1 Introduction

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***Estuarine Waterbirds at Low Tide* is a summary of the results achieved from the first seven winters of the WeBS Low Tide Counts (1992–93 to 1998–99). The book first sets out the methods used to carry out the scheme. It then summarises the results of the counts, first on a site-by-site basis and then species-by-species. Issues of data interpretation are then addressed, along with the potential uses of the data. It is hoped that the book will be of interest and of use to those people involved in the conservation of estuarine wildlife, to those counters involved in estuarine bird monitoring and all naturalists who appreciate the value of estuaries, one of the UK's greatest natural resources.**

The wetlands of the UK are vitally important for millions of migrant waterbirds which either spend the winter here or use the UK as a staging post on the way to and from wintering grounds further south. The numbers of birds involved have considerable international significance (Kershaw & Cranswick 2003, Rehfisch *et al* 2003, Stroud *et al.* 2001). Some of these birds breed in the UK, especially in upland regions. However, the majority spend the summer months in Arctic and sub-Arctic regions from north-east Canada, through Greenland, Iceland, Svalbard, Fennoscandia and along the northern coasts of Russia. Large numbers also come from north-eastern Europe (Wernham *et al.* 2002). These areas, although teeming with food in the summer months, are too cold in the winter to support large numbers of birds which thus have to migrate to areas with warmer climates. Such a journey can be energetically costly, often involving long sea-crossings (Gudmundsson *et al.* 1991, Gudmundsson and Lindstrom 1992, Alerstam *et al.* 1992). Since the UK is warmed by the Gulf Stream, its climate is abnormally mild for such a northerly latitude. As a result, waterbirds are better able to find food and are less likely to suffer cold-induced mortality than would be the case otherwise. Therefore, the distance required for their migration is minimised.

There are many different types of habitats in the UK that could be classified as wetlands, including the open ocean, rocky coastlines, lakes, reservoirs, rivers, ditches, marshes, sewage farms and even garden ponds. All of these habitats support non-breeding waterbirds. However, in terms of the sheer numbers of birds supported, the UK's estuaries are clearly the outstanding sites. Much of the following background information concerning estuaries is based on the standard work on estuary birds by Prater (1981), unless otherwise referenced.

ESTUARINE HABITATS

An estuary can be defined as 'a partially enclosed area at least partly composed of soft tidal shores, open to saline water from the sea, and receiving freshwater from rivers, land run-off or seepage' (NERC 1975, Davidson and Buck 1997). Many estuaries are clearly recognisable as such, but problems of delimitation occur in two ways. Firstly, the upstream and downstream limits of an estuary are not clear-cut, which is inevitable since an estuary is a transitional zone between river and sea. Secondly, one estuary can merge into another (as different rivers reach the sea in close proximity) and the definition of an individual site can be problematic as a result. Therefore, site definition can be subjective to a degree and different sites are treated on a case-by-case basis within this book with such issues discussed as appropriate.

There is a great deal of variety in estuaries, both between and within sites. Important factors include the rate of flow of the freshwater input, the degree of exposure to the marine environment,

the tidal range, the gradient of the surrounding land and the local geology. The intertidal flats can be formed from sediments brought in from the sea and/or inland sediments transported downstream by rivers. The nature of the flats depends upon the size of the individual particles present, which in itself is dependent upon the amount of energy in the water at any given place within an estuary. At the mouth of an estuary, the relatively high energy as a result of wave action means that only the large, heavier particles can settle out, leading to sandier sediments or even shingle. Finer sediments are deposited only in less exposed areas, usually in the sheltered inner estuary, thus forming mudflats. Conversely, sediment borne downstream by a river will settle out at a rate determined by the speed of flow of the water, with coarser sediments deposited first and finer sediments later as the speed of flow decreases.

Marine and riverine habitats support very different, often specialised, organisms. The major factor leading to this difference is salinity, which is the amount of inorganic material dissolved in the water expressed as parts per thousand (‰). In the sea, mean salinity is about 35‰, but in rivers it is generally less than 0.5‰. Few riverine animals can tolerate salinity levels higher than 5‰ whereas few marine animals can survive salinity less than 10‰. Therefore, there is a zone within estuaries which is inhospitable to most animal life, not only due to the absolute value of the salinity level but also due to its variability with each tide.

Although familiar enough to people in the UK, in international terms estuaries are a relatively scarce habitat. The UK is fortunate in having an estuarine resource which is large and varied, particularly in comparison with much of the rest of Europe (the main exceptions being parts of the French coast and the Wadden Sea, the huge intertidal zone on the North Sea shores of the Netherlands, Germany and Denmark).

ESTUARINE WILDLIFE

Although the diversity of species present within estuaries is relatively low, the total biomass of organisms present is extremely high. In most terrestrial ecosystems, the food-webs present are based upon the photosynthesis carried out by plants in that particular area. However, the intertidal zones of estuaries support little plant life, due largely to the physiological difficulties in coping with high and variable levels of salinity, but also due to the turbidity of the water and to the lack of suitable anchorage points in the sediments. Instead, the majority of production within an estuary is based upon the massive importation of nutrients into the system from the rivers and the sea.

Within the intertidal zone of UK estuaries, the principal plants able to survive are the eel-grasses *Zostera* and algae of the genus *Enteromorpha*. These species can form an important food-source for certain species of wildfowl. In rockier areas, seaweeds such as the brown wracks (*e.g. Fucus* spp.) may be present. Although the latter do not form a food resource in themselves, they provide shelter for numerous invertebrates which are preyed upon by waterbirds. Higher up the shore, a distinctive saltmarsh community of plants occurs, different species being found at different heights above mean high water, depending upon the frequency of inundation by salt water. Saltmarshes are important for certain estuarine waterbirds for both feeding and roosting, with the upper parts of the marsh also being used for nesting by some species, notably Redshank. At places around many UK estuaries, sand-dunes have formed and also support a distinctive vegetation, as do shingle structures at some sites.

The invertebrate species that have evolved to tolerate estuarine conditions are relatively few but can be exceedingly abundant in numbers. Some of these species are very important as a food resource for waterbirds, especially waders and, most notably amongst the wildfowl, Shelduck. Some of the most important prey items are the polychaete worms *Arenicola marina* (lugworm) and *Nereis diversicolor* (ragworm), the crustacean *Corophium volutator* and the molluscs *Mytilus edulis* (common mussel), *Cerastoderma edule* (common cockle), *Hydrobia ulvae*, *Scrobicularia plana* and *Macoma balthica*. Some wader species are generalists, taking a wide variety of prey species, whilst others are highly specialised, concentrating mainly on just one or two species. For example, Oystercatchers prefer mussels and cockles. Moreover, many species specialise as much by foraging method as by food species. Fish form another major group of animals frequenting estuaries and species such as Flounder *Platichthys flesus* may act as competitors with waterbirds for many of the smaller prey items (Furness *et al.* 1986, Raffaelli and Milne 1987). Fish themselves

are taken as food by certain estuarine waterbirds, with particular specialist fish-eaters being grebes, herons, cormorants, sawbill ducks (*Mergus* spp.) and Kingfisher.

Large numbers of waterbirds come to UK estuaries in the winter because the climate is relatively mild, because there is a large resource of estuarine habitat and because this habitat supports abundant food. The species involved are discussed in detail within this book. Food intake rates can vary depending upon a number of factors. Cold weather leads to higher energy requirements from the birds and can also cause a reduction in activity and availability of invertebrate prey (Zwarts and Wanink 1993). Although most waterbirds can cope with short periods of cold weather, longer periods can be more serious, particularly towards the end of a winter (Clark *et al* 1993, Dugan *et al.* 1981, Davidson 1982, Davidson and Evans 1982).

Windy weather can have a similar effect, chilling birds and drying out intertidal habitats, thus affecting feeding success (Dugan *et al.* 1981, Pienkowski 1983, Wiersma and Piersma 1994). The short day length in mid-winter, particularly in the north of the UK, can have an effect on those species which hunt by sight, although many species will also feed by night if necessary, albeit sometimes with reduced efficiency. For many species, a high density of birds can lead to interference and aggression between individuals, with dominant birds expelling others from favoured feeding areas (Goss-Custard 1980, Ens and Goss-Custard 1984, Cresswell 1994). Feeding efficiency is also age-related, with younger birds being less efficient at finding food (Groves 1978, Goss-Custard 1980). As well as maintaining body condition during the winter, large fat reserves need to be built up in the spring and autumn as migratory fuel (Metcalfe and Furness 1984). However, at all times there is a conflict between a bird having enough energy for survival (Pienkowski *et al.* 1979, Johnson 1985, Norman and Coffey 1994) and yet not so much additional body mass so as to unduly slow the bird down when escaping from a predator (Cresswell 1999).

HUMAN INFLUENCES ON ESTUARIES

Estuaries have always been favoured areas for human activities, many of which are potentially damaging to waterbirds and their habitats (Davidson *et al.* 1991). Estuaries often have cities associated with them and many support major industrial installations, such as oil refineries, docks and power stations. The level of industrialisation commonly found around estuaries leads to a particular risk of pollution, for example from chemical factories and oil spills (Armitage *et al.* 2000). Use of river channels for shipping often requires dredging for access by larger vessels, which can affect sedimentation patterns within an estuary. Around many estuaries, saltmarshes and intertidal flats have been claimed for agricultural land or for the building of industrial sites. Elsewhere, estuarine habitat has been used for refuse disposal. Over the last few decades, a number of schemes have been proposed for impounding estuaries to create freshwater reservoirs (a scheme on the Wash progressed as far as building trial bunds) or for tidal power generation. To date, none of these schemes have gone ahead, although Cardiff Bay on the Severn Estuary was dammed in 1999, to attract financial investment into Cardiff by a perceived improvement in its appearance and amenity value (Burton *et al.* 2001).

The natural resources present in and around estuaries are also attractive to human exploitation, with fish and shellfish (and even waterbirds themselves in some parts of the world) harvested at many sites. Although these are traditional activities, the potential for over-exploitation, particularly as a result of modern (often mechanised) techniques, is a real problem (Atkinson *et al* 2003, Bell *et al.* 2001). Estuaries are also enjoyed by many people for a variety of leisure pursuits, such as walking, sailing, windsurfing and bird-watching. The effect of such pursuits on birds, through disturbance, is one which is not fully understood but again it has a potential negative impact on estuarine birds (Burton *et al.* 2002a and b, Gill *et al.* 2001, Holloway 1997, Liley 2000). Such casual disturbance increases as people gain more leisure time. Finally, the most significant impact on estuarine habitats over the decades to come is likely to be sea-level rise caused by global warming, which is largely considered to be a result of human activities (Austin & Rehfisch 2003, Austin *et al.* 2001). Most estuaries are surrounded by sea-walls, created as flood defences. If the sea-level rises, but the estuary cannot 'migrate' landwards, the amount of estuarine habitat remaining will be reduced as a result, a phenomenon known as 'coastal squeeze'.

All these factors lead to increasing pressures and

potential conflicts between human demands on estuaries and waterbird dependence upon the same areas. In response to the potential threats to the conservation of estuaries, there are a number of key pieces of legislation which the UK has enacted, some effective at a national level and others international in scope. Most of these are based on the identification and designation of sites of importance for nature conservation. The number of different conservation designations on UK estuaries is large and it is beyond the scope of this volume to discuss them all in detail, although some, especially Special Protection Areas (SPAs), will be discussed where relevant throughout the book; a good summary of the different designations is to be found in Davidson and Buck (1997).

MONITORING OF ESTUARINE WATERBIRDS

To determine which sites are of importance for estuarine birds, it is first necessary to gather information on the numbers of individuals of each species using each site. However, in order to place a site's importance into its proper national and international context, the numbers present in the country and the size of the relevant international biogeographical population, respectively, also need to be determined. A site is considered internationally important if it regularly holds at least 1% of the individuals in a population of one species or subspecies of waterbird, or if it regularly supports 20,000 or more individual waterbirds (Ramsar Convention Bureau 1988). Similarly, a site is considered nationally important if it regularly holds 1% or more of the estimated national (British or all-Ireland) population of a species or subspecies of waterbird.

Within the UK, there is a tradition of voluntary monitoring of estuarine birds dating from the late 1960s (and earlier at some sites). For most of the ensuing period, two monitoring schemes were in place. The *Birds of Estuaries Enquiry* (BoEE) was designed specifically to assess bird populations on estuaries and was run by the British Trust for Ornithology (BTO) from the winter of 1969–70 onwards. The longer-running *National Wildfowl Counts* were targeted towards wildfowl at sites throughout the country, including many estuaries; this latter scheme was administered by The Wildfowl and Wetlands Trust (WWT). In the summer of 1993, these two schemes were merged into a combined monitoring scheme, the Wetland Bird Survey (WeBS). WeBS is now jointly administered on a day-to-day basis by the WeBS Secretariat, based at WWT, and BTO. In addition to these two organisations, the scheme is also jointly funded and steered by the Royal Society for the Protection of Birds (RSPB) and the Joint Nature Conservation Committee (JNCC), the latter on behalf of the four statutory country agencies, English Nature (EN), Scottish Natural Heritage (SNH), the Countryside Council for Wales (CCW) and the Environment and Heritage Service in Northern Ireland (EHS).

The WeBS Core Counts, as the combined scheme is more correctly termed, involve monthly co-ordinated counts, mostly by volunteers, made every year at around 2,000 wetland sites of all habitats. Within this framework, there is almost complete coverage of the UK's estuaries during the winter months, an impressive achievement. Most large inland waterbodies are also well surveyed, along with a selection of smaller inland wetlands plus some stretches of non-estuarine coastline. Additionally, an increasing number of counts are now carried out during the summer months, which can be useful in assessing the immature component of several migratory species. The Core Counts have enabled the identification of important sites and, subsequently, this assessment has made possible the designation of such sites for conservation.

The results of the WeBS Core Counts are reported upon annually in *Wildfowl and Wader Counts*, with summaries of important sites for each species as well as evidence of any trends in the numbers of each species, both at the site level or nationally (*e.g.* Pollitt *et al.* 2000, Pollitt *et al* 2003, Musgrove *et al.* 2001a). From the WeBS Core Counts, it is clear that estuaries are extremely important for non-breeding waterbirds. Some species are almost entirely confined to estuaries, such as Brent Goose, Shelduck and many of the waders such as Knot and Bar-tailed Godwit. However, even species with a wider habitat usage, such as Teal, may occur in estuaries in very large numbers. For the five winters between 1994–95 and 1998–99, of the 20 sites (out of about 2,000 monitored by WeBS) holding the highest overall numbers of waterbirds, 17 were estuaries, including all of the top nine (with Loughs Neagh and Beg in Northern Ireland being the most important inland site, in tenth place).

Estuaries differ from the large number of inland

sites counted for WeBS due to the influence of the tide. This means that the time of day and, especially, the state of the tide very much influence how the birds will be distributed within a site. In contrast, wildfowl on an inland gravel pit are clearly much less likely to be influenced by the time at which a count is carried out. On the majority of estuaries, the WeBS Core Counts are made at or around high tide. At such times, most estuarine birds gather at high density in relatively localised flocks, usually at traditionally favoured roost sites. Counters can then count the birds in the roost or, if the visibility of the roost is restricted (such as a roost in saltmarsh, for example) can count birds either entering or leaving the roost. Another way in which estuaries differ from inland sites, so far as waterbirds are concerned, is that the higher salinity of estuarine water means that estuaries are far less prone to freezing.

Such counts are often an excellent way to assess the number of birds in a particular area. However, there are a number of drawbacks. Firstly, although in many cases birds will roost close to favoured feeding grounds, it is not always possible to assume that birds roosting at a site are also feeding at the same site. In some cases, particularly along highly disturbed or highly industrialised shorelines, suitable roosting sites may be limited and birds may fly a long distance to a favoured roost (Rehfisch *et al* 1996, Scheiffarth 1996, Symonds *et al* 1984, Tubbs *et al.* 1992, Warnock and Takekawa 1996,). Also, birds feeding in a dispersed fashion along nearby non-estuarine coasts or even inland can make use of roosts within estuaries.

Secondly, even when (as in most cases) birds at estuarine roosts are feeding within the estuary, it is not possible to say anything about where within the estuary they are feeding. Therefore, the effect of a potentially damaging development on part of a site cannot be fully evaluated. Finally, there are some sites where the high tide roosts are either not fully known or not easily observed and here populations may be estimated on the basis of counts made at low tide (*e.g.* Da Prato and da Prato 1979, Moser 1987, Moser and Summers 1987, Bento and Rufino 2001, Dinsmore *et al.* 1998). At large estuarine sites, aerial surveys undertaken at low tide have also been used to estimate population sizes (Dunne *et al.* 1982, Zwarts 1988, Salvig *et al.* 1994, 1997). There may, however, be a level of discrepancy between counts undertaken at high and low tide (Yates and Goss-Custard 1991, Musgrove 1998). This may be for methodological reasons (*e.g.* difficulties in counting birds on distant mudflats at low tide) but it may also be for valid biological reasons (*e.g.* the birds may leave the counted site at high or low tide).

Given that the primary reason for non-breeding waterbirds to be present at an estuary is to feed, understanding their distribution away from the high tide period is of great importance. For this reason, the WeBS Low Tide Counts were initiated in the winter of 1992–93, initially by the BTO and RSPB, but integrated within WeBS the following year. The aim of the survey was to investigate the low tide distribution of estuarine waterbirds within sites, not with the intention of replacing the WeBS Core Counts but to add a further dimension to our understanding of estuaries, given both their dynamic nature and their critical importance to many species. This book describes the methods, results and conclusions from the first seven winters (1992–93 to 1998–99) of the WeBS Low Tide Counts.

2 Methods

Andy Musgrove

SITE SELECTION

The scope of the WeBS Low Tide Counts (LTCs) is estuarine sites throughout the United Kingdom. When the LTCs were originally planned, the aim was to 'systematically census each of the 59 main UK estuaries (defined as those supporting more than 5,000 wintering waders) on a five-year rotational basis using standardised methods'. However, this initial plan was modified in subsequent years, for a number of reasons. The waders-only emphasis was removed and monitoring of all waterbirds (notably including ducks and Brent Geese) was considered equally important. Also, as well as the main sites initially chosen, a number of smaller sites were also covered, due to local enthusiasm by counters or local management plans and/or development pressures on those sites leading to a requirement for data. The five-year rotation was extended to a seven-year cycle, to permit coverage of several sites where there were logistical difficulties in establishing a new counting scheme within the original time allocation and to cover an increased number of sites. Conversely, at a number of sites repeat counts were carried out on the initiative of the local counters, some even instigating LTCs on an annual basis.

It was always recognised that several very large sites (notably the Wash and Morecambe Bay) would be difficult to count. The problem with large estuaries (or rather, wide expanses of intertidal habitat) is that many birds may be present at very great distances, thus reducing an observer's ability to accurately determine the number and identity of birds present on the count section. Safety of counters has to be paramount and so they are discouraged from venturing out on to potentially dangerous intertidal habitats to record more distant birds. Although covering large sites requires the recruitment and co-ordination of large numbers of volunteers, this is not always an insurmountable obstacle. For example, excellent counts of the Moray Firth and Firth of Forth were achieved, both of which are large but relatively linear in shape. The potential of using aerial counts for counting waterbirds on estuaries like the Wash at low tide was examined (Musgrove and Holloway 1997). However, the conclusions were that any attempts to count large estuaries from the air were likely to lead to results which were not comparable with shore-based counts, owing to the possibility of missing a very large proportion of the numbers of some species. The WeBS partners are reviewing how to tackle LTCs of large intertidal areas, including reconsideration of aerial survey techniques.

SPECIES COVERAGE

The principal groups of waterbirds of interest for the LTCs are waders and wildfowl, along with additional species characteristic of wetland habitats such as divers, grebes, cormorants, herons, rails, gulls, terns and Kingfisher. The species involved are discussed individually in the Species Accounts. As well as recording at the species level, separation at subspecific level is requested of counters for Brent Goose and White-fronted Goose. Recording the presence or absence of raptors is also requested, although treated as a category of 'activity/disturbance' (see below) as opposed to a bird count.

Although data collection for all waterbird species is encouraged, recording of gulls and terns is optional at the discretion of the individual counter, as they are not priority species for the survey. This is because the counting and identification of gulls can be very time-consuming and consequently may compromise the quality of counts of the priority LTC species. Numbers of gulls on most estuaries vary more with the time of the day than with the state of the tide and many estuaries support important night-time roosts (Burton *et*

al. 2002c). Since the LTCs take place between November and February very few terns are recorded.

COUNTERS AND LOCAL ORGANISERS

Most LTCs are carried out by volunteers with a keen interest in and knowledge of their local estuary. Many of these counters also take part in WeBS Core Counts at the same site. Each counter takes responsibility for a number of count sections, depending on the amount of time they can commit to the survey. To enable efficient administration of the survey, a 'local organiser' is selected to co-ordinate the counts at the site level and to provide a single point of contact for the national organiser. At the end of a winter, counters are requested to return their forms to their local organiser who can then check for completeness and for any obvious mistakes before returning them to the national organiser. In some cases, the local organiser is a local professional ornithologist, often a reserve warden, although many local organisers work purely in a voluntary capacity. At some sites, local nature reserve staff are among the counters. This has been especially helpful in situations where special equipment (such as boats) has been required or where public access is generally restricted.

The co-ordinated network of volunteer fieldworkers forms the backbone of UK bird monitoring and is widely envied in other countries. Counters are experienced and skilled local birdwatchers and include many individuals possessing the most in-depth knowledge of the birds using UK estuaries. The LTCs appear to have been a generally popular survey, partly because the local counters could see the obvious value of the counts and partly because the plan was to count each site at low tide only on a periodic basis, thereby time-limiting the substantial commitment required.

SUBDIVISION OF SITES

The LTCs are organised around recognisable sites, which are then subdivided into smaller sections, leading to a two-tier count-unit hierarchy. Given their differing methodologies, a site counted for the Core Counts is not considered an identical entity to the same broad geographical site counted for the LTCs (although, clearly, there is a close relationship between the two). The principal distinction between Core Count and LTC site boundaries is their downshore limit. LTC sites are, by their very nature, precisely defined in terms of intertidal habitat, much of which may not be visible during Core Counts if the latter take place at high tide.

WeBS Core Count site boundaries on estuaries are more likely to incorporate adjacent nontidal habitats, especially where these are important roost sites. Such nontidal habitats are also frequently surveyed during LTCs, especially where the area is used by waterbirds during the low tide period. Additionally, at low tide some estuarine species, such as grebes and diving ducks, are present on the water below the tideline. Counters are encouraged to record these species and to assign such counts to the nearest section.

In general, the subdivision of a site into sections has been determined by local geography, identifiable features (natural and man-made), accessibility, ease of counting and existing Core Count sections, with a broad stipulation that sections should be relatively similar in size to one another. Generally, sections have been selected by the local organiser and counters themselves. A map of the subdivisions is then discussed with the national organiser. It is stressed that the same count sections should be used in subsequent count years. However, in a few cases, the experience gained from the first winter's survey led to the splitting of larger sections into several smaller ones, or *vice versa*, or sometimes to the addition of new count sections. Such details are fully described within the Site Accounts.

COUNT DATES AND TIMES

The LTCs take place during the four months of November to February inclusive and counters are asked to make one visit per month during this period. The mid-winter period was chosen partly because waterbird numbers on estuaries are at their highest then, partly to minimise between-month variation in counts and partly because this is the time of year when feeding constraints are likely to be at their greatest. Although three dates were initially considered to be satisfactory, it was decided that using four would allow for a certain amount of redundancy for missing counts due to factors such as poor weather. Although only one visit per month is requested, some counters do carry out more. In such cases, care is taken to select one count only in an unbiased fashion (*i.e.* without examining the actual numbers of birds

counted). In most cases where multiple visits are made to a count section in a particular month, the visit on the date most consistent with the counts on neighbouring sections is taken to be the visit to use for analysis.

Unlike the WeBS Core Counts, no pre-determined count dates are set at a national level but are decided upon by local organisers. Additionally, although simultaneous counts of all sections within a site are preferable, they are not compulsory. The principal reason for this is that the primary purpose of the scheme is to investigate relative distribution, averaged over several dates, and not to determine overall population sizes. Secondly, although weather conditions can affect the ease of carrying out any bird monitoring, conditions of fog, rain or strong winds make the counting of birds on distant mudflats particularly difficult and so the flexibility in count dates makes it possible to make best use of suitable counting conditions. Finally, given that most LTC participants also take part in the WeBS Core Counts which do occur on a pre-determined date each month, it was thought useful to allow a degree of flexibility to encourage a high level of participation.

LTC participants are asked to count during the two hours either side of low tide. There were several reasons for low tide being selected as the counting period. A key objective of the scheme is to record feeding distributions and studies have shown that for many of the specialist estuarine species, a high proportion of birds feed during this period (although this proportion varies between species – see Discussion). Also, since the position of the tideline (and thus the availability of food) is relatively stable during this period, changes in the numbers and distribution of waterbirds are consequently relatively small. Although the tideline varies between neap tides and spring tides, the fact that a mean low water (and high water) mark is shown on Ordnance Survey maps means that a standardised, repeatable measurement of area can be achieved. Finally, it is easiest to assign birds in the field to pre-defined count sections when all the features of the intertidal area are visible.

FIELD METHODS AND THE RECORDING FORM

Counters are provided with pre-prepared count forms (reproduced here as Figure 2.1) on which to record counts of feeding and roosting birds, along with the date, section code and the start and finish times of the count. Additional details on count accuracy, weather, human activities, raptors and disturbance are also requested. The count forms include the basic instructions on how to carry out the survey. Some counters use their forms in the field whereas others record counts in their notebooks and transfer details to the form later.

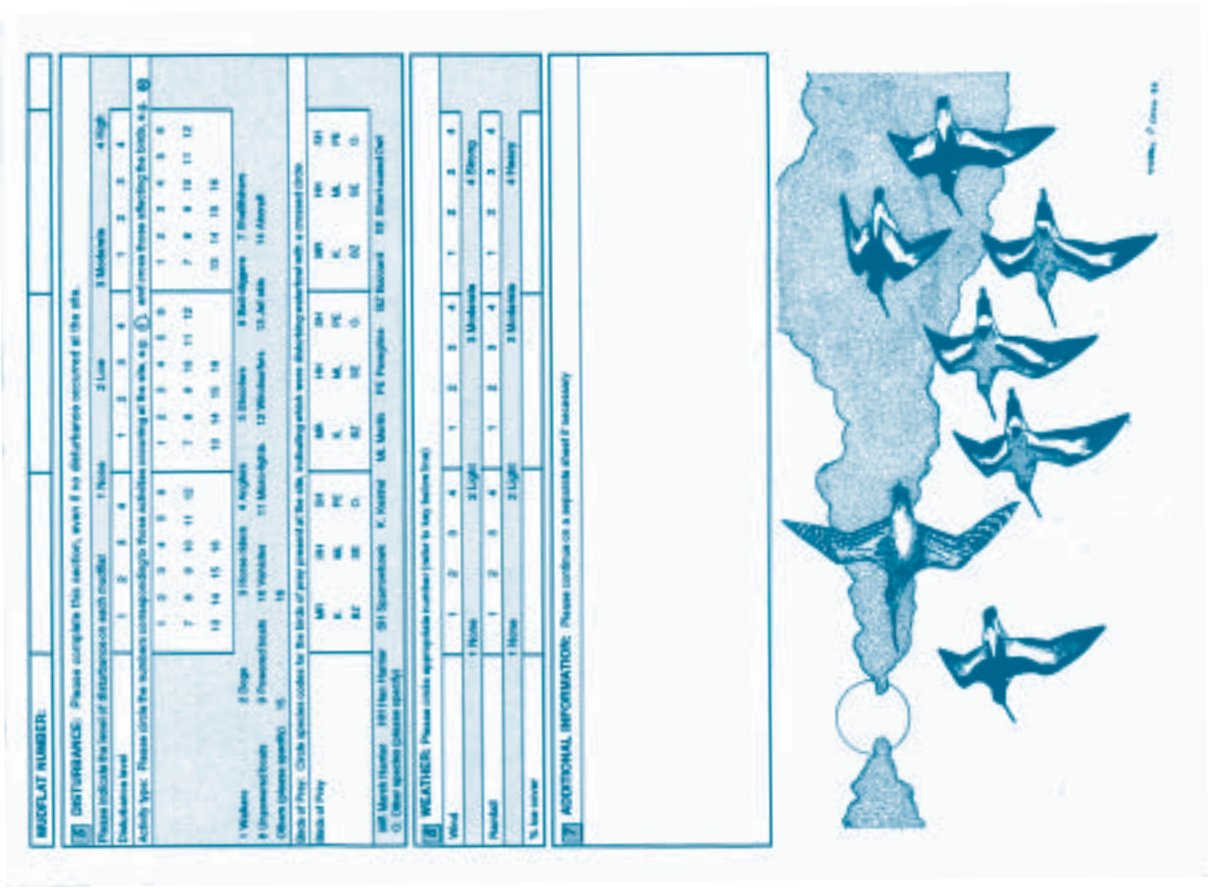
DATA STORAGE AND VALIDATION

Once the count forms for a site over a winter have been received, they are checked for completeness and any apparent irregularities are discussed with the local organiser. The data from all forms are then input independently by two different people, using a customised inputting form. The two resulting sets of digital data are then checked against one another by computer and any discrepancies are flagged, investigated and resolved. This ensures the virtual elimination of errors in the dataset due to inputting mistakes, since the chances of both people making the same inputting error are very small. Once both sets of data are the same, one set is loaded into the purpose-built LTC database.

Double-inputting, whilst effectively eliminating keyboard errors, cannot pick out other types of error. The most common of these are when a counter records a count against the wrong species (usually that adjacent on the count form to the intended target). Such errors can be easy to spot if, for example, an abnormally high count of an unlikely species occurs (*e.g.* a count of 50 Ringed Plovers mistakenly recorded as 50 Little Ringed Plovers). However, other mistakes in recording can be much less obvious and in some cases are probably undetectable (*e.g.* a count of 20 Mallards mistakenly recorded as 20 Teal). The only chance of discovering such errors is to create tables of summary data and distribution maps of each species on the site (as discussed below) and to return these to the local organiser and counters for checking, which generally identifies any gross errors outstanding. At the end of the process of checking, inputting, validation and loading, the end result is a rigorously-derived definitive dataset.

AREAS AND DENSITIES

Whilst the collection of LTC data is concerned



WeBS

LOW TIDE COUNTS

JOINT NATURE CONSERVATION COMMITTEE

RSPB

INSTRUCTIONS FOR WeBS LOW TIDE COUNTS RECORDING FORM

Figure 2.1 (i): WeBS Low Tide Counts recording form (front and back pages)

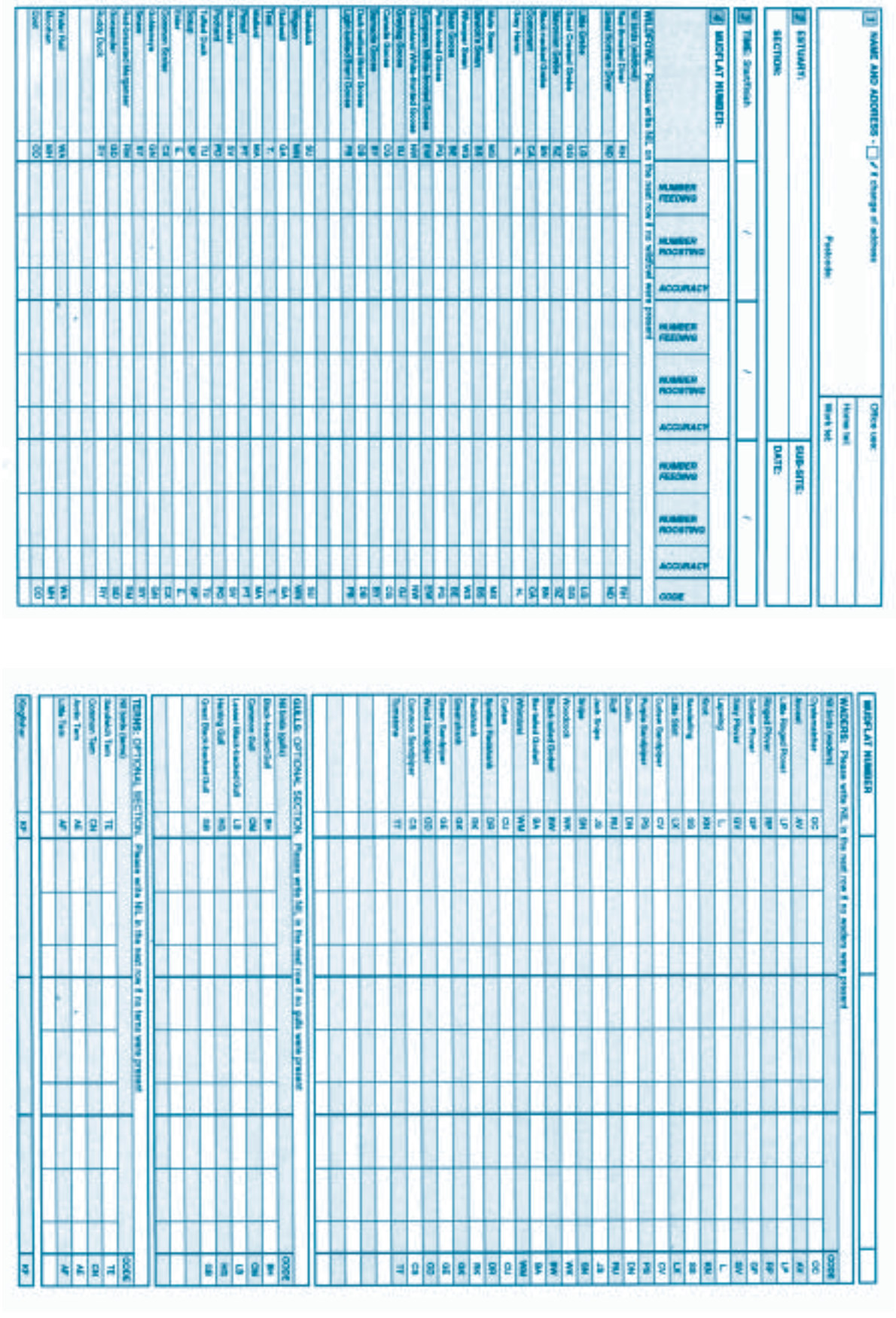


Figure 2.1 (ii): WeBS Low Tide Counts recording form (inside pages)

with making counts of birds, further presentation and analysis of results is based mostly around bird densities, for the simple reason that count sections are not of equal size. To calculate a density, it is clearly necessary to have an area measurement to divide a count by. Throughout the LTCs, areas are measured in hectares (1 ha = 100 m x 100 m) and consequently densities are given as birds per hectare (b/ha).

To derive the areas of count sections, a map of the site is drawn carefully onto a photocopy of a 1:25,000 map of the area, although for Northern Ireland only maps at the 1:50,000 scale are available. A digitising tablet is then used to transfer the relevant features of each paper map into digital form for incorporation into a Geographical Information System (GIS). One of the many advantages of the use of a GIS for storing and manipulating maps is that the area of each section can be calculated automatically. This is not only far faster than using traditional methods, but is also less prone to error and, importantly, completely repeatable.

For the purposes of determining useful area measurements, each count section is subdivided into up to three zones. The **intertidal** zone is that situated between mean low water and mean high water, the **subtidal** zone is below mean low water (both in creeks and 'offshore') and the **nontidal** zone is found above mean high water – often saltmarsh (so strictly not entirely lacking a tidal influence) but sometimes grazing marshes, higher areas of sandflats, adjacent freshwater reserves, *etc.* It is important to note that these definitions apply only within the context of the LTCs and these terms may (and do) have different meanings elsewhere. Although it is usually straightforward to define the intertidal and nontidal extent of a count section on a map, the subtidal zone being surveyed is less readily delineated. It is taken throughout that the subtidal zone of a count section extends half way across a channel or, where the channel is wide or the section has a more 'open-coast' aspect, the subtidal zone is taken to extend an arbitrary 500m offshore.

The area of each zone of each section is calculated separately by the GIS. To achieve this, the mean low water and mean high water marks around each site are also digitised. It should be noted, however, that on Ordnance Survey maps, whereas mean low water and mean high water are mapped for England and Wales, for Scotland the equivalent lines on the maps represent mean low water springs and mean high water springs. Thus, for the same actual area of intertidal habitat, a larger area will be depicted on a Scottish map than on an English or Welsh one. Unfortunately, there is no straightforward conversion factor, the difference between the two depending upon the gradient of the substrate between the two lines.

Estuaries are mobile systems and although intertidal flats, saltmarshes and channels are often of relatively stable shape between years, at some sites major changes occur. This means that commercially available maps may diverge increasingly from reality over the years. Although a counter can inform the national organiser that, for example, a particular saltmarsh has decreased in extent by 50% compared to that mapped, it is not straightforward to incorporate such information in a systematic fashion. Therefore, the commercial maps have to be taken as a standard, even where divergences are known to occur. This issue is discussed within the Site Accounts for those individual sites most affected. Aerial photographs have been suggested as a way to counteract this problem but in reality these are seldom taken frequently enough to allow a systematic determination of a mean low water mark.

Although the density of birds on a count section is expressed as a count divided by an area, with a basic knowledge of the ecological differences between species it is clear that it is not sensible to use the same area measurement for all species. For example, consider a count section of 100 ha in size, composed half of open mudflat and half of saltmarsh, on which a flock of 100 Knot was present. One might make the assumption that the Knot were evenly distributed over that count section, leading to a density of 1 b/ha. However, a basic knowledge of the feeding habits of Knot would tell us that they are seldom found feeding in saltmarsh and all or the majority would have been present on the mudflat, suggesting that the real density should be 2 b/ha. Throughout this book, densities have been calculated in such a way so as to take into account such species-specific habitat associations.

DISTRIBUTION MAPS

When data can be assigned to well-defined geographical areas, as is the case with the LTCs,

the presentation of results in map form has many advantages over a simple tabulation of statistics since it enables an appreciation of the relationship between different count sections. The production of maps depicting bird distribution has been a major theme from the beginning of the LTCs, with GIS technology providing great versatility in the range of presentational options available. After examining the possibilities, 'dot-density' maps were chosen as the preferred means of presentation.

To create a dot-density map, the GIS is instructed to take a number of dots equal to the mean number of individuals of a species present in a count section and to place them randomly within the polygon representing the count section. Although the information presented is actually a **number** of dots, the fact that the number is spread across an area makes it equivalent to a **density**. It is thus immediately apparent to anyone examining the map how the species is distributed across the site at low tide. Since the actual mean numbers are used for the display there is a continuous, not discrete, depiction of densities. The main potential misunderstanding arising from dot-density maps is that there is a tendency to equate the precise position of each dot with the precise position of a bird, whereas no conclusions should actually be drawn at a resolution greater than that of the count section. The higher the number of birds present, the less this is an issue. Ideally, one would distribute dots evenly within a count section, rather than randomly, but this has not been possible to date with the available software.

On some distribution maps, there appear to be artificially sharp boundaries between the dots representing one count section and those representing a neighbouring one. Clearly, these sharp demarcations are a product of the count sections selected and, in many cases, the change from a high density to a low density would be far less marked in reality. However, such marked changes in density may be realistic where there is a distinct change in habitat (such as with an isolated mussel scar, for example). It is thus important to assess maps on a case-by-case basis, with reference to any other available sources of information.

In some cases, slight modifications have to be made. For example, there may be such large numbers of a species (*e.g.* Dunlin) on many count sections that it is not possible to differentiate between densities. In such a case, either the size of the individual dots can be reduced or else the GIS can be instructed to display, for example, one dot for every ten Dunlin.

As with the calculation of densities discussed above, species-specific habitat associations have been applied in production of distribution maps and so, for example, Knot are plotted only on intertidal parts of a count section. Similarly, Great Crested Grebes would be plotted in the subtidal zone. Other species, less specialised in habitat use, have been assigned to more than one zone for mapping purposes (*e.g.* Curlew on both saltmarsh and mudflats).

3 Coverage

Andy Musgrove

SITE COVERAGE

At the end of the seven-year cycle, encompassing the winters from 1992–93 to 1998–99 inclusive, a total of 62 sites had been included in the scheme (Figure 3.1), although it was not possible to achieve full coverage in all cases. These sites were subdivided into almost 2,000 count sections. The coverage achieved at individual sites is detailed in the Site Accounts. JNCC (1993–1997) lists a total of 163 estuaries of varying sizes. A closer examination shows that, as planned, the majority of those sites holding important numbers of wintering waterbirds have been included within the scheme, as shown in Table 3.1. (It should be noted that a small number of sites were defined differently by the JNCC Inventory from the definitions adopted by the WeBS Low Tide Counts, explaining why a total of 65 sites are listed in Table 3.1 as having been covered.)

Table 3.1: **Numbers of sites in JNCC (1993–1997) which were covered and not covered by the WeBS Low Tide Counts during the winters 1992–93 to 1998–99, grouped by the numbers of wintering waterbirds per site**

No. of waterbirds	Covered by scheme	Not covered by scheme
100,000+	4	2
50,000 - 99,999	10	1
10,000 - 49,999	33	6
5,000 - 9,999	8	11
1,000 - 4,999	7	28
<1,000	3	50
TOTAL	**65**	**98**

There were only 20 sites not covered by the scheme during the period under review that regularly support in excess of 5,000 wintering waterbirds. Of those, eight have subsequently been included in the scheme, namely Carmarthen Bay (in part), Dyfi Estuary, Firth of Clyde, Loch Fleet, Dornoch Firth, Cromarty Firth, Alde Complex and Newtown Harbour. At two further sites on Islay (Bridgend Flats and Loch Gruinart) the large numbers of waterbirds comprise largely flocks of Barnacle Geese, which are already well-monitored. The remaining sites of interest are Tyninghame Estuary, the Wash, Maplin Sands (generally considered as part of the Thames within WeBS), Rother Estuary/Rye Harbour, The Fleet/Portland Harbour, Swansea Bay/Tawe Estuary, Morecambe Bay, Rough Firth/Auchencairn Bay, Lough Foyle and Carlingford Lough. Continued efforts will be made in the future to achieve coverage of these sites at low tide.

Coverage problems are posed by the sheer size of the Wash, Morecambe Bay and Maplin Sands, where the width of the intertidal flats is such that not all birds can be accurately identified and counted at low tide by a counter standing on the high water mark. Moreover, there are serious safety implications involved in venturing out onto extensive intertidal flats. A series of surveys of the Wash have been carried out in the past by professional fieldworkers (Goss-Custard *et al.* 1977, 1988) and these provide some useful baseline data. At Morecambe Bay, subsequent to the period under review in this book, the feeding distribution of waterbirds around parts of the site has been investigated by a series of mid-tide counts (roughly three hours after high water), although one problem with this approach is the lack of readily available maps describing the shape of the estuary at this state of the tide.

As well as entire sites that have not yet been covered by the scheme, at some of the sites included it has been possible to carry out only partial surveys to date, as detailed further in the individual Site Accounts. Some of these issues have been addressed in years subsequent to this review but particular areas that need to be included in the future are the outer south Humber

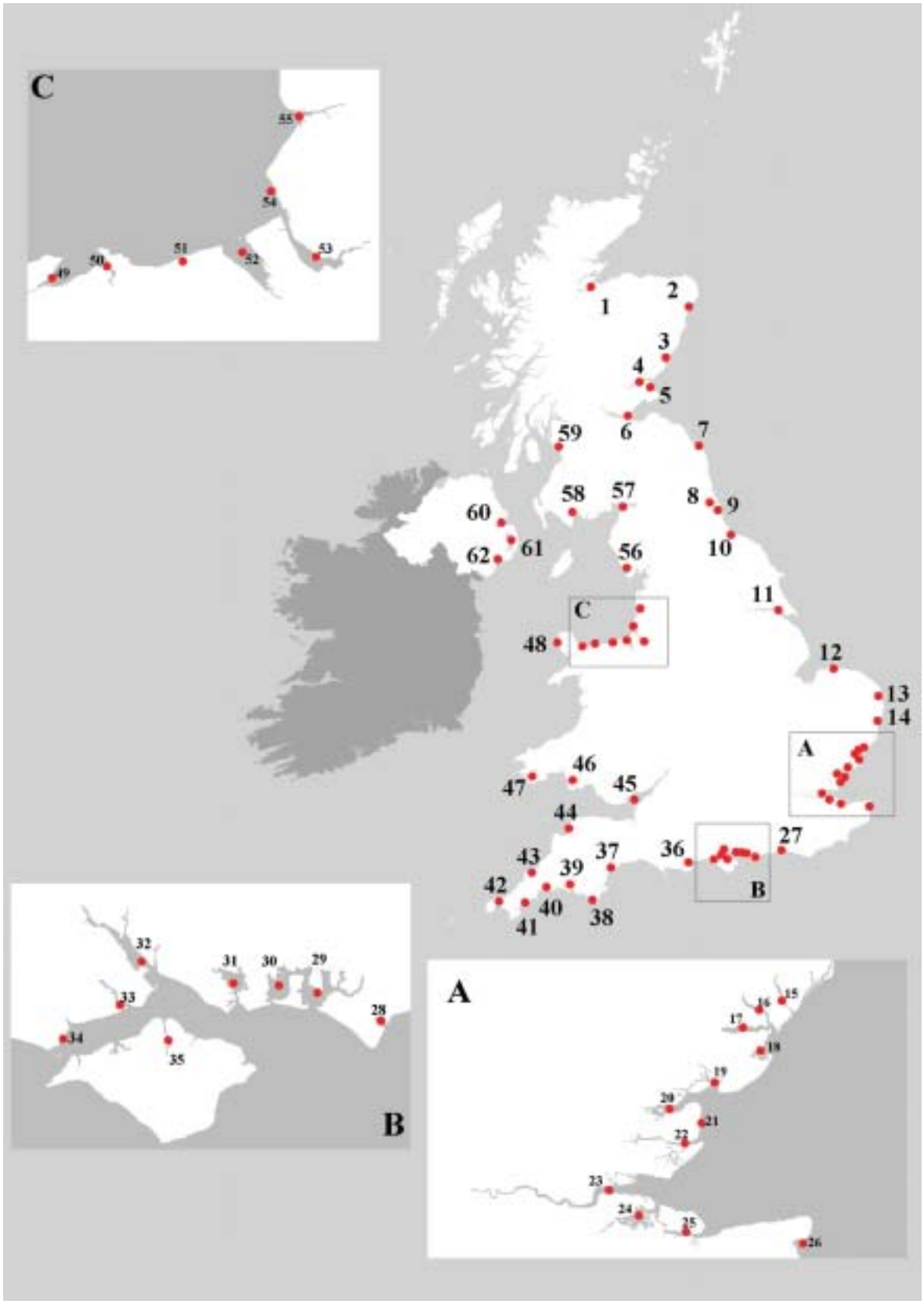


Figure 3.1: **Estuaries covered by the WeBS Low Tide Counts, 1992–93 to 1998–99**

1 Moray, 2 Ythan, 3 Montrose, 4 Tay, 5 Eden, 6 Forth, 7 Lindisfarne, 8 Tyne, 9 Wear, 10 Tees, 11 Humber, 12 North Norfolk, 13 Breydon, 14 Blyth, 15 Deben, 16 Orwell, 17 Stour, 18 Hamford, 19 Colne, 20 Blackwater, 21 Dengie, 22 Crouch/Roach, 23 Thames, 24 Medway, 25 Swale, 26 Pegwell, 27 Adur, 28 Pagham, 29 Chichester, 30 Langstone, 31 Portsmouth, 32 Southampton, 33 Beaulieu, 34 North-west Solent, 35 Medina, 36 Poole, 37 Exe, 38 Kingsbridge, 39 Tamar, 40 Fowey, 41 Fal, 42 Hayle, 43 Camel, 44 Taw/Torridge, 45 Severn, 46 Burry, 47 Cleddau, 48 Inland Sea, 49 Lavan, 50 Conwy, 51 Clwyd, 52 Dee, 53 Mersey, 54 Alt, 55 Ribble, 56 Duddon, 57 Solway, 58 Wigtown, 59 Irvine/Garnock, 60 Belfast, 61 Strangford, 62 Dundrum

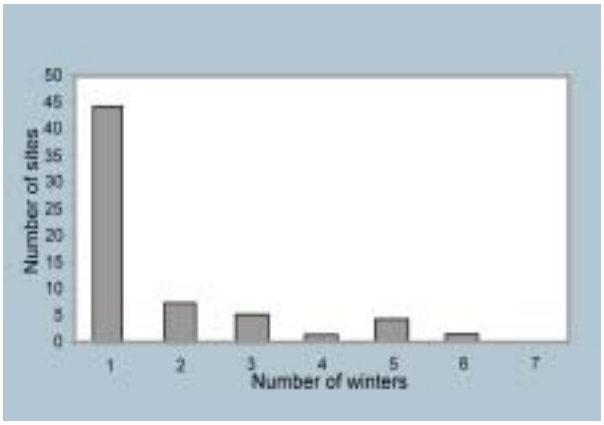


Figure 3.2: Frequency of site count repetition during the first seven winters of the WeBS Low Tide Counts

Estuary, much of Hamford Water, parts of the Thames Estuary, much of Carmarthen Bay and the outermost parts of the Solway Firth.

At most sites covered by the scheme during the period under review, data were collected in only a single season, as originally envisaged for the first cycle, but counts in additional winters were collected at some sites (Figure 3.2).

SPECIES COVERAGE

During the period under review, a total of 96,381 species counts were carried out by volunteers. The Species Accounts set out a summary of the information obtained for each species by the scheme during the period under review. The level of occurrence of different species is summarised in Table 3.2. Table 3.2 (i) lists the most frequently recorded species, by the proportion of visits to count sections (of a total of 11,915 visits) on which the species was recorded (not taking numbers of birds into account). There is a noticeably rapid decline from the ubiquitous Curlew, Redshank and Oystercatcher to more localised species.

Table 3.2 (ii) lists the 30 species most abundantly recorded by the scheme, derived by summing all counts made of each species. The numerical dominance of Dunlin is apparent, well ahead of all other species and representing over a quarter of all birds recorded (out of a total of 8,775,151). However, it is interesting to note how the pre-eminence of Dunlin changes when the numbers are weighted by the biomass of the species (*i.e.* number of birds of a species multiplied by the mass of a single bird of that species), as shown in Table 3.2 (iii), where the importance of the UK's estuaries for Brent Goose is highlighted.

In general, Table 3.2 confirms that there is a general pattern that more abundant species are more widespread. However, certain species are ranked more highly by numbers (column ii) than by ubiquity (column i) and thus tend to display more clumped distributions; notable examples are Wigeon, Eider, Golden Plover, Lapwing and Knot. Conversely, other species are more widespread than would be suggested by a simple consideration of numbers, such as Cormorant, Grey Plover, Curlew and Redshank.

Counters were asked to record all birds in the 'number feeding' column of the count form except those birds that were definitely roosting. The percentages of individuals of each species that were recorded separately as feeding and roosting is given in Table 3.3. It is clear that differences in feeding *vs* roosting proportions tended to occur between different species groups but less so within them. The species found most frequently feeding at low tide were mostly waders, sea-ducks, grebes and divers. Conversely, those species most frequently found roosting at low tide were geese, dabbling ducks and gulls, although exceptions were two waders (Lapwing and Golden Plover) and one sea-duck (Eider). Of course, it may be that some species feed at any state of tide, so no implications about other tidal states should be drawn. The feeding *vs* roosting proportions are discussed as appropriate within the individual species accounts.

TEMPORAL COVERAGE

During the period under review, LTCs took place throughout all available daylight hours, without the emphasis on the morning required for most terrestrial bird surveys. Most estuarine birds have activity rhythms based more around the tide than the time of day. Whilst the timing of LTCs at a site was thus largely dictated by the time at which low tide occurred on a site, local organisers had some leeway in determining the date on which they counted and could thus make allowance for local factors, notably the position of the sun in relation to the observer. In general, there is little reason to suppose that estuarine bird distributions would be affected by the time of day at which they were recorded, over and above the influence of the tide (although at any particular locality spring tides and neap tides tend to occur at a particular time of day). The main reason for a time-related change in distribution probably would be related to human disturbance (see further below) but such issues would be local in nature

Table 3.2: The top 30 species recorded by the WeBS Low Tide Counts during the winters 1992–93 to 1998–99, ranked by:
(i) proportion of section visits on which species was recorded
(ii) proportion of the total count of all individuals referable to a species
(iii) proportion of the total count, weighted by biomass
Note that the five listed species of gulls (*) were counted optionally so the tabulated percentages for those species are always minima. Consequently, for columns (ii) and (iii) the percentages listed for non-gull species are maxima. The values listed for Brent Goose represent the combination of the nominate race and the subspecies *hrota*.

POSITION	(i) % of visits on which recorded		(ii) % of total numbers recorded		(iii) % of total numbers, weighted by biomass	
	Species	%	Species	%	Species	%
1	Curlew	73.2	Dunlin	28.5	Brent Goose	14.8
2	Redshank	73.0	Lapwing	8.9	Oystercatcher	10.7
3	Oystercatcher	66.4	Oystercatcher	8.5	Shelduck	9.0
4	Dunlin	45.9	Black-headed Gull*	7.1	Wigeon	8.7
5	Shelduck	44.3	Knot	7.0	Herring Gull*	5.6
6	Black-headed Gull*	37.8	Wigeon	4.9	Curlew	5.0
7	Grey Plover	32.7	Golden Plover	4.6	Black-headed Gull*	4.9
8	Herring Gull*	29.9	Brent Goose	4.4	Lapwing	4.8
9	Mallard	28.7	Redshank	4.2	Dunlin	3.6
10	Brent Goose	28.3	Shelduck	3.3	Eider	3.3
11	Lapwing	27.5	Curlew	2.6	Mute Swan	3.3
12	Cormorant	23.1	Teal	2.4	Mallard	3.1
13	Wigeon	22.2	Herring Gull*	2.2	Knot	2.5
14	Turnstone	19.6	Grey Plover	1.7	Golden Plover	2.2
15	Common Gull*	18.7	Bar-tailed Godwit	1.6	Pink-footed Goose	2.1
16	Teal	18.1	Mallard	1.2	Teal	2.0
17	Ringed Plover	17.0	Common Gull*	0.9	Greylag Goose	1.6
18	Great Black-backed Gull*	16.9	Black-tailed Godwit	0.8	Redshank	1.4
19	Bar-tailed Godwit	16.5	Eider	0.6	Commorant	1.3
20	Grey Heron	15.6	Pintail	0.6	Pintail	1.3
21	Red-breasted Merganser	14.4	Turnstone	0.5	Canada Goose	1.2
22	Black-tailed Godwit	12.7	Pink-footed Goose	0.3	Bar-tailed Godwit	1.0
23	Goldeneye	11.8	Ringed Plover	0.3	Common Gull*	1.0
24	Knot	10.6	Great Black-backed Gull*	0.2	Great Black-backed Gull*	0.9
25	Mute Swan	9.9	Cormorant	0.2	Grey Plover	0.8
26	Great Crested Grebe	8.1	Greylag Goose	0.2	Black-tailed Godwit	0.5
27	Golden Plover	8.0	Sanderling	0.2	Great Crested Grebe	0.4
28	Little Grebe	7.5	Goldeneye	0.2	Goldeneye	0.4
29	Pintail	7.0	Great Crested Grebe	0.2	Red-breasted Merganser	0.3
30	Lesser Black-backed Gull*	6.8	Canada Goose	0.1	Lesser Black-backed Gull*	0.3

and not impact upon the overall dataset.

However, one important issue to consider is that many estuarine species also feed at night. In some cases, this may be in order to fulfil any shortfall resulting from inadequate feeding opportunities during the day, but in other cases, nocturnal feeding may be a preferred strategy (Dugan *et al.* 1981, Ward 1991). The degree to which night-feeding occurs depends upon the energetic requirements of an individual bird, the nocturnal activity of prey species (Pienkowski 1981), the amount of light available and the feeding techniques of the species in question (*e.g.* touch-feeders are generally more capable than visual feeders (Pienkowski 1983, Wood 1984)). The ability of the LTCs to predict the likely night-time feeding distribution of birds depends upon the reason as to why the birds are feeding at night. For example, if additional foraging is required due to disturbance of favoured feeding grounds during the day the distribution may differ from that recorded during the day (*e.g.* Burton *et al.* 2001, Burger & Gochfeld 1991). Therefore, it is important to recognise that the LTCs do not necessarily provide information on night-time distributions.

The majority of LTCs during the period under review were carried out during the weekend, especially on Sundays, which could clearly influence the data collected, with most sites likely to experience higher levels of recreational distur-

bance during the weekend (although industrial disturbance may be lessened). In Scotland, there is no shooting on Sundays and this was a factor influencing the choice of count day at the Moray Firth at least (D. Butterfield pers. comm.). The difference between weekdays and weekends is likely to be analogous to disturbance-related night-time *vs* day-time differences, in that otherwise suitable feeding habitat can become variably available dependent upon the level of disturbance (Burton et al. 2002b, Kershaw 1997). Thus, whilst LTCs give a good indication of the relative importance of parts of an estuary, this will represent the weekend distribution most closely. For a more detailed understanding of the use of a site, counts should be made during both weekdays and weekends.

Within the LTCs, there is no requirement for all sections at a site to be counted on a single date within a month, as this is not necessary for the determination of the relative use of different count

Table 3.3: Proportions of individuals of each species recorded separately as feeding and roosting (omitting species with less than 20 individuals observed)

Species	% feeding	% roosting	Species	% feeding	% roosting
Red-throated Diver	95	5	Water Rail	95	5
Great Northern Diver	97	3	Moorhen	95	5
			Coot	94	6
Little Grebe	99	1			
Great Crested Grebe	95	5	Oystercatcher	90	10
Slavonian Grebe	97	3	Avocet	91	9
Black-necked Grebe	100	0	Ringed Plover	92	8
			Golden Plover	25	75
Cormorant	44	56	Grey Plover	93	7
Shag	60	40	Lapwing	30	70
			Knot	85	15
Little Egret	95	5	Sanderling	98	2
Grey Heron	68	32	Little Stint	99	1
			Purple Sandpiper	98	2
Mute Swan	73	27	Dunlin	98	2
Bewick's Swan	96	4	Ruff	63	37
Whooper Swan	73	27	Jack Snipe	92	8
Pink-footed Goose	8	92	Snipe	85	15
White-fronted Goose	81	19	Black-tailed Godwit	75	25
Greylag Goose	35	65	Bar-tailed Godwit	96	4
Canada Goose	67	33	Whimbrel	77	23
Barnacle Goose	59	41	Curlew	83	17
Brent Goose	82	18	Spotted Redshank	99	1
Shelduck	85	15	Redshank	96	4
Wigeon	42	58	Greenshank	95	5
Gadwall	68	32	Common Sandpiper	88	12
Teal	39	61	Turnstone	99	1
Mallard	56	44			
Pintail	40	60	Mediterranean Gull	77	23
Shoveler	73	27	Black-headed Gull	60	40
Pochard	60	40	Common Gull	52	48
Tufted Duck	73	27	Lesser Black-backed Gull	44	56
Scaup	88	12	Herring Gull	52	48
Eider	42	58	Yellow-legged Gull	48	52
Long-tailed Duck	94	6	Great Black-backed Gull	38	62
Common Scoter	71	29			
Velvet Scoter	94	6	Kingfisher	98	2
Goldeneye	95	5			
Smew	92	8			
Red-breasted Merganser	91	9			
Goosander	88	12			

units. However, two-thirds of monthly counts at a site involved the whole site being counted simultaneously on one or two consecutive dates.

Although counters were encouraged to make four monthly visits to each section over a winter, coverage was not always complete due to a variety of factors, such as weather conditions, illness of counters, access difficulties, *etc.* In most cases, only individual sections were left uncounted in particular months, but sometimes whole sites were uncounted in a particular month. There were 103 site/winter count combinations undertaken and thus a theoretical 412 site-months. In practice, counts were made for 377 of these (92%).

HUMAN ACTIVITIES, RAPTORS AND DISTURBANCE

Counters were asked to specify the types of activities noted on each visit and to indicate whether they considered such activities to be affecting the birds. The occurrence of raptors was treated in an entirely analogous manner. Table 3.4 lists the frequency of recording of each activity and raptor. Additionally, the table indicates the proportion of occasions when each activity or raptor was perceived by the counter to be 'affecting the birds'. The most frequently recorded activities were walkers, dogs and bait-diggers, with the most commonly observed raptors being Kestrel, Peregrine and Sparrowhawk (in descending frequency). Certain activities were more frequently perceived to cause disturbance, notably vehicles, shellfishers, shooters and boats (powered and unpowered). Angling was seldom considered to be affecting the birds. Of the raptors, Marsh Harrier (although only a single observation), Hen Harrier, Merlin and Peregrine were the most disturbing species, with Sparrowhawk somewhat less so. Kestrel was the most frequently recorded raptor but seldom appeared to affect the birds (and neither did Buzzard). To some extent it would appear that the disturbance caused by different raptor species was broadly proportionate to the predation risk posed by each species.

Table 3.4: Numbers and proportions of total recorded activities/raptors assignable to each category and the proportion of occasions for each that the activity/raptor was considered by the counter to be affecting the birds

Activity/Raptor	No of records	% of total records	%'affecting' birds
Walkers	695	28.32	26
Dogs	476	19.40	25
Horse Riders	33	1.34	12
Anglers	129	5.26	8
Shooters	32	1.30	44
Bait diggers	268	10.92	33
Shellfishers	63	2.57	48
Unpowered boats	53	2.16	40
Powered boats	119	4.85	38
Vehicles	36	1.47	67
Microlights	14	0.57	7
Windsurfers	7	0.29	29
Jet skis	1	0.04	0
Aircraft	58	2.36	28
Others	78	3.18	52
Marsh Harrier	1	0.04	100
Hen Harrier	12	0.49	50
Sparrowhawk	85	3.46	24
Buzzard	38	1.55	5
Kestrel	115	4.69	3
Merlin	28	1.14	36
Peregrine	91	3.71	36
Short-eared Owl	10	0.41	0
Unspecified raptor	12	0.49	33
TOTAL	**2454**	**100**	**Overall = 28%**

4 Site Accounts

Andy Musgrove

The following site accounts describe the principal findings from the WeBS Low Tide Counts carried out on 62 estuarine sites between the winters of 1992–93 and 1998–99. The accounts are numbered in accordance with Figure 3.1, *i.e.* clockwise from north-east Scotland to north-west Scotland and then south down the coast of Northern Ireland. The aim of the accounts is to bring to attention the main factors to consider when investigating the conservation status of a part of the estuary concerned. Emphasis is therefore given to the overlap with statutory sites and to species considered to be of key importance. As a great deal of information is presented, it is important that the following interpretative notes are consulted in conjunction with the site accounts themselves.

TABULATED INFORMATION

For each site, the following information is tabulated:

LTC site code. This two-letter code is used internally within the scheme to identify the site and precedes the three digit count section number to produce an official LTC section code (*e.g.* the first section of the Alt Estuary is BA001).

Centre grid. A central grid reference for the site: this is not a mathematically derived central point, simply an approximation for ease of location or plotting.

JNCC estuarine review site. The number(s) of any sites from 'An inventory of UK estuaries' (JNCC 1993–1997) which overlap the LTC site.

Habitat zonation. The total area of the site ever covered by the LTCs during the seven winters under review (1992–93 to 1998–99), subdivided into three broad zones – intertidal, subtidal and nontidal. These three zones are as defined for the purposes of this book in Methods.

Statutory status. The names and codes of any SPAs and/or Ramsar sites overlapping the area covered by the LTCs, even if the degree of overlap is relatively minor. If no SPA or Ramsar sites are present, then any overlapping biological SSSIs (or ASSIs in Northern Ireland) are listed instead. In a few cases, the names and codes of potential SPAs and/or proposed Ramsar sites (*i.e.* pSPA and pRamsar respectively) are also listed.

Winter waterbird interest. The waterbird species listed here are a combination of those wintering species named on any relevant SPA citations (and for any pSPAs) and any additional species recorded in nationally important numbers on the site during the five-year period 1994–95 to 1998–99 (as listed in Pollitt *et al.* 2000). Species are listed in systematic taxonomic order, not in order of importance. SPA citations for a combined 'waterbird assemblage' are also noted here. Due to the current incomplete state of knowledge of their wintering populations, gulls are not included in this list.

SITE DESCRIPTION

This paragraph is intended to give broad information on the site's general geographical position, its habitat types, and any prominent human activities and conservation issues at the site. However, only a brief outline is provided and more detailed information should be sought elsewhere if the subject is of interest. General references used throughout were JNCC (1993–1997) and Barne *et al.* (1995–1998).

COVERAGE AND INTERPRETATION

The first paragraph describes the geographical and temporal coverage of the site achieved during the first seven winters of the scheme (1992–93 to 1998–99). For sites which have been surveyed during more than one winter, any differences in

coverage are described, although for a small number of more complex situations it is advised that the National Organiser of the scheme is contacted. Attention is drawn to the number of months during each winter (out of the possible four from November to February) during which the site was counted. It should be noted that the coverage of a site during a month does not imply that every section at that site was counted during that month.

The first map for each account depicts the count sections used for the survey (without any division into habitat types, as discussed in Methods, although the underlying habitat is depicted using background colours of yellow and green to represent intertidal and nontidal habitats respectively). Sections which are relatively small compared to the size of the site may not be displayed clearly at the scale used; more detailed outlines of the count sections in printed or digital form may be requested from the National Organiser.

For the majority of sites, a second map depicts the boundaries of the combined area covered by the LTCs during any winter under review, the boundaries of any SPAs overlapping the LTC site and the degree of overlap between the two areas. For those sites not overlapping an SPA, the combined area of any relevant biological SSSIs (or ASSIs) is shown instead. The maps thus clearly draw attention to areas covered by the LTCs but outwith a statutory site boundary and areas which are within a statutory site boundary but which were not covered by the scheme. It should be noted that narrow strips of non-overlap may represent slight differences in mapping. Additionally, it should be remembered that, in most cases, SPA boundaries do not currently extend below mean low water, whereas the LTC sections do (either to half way across a channel, or to an arbitrary 500m offshore, as described in Methods). Thus, many sites show these offshore zones of non-overlap.

The following paragraph describes the areas of overlap and non-overlap depicted in the second map and discusses any major discrepancies. Ramsar site boundaries are usually very close to those of SPAs but any differences are noted here also.

The final paragraph of the section discusses any known or likely regular movements of waterbirds in and out of the LTC site. 'Regular movements' are considered to be those taking place over every tidal cycle or at least every day, and not to movements of birds between sites over the course of a winter. It should be emphasised that much remains to be learnt about inter-site movements of birds and this brief discussion should be seen only as a pointer to further investigation.

WATERBIRD DISTRIBUTION

This section discusses the principal findings of the scheme relating to the low tide bird distribution at the site. Emphasis is given to the species tabulated at the beginning of the account under 'Winter Waterbird Interest' (as described above) and distribution maps are presented for most of these species. In cases where it was not considered necessary to present a species map, the reasons are given. There then follows a relatively brief description of the broad patterns of occurrence of the key species. Although the maps themselves are presented, this text tries to draw together patterns of occurrence of groups of ecologically similar species for the reader's consideration. In general, however, it is envisaged that the reader will want to study the maps themselves. For more detailed analyses of bird densities, data may be requested from the National Organiser at the BTO.

There then follows the set of dot-density species distribution maps (derived as discussed in Methods). Most species maps are presented at a standard dot size with one dot representing one 'averaged' bird, *i.e.* a count section supporting a mean count of 40 Redshank over a winter will contain 40 dots on the map. In some cases, mapped densities were so high that it was not possible at the scale of map production to visually differentiate between the densities on different sections; hence 400 dots in a small section may appear identical to 4000 dots in that section, if the effect of both is simply to shade the entire section black. In such cases, either the size of individual dots was reduced, or one dot was set to represent, for example, five birds, to aid interpretation. Such instances are fully described. To enhance clarity, the boundaries of the count sections are omitted from the species distribution maps. Again, background colours of yellow and green are added to represent intertidal and nontidal habitats respectively (as defined within Methods).

Additionally, two maps are presented which represent 'total waterbirds'. The first displays the combined number of individuals of all species, with the exception of gulls (for which counting is optional) and naturalised species. The second displays a weighted total, which gives greater emphasis to less common species. To derive the data underlying this map, the mean number of a species on a section was inversely weighted by its national 1% threshold value to yield a weighted total in threshold importance units (TIU). All species with a national 1% threshold value of less than 50 were assigned a nominal value of 50, in order to prevent individuals of some species, notably Greenshank and Spotted Redshank, exerting a disproportionate influence over the overall maps. The TIU for each species on a section were then summed to produce a value of summed threshold importance units (STIU). As the resulting value of STIU is low, the values are scaled up to yield a map which has the same number of dots on it as the 'total waterbirds', for ease of comparison. This second map also excludes gulls and naturalised species. The weighted total maps illustrate an alternative approach to presenting the data by taking into account national population sizes and so augment information on concentrations of distribution from unweighted totals. This method helps to pinpoint areas that may be important for the less numerous species but that may not necessarily hold high combined densities of all species. The concepts behind TIU maps are further explored in Austin *et al.* (2002).

4.1 MORAY FIRTH

LTC site code:	EM
Centre grid:	NH7152
JNCC estuarine review site:	77
Habitat zonation:	4504 ha intertidal, 4655 ha subtidal, 332 ha nontidal
Statutory status:	Inner Moray Firth SPA (UK9001624), Moray and Nairn Coast SPA (UK9001625), Inner Moray Firth Ramsar (7UK135), Moray and Nairn Coast Ramsar (7UK107)
Winter waterbird interest:	Red-throated Diver, Slavonian Grebe, Cormorant, Pink-footed Goose, Greylag Goose, Barnacle Goose, Wigeon, Teal, Scaup, Long-tailed Duck, Common Scoter, Velvet Scoter, Goldeneye, Red-breasted Merganser, Goosander, Oystercatcher, Knot, Dunlin, Bar-tailed Godwit, Curlew, Redshank, Waterbird assemblage

SITE DESCRIPTION

The Inner Moray Firth comprises, for the purposes of this survey, the coastline from Findhorn Bay to just north of Chanonry Point, including the Beauly Firth. There are wider areas of sand and mud flats in the Beauly Firth, Longman Bay, Munlochy Bay and Findhorn Bay, but much of the rest of the site comprises fairly open coast. There are several extensive areas of saltmarsh, particularly behind the sand-bars between Whiteness Head and Culbin Forest. Much of the area is backed by natural habitats and human population density is generally low, with the main built-up areas being at Inverness and Nairn. Wildfowling is widespread in the area in addition to fishing and bait-digging. A former oil platform yard at Whiteness is now closed (D. Butterfield pers. comm.).

COVERAGE AND INTERPRETATION

Low tide counts were carried out at Findhorn Bay during the winter of 1996–97 (no November count), but more complete counts of the whole firth were achieved in 1998–99 (all four months). Figure 4.1.1 shows the positions of the 64 sections counted for the survey in the latter winter.

Figure 4.1.2 shows the degree of overlap of the LTC site with the boundaries of two separate SPAs. In general, the LTCs achieved almost complete coverage between Rosemarkie Bay and Findhorn Bay, whereas the two SPAs include only a number of discrete sections without the (quite extensive) areas of intervening habitat. Areas of SPA not covered by the counts were the innermost Beauly Firth, part of the southern shore of Munlochy Bay, Whiteness Head dunes, Culbin Bar dunes, the marshes around the southern edge of Findhorn Bay and, much further east, the Spey Estuary. The boundaries of the two Ramsar sites present are entirely coincident with their respective SPAs.

With such an extensive site, the degree of regular movement in and out of the site is likely to be far less than the movement within the site for most estuarine species. However, it is known, largely from data collected by the Highland Ringing Group, that some interchange with the Cromarty Firth does occur, especially of Knot, Bar-tailed Godwits

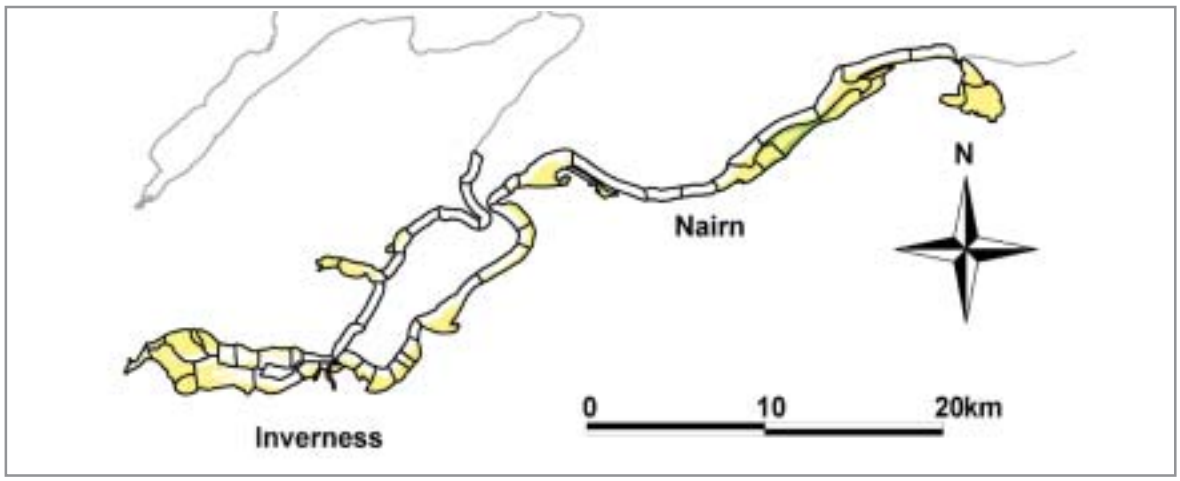


Figure 4.1.1. LTC sections at the Moray Firth, winter 1998-99

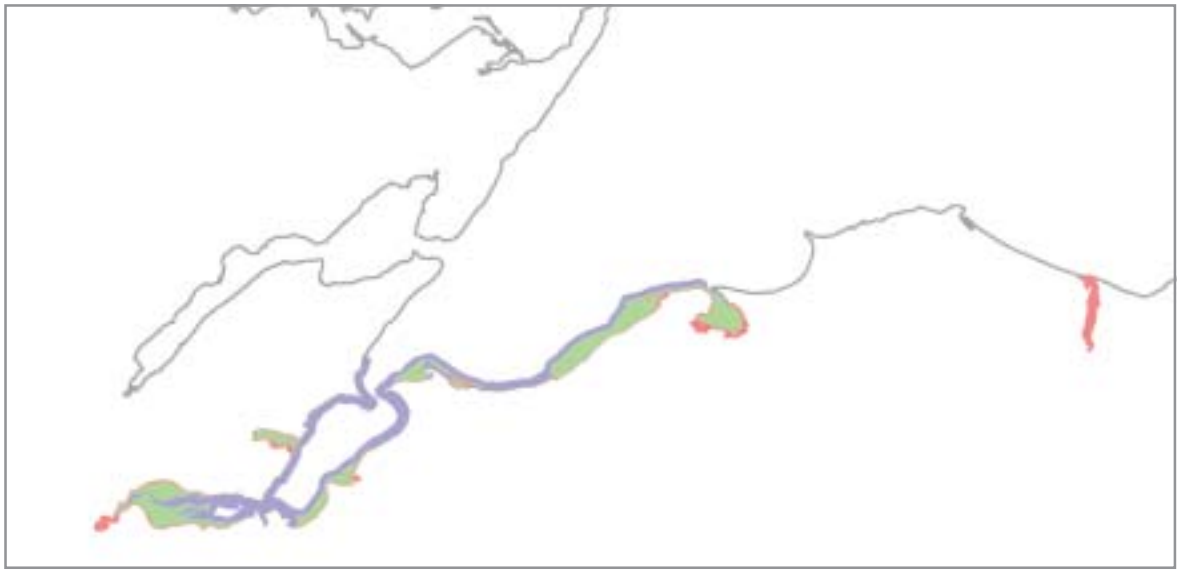


Figure 4.1.2. LTC and SPA boundaries, with overlap, at the Moray Firth

and perhaps Scaup. Some species may even move as far as the Dornoch Firth (D. Butterfield pers. comm.). Grey geese and grassland plovers will disperse to adjacent inland areas to feed. Similarly, sea-ducks, especially Long-tailed Ducks, can disperse far offshore into the outer Moray Firth and numbers recorded by the LTCs, or any land-based scheme, are unlikely to record their numbers accurately.

WATERBIRD DISTRIBUTION

Low tide distribution maps from the winter of 1998–99 are presented for 19 of the 21 species of principal interest listed above. For clarity, smaller dots are used to display the distributions of Greylag Goose, Wigeon, Teal, Common Scoter, Oystercatcher, Knot and Dunlin. Additional maps of total birds and total birds weighted by 1% threshold values are also presented (Figure 4.1.3). Of the remaining species, no more than two Slavonian Grebes were recorded in any month at low tide and Barnacle Goose was unrecorded. The latter species passes through the site usually in only small numbers on the way to and from the Solway Firth, although there was an abnormally high count of 492 birds in October 1995.

The totals map shows that the highest overall densities of birds occurred at Munlochy Bay, to the east of Ness Mouth, on the flats north of Fort George and at Findhorn Bay. Much the same general pattern is shown by the weighted total map, although with Findhorn less emphasised and the waters off Nairn and Culbin Bars highlighted. The Moray Firth supports important concentrations of sea-duck, the maps showing that these species had different distributions (although it should always be borne in mind that some species, notably Long-tailed Duck, are likely to be under-recorded due to some birds occurring further offshore). Long-tailed Ducks were noted widely along the shores of the outer parts of the site but much more locally upstream of Chanonry and Fort George. Common and Velvet Scoters were more localised, almost all being found off Nairn and Culbin Bars. Most of the Scaup, on the other hand, were on the inner firth at Longman Bay. Red-breasted Mergansers and Goosanders were mostly found on the Beauly Firth and Goldeneyes were widespread through the inner firths but were most concentrated around Ness Mouth around a sewage outfall; subsequently, this outfall has been closed down with most of the Goldeneyes moving to the new outfall off Alturlie (D. Butterfield pers. comm.). Cormorants occurred more on the inner firth and Red-throated Divers the outer firth. Wigeon were widespread but Teal more local, especially at Munlochy, Beauly and Longman. All six waders of note occurred throughout, although Knot and Bar-tailed Godwits were more patchily distributed. As at other sites, the low tide distribution recorded for Greylag and Pink-footed Geese was potentially misleading, given the major use of the site being at night for these species.

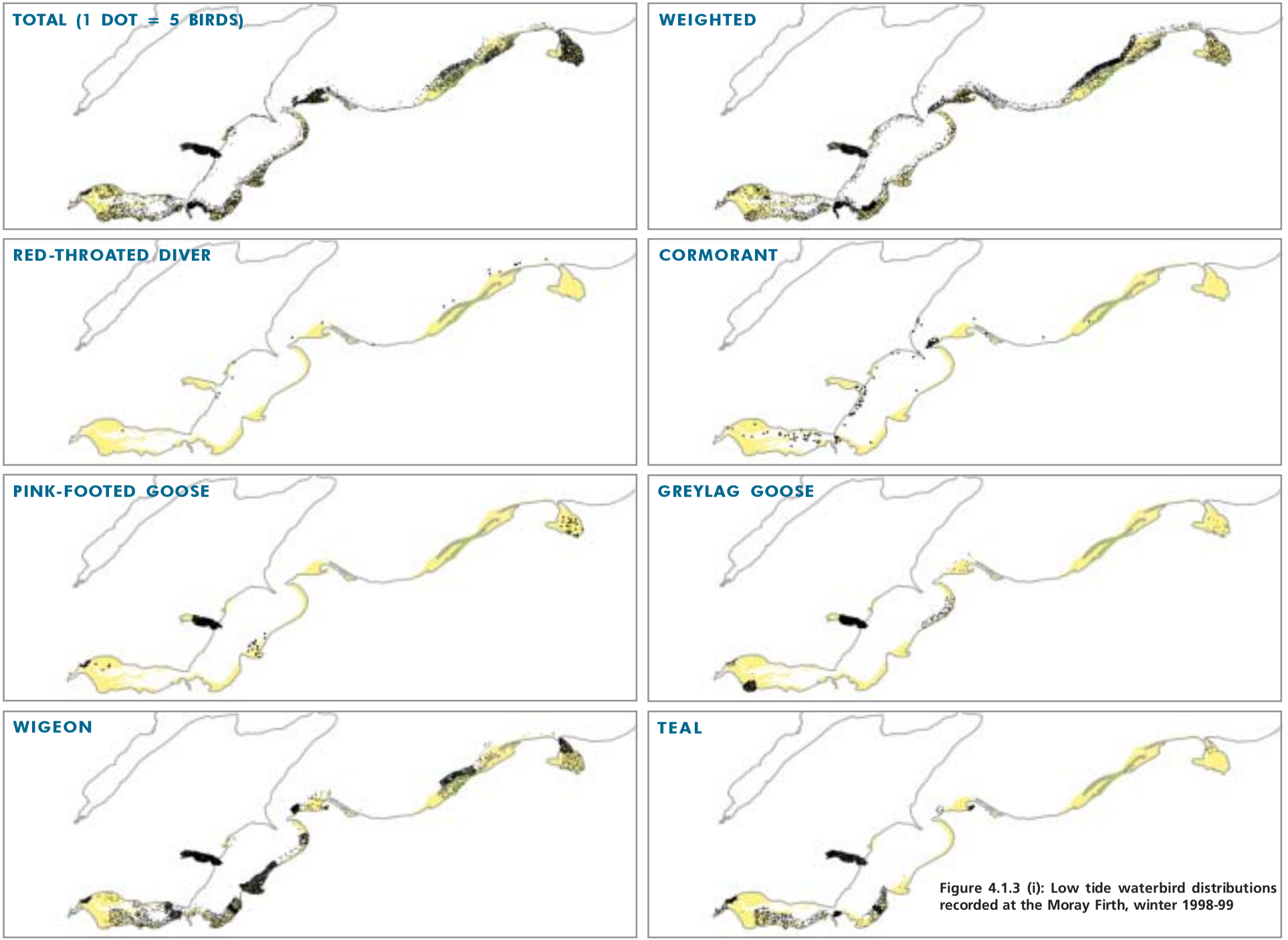


Figure 4.1.3 (i): Low tide waterbird distributions recorded at the Moray Firth, winter 1998-99

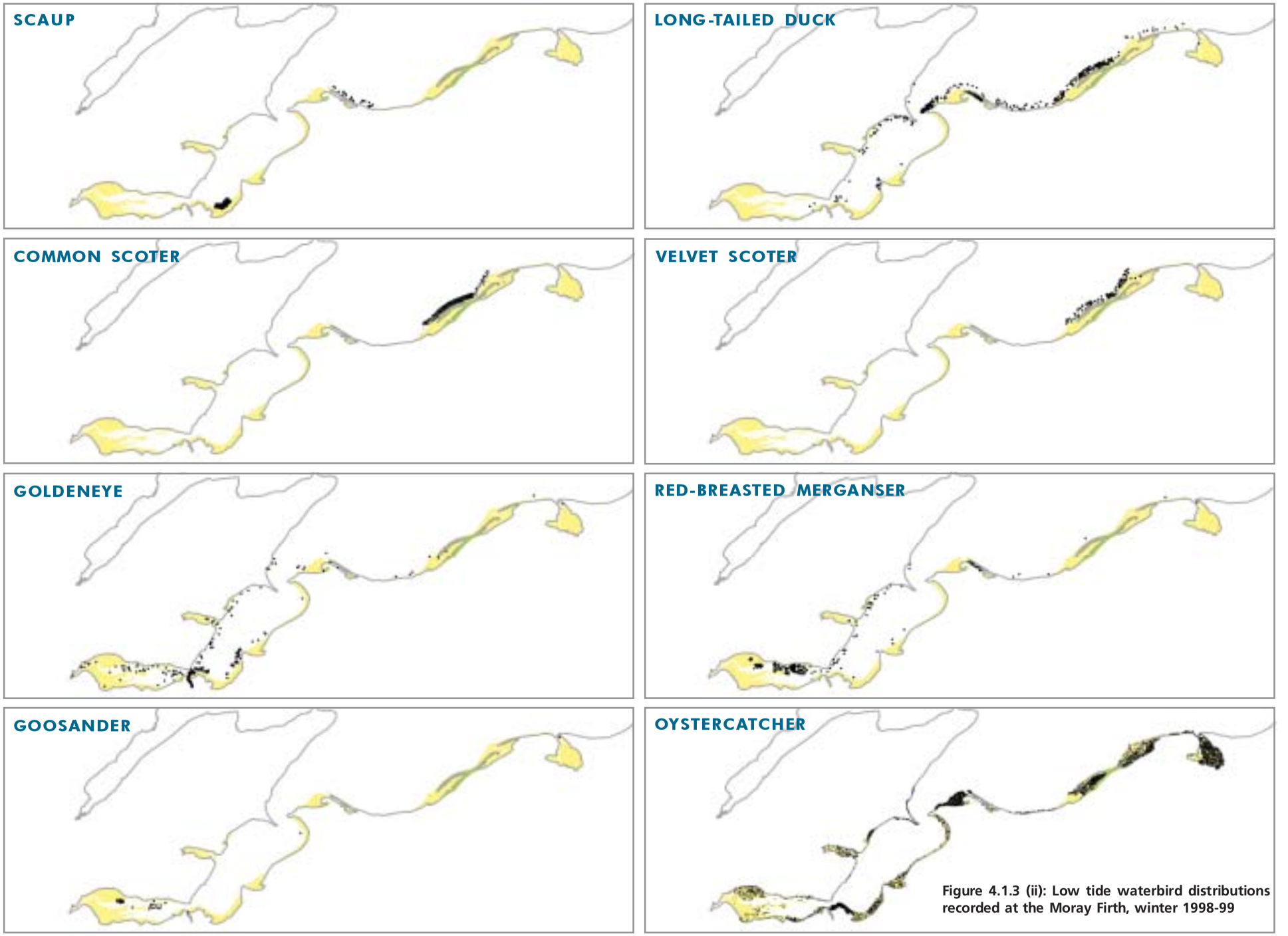


Figure 4.1.3 (ii): Low tide waterbird distributions recorded at the Moray Firth, winter 1998-99

Figure 4.1.3 (iii): Low tide waterbird distributions recorded at the Moray Firth, winter 1998-99

4.2 YTHAN ESTUARY

LTC site code:	BY
Centre grid:	NK0026
JNCC estuarine review site:	81
Habitat zonation:	201 ha intertidal, 50 ha subtidal, 2 ha nontidal
Statutory status:	Ythan Estuary, Sands of Forvie and Meikle Loch SPA (UK9002221), Ythan Estuary and Meikle Loch Ramsar (7UK122)
Winter waterbird interest:	Pink-footed Goose, Eider, Lapwing, Redshank, Waterbird assemblage

SITE DESCRIPTION

The Ythan is a relatively small estuary in north-east Scotland, about ten miles north of Aberdeen. Despite its small size, it is the largest estuary between Montrose Basin and the Moray Firth and as such is important in a local context. The estuary has a narrow shape and is shielded from the sea by the important dune system known as the Sands of Forvie. The inner estuary is muddy and the outer stretches more sandy, but there is relatively little in the way of saltmarsh. The principal issue of conservation concern in recent years has been the level of nitrogen leaching into the Ythan from surrounding farmland, leading to algal growth covering the sediments; the catchment was recently designated a Nitrate Vulnerable Zone. Otherwise, the main human influences on the estuary are through recreation, including wildfowling (A. Duncan pers. comm.).

COVERAGE AND INTERPRETATION

The Ythan Estuary was counted for the scheme during the winter of 1997–98, although no November count was made. Figure 4.2.1 shows the positions of the 12 sections counted for the survey.

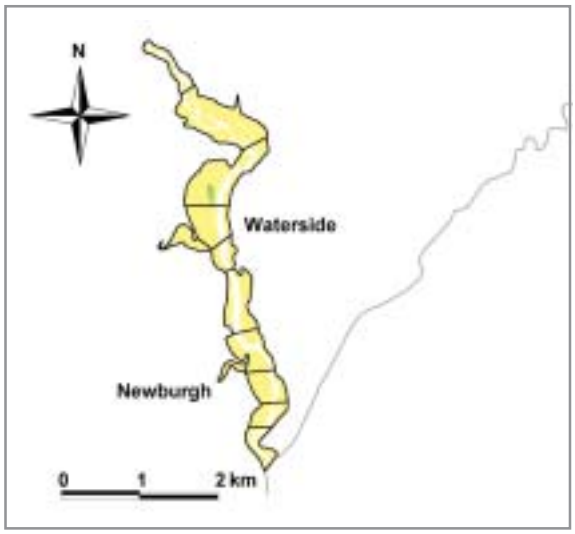


Figure 4.2.1: LTC sections at the Ythan Estuary, winter 1997–98

It can be seen in Figure 4.2.2 that the area covered for the LTCs is only a part of the larger SPA. The main parts of the SPA which were not counted for the scheme are the non-estuarine Meikle Loch (included for its importance to roosting geese) and the Sands of Forvie (an important area for breeding terns). These two areas aside, there was a high degree of overlap, with most of the discrepancy being areas of surrounding rough grassland and saltmarsh. None of the counted area was outwith the SPA (apart from the main channel below mean

Figure 4.2.2: LTC and SPA boundaries, with overlap, at the Ythan Estuary

low water). The Ramsar site agrees more closely with the area covered by the LTCs, since it does not include the Sands of Forvie, although Meikle Loch is still a discrepancy.

The Ythan Estuary is a long distance from other estuaries and no interchange is likely on a daily basis. However, much of the nearby non-estuarine coast is suitable for waterbirds and regular interchange seems likely. Additionally, some species will move onto surrounding terrestrial habitats (A. Duncan pers. comm.).

WATERBIRD DISTRIBUTION

Low tide distribution maps from the winter of 1997–98 are presented for three of the four species of principal interest listed above. For clarity, smaller dots are used to display the distribution of Eider and Lapwing. Additional maps of total birds and total birds weighted by 1% threshold values are also presented (Figure 4.2.3). Pink-footed Geese, the other listed species of interest, use the site (and Meikle Loch) as an overnight roost but most birds vacate the estuary by day and none were recorded during the counts.

The totals map suggests a fairly even all-bird density across much of the site, but with higher densities at the mouth of the estuary, to the north of Waterside Bridge and towards the northern end of the site. The estuary mouth was emphasised by the weighted total map, mostly due to the large flock of Eiders present here, although all of the Knot and the majority of the Red-breasted Mergansers were also found at the mouth. Lapwings and Redshanks were both widespread with Lapwings being more concentrated at the northern end but Redshanks occurring more densely in the central region.

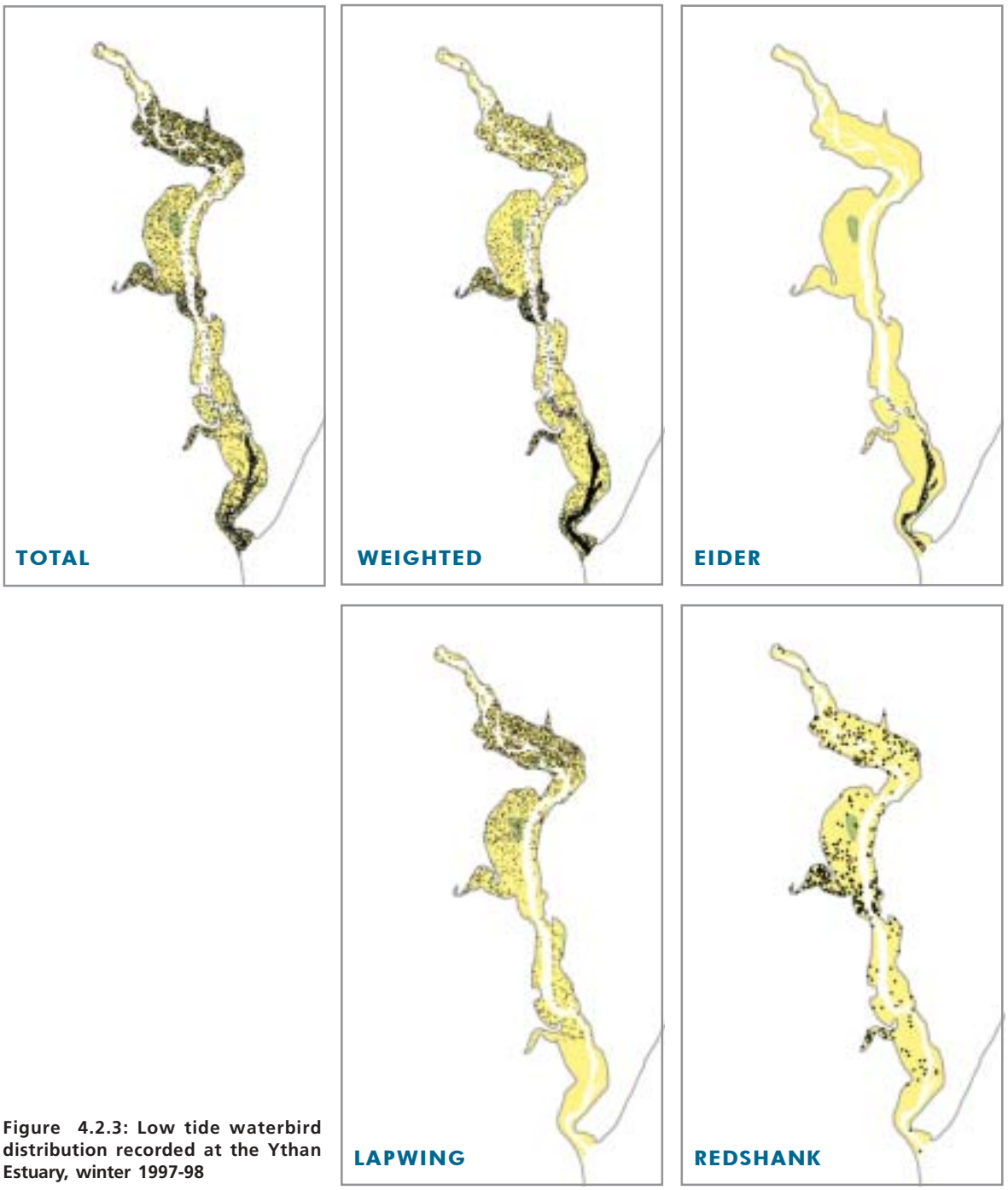


Figure 4.2.3: Low tide waterbird distribution recorded at the Ythan Estuary, winter 1997-98

4.3 MONTROSE BASIN

LTC site code:	DM
Centre grid:	NO6957
JNCC estuarine review site:	85
Habitat zonation:	718 ha intertidal, 43 ha subtidal, 2 ha nontidal
Statutory status:	Montrose Basin SPA (UK9004031), Montrose Basin Ramsar (7UK082)
Winter waterbird interest:	Mute Swan, Pink-footed Goose, Greylag Goose, Shelduck, Wigeon, Eider, Red-breasted Merganser, Goosander, Oystercatcher, Knot, Dunlin, Redshank, Waterbird assemblage

SITE DESCRIPTION

Montrose Basin, the estuary of the South Esk River, is an almost circular basin about 3 km across. The basin is separated from the sea by a broad spit on which the town of Montrose is situated; the river discharges to the sea through a narrow channel at the southern end of the spit. The intertidal flats range from sand to mud and shingle and there are also extensive mussel beds. Eelgrass and algae are also present on the basin, providing a food source for some of the waterfowl. There are areas of saltmarsh on the inner edge of the basin and grazing fields nearby. Pressure from wildfowling used to be heavy on this site but has been restricted since 1981 when a Local Nature Reserve was created; this led to a dramatic rise in the numbers of waterfowl using the site, particularly Pink-footed Geese. Although there has been some land-claim for waste disposal, the site is mostly untouched by industrial development or pollution (R. Goater pers. comm.).

COVERAGE AND INTERPRETATION

Montrose Basin was counted for the scheme during the winters of 1992–93 (no January count) and 1997–98 (no February count). During 1992–93, 19 count sections were used for the survey but these were subdivided further for 1997–98 into the 33 sections shown in Figure 4.3.1. Precise details concerning the subdivision of sections can be obtained from the National Organiser.

Figure 4.3.2 shows that the whole area covered by the LTCs lies within the Montrose Basin SPA. In addition, some other non-estuarine areas, mostly fields, are included within the SPA boundary. The separate area of the SPA to the north-west is a small eutrophic loch called Dun's Dish, not included within the counts.

The boundaries of the Ramsar site are entirely coincident with those of the SPA. It is unlikely that many birds move on a daily basis between

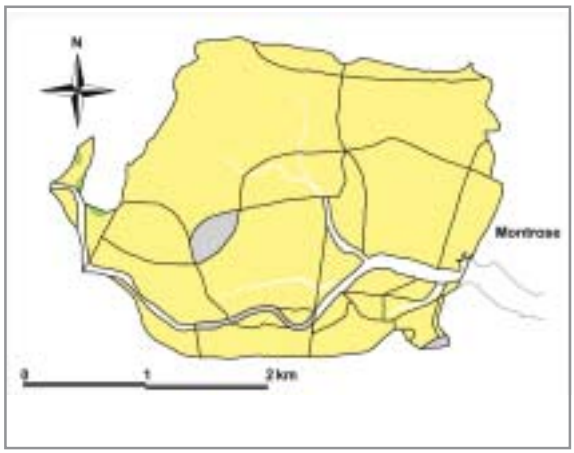


Figure 4.3.1: LTC sections at Montrose Basin, winter 1997–98

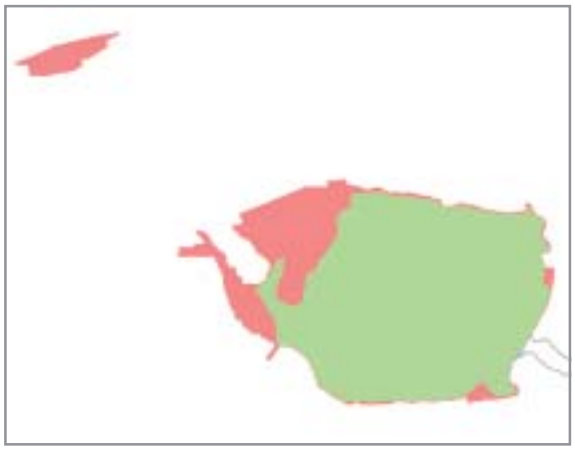


Figure 4.3.2: LTC and SPA boundaries, with overlap, at Montrose Basin

Montrose Basin and other estuarine sites, given the distance involved, but some may disperse to nearby stretches of non-estuarine coast. Geese and grassland plovers also use inland habitats for feeding.

WATERBIRD DISTRIBUTION

Low tide distribution maps from the winter of 1997–98 are presented for 11 of the 12 species of principal interest listed above. Additional maps of total birds and total birds weighted by 1% threshold value are also presented (Figure 4.3.3). The species not mapped, Greylag Goose, has declined in numbers in recent winters at the site

and was not even recorded during the survey (although the site is mostly used as an overnight roost by the species).

The totals map illustrates higher overall densities of birds in the eastern half of the basin, with little difference revealed by the weighted total map. For one count section, however, the overall high bird density was clearly strongly influenced by a flock of 15,000 Pink-footed Geese which were present on one occasion; there were otherwise just a handful of records of small numbers of this species which mostly uses the estuary as a nocturnal roost. Shelducks were mostly found in the north-east corner, with more Wigeon in the south-central parts. Red-breasted Mergansers and Eiders used the lower reaches of the main channels, while Mute Swans were present along the whole of the main river channel with a slight concentration upstream. Small numbers of Goosanders were found only on the upper reaches of the main channel, although this is a species which tends to disperse widely during the day and returns to favoured sites such as this at night. Dunlin were much more widespread than Knot, although both showed a general preference for the mid-south part of the basin. Redshanks and Oystercatchers were both more widespread throughout the whole site.

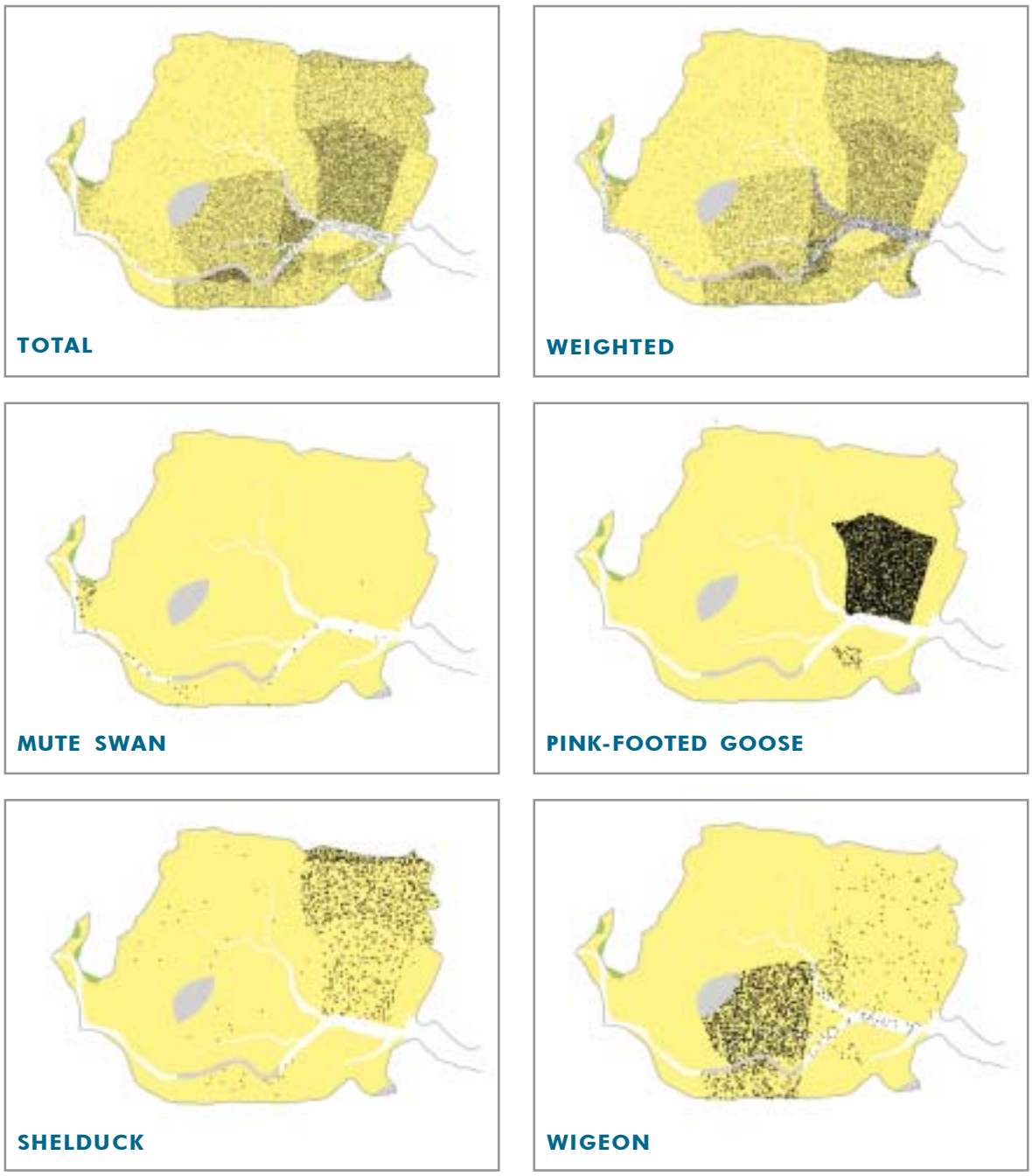
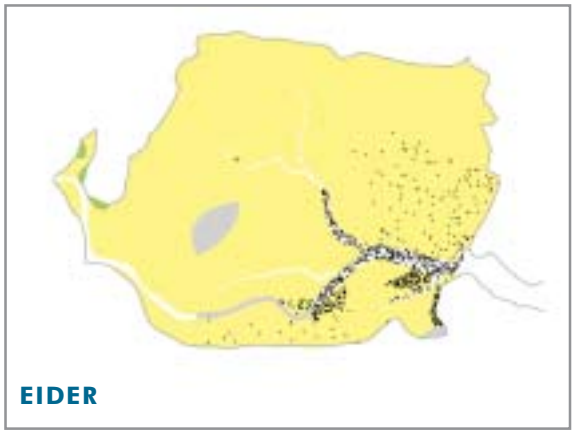
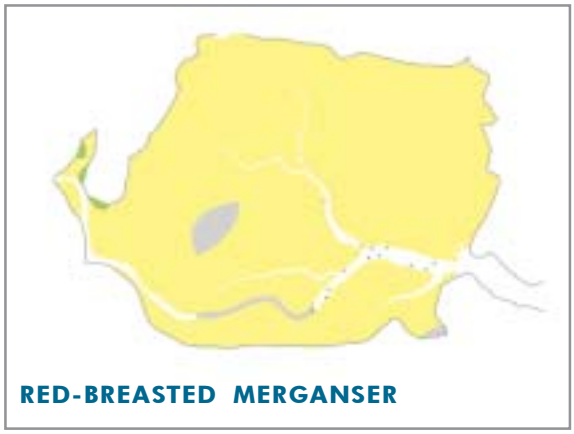
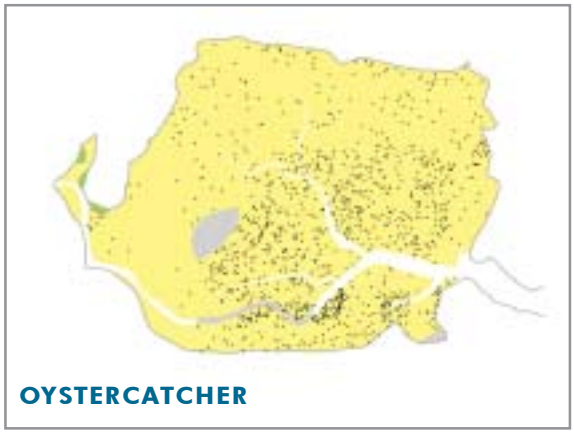


Figure 4.3.3 (i): Low tide waterbird distributions recorded at Montrose Basin, winter 1997-98







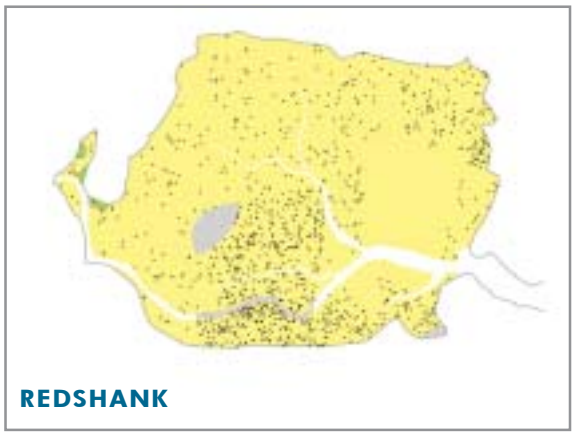


Figure 4.3.3 (ii): Low tide waterbird distributions recorded at Montrose Estuary, winter 1997-98.

4.4 FIRTH OF TAY

LTC site code:	BT
Centre grid:	NO3527
JNCC estuarine review site:	86
Habitat zonation:	5425 ha intertidal, 5417 ha subtidal, 87 ha nontidal
Statutory status:	Firth of Tay & Eden Estuary SPA (UK9004121), Firth of Tay & Eden Estuary Ramsar (7UK144)
Winter waterbird interest:	Cormorant, Pink-footed Goose, Greylag Goose, Shelduck, Eider, Long-tailed Duck, Common Scoter, Velvet Scoter, Goldeneye, Red-breasted Merganser, Goosander, Oystercatcher, Grey Plover, Sanderling, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Redshank, Waterbird assemblage

SITE DESCRIPTION

The Firth of Tay is a large site with extensive mudflats in the inner parts, a narrow intertidal fringe around Dundee and then wide sandflats at the mouth, notably forming a long spit at Tentsmuir Point and Abertay Sands. The inner flats are naturally impoverished due to the unstable nature of the coarse sediments. There are extensive areas of saltmarsh in the inner estuary and the northern shore is backed by the largest continuous brackish reedswamp in Britain. The outer estuary is bordered by sand dunes on the north and south shores. There is a large dock at Dundee and a smaller harbour at Tayport. Commercial sediment dredging occurs and further industrial activities are centred on Dundee. Most watersports occur around the mouth of the estuary.

COVERAGE AND INTERPRETATION

The Firth of Tay was counted for the scheme during the winter of 1993–94, during all four winter months. Following this, further counts were made during the 1996–97 winter (no November count) and a more restricted area during the 1997–98 winter. Figure 4.4.1 shows the positions of the 70 sections counted for the survey during 1996–97 (when the most complete coverage was obtained). Coverage during 1993–94 did not include the outermost sections, the innermost parts of the site and the area roughly between the Tay rail bridge and Tayport. The 1997–98 counts focused on several restricted parts of the middle and outer estuary. For precise information on the extent and position of LTCs on the Tay, the National Organiser should be consulted.

Figure 4.4.2 shows that, with the obvious exception of the Eden Estuary (which is treated as a separate site by WeBS), the SPA and LTC boundaries follow each other closely. The main areas that are within the SPA but not yet covered by the LTCs are Abertay Sands and the dunes at

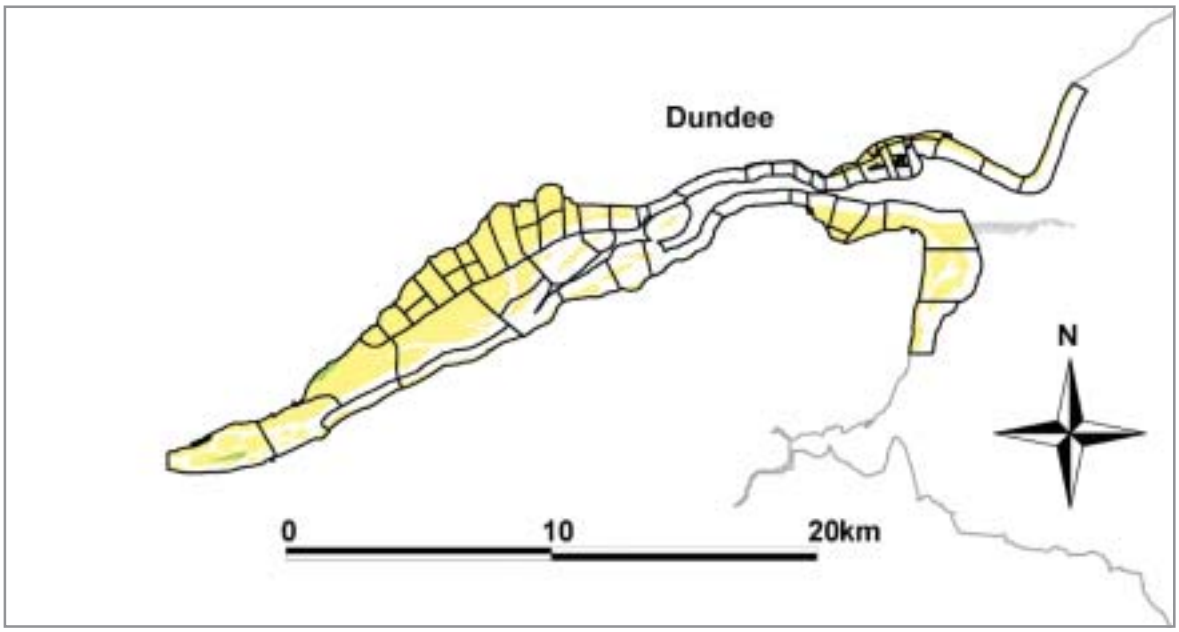


Figure 4.4.1: LTC sections at the Firth of Tay, winter 1996-97

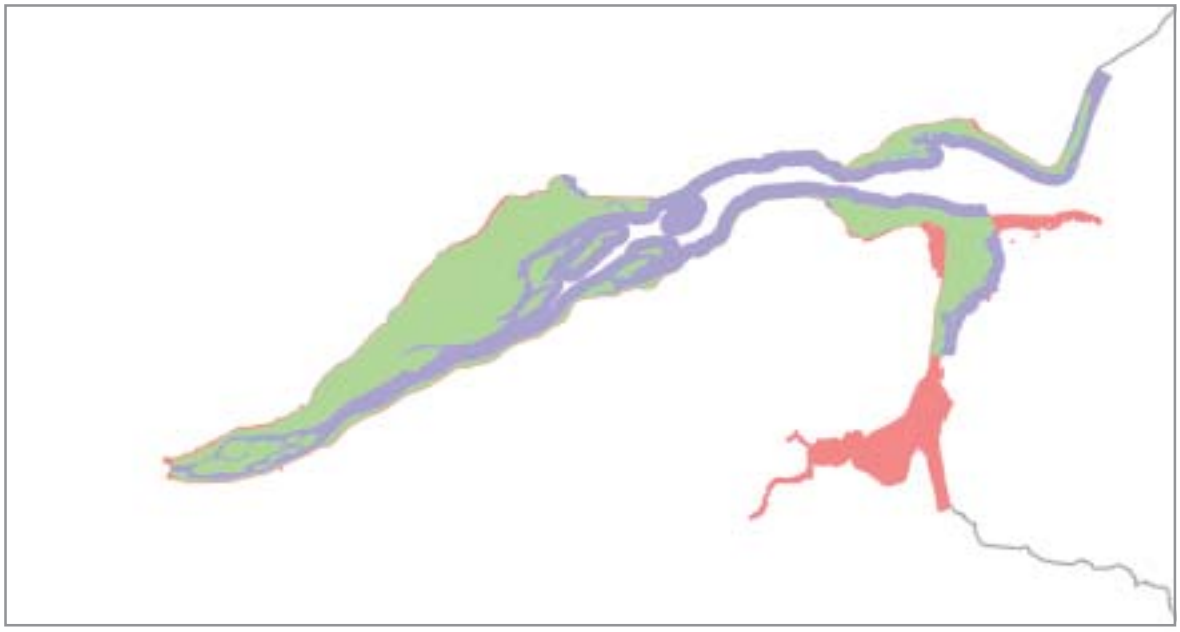


Figure 4.4.2: LTC and SPA boundaries, with overlap, at the Firth of Tay

Tentsmuir Point. Conversely, the area covered by the LTCs extended slightly further out on the northern shore and also covered central parts of the firth not designated as part of the SPA. The boundaries of the Ramsar site are entirely coincident with those of the SPA.

Movement of some birds between the Firth of Tay and the Eden Estuary occurs on a daily basis and there is also some dispersal north along the non-estuarine coastline of Angus (Elkins and Lynch 1997). Some species, notably wild geese and grassland plovers, also disperse inland to feed.

WATERBIRD DISTRIBUTION

Low tide distribution maps from the winter of 1996–97 are presented for 14 of the 18 species of principal interest listed above. For clarity, smaller dots are used to display the distributions of Eider, Oystercatcher, Dunlin, Bar-tailed Godwit and Redshank. Additional maps of total birds and total birds weighted by 1% threshold value are also presented (Figure 4.4.3). The four interest species not mapped mostly occur elsewhere in the SPA, although Goosanders use the Tay as a late summer moult site (Elkins and Lynch 1997). During the 1997–98 LTCs of the Tay, up to 280 Common Scoters were recorded offshore to the south of Tentsmuir Point but the species was unrecorded during the 1996–97 winter.

The totals map clearly depicts the higher overall bird densities on the outer estuary. Although the birds using the inner firth were mostly found in the north-eastern parts, the weighted total map suggests that only the shoreline adjacent to Dundee Airport held weighted bird densities comparable to those on parts of the outer firth. The overall picture was strongly influenced by the distribution of Eider, which was found almost exclusively at low tide on the south side of the mouth of the Tay at Tentsmuir Point. Other species frequenting the outer firth were Long-tailed Duck (although these are more common elsewhere in the SPA at St Andrew's Bay), Grey Plover and Sanderling, with Bar-tailed Godwits also common on the outer firth as well as making use of the area south of Dundee Airport. A large proportion of the Goldeneyes occurred from the airport eastwards along the north shore, although the upper reaches of the inner firth were also occupied. Red-breasted Mergansers and Cormorants were much more widespread, as were Shelducks, although this latter species was found in only low numbers on the firth. Oystercatchers, Dunlin and Redshanks were widespread although few were found on the upper reaches. Pink-footed and Greylag Geese were widely recorded in the central parts of the site.

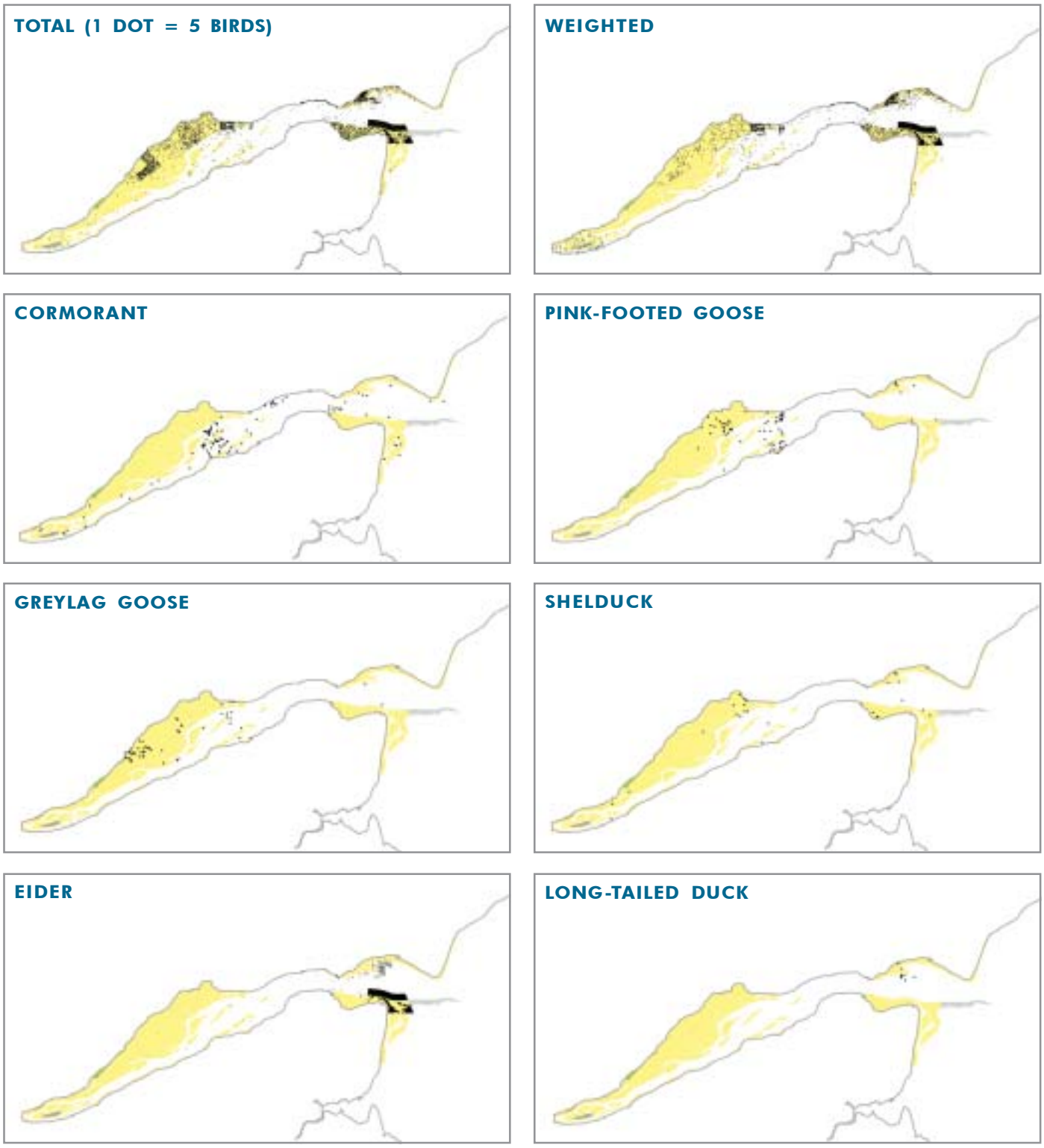


Figure 4.4.3(i): Low tide waterbird distributions recorded at the Firth of Tay, winter 1996-97

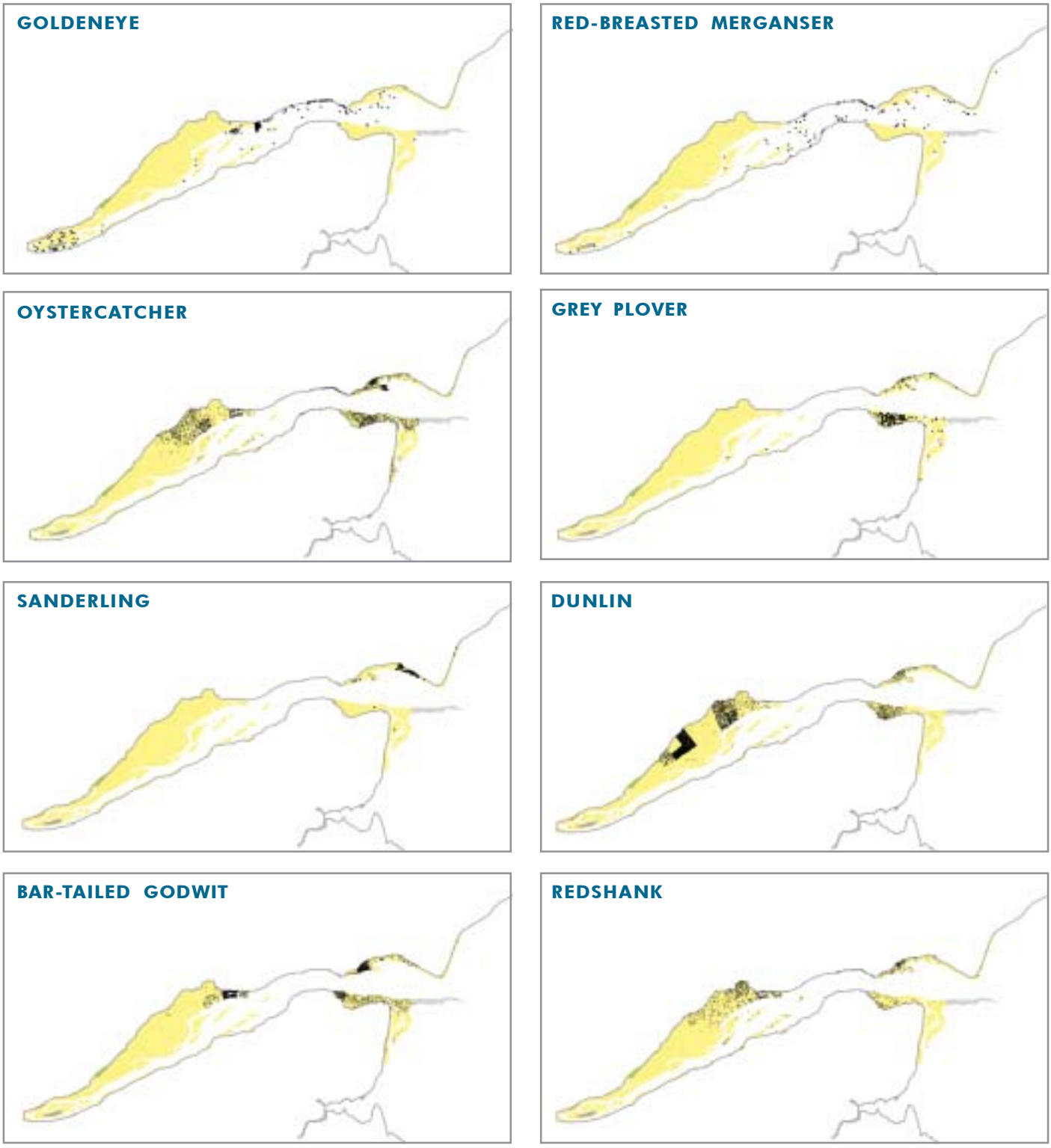


Figure 4.4.3(ii): Low tide waterbird distributions recorded at the Firth of Tay, winter 1996-97

4.5 EDEN ESTUARY

LTC site code:	BE
Centre grid:	NO4819
JNCC estuarine review site:	87
Habitat zonation:	821 ha intertidal, 278 ha subtidal, 13 ha nontidal
Statutory status:	Firth of Tay & Eden Estuary SPA (UK9004121), Firth of Tay & Eden Estuary Ramsar (7UK144)
Winter waterbird interest:	Cormorant, Pink-footed Goose, Greylag Goose, Shelduck, Eider, Long-tailed Duck, Common Scoter, Velvet Scoter, Goldeneye, Red-breasted Merganser, Goosander, Oystercatcher, Grey Plover, Sanderling, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Redshank, Waterbird assemblage

SITE DESCRIPTION

The Eden Estuary is a relatively small site just north of St Andrews on the Fife coast. At low tide, there is only a narrow river channel through the intertidal flats, which are mostly muddy but sandier towards the mouth. The mudflats at the western end of the site support mussel beds and the eel-grass *Zostera angustifolia*, with extensive beds of *Zostera noltii* on the north shore. Small patches of saltmarsh occur around the edges of the site. The mouth of the estuary is partially closed by a long spit on the southern side; seawards of this spit a sandy beach (West Sands) extends south to St Andrews. To the north, the sandflats are contiguous with the southern extent of the Firth of Tay LTC site. Watersports are prohibited within the estuary local nature reserve but occur on West Sands. Wildfowling does occur but there are two sanctuary areas where no shooting is permitted. Small-scale industry is present at Guardbridge and the area is immediately adjacent to a major RAF base. There is also an issue of eutrophication, the Eden having the highest levels of dissolved nitrogen of any estuary in Scotland, leading to an increase in green algae. Finally, potentially the most important conservation issue is that of coastal squeeze, with evidence of saltmarsh regression around much of the estuary, impacting on high tide roosts and leading to a concomitant loss of intertidal feeding area (L. Hatton pers. comm.).

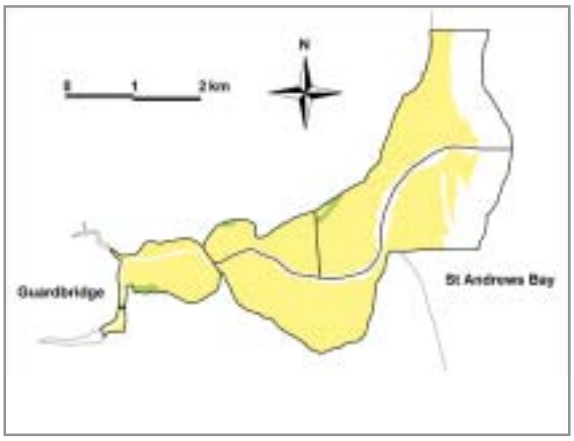


Figure 4.5.1: LTC sections at the Eden Estuary, winter 1992–93

COVERAGE AND INTERPRETATION

The Eden Estuary was counted for the scheme during the 1992–93 winter, with all four monthly counts carried out. Figure 4.5.1 shows the positions of the five sections counted for the survey.

As Figure 4.5.2 shows, the Eden LTC site is only a small part of the wider Firth of Tay and Eden Estuary SPA. Of most relevance to the Eden Estuary, the beach at West Sands and lengths of the channels of the River Eden and Motray Water are also within the SPA but were not covered by the LTCs in 1992–93. The boundaries of the Ramsar site are entirely coincident with those of the SPA.

There is regular daily movement of at least some species between the Eden Estuary and the Firth of Tay (Elkins and Lynch 1997) and there are plans to investigate such movements further (L. Hatton pers. comm.). The estuary is also a nocturnal roosting site for Pink-footed and Greylag Geese with these birds using the surrounding farmland during the daytime.

WATERBIRD DISTRIBUTION

Low tide distribution maps from the winter of 1992–93 are presented for eight of the 18 species of principal interest listed above. Additional maps of total birds and total birds weighted by 1% threshold value are also presented (Figure 4.5.3). Of the remaining species, Cormorants were present in very low numbers and the other species

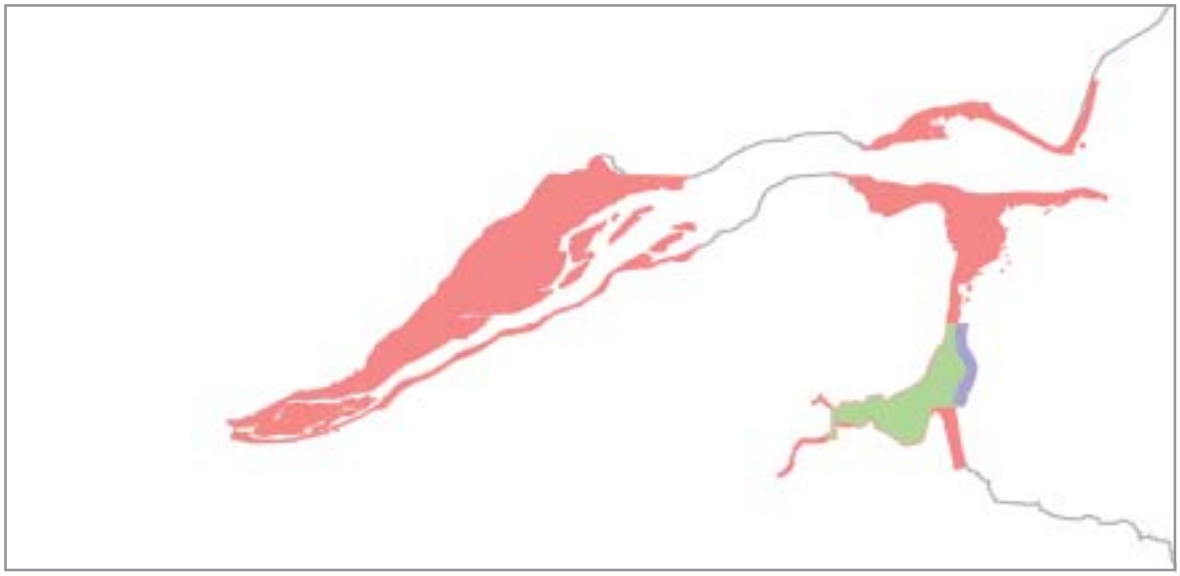


Figure 4.5.2: LTC and SPA boundaries, with overlap, at the Eden Estuary

were unrecorded. Pink-footed and Greylag Geese mainly use the SPA as an overnight roost and most of the remaining wildfowl species occur offshore from West Sands but were absent from the Eden Estuary itself during the counts. However, Goldeneyes and Red-breasted Mergansers are usually present on the estuary throughout the winter and were simply not recorded as the recording form during this first winter of the scheme did not list these species (the methodology of the scheme still being under development). The counters decided to concentrate only upon the intertidal species (L. Hatton pers. comm.).

Both the totals map and the weighted map suggest overall densities which were somewhat higher in the inner parts of the estuary, although the number of count sections was small, reducing the level of definition. Sanderlings and Shelducks were especially found in the outer northern parts of the site, but Grey Plovers and Bar-tailed Godwits showed an opposite pattern, with few in this area. Black-tailed Godwits, for which the Eden is one of the most important sites in Scotland, were mostly confined to the inner estuary, and Dunlin and Redshank, although both widespread, also occurred on the inner estuary at higher densities. Oystercatchers were widespread at a fairly even density.

Figure 4.5.3 (i) Low tide waterbird distributions recorded at the Eden Estuary, winter 1992-93

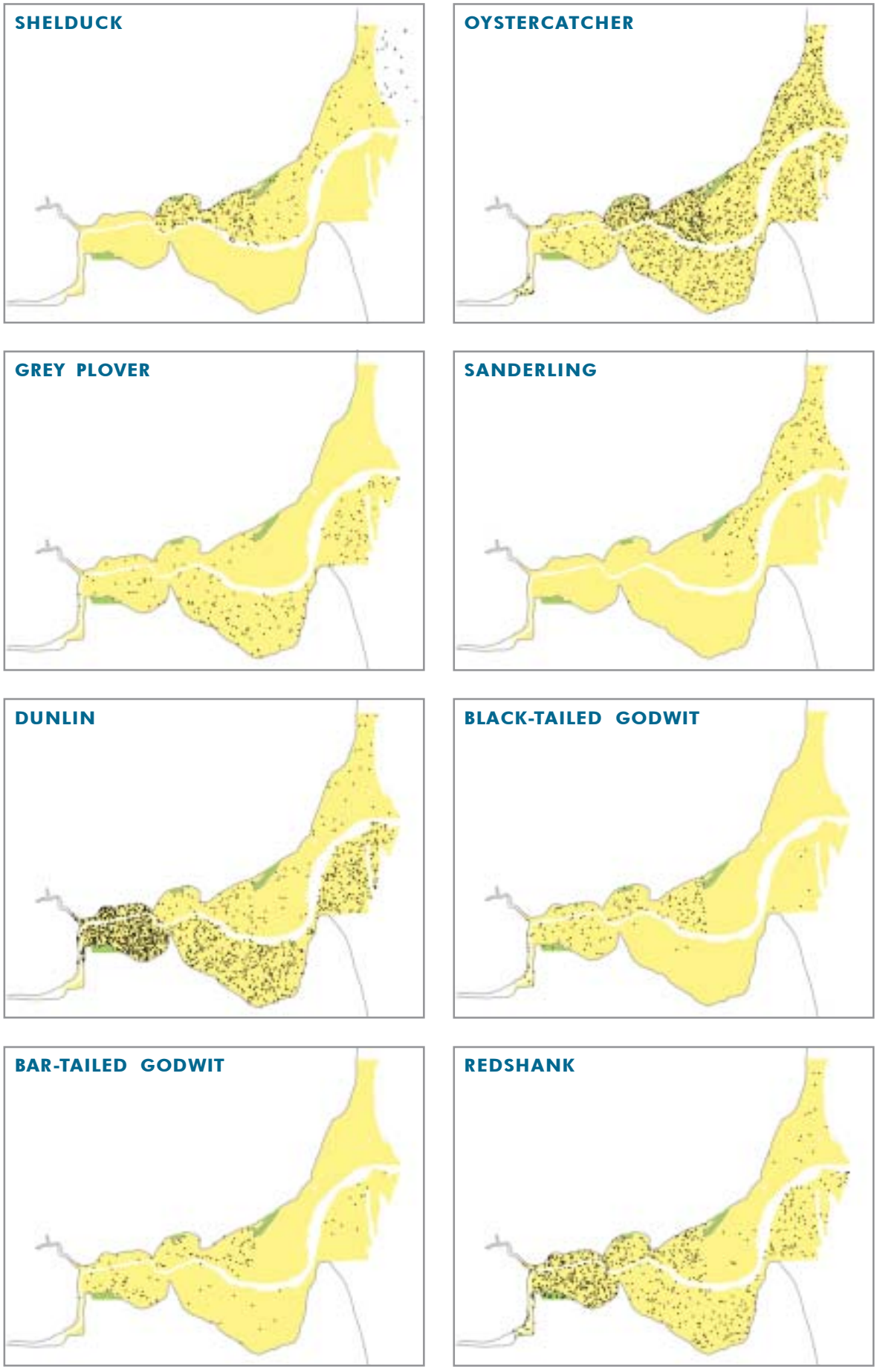


Figure 4.5.3 (ii) Low tide waterbird distributions recorded at the Eden Estuary, winter 1992-93