuary on one visit. However, very large numbers of birds may go unrecorded and thus the results may not be considered complete (see Section 4). Additionally, aerial counts are more likely to be constrained by weather and access problems.

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Estuary	Waterfowl	Internationally important species
Dee Est.	127,006	SU,T.,PT,OC,GV,KN,DN,BW,CU,RK
Mersey Est.	102,301	SU,WN,T.,PT,DN,RK
Stour Est.	91,190	GV,DN,BW,RK
Forth Est.	85,917	PG,SU,KN,BA,RK,TT
Blackwater Est.	74,980	DB,SU,GV,DN,BW,RK
Medway Est.	69,918	DB,SU,RP,GP,DN,RK
Swale Est.	67,985	SU,WN,PT,SV,GV,KN,BW,RK
Strangford Lough	57,195	PB,KN,RK
Chichester Harbour	54,309	DB,RP,GV,DN,BW,BA
Montrose Basin	53,953	PG,KN,RK
Langstone Harbour	47,335	DB,GV,DN
Lindisfarne	42,912	GL,PB,WN,BA
Hamford Water	39,058	DB,RP,GV,BW
Duddon Est.	38,629	PT,KN,RK
Colne Est.	37,564	DB,RK
Burry Inlet	34,101	PT,OC
Dengie Flats	31,826	GV,KN,BA
Poole Harbour	38,052	SU,BW
Crouch/Roach Est.	27,021	DB
Orwell Est.	22,980	RK
Belfast Lough	21,197	RK,TT
Tay Est.	20,361	BA
Southampton Water	18,963	BW
Tees Est.	17,010	BA
Eden Est.	16,490	BA
Pagham Harbour	15,646	DB
North-west Solent	14,377	DB
Wigtown Bay	14,130	PG
Lavan Sands	11,944	
Portsmouth Harbour	11,577	DB
Taw/Torridge Est.	11,524	
Beaulieu Est.	10,513	
Camel Est.	9,028	
Dundrum Bay	8,798	PB
Pegwell Bay	7,464	
Inland Sea	4,972	
Fal Complex	4,556	
Conwy Est.	4,032	
Clwyd Est.	3,935	
Kingsbridge Est.	3,920	
Medina Est.	1,492	
Fowey Est.	256	
Wear Est.	No counts	

Table 1.2.1 Estuaries on which WeBS Low Tide Counts have been carried out.

Estuary	Waterfowl	Internationally important species
Wash	343,381	PG,DB,SU,PT,OC,GV,L,,KN,DN,BA,CU,RK,TT
Ribble Est.	266,702	BS,WS,PG,SU,WN,T,,PT,OC,GV,L,,KN,SS,DN,BW,BA,RK
Morecambe Bay	224,726	PG,SU,PT,OC,GV,KN,DN,BA,CU,RK,TT
Humber Est.	166,752	DB,SU,GP,GV,L,,KN,SS,BA,RK
Thames Est.	152,696	DB,SU,OC,RP,GV,KN,DN,BA,RK,TT
Solway Firth	133,382	WS,PG,BY,PT,SP,OC,KN,DN,BA,CU,RK
Severn Est.	85,308	BS,SU,GA,DN,CU,RK
Inner Moray Firth	46,966	GL,WN,RM,BA,RK
Cromarty Firth	39,435	WS,PG,GL,WN,BA,RK
Breydon Water	38,795	BS,L
Lough Foyle	36,275	WS,PB,WN,BA
Alt Est.	33,283	KN,BA
Dornoch Firth	27,751	GL,WN,BA
Carmarthen Bay	24,004	
Alde Complex	23,751	AV,RK
Exe Est.	23,634	
Inner Clyde	22,242	RK
Ythan Est.	19,801	PG
Fleet/Wey	19,660	DB
Deben Est.	15,731	
Cleddau Est.	15,183	
Tamar Complex	13,439	
Dyfi Est.	10,955	
Blyth Est. (Suffolk)	10,591	
Irvine Est.	9,784	
Loch Fleet	8,783	GL
Newtown Est.	8,126	
Tyningham Est.	7,097	
Carlingford Lough	6,652	PB
Loch Indaal	6,040	
Foryd Bay	5,587	
Christchurch H'bour	5,573	
Hayle Est.	5,116	

Table 1.2.2 Estuaries holding over 5,000 waterfowl on which WeBS Low Tide Counts have not been carried out.

Species	S.J.H.	A.J.M.	% difference
Mallard	25	10	60
Grey Plover	0	1	-
Knot	48	37	23
Dunlin	310	268	14
Curlew	2	2	0
Redshank	6	0	-

Table 3.1 Shore-based count totals from Snettisham Scalp.

Species	A.J.M.	M.M.R.	% difference
Brent Goose	365	376	3
Shelduck	151	171	13
Mallard	0	2	-
Oystercatcher	11	15	36
Golden Plover	260	240	8
Grey Plover	3	3	0
Lapwing	470	255	46
Knot	0	"thousands"	-
Dunlin	5	0	-
Curlew	21	18	14
Redshank	10	5	50
Unidentified Wader sp.	4720	0	

Table 3.2 Shore-based count totals at Nene Mouth.

Species	East (1)	East (2)	West
Cormorant	0	0	2
Brent Goose	0	0	1476
Shelduck	159	160	142
Oystercatcher	10	1020	870
Grey Plover	0	30	12
Knot	0	60	0
Dunlin	0	0	870
Knot/Dunlin	0	1400	550
Curlew	10	25	11
Redshank	1	10	7

Table 3.3 Shore-based count totals at Holbeach St Matthew.

Species	Number
Shelduck	6
Mallard	5
Oystercatcher	23
Grey Plover	1
Lapwing	151
Knot	1600
Dunlin	300
Curlew	24
Redshank	2
Unidentified Duck sp.	30
Unidentified Wader sp.	2900

Table 3.4 Shore-based count totals at Wrangle Flats.

Species	Aerial (12/2/94)	Core (13/2/94)	%	Aerial (21/8/94)	Core (21/8/94)	%	Aerial (9/10/94)	Core (9/10/94)	%	Aerial (9/3/95)	Core (13/3/95)	%	Overall mean %
Brent Goose	3,929	17,435	23	0	8	0	1,887	2,692	70	3,476	17,828	19	28
Shelduck	5,580	3,562	157	512	1,971	26	3,617	7,664	47	1,190	7,838	15	61
Oystercatcher	6,173	10,154	61	2,366	25,369	9	4,883	20,040	24	4,721	17,940	26	30
Grey Plover	973	6,840	14	282	10,335	3	327	11,127	3	255	17,404	1	5
Knot	18,175	28,999	63	6,927	71,118	10	47,779	67,042	71	18,856	32,462	58	50
Dunlin	8,598	24,930	34	519	21,713	2	1,900	36,271	5	1,785	38,235	5	11
Curlew	71	1,273	6	114	5,156	2	153	6,370	2	125	3,920	3	3
Redshank	48	1,859	3	172	4,587	4	202	4,205	5	531	3,282	16	7
Total	43,547	95,052	46	10,892	140,257	8	60,748	155,411	39	30,939	138,909	22	28

Table 4.1 Comparisons of Aerial and WeBS Core counts made at the Wash during 1994 and 1995.

Site	Flight cost
The Wash	£3,438
Ribble Estuary	£1,719
Morecambe Bay	£3,800
Solway Firth	£3,257
Thames Estuary	£2,171

Table 5.1 Calculated approximate flight costs for the five large estuaries.

Site	% intertidal > 4 km from shore
The Wash	18
Ribble Estuary	4
Morecambe Bay	19
Solway Firth	16
Thames Estuary	14

Table 5.2 Proportions of the large estuaries which are not countable by foot.

Site	Counter-days	Cost
The Wash	100	£15,000
Ribble Estuary	44	£6,600
Morecambe Bay	104	£15,600
Solway Firth	80	£12,000
Thames Estuary	60	£9,000
Total	388	£58,200

Table 5.3 Calculated approximate costs of foot-based counts.