8.4 Fish

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8.4.1 Introduction

Over 353 species of fishes have been recorded in and around the British Isles (Maitland 1974). 122 of these species are known to inhabit British inshore marine waters and of these 118 species have been recorded from the intake screens of 12 coastal power stations (Henderson 1988). However, only 18 species of fish are recognised by Maitland (1974) as occurring regularly in estuarine waters or are considered to be true estuarine species (Table 8.4.1). This Chapter concentrates on these 18 species. In addition, however, a number of freshwater species colonise the upper reaches of many estuaries whilst the lower, fully marine, areas are penetrated by numerous species of truly marine fish during high tide. Marine fish also enter and remain within estuaries for extended periods of time, often in very large numbers and particularly when immature (Claridge, Potter & Hardisty 1986).

The 18 species of fish that regularly use estuaries during some part of their life-cycle can be divided into three species groups: estuarine, anadromous and catadromous. True estuarine fish, as the name implies, are those that are generally dependent on estuarine conditions in order to complete their life-cycle. Some other species, however, are dependent on estuaries as migration

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Life-style</th>
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<tbody>
<tr>
<td>Sea lamprey</td>
<td>Petromyzon marinus</td>
<td>anadromous</td>
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<tr>
<td>River lamprey</td>
<td>Lampetra fluviatilis</td>
<td>anadromous</td>
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<tr>
<td>Sturgeon</td>
<td>Acipenser sturio</td>
<td>anadromous</td>
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<tr>
<td>Allis shad</td>
<td>Alosa alosa</td>
<td>estuarine/anadromous</td>
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<td>Twait shad</td>
<td>Alosa fallax</td>
<td>estuarine/anadromous</td>
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<tr>
<td>Salmon</td>
<td>Salmo salar</td>
<td>estuarine/anadromous</td>
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<tr>
<td>Trout (brown, sea, etc.)</td>
<td>Salmo trutta</td>
<td>estuarine/anadromous</td>
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<tr>
<td>Humpback salmon*</td>
<td>Oncorhynchus gorbuscha</td>
<td>anadromous</td>
</tr>
<tr>
<td>Houting</td>
<td>Coregonus oxyrinchus</td>
<td>estuarine/anadromous</td>
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<tr>
<td>Smelt</td>
<td>Osmerus eperlanus</td>
<td>estuarine/anadromous</td>
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<tr>
<td>Eel</td>
<td>Anguilla anguilla</td>
<td>catadromous</td>
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<tr>
<td>Three-spined stickleback</td>
<td>Gasterosteus aculeatus</td>
<td>(estuarine)</td>
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<tr>
<td>Sea bass</td>
<td>Dicentrarchus labrax</td>
<td>estuarine</td>
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<tr>
<td>Common goby</td>
<td>Pomatoschistus microps</td>
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<tr>
<td>Thick-lipped grey mullet</td>
<td>Chelon labrosus</td>
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<td>Thin-lipped grey mullet</td>
<td>Liza ramada</td>
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<td>Golden mullet</td>
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</tr>
<tr>
<td>Flounder</td>
<td>Platichthys flesus</td>
<td>catadromous/estuarine</td>
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* The humpback salmon is an introduced species

Anadromous = ascending rivers from the sea to breed
Catadromous = descending rivers to the sea to breed
Parentheses indicate occurrence in fresh water as well as in these circumstances
routes to and from the freshwater reaches or sea. Anadromous species are those that migrate from the sea into the freshwater parts of rivers to breed. Catadromous species do the reverse, migrating to the sea to breed. On a gross scale this division works well, but for some species variations in habitat preference occur with changes in latitude. For example, flounders Plachitpsoises show an increasing liking for freshwater environments in higher latitudes, while in contrast three-spined sticklebacks Gasterosteus aculeatus become more common in marine habitats towards the north of the British Isles (Wheeler 1977).

The nomenclature used throughout this section follows that defined by Howson (1987) in the Marine Conservation Society's Species Directory to British Marine Flora and Fauna.

8.4.2 Estuarine fish

Britain has very few truly estuarine fish species. Of the approximately 350 fish species recorded for Britain, only five (1.4%) are considered to be true estuarine species — species that generally require estuarine conditions in order to complete their lifecycle. Maitland (1974) lists these five species as the sea bass Dicentrarchus labrax, the common goby Pomatoschistus microps, the thick-lipped grey mullet Chelon labrosus, the thin-lipped grey mullet Liza ramada and the golden mullet Liza aurata. A further seven species are classified by Maitland (1974) as estuarine but these species also occur in fresh water or are also catadromous or anadromous. These additional species are the flounder Plachitps flexilis, the sturgeon Acipenser sturio, the allis shad Alosa alosa, the white shad Alosa sapidus, the houting Coregonus oxyrinchus, thicksmelt Osmerus eperlanus and the three-spined stickleback. All 18 regularly occurring estuarine species are illustrated in Figures 8.4.1, 8.4.2 and 8.4.3.

The sea bass (Figure 8.4.1a) is a large, silverly, spiny-finned fish. It is an indigenous, widespread and common species in estuaries, particularly in southern and western Britain, although it is also abundant on off-shore reefs such as the Eddystone (Wheeler 1979). Adults can grow up to 30-50 cm long (Maitland 1972). Estuaries are particularly important to sea bass (Kelly 1988b), especially for juvenile fish and as spawning and nursery grounds, with the late postlarvae (essentially very juvenile fish) congregating around the saltwater/freshwater boundary at the top end of many Estuaries Review sites (Sabrye, Reay & Coombs 1988).

The common goby (Figure 8.4.1b) is an extremely abundant shallow-water small goby and is only the British species of this genus to be found regularly in fresh and estuarine waters. It occurs especially in estuaries and in intertidal sandy-bottomed pools on muddy saltings. Along the Essex coast it is extremely abundant in such habitats and Wheeler (1960) notes that reports of gobies on the north Kent marshes in the late 1950s probably refer to this species. As an abundant estuarine species it has a significant impact, both as predator and prey, on the ecosystems of British estuaries (Rogers 1985). It breeds prolifically throughout the summer months, following out a small 'nest' under a pebble or shell, and occurs in huge numbers in many inlets including, for example, the sheltered, shallow East Anglian waters of the Crouch-Roach, Blackwater and Colne Estuaries, and, during the autumn, in Hamford Water (Wheeler 1979).

Several other species of goby occur irregularly in brackish waters. These are generally restricted to the lower reaches of estuaries, as, for example, the sand goby Pomatoschistus minutus (Wheeler 1979). Sand gobies spend the summer and autumn in estuaries, migrating out to the sea during the winter. Large populations can be found in, for example, the Ythan Estuary in eastern Scotland (J. R. A. Rands & Raffaelli 1988). Three species of mullet occur in British estuaries: the thick-lipped grey mullet (Figure 8.4.1c), the thin-lipped grey mullet (Figure 8.4.1d) and the golden mullet (Figure 8.4.1e). (A fourth species of mullet, Mugil cephalus, has now been recorded in Britain but only from the Camel Estuary, as a result of the capture of just a single fish weighing only 0.27 g (J. Reay pers. comm.).) All three species are indigenous but only the thick-lipped grey mullet is considered widespread and common (Maitland 1972). Thick-lipped grey mullet are distributed throughout European seas but become less common in Scottish waters and rarer still further north (Wheeler 1979). The thin-lipped grey mullet has a more restricted distribution, only extending as far north as Scotland. The golden mullet has not been recorded from Scotland but is present in England and Wales. Like the golden mullet, the thin-lipped grey mullet is, in general, fairly local and uncommon, occurring in coastal as well as estuarine waters. Both species seem to be mainly restricted to coasts between south Wales and Essex (J. Reay pers. comm.). In some locations, such as The Fleet in southeastern England, golden mullet can be more common than the other two species (Bass 1986). Generally, however, within estuaries the thin-lipped grey mullet is more common, penetrating as far as the freshwater reaches (Wheeler 1979). Thick-lipped grey mullet are, by contrast, generally more abundant in the lower, more marine reaches, favouring in particular the high salinity harbours on the south coast (J. Reay pers. comm.).

Maitland (1974) classified seven other species (Figure 8.4.2) as facultative estuarine fish: species that also occur in fresh water or are catadromous or anadromous. These fish spend most of their lifecycles within the estuarine and/or freshwater reaches and display migratory behaviour, moving down to the sea or up river to breed. Such facultative estuarine fish include the flounder (Figure 8.4.2a). The flounder is the only flatfish to be found in fresh water and in abundance in the upper reaches of British and European estuaries. Superficially, flounder resemble plaice.
Figure 8.4.1 True estuarine fish, after Maitland (1972). a) Sea bass *Dicentrarchus labrax*; b) common goby *Pomatoschistus microps*; c) thick-lipped grey mullet *Chelon labrosus*; d) thin-lipped grey mullet *Liza ramada*, and e) golden mullet *Liza aurata*. Scale bars show the average length of adult fish. Unless otherwise stated the scale bar represents 10 cm.
Pleuronectes platessa but lack the bright orange spots. They are coloured dull olive brown on the back and white ventrally and have a line of small prickles along the bases of the fins (Wheeler 1979). It is an indigenous species, widespread and common throughout Britain in estuaries, sandy rivers and lakes which are easily accessible from the sea. It is catadromous, migrating to the open sea to breed. The juvenile fish are extremely common close inshore and enter estuaries at an early age, using the incoming tides to help them upstream (Wheeler 1979). The return of the flounder to the Thames Estuary is just one illustration of the improving water quality of this river. Between the 1920s and 1968 no flounder were caught in the Thames. By the end of the 1960s flounder were starting to be caught above London and the numbers present increased, resulting now in a resident population (Wheeler 1979).

The sturgeon (Figure 8.4.2b) is one of a number of species in the group that displays anadromous behaviour, migrating up river to breed. It is a large and distinctive fish which can reach lengths of 150 to 250 cm (Maitland 1972) and which is perhaps best known as the 'Royal fish' and for the 'caviar' eggs laid by the female. Exceptional specimens have been recorded reaching lengths of up to 500 cm, making the sturgeon one of the largest species of fish to occur in British waters (Newick 1979). The sturgeon is now an enchannelled species in western Europe and the nearest breeding population is in the River Gironde in France. It is a vagrant in British estuaries and is rare, since 1960 being recorded at only a handful of Estuaries Review sites, including the Severn, Thames and Fal Estuaries in England and Wales and the Moray Firth in Scotland.

Two species of shad occur in British estuaries, the allis shad (Figure 8.4.2c) and the twaite shad (Figure 8.4.2d). Both species are anadromous and indigenous, occurring in estuaries and the lower reaches of rivers. The allis shad is the bigger of the two species, growing up to 60 cm in length. It is much rarer than the twaite shad, being mainly restricted to parts of the west coast of England and Scotland and, to a lesser extent, to some south coast estuaries (Newick 1979). Maitland (1972) described the allis shad as fairly local and rare. There are suggestions that the current restricted distribution may be due to pollution of rivers and disruption of traditional migration routes (Wheeler 1979). Maitland (1972) indicates that since 1890 the allis shad has been recorded from only two Estuaries Review sites, the Severn Estuary and the top end of Southampton Water, although these data may now be out of date, given Wheeler's (1979) report of allis shad in the Thames and Newick's (1979) suggestion that it may still be present in the Firth of Forth. The twaite shad is, however, more widespread, with a wide distribution in European seas. In Britain it is present around most of the coastline, although more frequently on the west coast (Newick 1979). The twaite shad ascends rivers in late spring to spawn in the lower reaches of freshwater still within tidal influence, the adults subsequently returning to the estuary later in the year (Aprahamian 1988). The allis shad displays similar behaviour but breeds far up in the freshwater reaches and not in areas of tidal influence (Wheeler 1979).

Houting (Figure 8.4.2e), another anadromous species, is indigenous but very local and very rare. Adult fish reach lengths of 25 to 35 cm. After a decline in numbers in recent years it can best be described as a vagrant in British estuaries. It is likely to be found only in estuaries on the North Sea coast (Newick 1979). Breeding takes place between December and January but it has never been known to occur in the British Isles (Maitland 1972), and in general little appears to be known about this species in Britain.

A more widespread anadromous species is the smelt – a close relative of the salmon family. It is a relatively small fish with a small silver fin on the back between the dorsal fin and tail fin (Figure 8.4.2f), and like salmon and trout it is migratory. An unusual characteristic of smelt is its strong scent of cucumber. Smelt are fairly widespread and common, occurring in rivers, the lower reaches of estuaries and inshore waters (Maitland 1972; Newick 1979). Smelt breed in fresh water or at the extreme tops of estuaries, at the upper limit of tidal influence (Wheeler 1979). Estuaries are particularly important to smelt, not just as feeding sites but also as larval or juvenile nursery areas (Davies 1975). Like the flounder, smelt were absent from the Thames in the earlier part of this century, possibly due to pollution. It had previously been common, but it was not until the late 1960s that smelt were caught once more in the river. Now, once again, the species is common in the estuary and, as an 'indicator' species, clearly demonstrates the success of the various authorities in controlling pollution (Wheeler 1979; Andrews 1988).

The three-spined stickleback (Figure 8.4.2g) is a species which generally occurs in estuaries and a variety of freshwater habitats. As mentioned above (Section 8.4.1), in higher latitudes this species becomes increasingly common in marine habitats, predominantly inshore pools. In Scotland it occurs in the open sea and has occasionally been captured far out to sea. Changes in salinity are seemingly of little importance but it is more sensitive to low levels of dissolved oxygen and is therefore absent from badly polluted rivers and estuaries. It has been recorded from a large number of Estuaries Review sites including the Fal, Thames, Humber and Severn Estuaries, The Wash and the Dornoch, Cromarty and Moray Firths.

8.4.3 Anadromous fish

Britain has four species of fish that are anadromous, migrating up river from the sea to breed. These are the sea lamprey Petromyzon marinus, the river lamprey Lampetra fluviatilis, salmon Salmo salar and
Figure 8.4.2 Fish species that are estuarine and catadromous, or estuarine and anadromous, after Maitland (1972). a) Flounder *Platichthys flesus*, b) sturgeon *Acipenser sturio*, c) allis shad *Alosa alosa*, d) twaite shad *Alosa fallax*, e) houting *Coregonus oxyrinchus*, f) smelt *Osmerus eperlanus*, and g) three-spined stickleback *Gasterosteus aculeatus*. Scale bars show the average length of adult fish. Unless otherwise stated the scale bar represents 10 cm.
the humpback salmon *Oncorhynchus gorbuscha*. Brown and sea trout *Salmo trutta* are also partly freshwater, and a further five species (sturgeon, allis and white shads, houting and smelt) are anadromous as well as estuarine in nature (see Section 8.4.2).

Lampreys are jawless fish which obtain nourishment by sucking the blood from bony fish. They attach themselves to fish by way of a sucker disc on the underside of the head which is well armed with teeth. The sea lamprey (Figure 8.4.3a) is the larger of the two species which occur in British estuaries, growing to adult lengths of between 80 and 90 cm. The river lamprey or lampen (Figure 8.4.3b) is smaller, reaching between 30 to 50 cm in length when adult. Both species occur in estuaries and easily accessible lakes, rivers and streams (Maillard 1972). The sea lamprey is fairly widespread, occurring all around almost the entire coastline but more frequently in England and Wales than in Scotland, whilst the river lamprey is widespread and generally common but scarce in northern Scotland (Newdick 1979). The sea lamprey spawns in fresh water, migrating up river from the sea to do so. River lampreys undertake a similar migration which, in the Severn Estuary, occurs between mid-November and mid-February (Hardisty & Huggins 1975). A similar migration occurs in the Thames (Wheeler 1979). The onset of the main migration occurs after the first heavy rainfall of the autumn when river levels start to rise. The sea lamprey, although fairly widespread, is now a rare fish in industrialised lowland regions, owing to widespread pollution and disruption to migration routes from the construction of weirs, dams and other structures (Lelely 1987). Similarly the river lamprey is also less common than formerly, for the same reasons.

The salmon (Figure 8.4.3c) is almost certainly the best known of all British fishes. It is indigenous, widespread (apart from the coastline of eastern England south from the Humber Estuary to the Solent) and common, inhabiting clear stony rivers, streams and lakes. Its distribution range covers the whole of the northern European coast, from northern Spain up to Iceland, and the Atlantic coast of North America. Salmon spawn in the headwaters of rivers. The eggs are laid in winter in small gravel hollows or ‘redds’ and hatch in the spring. The young fish remain in the river for one to three years, ascend to the sea for up to four years and then return to spawn in the river where they originally hatched.

Salmon favour clean water and are now, with increasing implementation of pollution controls, returning to previously polluted rivers such as the Thames. Indirect pollution through the atmosphere and more intensive agricultural practices have increased but, so far, do not seem to have had any large effect on the distribution of salmon populations. In Scotland salmon occur in all Scottish river systems but local distribution within some rivers in the central industrial belt is limited by pollution and weirs (Williamson 1996). Direct industrial pollution is decreasing in Scotland. For example, in the Clyde Estuary, Curran & Henderson (1988) have described how the gradual improvement in dissolved oxygen levels has resulted in the return of significant numbers of salmon to the River Clyde and its tributary around 1979, and to the Clyde itself in 1983.

Within the last decade research using radio tracking devices has revealed much new information about how salmon move through estuaries. Such studies have been undertaken at a number of sites including the Ribble (Priede et al. 1988), the Dee in Aberdeenshire (Hawkins et al. 1988) and the Fowey in Cornwall (Solomon & Potter 1988). Results from the Fowey Estuary indicated, for example, that most salmon entered the fresh water at the top of the estuary on flood tides and at night (Potter 1988).

The humpback salmon (Figure 8.4.3d) is much rarer than the salmon *Salmo salar*. It is not truly native since its occurrence in Britain results from introductions made from rivers in north-west Russia (Shearer & Trewavas 1960) and it is only an occasional and rare vagrant. Like the salmon it favours clear stony rivers and streams. Maillard (1972) indicates that since 1930 this species has been recorded from only one review site, the Cromarty Firth. There is no record of it breeding in the British Isles (Maillard 1977).

The trout *Salmo trutta* (Figure 8.4.3e) is another well known species and is also, like salmon, exploited commercially, mostly for sport fishing. It is widely distributed in northern Europe and is widespread and common in Britain, being found in almost all types of unpolluted freshwater bodies where spawning grounds are available but where there are not too many predators. Trout exist in two types, a migratory type, the sea trout, and a non-migratory type, the brown trout. These types are not genetically or morphologically distinct and are not recognised as distinct subspecies.

### 8.4.4 Catadromous fish

Only two species of fish in Britain are catadromous, migrating to the sea to breed. These are the flounder described above (Section 8.4.2) and the eel *Anguilla anguilla*.

The eel (Figure 8.4.3f) is an abundant fish in Europe, although most widespread in the countries bordering the Atlantic Ocean and the Baltic, North and Mediterranean Seas (Wheeler 1979). In Britain it is indigenous, widespread and common with substantial numbers living in estuaries and on the sea coast. Eels which inhabit British estuaries and rivers breed at sea, in the Atlantic Ocean, south-east of Bermuda. The postlarvae cross the Atlantic, mainly by ocean currents, and change into transparent eels in British coastal waters. The eels then migrate into estuaries and up river during late winter and early spring (Wheeler 1979).
Figure 8.4.3 Anadromous and catadromous fish, after Mailland (1972). a) Sea lamprey *Petromyzon marinus*. b) River lamprey *Lampetra fluviatilis*. c) Salmon *Salmo salar*. d) Humpback salmon *Oncorhynchus gorbuscha*. e) Brown and sea trout *Salmo trutta*, and f) eel *Anguilla anguilla*. Scale bars show the average length of adult fish. Unless otherwise stated the scale bar represents 10 cm.
8.4.5 Other fish species

The 18 fish species described above are just a fraction of the actual number of species that can be found in marine inlets and estuaries. Much information on the full range of species present has been derived from fisheries operations, individual studies and from fish caught on the intake screens of coastal power stations.

Henderson (1988), for example, records 118 species from the intake screens of 12 coastal power stations. Species caught include commercially important ones such as cod Gadus morhua, whiting Merlangus merlangus, plaice Pleuronectes platessas, dab Limanda limanda, Dover sole Solea solea and herring Clupea harengus (Turner 1988). Research in the Firth of Forth has shown that at least 34 species of fish use the estuary throughout, or at some time during, the year (Elliott, O'Reilly & Taylor 1990). Species present include commercially important ones, such as those listed above, as well as more unusual species like the angler fish Lophius piscatorius, five-bearded rockling Chilata mustela, poacher Agonus cataphractus and lump sucker Cyclopterus lumpus.

Studies undertaken in the shallow creeks of estuaries in west Wales and south-west England show that, in addition to grey mullet and flounders, large numbers of sand smelt Atherina boyeri, sand eels and clupeids also inhabit these areas (Kelley 1988a). Sand smelt also occur elsewhere and The Fleet in southern England supports a local breeding population (Henderson & Bamber 1986). More widespread are sand eels which can be found in estuaries wherever there are sandbanks. There are bait fisheries for sand eels in, for example, the Camel and Fowey Estuaries (J Reay pers. comm.). The main species involved is Ammodytes tobianus, but in the Camel Estuary, for example, Raitt's sandeel Ammodytes marinus, Corbin's sandeel Hyporophus immaclus and the greater sandeel Hyperopis lanceolatus have all been recorded (J Reay pers. comm.).

Dipper (1987) records a number of fully marine species that are tolerant of reduced salinities and that live in or enter estuaries to feed. These species include the brill Scophthalmus rhombus and turbot Scophthalmus maximus, the black goby Gobius niger, the leopard-spotted goby Thorogobius ephippatus and the broad-snouted pipefish Syngnathus typhle. The young of the red gurnard Aspitrigla cuculus are often found in estuaries whilst adults of a more exotic species, the sting ray Dasyatis pastinaca, can be found in south coast estuaries but only during the summer and autumn when this species moves north into the English Channel.

8.4.6 Spawning grounds and nursery areas

The sheltered waters provided by estuaries and marine inlets in Britain are particularly important as spawning and nursery areas for a number of species and are vitally important to a restricted number of estuarine-dependent species. These estuaries are important not only for a number of the estuarine, anadromous and catadromous species described earlier (Section 8.4.8) but also for some more fully marine species in the extreme lower reaches of inlets. In addition, marine fish will also enter estuaries and inlets when young, to feed and to obtain protection from the effects of adverse weather in the open sea.

For example, in the Tamar Estuary in Plymouth, juvenile Dover sole use the estuary as a nursery area. They enter the estuary during April and May when they are only 10 mm long and remain there for two summers. When they leave the Tamar they are 150 to 200 mm in length. During their time in the estuary individual fish appear to inhabit and restrict themselves to a single mudflat, with only limited movement of fish between adjacent mudflats (Coogan & Dando 1969). Such sedentary populations are very susceptible to localised disturbance or the destruction of mudflat areas. Dover sole will also spawn in estuaries, and in the Humber spawning has been reported upstream of Spurn Head (Riley 1979).

The Humber Estuary also acts as a significant nursery area for other commercially important species, notably plaice and cod (Rees et al. 1988). The juvenile cod are winter visitors to the Humber and are survivors of spawning which occurs off Flamborough Head in February.

Other commercially important species that use estuaries as nursery areas or spawning grounds include sea bass and herring.

Significant numbers of young sea bass occur in 32 Estuaries Review sites (Figure 8.4.4) in England and Wales (MAFF pers. comm.). These sites include The Fleet, as well as Plymouth sound, in south-west England, and the shallow estuaries around the south and east of Britain such as Portsmouth and Langstone Harbours and the estuaries of the Medway and Swale. Dwelling stock numbers in the last ten years have prompted the introduction of new legislation in 1990 to conserve stocks (see Section 8.4.9).

Herring use the extreme outer parts of estuaries and inlets, particularly in Scotland, as nursery areas or spawning grounds. Herring used to spawn in the Firth of Forth and were commercially exploited up to the early 1940s. The fishery was based on a population of spring-spawning herring, spawning inside the firth. This important local fishery reached its peak in 1938 when a total catch of over 16,000 tonnes was taken. In 1946 the fishery failed and there has been no subsequent recovery (Howard, McKay & Newton 1987).

The Fleet in southern England is important as a spawning and nursery area for a number of fish species including sand smelt. Sand smelt also use
nets occurs in a handful of estuaries, mainly for bottom-living species such as flounder, sole and dabs, but other species are also caught, including herring and species of grey mullet. Apart from angling on a non-commercial basis, fyke netting for eels is the most widespread fishery, known to occur on over 20% of review sites. In many estuaries it is carried out at a comparatively low level and on a non-commercial or semi-commercial basis. On some sites however, and in particular the Severn Estuary, this fishing practice rivals even salmon fishing in terms of financial reward (Severn-Trent Water Authority pers. comm.).

Wheeler (1979) provides an excellent account of the fisheries of the tidal Thames, from historical times to the present day. In the Thames the theme has been one of controlled commercial exploitation of native stocks providing employment for the fishing community and providing food for the populations of the local communities and London. Within the last century most of these fisheries have been badly affected by pollution stemming from the development of London and by interference with the river’s flow. Traditional fisheries in the upper reaches for smelt, salmon, lampreys and shad were ruined; whilst the mid-reach fisheries for flounder, eel and whitebait were seriously affected. Those fisheries that continued were forced to move downstream, away from the most polluted areas, to the mouth of the Thames.

In the Humber Estuary there are currently commercial fisheries for marine species such as sole, plaice, rough, cod, dogfish and eel, although as elsewhere they are mostly part-time concerns (Rees et al. 1988). Many other species are of lesser importance and are considered to be of value at a local rather than national level. A summary of the value of the 18 British estuarine fish is given in Table 8.4.2, which indicates whether species are primarily of scientific, angling, recreational or commercial value.

Many of the economically important species are under pressure from fishing operations, whether sporting or commercial, and through disturbance to the estuarine habitat and pollution. Legislation to control many fisheries and ensure continued viability of stocks. Two commercially important species are considered in detail below: the sea bass and the salmon.

Sea bass are under growing pressure from both anglers and commercial fishermen, its value to the latter being increased by high prices and improvements in capture and location techniques (Kelley 1988b). Accordingly much work has been carried out on this species by the Ministry of Agriculture, Fisheries and Food (MAFF) and Kelley (e.g. 1988b), most recently in response to a long-term downward trend in stock abundance. MAFF’s strategy for managing the bass resource is to reduce the mortality of juvenile fish so as to improve yields to the industry and sustain the spawning stock. Studies have been undertaken

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**Figure 8.4.4** Major sea bass *Dicentrarchus labrax* nursery areas in England and Wales (MAFF pers. comm.)

The Fleet for the first year or two of adult life before passing into the open sea. Studies suggest that there is probably minimal mixing with other localised populations (Henderson & Bamber 1986). Such populations dependent on individual inlets, are vulnerable and highly susceptible to disturbance.

### 8.4.7 Commercial and non-commercial fisheries

A number of fish species that occur in estuaries are of considerable economic importance and many have established fisheries. Information obtained during the Estuaries Review shows that, for example, netting for fish occurs in most of the larger review sites but, on a commercial basis, only on about 15% of sites. Netting is predominantly for salmon and sea trout but is also used for species such as bass, mullet, flounder, dabs and sole. Fixed nets and other devices are also used for catching (predominantly) salmon, although the extent of such operations appears now to be less extensive than formerly. Occasional trawling of

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### Table 8.4.2 Value of British estuarine fish (based on Maitland 1974)

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Britain</th>
<th>International*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea lamprey</td>
<td>Petromyzon marinus</td>
<td>Scientific</td>
<td>Commercial</td>
</tr>
<tr>
<td>River lamprey</td>
<td>Lampetra fluviatilis</td>
<td>Scientific</td>
<td>Commercial</td>
</tr>
<tr>
<td>Sturgeon</td>
<td>Acipenser sturio</td>
<td>Scientific</td>
<td>Commercial</td>
</tr>
<tr>
<td>Allis shad</td>
<td>Alosa alosa</td>
<td>Angling</td>
<td>Commercial</td>
</tr>
<tr>
<td>Twaitie shad</td>
<td>Alosa fallax</td>
<td>Angling &amp; commercial</td>
<td>Commercial</td>
</tr>
<tr>
<td>Salmon</td>
<td>Salmo salar</td>
<td>Scientific</td>
<td></td>
</tr>
<tr>
<td>Trout (brown, sea, etc.)</td>
<td>Salmo trutta</td>
<td>Angling &amp; commercial</td>
<td></td>
</tr>
<tr>
<td>Humpback salmon</td>
<td>Oncorhynchus gorbuscha</td>
<td>Scientific</td>
<td>Commercial</td>
</tr>
<tr>
<td>Houting</td>
<td>Coregonus oxyrinchus</td>
<td>Scientific</td>
<td>Commercial</td>
</tr>
<tr>
<td>Smelt</td>
<td>Coregonus aspertus</td>
<td>Scientific</td>
<td></td>
</tr>
<tr>
<td>Eel</td>
<td>Anguilla anguilla</td>
<td>Angling &amp; commercial</td>
<td></td>
</tr>
<tr>
<td>Three-spined stickleback</td>
<td>Gasterosteus aculeatus</td>
<td>Recreation</td>
<td></td>
</tr>
<tr>
<td>Sea bass</td>
<td>Dicentrarchus labrax</td>
<td>Angling</td>
<td></td>
</tr>
<tr>
<td>Common goby</td>
<td>Pomatoschistus microps</td>
<td>Recreation</td>
<td></td>
</tr>
<tr>
<td>Thick-lipped grey mullet</td>
<td>Chelon labrosus</td>
<td>Angling</td>
<td>Commercial</td>
</tr>
<tr>
<td>Thin-lipped grey mullet</td>
<td>Liza ranae</td>
<td>Angling</td>
<td>Commercial</td>
</tr>
<tr>
<td>Golden mullet</td>
<td>Liza aurata</td>
<td>Angling</td>
<td>Commercial</td>
</tr>
<tr>
<td>Flounder</td>
<td>Platichthys flesus</td>
<td>Angling &amp; commercial</td>
<td></td>
</tr>
</tbody>
</table>

* Value stated only when different from that in Britain

throughout England and Wales, especially in nursery areas, where juvenile bass are particularly vulnerable to capture. These studies have shown, for example, that in the Solent: seasonal movements take place. Juvenile bass move to the west through the Solent in summer and autumn, travelling as far as Christchurch and Poole Bays before returning east in the following spring (Pawson 1988). Similar winter migrations have been reported in the Severn Estuary (Hardisty & Huggins 1975) and the Thames Estuary (Wheeler 1979).

Legislation has been introduced in 1990 to protect sea bass nursery areas. This legislation also indirectly protects the nursery areas of other estuarine and marine species in response to reductions in stock abundance. 34 estuaries and inlets, covering 36 Estuaries Review sites, have been identified (Figure 8.4.4) and are now protected under Section 5 of the 1967 Sea Fish (Conservation) Act. Within these areas regulations will be introduced to prohibit certain fishing methods for all or specific months of the year. A year-round ban on fishing, not just for sea bass but for all sea fish, will operate in The Fleet, Plymouth Sound and the Medway Estuary. Within the other sites identified, fishing will be prohibited between May and October. It is hoped that such action will result in a recovery of stocks of sea bass and other species.

Salmon are another economically important species and in many places have provided local fishermen with a living, not just in Scotland but also further south. In the Severn Estuary for example, the annual salmon catch 60 years ago was in the order of 25,000 to 30,000 fish per season. A salmon fishery still exists, but today's catches are much smaller, the total averaging between 3,000 and 4,000 fish for all types of commercial fishing (Severn-Trent Water Authority pers. comm.).

In Scotland there are no public rights of salmon fishing. Instead, exclusive salmon fishery rights for each stretch of river and shore are under private ownership. The salmon themselves do not belong to anyone until caught and, once caught, belong to whoever catches them. The salmon rights are heritable property and can be bought, sold or leased independently of adjacent land, although a minor exception to this occurs in Orkney and Shetland. For whoever owns the local fishing rights salmon fishing can be very lucrative, with very high prices paid for fishing permits on the best runs. There is also an indirect but significant input into the local economy, resulting from anglers' incidental requirements for board and lodging. On a national Scottish basis a study of the economic value of the sporting salmon fishery in three areas of Scotland estimated the total annual value to be in the region of £34 million (Edinburgh University Tourism and Recreation Unit 1984).

Since 1962 there has been a decline in the abundance of spring salmon caught (Figure 8.4.5). In 1987 the total number of salmon and grilse caught in Scotland was 268,779, the lowest reported number since records began in 1962 (Department of Agriculture and Fisheries 1988). (A grilse is a fish that has returned to the river after spending only one year at sea.) In England and Wales the commercial catch for 1987 was 24% below the average for the previous five years (Russell & Buckley 1989). Williamson (1988) has suggested that the decline in abundance may be due to the significant exploitation of Scottish-origin fish in Greenland, north-east England, (probably) off the coast of Ireland and in the Faroe Islands.
Much of the commercial salmon fishing is carried out using fixed nets set at right-angles to the shores outside river mouths. These nets are designed to catch salmon as they move along close to the shore before migrating through estuaries and moving further up-river to spawn. Within some estuaries there are also commercial salmon fisheries using various other netting techniques. Salmon fishing in the upper parts of estuaries is, as on freshwater rivers, restricted to rod and line sport fishing.

There is currently debate over the extent to which the diminishing fish stocks are a consequence of river-mouth netting. Around some estuaries netting rights are now being acquired and rendered inactive by the Atlantic Salmon Trust, with the aim of maintaining up-river salmon stocks for sport fishing.

8.4.8 Threats to estuarine fish

Fish species that occur in estuaries and are dependent on them for part of their life-cycle, whether as a migration route or as spawning or nursery grounds, are very vulnerable to disturbance and exploitation. Disturbance may take the form of pollution of the water mass, disruption of water flow, loss of estuarine area to land/water-based developments or recreational activities. Populations in estuaries are also susceptible to exploitation in the form of commercial or non-commercial fishing, and where stocks, especially those dependent on a single estuary, are over-exploited subsequent declines in populations can occur.

Pollution comes mostly from domestic, agricultural or industrial wastes and includes thermal pollution from power stations and industry. In relation to estuarine fish populations, pollution can be either toxic, eliminating all fish species present, or selective, killing off sensitive species or altering the environment to favour only a few species (Matland, 1974). Estuarine fish and those with marine affinities are particularly threatened by water pollution. It is normally the lowest reaches of rivers and estuaries that are most seriously polluted. Resident species will be affected, as will those anadromous or catadromous species that must pass through the lower reaches to complete their life-cycles. The flesh of salmon may become discoloured, as in the River Don, or individual fish may contain high levels of pesticides, like the eels in the River Lossie (Brown, 1990). Such effects, whilst not necessarily killing the fish, may have severe consequences for predators and species further up the food chain. Implementation of pollution controls over the last few decades has, however, resulted in fish returning to previously grossly polluted British estuaries and rivers.

Overall changes to water bodies, such as eutrophication, are also potentially damaging to resident fish populations. Eutrophication, the nutrient enrichment of the water mass, usually from the surrounding land, results in increased growth rates of fish, increased fish parasite populations and the selective loss of certain fish species from affected water bodies. For example, one of the consequences of eutrophication is lowered oxygen levels in the water which results in some species being more favoured than others. In the lower reaches of estuaries dinoflagellate blooms can also be devastating to local marine fauna (G Potts pers. comm.).

The disruption of estuarine water masses by the construction of weirs, dams or barrages is another serious threat to the local fish populations. Such structures can result in anadromous or catadromous fish being unable to complete their life-cycles successfully. Some dams and weirs now have fish passes to ensure the continued successful migration of species, and much work has been conducted to investigate the success and mortality rates of fish passing through the turbines of tidal barrages (e.g. Davies, 1988). The construction of these structures also has, however, a more widespread effect on local fish populations, transforming shallow tidal areas into deeper water areas, with associated changes in the tidal regime. Barrages alter the tidal range and can cause changes in the turbidity of the water, the distribution of water currents and the degree of exposure of the estuary to prevailing winds. Weirs and dams result in a partial to complete loss of tidal influence and a reduction of the estuarine area available to the fish.

Land-claim can also be a threat to estuarine fish, although it may less serious than some of the pressures already described. Major land-claim projects will, however, result in large-scale loss of intertidal and subtidal estuarine habitats. These areas may be vial to some species as nursery areas, spawning grounds or feeding areas. On a large scale, land-claim will also alter the hydrodynamic regime of the inlet and this may result in the loss of sheltered areas and the favouring of species that prefer higher rates of
water flow. The dredging of navigation channels in harbours and estuaries may also be a problem as this operation releases fine suspended matter into the water column which can clog the gills of fish.

Power stations are another threat, not only from thermal discharges but also because the intake screens destroy very large numbers of small fish each year. This threat could be alleviated by better design of the intake screens to ensure that they are less destructive and by better siting of the screens to avoid fish migration routes (G Potts pers. comm.).

Individual fish species may also be under threat from more insidious sources. For example, concern has recently been expressed over the genetic purity of wild Scottish salmon and the problems that may develop if interbreeding occurs between native stocks and escaped fish-farmed salmon. Escaped fish may also disturb the native stocks. Concern is based on the fact that breeding activity may be disrupted in rivers and that there is a possibility of fish-farmed salmon disrupting the natural behaviour of native salmon at sea when the native stocks prepare to move up-river (NCC 1988b).

8.4.9 Conservation of estuarine fish

The term ‘conservation’, in relation to fish species that inhabit estuaries, can be interpreted in a number of different ways. Most of the discussion on fish conservation in the past has been based on species that are considered to be commercially important. Recently, however, other aspects have been receiving attention, such as the amenity and recreational value of fish and the conservation, in the true sense of the word, of rare or endangered species.

Four out of the 18 species of fish that occur regularly in estuaries are considered by Maitland (1974) to be rare or of restricted distribution and so are of particular nature conservation interest. These species are the sturgeon, allis shad, twaite shad and the houting. Until recently none of these species was protected under the Wildlife & Countryside Act 1981, but the allis shad has now been added to Schedule 6 of the Act.

The Berne Convention on the Conservation of European Wildlife and Natural Habitats 1979 (see Chapter 9) covers fish. Appendix III of the Berne Convention lists these six estuarine species as rare:

- Salmon *Salmo salar*
- Sea lamprey *Petromyzon marinus*
- River lamprey *Lampetra fluviatilis*
- Twaite shad *Alosa fallax*
- Allis shad *Alosa alosa*
- Common goby *Pomatoschistus microps*

The sturgeon *Acipenser sturio* is listed under Appendix I and II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

It is not entirely clear, however, what actually constitutes a ‘rare’ British marine fish. Work is currently underway at the Marine Biological Association of the United Kingdom, under contract to the Nature Conservancy Council, to rectify this situation by collating all records of fish reported as rare or uncommon. A provisional list is given in Table 8.4.3. Such information will be invaluable in the conservation of these species, although any measures will have to be taken in conjunction with the protection of estuaries as a whole and the management of the more damaging of man’s activities.

In general the main hope for the future, in terms of the general conservation of estuarine fish, would seem to lie in persuading those concerned in sport and other fisheries’ management to maintain a responsible attitude towards our native fish stocks (Maitland 1974). In addition, those concerned with all aspects of estuarine and general water use need to be stimulated into taking account of the value of these native fish populations.

Practical steps that could be taken to help conserve some of these rarer species range from maintaining free access to streams where anadromous species such as the sea lamprey are known to occur, to making further improvements in water quality in estuaries (Lelek 1987). Water quality has been a major factor in the decline of many species and improvements would assist not only populations of commoner estuarine, catadromous and anadromous species, but also species such as the sturgeon, the allis shad and the twaite shad.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific name</th>
<th>IUCN category of threat</th>
<th>Abundance</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sturgeon</td>
<td><em>Acipenser sturio</em></td>
<td>endangered</td>
<td>scarce</td>
<td>localised</td>
</tr>
<tr>
<td>Allis shad</td>
<td><em>Alosa alosa</em></td>
<td>vulnerable</td>
<td>scarce</td>
<td>localised</td>
</tr>
<tr>
<td>Twaite shad</td>
<td><em>Alosa fallax</em></td>
<td>vulnerable</td>
<td>scarce</td>
<td>localised</td>
</tr>
<tr>
<td>Houting</td>
<td><em>Coregonus oxyrinchus</em></td>
<td>endangered</td>
<td>scarce</td>
<td>single pop⁷</td>
</tr>
</tbody>
</table>

Table 8.4.3 Rare estuarine fish (based on Swaby & Potts in press)
8.4.10 Conclusions

Overall, estuaries play a crucial role for many species of fish, by providing the necessary migration routes, spawning and breeding areas, or by providing an environment in which the limited number of true estuarine species can spend almost the whole of their lives and in which a larger number of less estuarine-dependent species spend part of their lives.

The pressures on estuaries and their fish populations is likely to continue and to be augmented by other complications as the demand for water by industrial, domestic and recreational users increases (Maitland 1974). It is only through careful planning and the management of exploited stocks that we will be able to ensure the continued diversity, abundance and viability of British estuarine fish populations.

8.4.11 References


Amphibians and reptiles

12 species of native amphibians and reptiles occur in Britain. Most are widespread but three species, the natterjack toad *Bufo calamita*, the sand lizard *Lacerta agilis* and the smooth snake *Coronella austriaca*, are much more restricted in their population size and distribution.

Natterjack toads are particularly associated with estuaries in Britain and of an estimated adult population of a few tens of thousands, approximately 95-96% occur on coastal areas adjacent to estuaries (A S Cooke pers. comm.). The great majority (at least 81%) of the British population lives in the extensive dune and marsh systems associated with the estuaries of the Solway, Esk, Duddon, Ribble and Alt in south-west Scotland and north-west England (Figure 8.5.1). Elsewhere there is a small population on Morecambe Bay, and there are small populations, each amounting to no more than 2% of the total, on the Dee in north-west England and the Humber and North Norfolk Coast. Those on the North Norfolk Coast have been reintroduced there. Away from estuaries natterjack toads occur only on a coastal dune system in East Anglia and two heathlands in southern and eastern England (NCC 1986).

Sand lizards now number only a few thousand adults and are restricted chiefly to mature heathland in southern England, including the heathlands surrounding Poole Harbour. Elsewhere in Britain there is a small isolated population in the Merseyside dunes within 2 km of the shores of the Ribble and Alt estuaries, with an estimated 5% of the British population. The smooth snake is now restricted to mature southern England heathlands including those surrounding Poole Harbour.

The ranges of all three species have contracted substantially during the last century largely as a consequence of the destruction of and damage to their heathland and sand-dune habitats by afforestation, urbanisation, agricultural land-claim, military activities, mineral extraction and leisure and recreational pursuits. The combined effects have been considerable: there are historical records of about 70 heathland populations of natterjack toads of which only one or two survive. The populations in the north-west England coastal systems have fared better; these habitats have been subject to less change and, especially further north, are of crucial importance to natterjack toads in Britain.

The endangered status of the natterjack toad, sand lizard and smooth snake was recognised when they were afforded special protection under the Conservation of Wild Creatures & Wild Plants Act 1975 and the Wildlife & Countryside Act 1981. It is illegal to disturb, catch, kill, possess or sell these species without an appropriate licence.

Reference

8.6 Birds

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Moult in waders
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Lapwing
Curlew
Snipe
Dunlin
Págrove plover
Avocet
Other breeding waders
Total estuarine-breeding wader populations

Breeding seabirds
General estuarine distribution
Black-headed gull
Lesser black-backed gull
Herring gull
Sandwich tern
Common tern
Arctic tern
Little tern
Other breeding seabirds

8.3.5 Conservation of British estuarine birds
Conservation of breeding birds
Conservation of migrant and wintering birds

8.6.6 References

Summary

British estuaries are of major national and international importance for migrant and wintering waterfowl. Many species depend wholly or largely on British estuaries for crucial periods of the year. Three groups of birds are particularly striking and abundant: waders and wildfowl (together known as waterfowl), and seabirds.

Many waterfowl that breed across vast areas of arctic, sub-arctic and temperate regions crowd onto British estuaries in winter. Many others use them as vital staging areas before flying south to overwinter in Europe and Africa and then back north to their breeding grounds in spring. Some waders and seabirds breed at high densities on saltmarshes and the habitats surrounding estuaries.

Estuarine birds can be highly mobile, and depend on a network of sites or parts of sites during their annual cycles. Their use of a particular estuary varies from bird to bird, from species to species and from year to year.

Migrant and wintering waterfowl

Wintering waterfowl depend on the mosaic of habitats within estuaries. Many waders and some wildfowl feed on the intertidal mudflats and saltmarshes, and sometimes during high tide on surrounding pools and pastures. Many roost on undisturbed saltmarshes and shingle banks and other surrounding terrestrial habitats. Other wildfowl feed on surrounding marshes and farmland, returning to roost on the estuary.

In January over 1,740,000 waterfowl are present on estuaries – 62% of the British wintering population, and over 10% of the relevant international populations. 581,000 of these are wildfowl (38% of the British and almost 4% of north-west European populations); and almost 1,159,000 are waders – a massive 90% of the British and over 15% of the East Atlantic flyway populations.

Waterfowl are widely distributed around estuaries. Major concentrations are on The Wash (over 180,000 birds), Morecambe Bay (over 140,000 birds) and the estuaries of Essex and north Kent (almost 229,000 birds – over 13% of the British...
Twenty-six wildfowl species and 18 wader species occur regularly in winter on estuaries. Almost three-quarters of the waders are dunlins, knots and oystercatchers, and over half the wildfowl are wigeon, dark-bellied brent geese and shelduck.

In January estuaries support more than half of 18 British waterfowl populations and more than 10% of 21 international waterfowl populations.

Estuaries are of particular international importance for knots (67% of the international population), redshanks (55%), bar-tailed godwits (50%), alpina subspecies dunlins (27%) and oystercatchers (26%). Amongst wildfowl, estuaries support over 75% of the small Svalbard-breeding population of light-bellied brent geese, and major proportions of international populations of dark-bellied brent geese (over 50%) and barnacle geese (100% of the Svalbard population, 70% of the Greenland population).

Five wader species and three wildfowl species (redshank, curlew, oystercatcher, dunlin, ringed plover, mallard, shelduck and wigeon) are particularly widespread on estuaries. In contrast, most goose populations are restricted to less than one-quarter of estuaries.

Estuaries are important for waterfowl not just as wintering sites but also as refuges in cold weather, as moulting sites and as migration staging areas. At these times many other populations and individuals depend on British estuaries. During migration many more waterfowl use British estuaries than are present at any one time — at least 15-20% of the international waterfowl population in autumn and in spring. Maintenance of late spring staging areas is particularly critical as birds are then rapidly storing energy and nutrient reserves for long-distance migration and for survival on their breeding grounds.

The key implications for estuarine conservation of these winter and migratory waterfowl numbers and distributions are that:

- British estuaries overall are of major national and international importance for waterfowl assemblages, and for many individual species.

- Although many waterfowl are widely dispersed around estuaries, many are almost entirely dependent on them for their winter and migratory survival, and for some species a few particular sites are crucial.

- Wintering waterfowl depend on habitats on both small and large estuaries.

- Movements and population turnover, especially during migration, mean that a much greater proportion of the international population of each species depends on estuaries than is present at any one time.

- Estuaries are used as a network, and different parts of the network are important for different species and populations, and at different times.

Estuaries support a variety of other wintering birds, notably divers, grebes and sea-ducks (especially in north-east Scotland), gulls, birds of prey (especially hen harrier, peregrine and merlin) and passerines, for example Lapland buntings and twites.

Breeding birds

Estuaries are of particular conservation importance for their breeding bird assemblages, typically dominated by waders or locally by seabirds.

Saltmarshes around Britain support some very high densities of breeding waders — sometimes over 100 pairs per square kilometre. Some grasslands associated with estuaries also support large populations, but generally total densities, and densities of individual species such as redshank, are higher on saltmarshes than on nearby coastal grasslands.

British estuarine populations of redshanks and ringed plovers are particularly important in a national and international context. 7% of the international population of redshanks and 19% of ringed plovers breed around estuaries.

Britain is of major international importance for breeding seabirds, supporting over half the European Community population of each of 14 species. Gulls and terns breed on at least 75 estuaries. Most estuarine breeding seabirds are on upper saltmarshes, sand-dunes and shingle, and estuaries support over 1% of the international breeding population of six species. Estuaries support almost three-quarters of the scarce British breeding population of little terns.

The conservation of estuarine birds depends on safeguarding remaining areas of estuarine habitats. The dependence of birds on site networks means that they are particularly vulnerable to piecemeal habitat loss. The loss of one part can destroy the integrity of the network. Maintaining the health of all parts of an estuary is also vital, since breeding and wintering birds depend on the habitat mosaic and are vulnerable to pollution and recreational disturbance.

8.6.1 Introduction

Birds are one of the most striking features of estuarine wildlife. Three groups of birds are particularly abundant on estuaries: waders (sometimes also called shorebirds), wildfowl (including grebes, ducks, geese, swans and coots)
and seabirds (especially gulls and terns). Migrant waders and wildfowl, together called waterfowl, congregate in large numbers on estuaries during their non-breeding seasons. Here the abundance of invertebrate animals in the mudflats and sandflats provides food for many species of waders and some wildfowl, and grasses and seeds on both intertidal areas and the surrounding sub-maritime habitats provide food for wildfowl. The open nature of estuaries and the relative inaccessibility of many parts of them provide security from attack by predators and safe undisturbed roosting sites for waders when their feeding grounds are covered by the tide, and for wildfowl at night.

The large number and size of British estuaries and their location in the east Atlantic leads to their providing particularly favourable conditions for waterfowl (see Chapter 5). British estuaries are of major national and international importance for many of these species. Many waterfowl breeding throughout the tundras and other arctic habitats use Britain as a wintering ground or as a migration staging area before flying further south to overwinter in southern Europe and on the western seaboard of Africa. These waders, ducks, geese and swans visiting Britain breed across a vast area of the northern hemisphere from as far west as the central Canadian arctic (105° W) and east to central Siberia (110°E). Other species, particularly some ducks, that reach Britain in winter breed further south over a large area of temperate and boreal Europe and western Asia (Figure 8.6.1).

The short summers and limited natural productivity impose constraints on the breeding densities of arctic-breeding birds, and most waders and wildfowl nest at low densities over extensive areas of the arctic. For example, Meltote (1985) found a maximum breeding density of 16.6 pairs km\(^{-2}\) for waders in high arctic Greenland and northern Canada. By contrast, in winter these waders are highly concentrated on estuaries such as those in Britain and often occur in flocks of tens of thousands. Densities on British estuaries are exceptionally high and exceed 500 birds km\(^{-2}\) km on many estuaries. The wintering population on a single estuary can therefore represent the breeding birds from a vast area of the arctic. Similarly, high densities of wildfowl occur in winter on many British estuaries yet these species too breed at very low densities in the arctic. There were, for example, only 16 breeding pairs of Greenland white-fronted goose Anser albifrons in a 750 km\(^{2}\) area of prime breeding habitat in west Greenland - a density of 0.02 pairs km\(^{-2}\) (Stroud 1981).

Many estuarine birds are highly mobile; they depend on a network of estuaries during their annual cycle and the ways in which they use estuaries are complex. Their use of estuaries emphasises the importance of conserving networks of such sites on both a national and international basis, since the loss of one site in the network may critically affect the success with which migrant birds can move between their breeding and wintering grounds. So international conventions and directives, notably the Convention on Wetlands of International Importance especially as Waterfowl Habitat (the 'Ramsar Convention') and EEC Directive 79/409/EEC on the Conservation of Wild

![Figure 8.6.1 Breeding range of waders and wildfowl that use Britain as a wintering area and migration staging area. Arrows show generalised migration routes of birds returning from their breeding grounds in autumn.](image-url)
Birds play a particularly significant part in the conservation of estuarine birds and the protection of their habitats. The implementation of these international measures is described in Sections 9.2.3 and 9.2.7.

The saltmarshes, shingle ridges, sand-dunes and grasslands around estuaries provide important breeding habitats for waders, wildfowl and seabirds, and for some of these species British estuaries are internationally important. Some species of wader breed at very high densities around parts of British estuaries (Fuller et al. 1986), much higher densities than for arctic-breeding waders. The areas of suitable breeding habitat in Britain — as elsewhere in western Europe — are, however, much smaller than in the arctic. Some birds breeding on estuaries (for example some ringed plovers Charadrius hiaticula) remain close to their breeding areas throughout the year (e.g. Pienkowski 1980). Other waders and terns migrate further south and west after breeding to overwinter in southern and western Europe and western Africa.

This chapter describes the ways in which British estuaries are used by birds, the species involved, their distribution and abundance in both national and international terms, and the conservation significance of estuaries for them. It focuses first on general features of the use of British estuaries by migrant and wintering waterfowl. This provides an important contextual basis for understanding the analysis of the winter distribution and size of the waterfowl and other wintering bird assemblages, and for deciding the approaches to their conservation. The significance of British estuaries for breeding waterfowl and seabirds is then assessed and the chapter finishes with a description of the approaches to estuarine bird conservation and the main conservation issues affecting the use by birds of Britain's estuaries.

8.6.2 Migrant and wintering waterfowl

Background

A great deal is known about the distribution, behaviour and ecology of migrant and wintering waterfowl, through extensive research and surveys in Britain and elsewhere throughout their range. The origins and destinations of waders and wildfowl have been discovered, particularly since the mid-1960s, by the extensive catching, ringing (with individually numbered metal leg-rings), releasing and subsequent reporting of many thousands of birds. This work has been undertaken extensively on their wintering grounds in Britain and elsewhere, on their migration staging areas and, to a lesser extent, on their breeding grounds. More recently the use of a variety of colour-marks (especially temporary plumage dyes, temporary coloured leg-flags and permanent colour-rings) has become widespread in Europe and elsewhere, as a means of identifying the origins of birds without the need to recapture them and as an aid to the detailed behavioural studies that have revealed much of importance in the conservation of waterfowl (e.g. Townshend 1985). Since waterfowl are so mobile the success of many of these studies has depended on national and international cooperation on a wide scale, often arranged through the Wader Study Group (e.g. Pienkowski & Pienkowski 1983; Piersma et al. 1987a).

The distribution of waders and wildfowl during their non-breeding seasons has been established through regular coordinated counting of birds, involving the cooperation of a large number of voluntary counters simultaneously visiting estuaries and other wetlands, usually monthly (e.g. Prater 1981; Owen et al. 1986; Salmon et al. 1989). In addition there are a large number of more detailed studies of individual estuaries and species, that have provided much vital information on how waders and wildfowl use estuaries.

Sources and treatment of information

The major source of comparable information on non-breeding waders and wildfowl on different British estuaries is the monthly counts undertaken by the Birds of Estuaries Enquiry (BoEE), begun in 1989 and organised by the British Trust for Ornithology, with funding from the NCC, RSPB and recently from the Department for the Environment for Northern Ireland. This enquiry gives information on the distribution of estuarine waders and permits monitoring of population trends.

Counts of wildfowl made during BoEE counts are incorporated into the National Wildfowl Counts (NWC). This programme was established by the Nature Conservancy (the forerunner of the NCC) and has been operated since 1947 by the Wildfowl and Wetlands Trust, funded by the NCC. NWC counts are made monthly between September and March and cover over 1,000 sites in Britain and Northern Ireland. In addition special censuses are made of some goose species that feed away from wetlands during the day. National Wildfowl Counts provide information for some review sites not covered by the BoEE. The results of the NWC are analysed in detail in Owen et al. (1986).

The results of the first five years of BoEE which provide information on both wintering birds and those present in autumn and spring, are described in detail by Prater (1981), and more recent results are summarised in annually produced reports, the most recent being Salmon et al. (1989). Waders, wildfowl and some other estuarine birds are included in BoEE counts which regularly cover 112 British sites listed by Mose (1987). The BoEE provides a long-term and comprehensive picture of estuarine bird populations unparalleled anywhere else in the world.

The Estuaries Review includes some sites not covered by the regular wildfowl and wader counts. Information on these sites is less comprehensive.
In 1984–1986 over 90% of the non-cliff shores outside estuaries (sensu Moser 1987) were surveyed for waders in midwinter by the Winter Shorebird Count, which was undertaken as an extension of the BoEE and co-sponsored by the Wader Study Group (Moser & Summers 1987). This survey aimed to provide an estimate of the total coastal wintering populations of waders and to provide contextual information about estuarine waders. Some of these ‘non-estuarine’ sites that fall within review sites have subsequently been counted regularly as part of BoEE.

**Review site coverage**

Taking all these sources together, midwinter numbers could be calculated for 138 review sites (89%) for waders and 118 review sites (75%) for wildfowl. Site coverage is shown in Figures 8.6.2 and 8.6.3. In total there is coverage for waders and/or wildfowl for 142 review sites. Sites not covered for waders are scattered round the coast of Britain and are chiefly small sites with little intertidal area. In a few instances a site has been excluded from the Estuaries Review analysis when the only relevant count comes from a Winter Shorebird Count that also covered a long stretch of open coast outside the review site. Most review sites for which there are no data for wildfowl are those in north and west Scotland that have received only Winter Shorebird Count coverage for waders.

**National and international population sizes**

The numbers for each species and review site are set into their national and international context by comparison with estimates of the total British and international numbers of the appropriate biogeographical populations. A biogeographical population is described as a more or less discrete group of birds which live in a particular area (or group of areas in the case of a migratory population), interbreed freely within the group and rarely breed or exchange with individuals of other groups (Mayr 1970). In most cases a biogeographical population relates directly to a species or subspecies, but for some geese that overwinter in Britain there are several distinct biogeographical populations within a subspecies (see Owen et al. 1986; Stroud et al. 1990). This approach fits with the accepted approach to conservation planning embodied in the Ramsar
Convention. Note however, that in some cases the BoEFE/NWC data do not permit full separation into biogeographical populations, particularly when there are small numbers of birds present away from their main wintering areas. In these instances the biogeographical populations are summed in the general analysis for consistency of treatment, and are later described in more detail based on additional biological studies.

The most recent comprehensive estimates of the British populations of waders in January are given by Moser (1987) for the period 1981 to 1985. Similar estimates of British wildfowl populations are given for 1977-1981 by Owen et al. (1986).

International population estimates come from data co-ordinated by the International Waterfowl and Wetlands Research Bureau (IWRB). Wildfowl population sizes are derived, for the western Palearctic and Sahelian Africa, largely from January counts made during the International Waterfowl Census, recently updated by Pirot et al. (1989). International wader population estimates have also been recently updated by Smit & Piersma (1989). The relevant international wintering populations are those of north-west Europe for wildfowl and the East Atlantic Flyway for waders (Figure 8.6.4).

**Choice of data to describe wintering populations**

The total populations of waders and wildfowl used for individual site conservation assessments are generally the mean of the peak totals counted during the course of the winter (November - March for waders, September - March for wildfowl) (Prater 1981; Salmon et al. 1989). These values are usually calculated over the most recent five winters, to allow for annual variations in population size, and give a good general assessment of numbers at that site. For species that are mobile, i.e. most waders and wildfowl, the sum of the mean peaks is, however, usually greater than the total population of the birds. This is because birds move between estuaries and so can be counted in different months on different sites. The importance of this population turnover is further discussed below. Because of this turnover, peak means are, however, inappropriate for analyzing the proportions of the biogeographical populations occurring on review sites.

As the basis for describing the distribution and significance of wintering waterfowl on British estuaries we have therefore used the numbers present in January. For sites for which there are BoEFE/NWC counts we have calculated a five-year January mean for the most recent years of data available to us - 1983-1987. To those have been added the Winter Shorebird Count data for other review sites collected mostly in midwinter 1984/85. The population sizes so calculated thus represent the best estimate of the size and distribution of the midwinter population.

Use of January counts for this assessment has several advantages, in addition to permitting the incorporation of Winter Shorebird Count data. January is usually the month in which peak numbers of many species of waders and wildfowl occur in Britain, although some do occur in greater numbers during migration periods (see Salmon et al. 1989). January is also the month in which greatest coverage of sites is achieved in Britain (Salmon et al. 1989). It coincides also with the International Waterfowl Counts, and so permits direct comparison of the populations on British estuaries with the international population estimates (Pirot et al. 1988; Smit & Piersma 1989).
Furthermore, January is the period of the winter in which there is least population movement (except when a period of severe weather causes birds to move—see later) since most waterfowl have by then reached their winter quarters but have not yet begun their return spring migration. Note however that the January distributions and numbers described below provide a minimum indication of the numbers of birds using an estuary and are not directly applicable to the conservation assessment of nationally and internationally important sites (see Stroud et al. 1990).

It is important to note that the estimates of national and international population totals are made only periodically and so are held fixed for periods of several years. This has important advantages in establishing medium-order stability in conservation assessments of waterfowl populations. However, since many high arctic waterfowl, especially species such as brent goose, have very variable breeding success, actual numbers may fluctuate round the average value. The calculation of a five-year mean does, however, help to smooth out these fluctuations. For populations undergoing a long-term decline or increase in numbers it means that the best estimate for the biogeographical population lags behind the true population. So in some instances the observed population may apparently exceed the total national or international population. Calculated percentages of total populations should therefore be treated as approximate and indicative.

Assessing autumn and spring populations

Assessing the patterns of usage of British estuaries during autumn and spring from BoEE/NWC counts is more difficult than for winter for a variety of reasons. Firstly, coverage of sites is more restricted during these periods. Secondly, several biogeographical populations behaving in different ways may be present on an estuary at the same time, but are not usually distinguishable in total counts. In autumn some birds arrive on estuaries in Britain and elsewhere in western Europe and then spend several weeks or months there molting their body and wing feathers. At the same time other populations from different breeding grounds depend more briefly on the same estuaries without molting, before migrating further south to southern European and African wintering grounds. For such birds these sites provide vital feeding areas that permit them to store the fat and protein reserves essential for their onward migration to more southerly wintering areas. At these times the rate of turnover can be very rapid so that a single monthly count does not adequately represent the total usage of the site.

Spring, when there is rapid turnover of birds returning from southern wintering grounds joining those that may have overwintered in Britain, presents a similar problem. Many spring migrant waterfowl also spend only two to three weeks on such staging areas so that monthly counts, as in autumn, cannot elucidate site use; such single snapshot counts underestimate the numbers using a site. Nevertheless such staging sites provide vital feeding grounds that enable these birds to accumulate sufficient nutrient reserves to return to their breeding grounds and breed successfully. Accordingly we describe the use of British estuaries outside the midwinter period from the evidence of the more detailed studies of moult and migration that have been carried out in some places (e.g. Stevenon 1977; Ferns 1980a, 1980b, 1981a, 1981b; Moser & Carrier 1983; Prys-Jones et al. 1986).

The use of BoEE/NWC counts for assessing bird populations on review sites

BoEE/NWC counts provide the most comprehensive and comparable information for describing the distribution and abundance of British estuarine waterfowl but their interpretation requires an understanding of their limitations in relation to the behaviour of the birds. Counts are made usually during the period of high tide, when waders are either aggregated on their roost sites or arriving at or leaving the sites, since at this time the birds are most readily counted. At low tide birds are dispersed widely over often extensive tidal flats and cannot readily be counted accurately, particularly on large estuaries. The counts therefore provide a reliable assessment of the numbers of birds roosting in the area. Whilst in many instances waders roost close to their feeding grounds, some, however, can move considerable distances to roost (Furness 1973; Davidson & Evans 1988; Mitchell et al. 1988), even into adjacent estuaries. So high tide counts may not always represent the numbers that feed on the same estuary.

The feeding distribution and numbers of waterfowl present during low water are becoming known for an increasing number of British estuaries, but not yet widely enough for a comparative assessment of review sites. Furthermore such data have often been collected for only one year, or at most a few years, frequently as part of environmental impact studies for proposed developments. Low-water count distributions cannot yet provide the long-term picture needed for adequate site assessment for these mobile birds with their variable breeding success.

High-tide counts provide a good assessment of the numbers of those wildfowl species that both feed and roost on the same estuary. Some species, especially swans and geese, feed during daylight on farmland away from the estuary, returning there only to roost at night. Since high-tide counts are made during daylight they can underestimate the numbers of wildfowl using the estuary, and for these species special counts are made. Numbers of wildfowl counted on estuaries should therefore be regarded as minima.

Boundaries of review sites have been set on a geographical basis and have been designed to permit the assessment of a wide variety of wildlife
features and human activities rather than just the bird populations. In most cases BoEE sites (Mose 1987) fall within review sites. Boundaries of BoEE sites are, however, generally more limited than review site boundaries since they are determined by the location of roost sites and not the location of the intertidal feeding areas. For some review sites this means that only part, usually the lower reaches, is covered by BoEE counts. Since the counts are designed to cover the places where there are waterfowl present, and since generally few waterfowl occur on the narrow upper tidal river channels, this is unlikely to affect the counts substantially. Some review sites, e.g. the Moray Firth and the Firth of Forth, are covered by several BoEE sites: counts for these have been summed to provide a total coincident with the relevant review site boundaries. Detailed studies on the mobility of waders using these estuaries (Symonds et al. 1984; Symonds & Langstow 1986) have shown that the tidal line between contiguous intertidal areas, used to delimit Estuaries Review sites, coincides with natural boundaries for some species, although some other studies link several of these areas together, as for example on the Dornoch, Cromarty and Moray Firths (see Figure 5.6.18).

In some parts of Britain, areas of freshwater wetlands adjacent to the upper parts of review sites are used extensively by wintering waterfowl. Such places include the Ouse and Nene Washes (The Wash) and Amberley Wild Brooks (Arun Estuary). These wintering waterfowl populations are not directly associated with estuaries at any time and they have been excluded from the calculations of waterfowl population sizes, since their inclusion would greatly distort the apparent population sizes and densities on some estuaries.

The 1% criterion as an indicator of population importance

In some of the analyses we have described patterns of population dispersal in relation to populations comprising at least 1% of the estuarine, national or international populations. The 1% criterion has proved valuable as a basis for evaluating the international importance of a site for birds since it has been found to provide an appropriate degree of protection for many populations and is useful in the definition of ecologically coherent sites (Atkinson-Willes et al. 1982; Fuller & Langslow 1988). The criterion has gained wide acceptance throughout the world and is used by the Contracting Parties of the Ramsar Convention as a criterion for identifying wetlands of international importance (Atkinson-Willes et al. 1982). However, the 1% measure works well only for those populations which tend to congregate. This means that it is a particularly effective criterion for those species such as whooper swan and brent goose that depend on just a few traditional wintering areas. It is important to remember that, although we describe the distribution of many waders and waterfowl as being widespread around estuaries, estuaries form only 2.3% of the total area of Britain (see Chapter 6), so that all waterfowl species that are substantially dependent on estuaries have a highly restricted distribution in national and international terms. Nevertheless this analysis shows later that, even for some of the waterfowl that are more widely dispersed around British estuaries, a 1% site assessment criterion alone is inadequate to identify the location of all sites important to a wintering population.

This 1% assessment is, however, only one aspect of the assessment of the significance of an estuary for its wildlife importance (see Stroud et al. 1989), and it generally provides a minimum assessment the importance of a site. All sites supporting 1% or more of a population at any one time are undoubtedly of national or international importance. With supplementary understanding of the ways in which birds use these sites (see below) these sites generally assume even greater importance and others attain such significance (see e.g. Stroud et al. 1990; Ridgill & Fox 1990). Even as a direct numeric assessment there are, however, complications with the use of this 1% criterion alone, as is discussed below.

Stroud et al. (1990) point out that the 1% level is fairly conservative for both national and international assessments. For example, human populations are an extreme example of a numerous species that forms dense concentrations, with a British population of about 56,000,000 and hence a 1% level of 560,000. On the 1% basis the only cities qualifying as 'nationally important' would be London, Birmingham, Sheffield, Manchester and Liverpool. Glasgow could be included if its satellite towns (e.g. Paisley) were included. Only London would be defined as 'internationally important'.

The 1% levels quoted in this review generally underestimate the importance of individual sites since they are expressed in relation to January population sizes only, rather than to the values for the average peak wintering populations used in site conservation assessment. Even so a 1% value based on peak monthly counts is still conservative since the turnover of individuals present on an estuary means that the total proportion of an international population using it can be very much higher than the number of individuals present at any one time (see e.g. Smit & Piersma 1989). The effects of population turnover are described further below. It important to recognise that the analyses in this report are designed to describe the ways in which wintering waterfowl use British estuaries, and do not provide the definitive assessment of their individual conservation importance for birds. The approach to such conservation assessments is set out in NCC (1989) and Stroud et al. (1990).

Reliable use of 1% values in assessing demographic patterns and site importance depends on there being good estimates of the total national and biogeographical populations. The BoEE programme of co-ordinated monthly counts provides this detailed information for Britain and forms a part of extensive co-ordinated counts in western Europe that provide good estimates for
North-west European wader populations and
waders on the East Atlantic Flyway (Piot et al.
1989; Smit & Piersma 1989), and, recently, in
the New World, particularly in South America
(Morrison & Ross 1989). However, for most other
parts of the world such necessary and detailed
information on the status of migratory bird
populations is incomplete or non-existent (Pari:
sh et al. 1987; Summers et al. 1987; Parish 1989).

A further complication of using only a 1% popu-
lation level in site assessment is the variations
in the preference shown by birds for different sites.
When populations are small, birds select first those
sites that most fully provide for their requirements
and where their chances of survival are highest
(Pienkowski & Evans 1985). As populations
increase, however, not all birds are able to use
these favoured sites and an increasing number use
less suitable sites elsewhere. Hence the proportion
of the population on the most preferred sites
decreases as the overall population increases.

The clearest demonstration of this phenomenon is
for grey plover Pluvialis squatarola. The numbers
of grey plovers wintering on British estuaries, and
the range of sites used, have greatly increased in
recent years, such that the index of British
midwinter population size is now almost four times
larger than in 1973 (Salmon et al. 1988). Moser
(1988) showed that there seems to be a limit to the
numbers of grey plovers that can use any one site.
Thus at many preferred sites, where carrying
capacity has apparently been reached, the
midwinter population is no longer increasing. As a
consequence of the overall increase in numbers, the
proportion of the population using these
preferred sites (some of which are small estuaries)
has declined. As Moser (1988) points out, this
trend means that even an area such as the north-
west Solent (Beaulieu River and Lymington Estuary
review sites), which is one of the most preferred
sites for grey plovers in Britain, would cease to be
'nationally important' in numerical terms (on the
arbitrary 1% criterion) once the national popula-
tion levels rose to 30,000, although the area probably
held 5% of the national population when there were
only 5,000 grey plovers wintering in Britain.

Moser (1988) proposed a refinement to the 1%
criterion to take into account the ranking of sites on
their degree of preference by different species,
where such data exist. Even less-preferred sites
are, however, important for arctic-breeding bird
populations with variable breeding success, since
there is a need to support a population when it is at
a high level so as to ensure that there will still be
adequate breeding populations after a sequence of
years of poor breeding success (Stroud et al.
1990).

Overall, then a 1% criterion provides an effective
initial tool in the identification of important wetlands
for wintering waterfowl, particularly where a more
detailed understanding of the behaviour and
ecology of waterfowl using a site is lacking.
Assessment of the overall conservation importance
of a wetland must, however, also take into account
other factors, such as the favourability of the site
and its population turnover, and various additional
values of the site such as its use when birds are
moulting their feathers, and when accumulating
nutrient reserves before or during migrations
(Piersma et al. 1987a; Smit & Piersma 1989). The
role that British estuaries play in relation to these
features is described further in the following part of
this review.

**General features of the use of British
estuaries by waterfowl**

The annual cycle of migrant waterfowl
The severe winter weather and general absence of
available food mean that waders and wildfowl that
breed in the arctic and also in some more southerly

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**Figure 8.6.5** Summaries of the annual cycles of high-arctic breeding waders and wildfowl, typified by islandica race knot
(derived from Davidson & Wilson 1983) and dark-bellied brent goose (derived from Owen et al. 1986). Shaded parts of
the year show when birds depend on review sites.
latitudes cannot spend the whole of the year where they breed. Indeed, high-arctic breeders spend a very short time on their breeding grounds—often only the six to eight weeks between their arrival in early June and departure in mid-July to early August. In the other 10 months of the year they move great distances to and from their wintering grounds in places such as British estuaries, where they spend more than half the year. The annual cycle of typical high-arctic waders and wildfowl is summarised in Figure 8.6.5.

In the short period on their breeding grounds, arctic-breeding waterfowl must lay eggs, incubate them and, if successful, care for their precocial young until they have fledged, and also accumulate sufficient energy reserves to fly south towards their wintering areas. In general, adult waders leave their breeding grounds rather earlier than their young, since the juvenile birds have to grow a full set of flight feathers and also store reserves for their first migration. In contrast, adult geese stay with their young throughout the autumn and subsequent winter.

Migrations to and from arctic breeding areas often involve birds making flights of several thousand kilometres over inhospitable terrain such as mountains, oceans, high-altitude ice-caps, snow-covered land and other areas lacking suitable feeding grounds. To do this, waders and wildfowl store large amounts of fat and muscle protein that provide the fuel and the power for non-stop flights. These are often of over 3,000 km and last several days (e.g. Davidson 1964; Davidson & Evans 1986a; Piersma & Jukema 1990).

Many species stop at one or more migration staging areas, where they pause usually for only one or two weeks to replace nutrient and energy reserves used during the previous migratory flight en route to their wintering grounds. By early August many wader populations have left their breeding grounds and have reached estuaries in Britain and elsewhere in the southern North Sea, where they moult their wing feathers and body plumage. Other wader populations again pause for only a few days in western Europe to store further fat reserves and then fly on to western African shores before moulting. In contrast to waders, both arctic-breeding wildfowl and those of lower latitudes undergo a rapid moult in late summer before leaving their breeding grounds. During this period many wildfowl become flightless (Owen et al. 1986). Waders remain able to fly but their flying performance may be impaired (see e.g. Pienkowski et al. 1976).

Wing moult in waders takes about two to three months and by early October most birds have completed their moult. Some remain on the same estuaries to overwinter, others move to wintering grounds elsewhere in Britain and western Europe. Likewise most wildfowl begin to arrive on their British wintering grounds from mid-September onwards. Some remain on one estuary throughout the winter, but others are known to move between a network of estuaries during the course of the winter (e.g. Pienkowski & Pienkowski 1983; Pienkowski & Evans 1984, 1985).

Most waders and wildfowl begin to prepare for their return migration to their breeding grounds in March, when they begin to accumulate fat and protein reserves. To do so some remain in the same places in which they overwintered; others move in March to early-spring staging areas which provide particularly favourable feeding conditions for rapid acquisition of nutrient reserves. Many of the waders that overwinter on the west coast of Africa begin to return to west European staging areas at this time (Ens et al. 1989). By April and early May many of the waterfowl breeding in boreal regions are returning to their breeding grounds. High-arctic breeders remain on staging areas, some moving further north in early May to late spring staging areas in Iceland and northern Scandinavia (e.g. Wilson 1981; Davidson et al. 1986a). There they replenish nutrient reserves for further migratory flight. During spring, waders also moult their body feathers from a wintering plumage into an often more brightly coloured breeding plumage.

Waders particularly show a great variety of migration strategies in moving between wintering and breeding grounds (Burger & Olla 1984; Piersma 1987). These range from making a large number of "small hops"—a strategy dependent on availability of suitable feeding in many places and one in which the birds need to store only small reserves of fat as fuel for the short flights—to the behaviour of species such as knot Calidris canutus and bar-tailed godwit Limosa lapponica that "jump" between very few staging areas and store large amounts of fat for long flights (Piersma 1987). In some birds this pre-migratory accumulation of fat and muscle protein results in a doubling of their body weight.

This variety of migration strategies means that the significance of a particular British estuary during spring or autumn differs considerably between the members of a waterfowl assemblage present on the site. Different individuals of the same species may even have different migration strategies (see e.g. Pienkowski & Evans 1984). Furthermore, individuals may also require a different series of sites in different years (see e.g. Townshend 1985; Pienkowski 1990).

High-arctic waterfowl mostly leave their final spring staging areas in late May and early June, arriving on their breeding grounds a few days later. Such timing appears generally to have evolved to coincide with the period of snow-melt on the breeding grounds, so that food is available when, or soon after, the birds arrive (Green et al. 1977; Meloite 1985).

Not all individuals return to the breeding grounds in late spring, and some non-breeding individuals of many species, especially waders, remain on estuaries in western Europe and West Africa.
These summering birds are largely juveniles or sub-adults in species that do not usually breed at one year old (e.g. Prater 1981; Smit & Wolff 1981). Their survival is thus a crucial component of the conservation of the populations.

Long-term population trends and variations in breeding success

The numbers of each waterfowl species reaching its wintering grounds in Britain and elsewhere depends on the survival of the adult birds during their migrations and breeding season, on how many young they have managed to rear successfully and on the success of these young birds in making their first migration to their wintering grounds. Numbers, particularly of those species that breed in the high arctic, can vary substantially from year to year.

From detailed studies of individually-marked birds, Evans & Pienkowski (1984) showed that the annual survival of adult waders is very high, averaging over 80%, and that generally at least half the mortality occurred on their wintering grounds. So despite flying such long distances over inhospitable terrain, mortality on migration and breeding grounds is generally small, although Evans & Pienkowski did detect some years in which migration and summer mortality in high-arctic breeders were unusually high. This fits with observations that in occasional years there is high adult mortality of these species when severe weather occurs after the birds have started to breed (Morrison 1975; Meigle 1985; Boyd in press). Similarly high annual survival of adult waterfowl has been found in detailed studies of many species (Owen et al. 1986).

There is much more variation in the numbers of juveniles reaching western Europe. In part this is because many inexperienced young birds die in early autumn during their first migratory flight from their natal area (Pienkowski & Evans 1986; Owen & Black 1989). Once they have reached their wintering grounds the mortality of first-year waterfowl is often only slightly higher than that of adults. Migratory mortality is, however, superimposed on the often considerable variation in the numbers of young reared successfully to fledging. This has been particularly well studied in arctic-breeding swans and geese since they remain in family parties throughout the winter. So the numbers of young raised by each breeding pair can be readily counted when the birds are on their wintering grounds. This permits the use of age-related plumage differences to assess overall proportions of juveniles in flocks.

There are large variations in the annual breeding success of geese breeding in many different arctic and sub-arctic areas. The breeding success of dark-bellied brent goose Branta bernicla bernicla that nest on the Taymyr peninsula in northern Siberia has been particularly well studied, and found to vary greatly—between over 80% of the winter population being juveniles in some years to almost no juveniles in others. There is much current debate over the causes of these variations in breeding success, centring on the contributions to breeding success of the accumulation of sufficient nutrient reserves on spring staging areas, the weather conditions on the breeding grounds, and the impact of predation of eggs and young by arctic foxes Alopex lagopus (Ebbinge 1985, 1987, 1989; Summers 1986; Boyd 1987, Dhirar 1987; de Loor & Druint 1989). It has been suggested that in years when lemming populations are low but fox populations remain high the foxes change their diet to eat more waterfowl eggs and chicks (Summers 1986).

There is also a striking link between the breeding success of brent geese and waders such as curlew sandpipers Calidris ferruginea and canutus subspecies knots that are believed to breed in the same areas of Siberia (Summers & Underhill 1987; Underhill et al. 1989). Waders such as knots breeding in the nearctic also vary greatly in their breeding success but the annual success is not correlated between the two areas (Underhill et al. 1989; Davidson & Wilson 1991).

Whatever the underlying causes of these variations in breeding success, they result in sometimes large annual variations in the numbers of waterfowl occurring during autumn migration and in winter on estuaries in Britain and elsewhere in western Europe. As described above these variations in wintering population size affect the ways in which the distribution of populations and their conservation significance are described.

Breeding failures can also contribute to longer-term changes in population size. A series of poor breeding seasons in the early 1970s, attributed to late springs and severely cold summer weather on their breeding grounds, appears to have contributed to the prolonged decline in the total population size of the knots that breed in Greenland and northern Canada (Boyd 1991). The total wintering population of this subspecies has not recovered substantially in numbers since the mid-1970s (Davidson & Wilson 1991).

A number of other waterfowl populations wintering in western Europe and Africa have also been undergoing long-term changes. These are summarised by Pirot et al. (1989) and Smit & Piersma (1989). In some cases it is difficult to identify the effects of improvements in international counting coverage. In comparison with counts made from the early 1970s—summarised by Prater (1976)—Smit & Piersma (1989) found increases that they considered to be at least in part due to real changes in population size in the west European wintering populations of several wader species. These are oystercatcher Haematopus ostralegus, grey plover, bar-tailed godwit and ringed plover. Smit & Piersma found decreases in dunlin Calidris alpina, knot and, to a small extent, redshank Tringa totanus. These overall changes are apparent in Britain in increases in the population indices of oystercatcher and grey plover and decreases in
the indices of knot and dunlin, as derived from the BoEE (Figure 8.6.6).

![Graph showing population indices for knot and dunlin](image)

**Figure 8.6.6** Indices of wintering population size of increasing and declining waders in Britain, from Smit & Pierson (1989), with data derived from Salmon et al. (1987). The indices were set at an arbitrary value of 100 (shown by the dashed horizontal lines) for 1973.

There can be many causes of changes in population sizes, which may arise from conditions on breeding grounds, wintering grounds and/or migration staging areas. The changes in different wader populations seem to arise for different reasons. In oystercatchers an expansion of breeding range and diversification of habitat use is implicated (Sharrock 1976; Pierson 1986). The reasons for the increase in grey plover and bar-tailed godwit populations are not clear, although for grey plovers Tubbs (in press) suggests that the cessation in 1954 of formerly heavy shooting pressure in Britain may be a contributor. The decline in nearctic knot, as described above, seems to have arisen through adult mortality and poor breeding success in the early 1970s, but the reasons for the failure of the population to recover its numbers since then are not clear.

The decline in dunlin numbers has been particularly marked in Britain but has also occurred elsewhere in Europe. Goss-Custard & Moser (1989) have shown that loss of feeding grounds in wintering areas is implicated in this decline. They showed that declines have been largest where the spread of cord-grass *Spartina anglica*, which largely prevents dunlin from feeding within its dense sward, has been most extensive. (This species of *Spartina* resulted from the hybridisation of native and introduced species — see Section 8.1.5.) Long-term population changes can improve understanding of the significance of British estuaries for wintering waterfowl. A larger proportion of the total wintering population of knots now occurs on British estuaries than when the population was high in the early 1970s (Davidson & Wilson 1991), a further indicator of the likely preferred nature of British estuaries as wintering sites.

Piot et al. (1989) report stable or increasing population sizes for many wildfowl overwintering in north-west Europe but a decrease in pochard *Aythya ferma* numbers. The various biogeographical populations of geese have increased mostly significantly during the last few decades — see the example of dark-bellied brent geese in Figure 8.6.7. For many, including these brent geese, these increases are recoveries to formerly much larger populations rather than increases from healthy populations. These population increases have been attributed by Ebbinge (1985) and Madsen (1987, 1989) largely to reductions in mortality, brought about by restrictions on shooting in many parts of Europe, and to changes in agricultural practices which have provided better winter foraging. Several geese such as dark-bellied brent geese *Branta bernicla bernicla* have moved from saltmarsh and grazing marshes to feed increasingly in recent years on arable arable land. This seems to have arisen in part because the area of available saltmarsh has become increasingly restricted (see Chapter 10) and partly from the conversion of coastal grasslands, formerly used extensively by geese, to arable.

![Graph showing increase in the population of dark-bellied brent geese](image)

**Figure 8.6.7** The increase in the total population of wintering dark-bellied brent geese in Britain and northwest Europe, from Owen et al. (1986)

One small goose population has not increased since the relaxation of shooting pressure. The Svalbard population of the light-bellied brent goose *Branta bernicla hrota*, many of which overwinter in Britain at Lindisfarne, still numbers only less than 4,000 b.f.ds. Madsen et al. (1989) suggest that it may now be under pressure from competition on its breeding grounds from an expanding population of barnacle geese *Branta leucopsis* (Prestrud 1989), but the reasons for the decline are complex (see Stroud et al. 1990).

An understanding of population sizes and dynamics is important in developing conservation measures for waterfowl, particularly since annual population sizes may vary substantially. Small populations and/or those that depend on just a few estuaries are clearly vulnerable to loss or damage to their habitats. Substantially larger populations may, however, be more vulnerable than they seem. Baker & Strach (1988) and Baker (1991) have
recently found that most shorebird populations are much less genetically variable than those of other bird taxa. This means that the effective genotypic population size can be very substantially smaller than the observed number of birds, and that even apparently large and less vulnerable populations may face substantial risks from genetic bottlenecks leading to extinctions. Maintenance of population sizes and geographical ranges is therefore vital for the future conservation of these species.

**Autumn migration on British estuaries**

In addition to the arrival of birds returning to overwinter on British estuaries, these places have an added importance in autumn as staging and moulting areas for other waderfowl populations that overwinter further south.

**Migration routes and timings in waders**

The first waders returning to British estuaries in late July are adults. These are mostly birds whose breeding attempts have failed. Numbers of adults of most species then increase rapidly in August and September as those adults that have successfully reared young return. Juveniles generally arrive later than most adults, in August and September (e.g. Branson & Minton 1975, Insley & Young 1981; Townsend 1985).

Many arctic-breeding waders reach Britain, and other estuaries in western Europe, after pausing to refuel at migration staging areas such as Iceland (Wilson 1981); most of those breeding further south probably move directly from their breeding grounds to the estuaries. It is difficult to disentangle the patterns of use of British estuaries during autumn since there is often more than one age-class and population of a species present on one estuary at any given time.

This mixing of populations is particularly complex in dunlins where adults and juveniles of three different subspecies (four biogeographic populations) use British estuaries in autumn (Cramp & Simmons 1983). The small Greenland-breeding arctica population passes through British estuaries, en route for West African wintering grounds, in small numbers in August. This is also the main period of arrival of the nominate alpina dunlins from northern USSR and northern Scandinavia. Adult alpina dunlins remain on these estuaries to moult during the next few months (see below). After moult some remain on the same estuary to overwinter, while others disperse either locally or to estuaries elsewhere in Britain. The large Icelandic population of schinzii dunlins begins passing through Britain in early to mid-July, pausing on many British estuaries to replenish nutrient reserves for flight onward to north and west African wintering grounds. The presence of the much smaller Baltic and British-breeding population of schinzii dunlins is generally masked by the presence of large numbers of Icelandic birds, but ringing recoveries have shown that these temperate schinzii begin to pass through British estuaries in early July, with females arriving rather earlier than males (Piękniowski & Dick 1975). As a further complication, some schinzii dunlins begin to moult their wing feathers on south coast British estuaries such as Portsmouth, Chichester and Langstone Harbours (Stevenson 1977), before flying further south to complete their moult. Juveniles of each population pass through British estuaries later than the adults. Thus the composition of the dunlin population (summarised in Figure 8.6.8) that is present in autumn on British estuaries is complex and rapidly changing. To elucidate the ways in which wader populations use estuaries in autumn requires detailed studies on a site, involving catching, ringing and measuring birds to identify their origins and destinations.

![Figure 8.6.8 Periods of presence of different biogeographical populations of dunlins on British estuaries in autumn, derived from Piękniowski & Dick (1975). Solid bars are adults and shaded bars are juveniles. Alpina dunlins remain to overwinter in Britain; other populations migrate further south.](image)

There are similarly complex patterns of use by other waders using British estuaries in autumn. For example ringed plovers on British estuaries in autumn include moulters from the populations breeding locally, and from elsewhere in Britain, the southern North Sea and the Baltic. These birds generally remain to overwinter in Britain. In addition there are passage populations of arctic and subarctic breeding birds from Iceland, Greenland and northern Scandinavia. Some of these birds may have already started moultng before leaving their breeding grounds. These populations move further south to overwinter in north and west Africa after storing large reserves of fat (Clapham 1978; Insley & Young 1981; Cramp & Simmons 1983; Davidson et al. 1986b).

Similarly, the autumn redshank population includes moulters from three biogeographic populations (robusta from Iceland, totanus from Britain and totanus from Scandinavia and continental western Europe). The moulters remain to overwinter in Britain, but others from Britain and Europe move further south to moult and overwinter in Africa (Cramp & Simmons 1983, Davidson et al. 1986b).

In other species such as knot and curlew Numenius arquata the autumn populations on British estuaries are much less complex and consist almost entirely of one biogeographic population. Knots belong...
almost entirely to the Nearctic islandica race. Knots in Britain in autumn moult chiefly on a few major estuaries, notably The Wash, the Dee and North Wirral, the Ribble Estuary and Morecambe Bay, some before dispersing to overwinter elsewhere on British estuaries. Curlews in Britain in autumn are a moulting population of birds that have bred in Scandinavia, the southern Baltic and as far west as Belgium (Sainbridge & Minton 1978; Davidson et al. 1986b).

Several other waders, notably whimbrel Numenius phaeopus, greenshank Tringa nebularia and ruff Philomachus pugnax, occur on British estuaries almost exclusively during passage in autumn and spring (Prater 1981).

Juvenile waders generally leave their breeding grounds after the adults have departed and so must make their first migrations without any of the advantages accruing from making the flight with adults. Juvenile waders may not inherit a precise migration destination for this autumn flight; Pienkowski & Evans (1985) have suggested that instead juveniles leave their natal area with a general direction and a minimum distance to travel before alighting at a potential staging site. This pattern of autumn migration would explain why juveniles disperse more widely and appear on many estuarine and non-estuarine sites in which adults are scarce or absent (Pienkowski & Evans 1985; OAG Munster 1987).

In some biogeographic populations using the East Atlantic Flyway large numbers of adults occur in Britain only in exceptional circumstances, even during migration times. Examples are the Siberian-breeding curlew sandpipers and calidris tenuirostris. However in some years many birds, particularly juveniles, appear in Britain in autumn, often mostly on the east coast. These appear to be mainly birds that have overshot their normal staging areas further east (such as the Wadden Sea), often apparently assisted by strong easterly winds at the time of migration (Stanley & Minton 1972; Dick et al. 1987; Kirby et al. 1989). Influxes of curlew sandpipers seem to occur in years when breeding productivity is high (Kirby et al. 1980) and the birds are then more widespread on British estuaries and not restricted to the 39 review sites on which they regularly occur in small numbers (Figure 8.6.9).

Establishment of autumn migration patterns in waders

The pattern of migration established by a juvenile wader during its first autumn and winter appears to be very important. Townshend (1985) has shown that the migration phenology followed by juvenile grey plovers determines the migration and wintering areas they use later in their lifetime. Some first-year grey plovers arriving at Teessmouth in autumn managed to remain there along with the adult population throughout the winter. These birds returned to overwinter at Teessmouth as adults in subsequent years. In contrast, some first-year grey plovers were competitively excluded by adults from the feeding grounds. These birds left Teessmouth in the autumn and early winter, and some are known to have flown further south and attempted to overwinter in France. In subsequent years such birds used Teessmouth only briefly as a migration staging area in autumn. These findings also illustrate the migration staging site fidelity shown by many individual waders and species (e.g. Pienkowski & Evans 1984).

Autumn wader distributions on British estuaries

The distribution of many species of waders on British estuaries is much the same in autumn as it is in winter, although some species, such as knot, are particularly concentrated on a few sites, mainly because these are used as moulting areas (Prater 1981). The species assemblage of waders on British estuaries in August, the period of peak migration for many species, is illustrated in Figure 8.5.9. Autumn peak counts of curlew sandpipers in Britain in 1988, from Kirby et al. (1989). Note that most localities are estuarine. Sites in which there are regularly small numbers (average peak autumn count <35 birds) are marked with a triangle.
many more individuals use British estuaries at some point in autumn. Studies of turnover (see Smit & Piersma 1989, and below) indicate that actual numbers of a migrant population using an estuary are at least 1.5 times the number present at any one time. Thus the total number of waders using British estuaries in autumn may be in excess of 1,250,000 birds (at least 17% of the East Atlantic Flyway population – Table 8.6.1).

Comparison with the midwinter population (Figure 8.6.33) shows some broad similarities with the August population, which is dominated, although to a lesser extent than in midwinter, by dunlins, knots and oystercatchers. Together these three species form over 55% of the August assemblage. The approximately 160,000 knots are all juveniles and molting *islandica* adults and were about 30% of the international population of this species in the early 1970s. Almost all the remainder of this population moults on the Wadden Sea (Davidson & Wilson 1981). Much of the population occurs on four major estuaries: The Waith, Morcombe Bay, the Ripplet Estuary, and the Dee Estuary and North Wirral (Prater 1981; Davidson & Wilson 1990).

Oystercatchers and dunlins are much more widespread around British estuaries (Prater 1981). The assemblage in autumn is more diverse than in midwinter, with 13 species each forming more than 1% of the assemblage. Two of these species, whimbrel and greenshank, are almost entirely migratory on British estuaries. In other species at least part of the autumn population remains to overwinter.

### Table 8.6.1 Totals of waders, wildfowl and waterfowl on British estuaries in January 1983-1987. Data are from BoE/NWC counts.

#### a) All review sites

<table>
<thead>
<tr>
<th></th>
<th>No. of sites</th>
<th>No. of birds</th>
<th>% British population</th>
<th>% International population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waders</td>
<td>138</td>
<td>1,158,943</td>
<td>90.1</td>
<td>15.4&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Wildfowl</td>
<td>116</td>
<td>585,638</td>
<td>37.9</td>
<td>3.7</td>
</tr>
<tr>
<td>Waterfowl</td>
<td>142</td>
<td>1,740,181</td>
<td>61.7</td>
<td>10.2</td>
</tr>
</tbody>
</table>

#### b) Sites with large populations<sup>5</sup>

<table>
<thead>
<tr>
<th></th>
<th>No. of sites</th>
<th>No. of birds</th>
<th>% British estuarine population</th>
<th>% British population&lt;sup&gt;2&lt;/sup&gt;</th>
<th>% International population&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waders</td>
<td>27</td>
<td>924,451</td>
<td>79.8</td>
<td>71.9</td>
<td>12.2</td>
</tr>
<tr>
<td>Wildfowl</td>
<td>21</td>
<td>376,764</td>
<td>64.8</td>
<td>24.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Waterfowl</td>
<td>24</td>
<td>1,447,419</td>
<td>83.2</td>
<td>51.3</td>
<td>8.5</td>
</tr>
</tbody>
</table>

<sup>1</sup> Waterfowl = waders and wildfowl combined

<sup>2</sup> British populations: waders 1,286,130 (Moser 1987); wildfowl 1,533,750 (Stroud et al. 1990)

<sup>3</sup> International populations: waders (East Atlantic Flyway) 7,547,000 (Smit & Piersma 1989); wildfowl (north-west Europe) 16,231,000 (Prout et al. 1989)

<sup>4</sup> % on European Atlantic coast, of 3,207,900 birds (Smit & Piersma 1989) = 36.1%

<sup>5</sup> Waders >10,000 birds; wildfowl >10,000 birds; waterfowl >20,000 birds
Migration routes and timings in wildfowl

Wildfowl have rather different autumn migratory patterns from waders, since they generally moult on their breeding grounds before returning to western European estuaries. In addition, for geese and swans there is no difference in the timing of migration of adults and juveniles since they migrate as family parties which remain together during the subsequent winter (e.g. Evans 1979a; Owen 1982, 1984). Arctic and subarctic-breeding geese from Iceland and Greenland do not generally reach Britain until late September and October, with the Greenland populations of species such as the white-fronted goose and barnacle goose staging in Iceland. Many Siberian-breeding geese and swans reach areas of Denmark, West Germany and the Netherlands in autumn, some after staging in Norway and the Baltic. Movement to Britain generally occurs gradually in early winter, with the exact timing and numbers of birds reaching Britain dependent on the severity of winter weather (Owen et al. 1986). In some instances, however, autumn staging sites in Britain are of major importance to wildfowl. Substantially the whole population of Greenland barnacle goose Branta leucopsis arrives in October at one review site, Loch Gruinart on Islay in the Inner Hebrides (Easterbee et al. 1987). Here they feed for a few weeks before dispersing throughout their wintering range in Ireland and western Scotland, when a slightly smaller proportion of the population depends on estuaries.

Most ducks also move to their wintering grounds only in very late autumn and early winter, after they have moulted in autumn, generally near their breeding grounds. Arrivals on British estuaries occur mostly from late October onwards. Very few of the arctic and northern-breeding species move further south than France to overwinter, so in marked contrast to waders there is little staging and onward migration of waterfowl on British estuaries. A notable exception is the shelduck Tadorna tadorna which undertakes a moult migration in late summer, with some birds moving to Bridgewater Bay and many others moving from Britain to Heligoland in the German Bight (Patterson 1982) - see below.

The total number of wildfowl on British estuaries in early autumn is less than 50,000 and the assemblage is dominated by locally-breeding ducks such as mallard Anas platyrhynchos, shelduck and eider Somateria mollissima (Figure 8.6.10), since few of the main wintering populations have reached Britain by then.

Moult

Bird’s feathers fulfil vital functions of insulation and flight, but, with use, feathers wear and become less effective as insulators and less efficient aerodynamically. Birds therefore generally replace their feathers on a regular basis, although the pattern of timing in the annual cycle differs between populations and markedly between waders and wildfowl. Safe and undisturbed mouling areas, which for many migratory waterfowl are found on estuaries, are vital for these species.

Moult in waders

The main annual moult in waders wintering in northern temperate areas occurs in late summer and autumn, when adults moult their body feathers from a breeding plumage to a wintering plumage, and also moult their wing and tail feathers. A second annual moult, of body feathers only, takes place during spring migration, when waders change to their breeding plumage. A typical annual cycle of moult is shown in Figure 8.6.11.

![Figure 8.6.11 The annual moult cycle of grey plovers, summarizing annual changes in appearance and timing of body moult and wing moult (labelled as ‘primary moult score’), from Smit & Piersma (1989)](image)

For many populations the autumn moult takes place on estuaries in Britain and elsewhere in western Europe between August and October. As described above, in some more southerly wintering populations of waders such as ringed plovers, wing moult may be started on staging areas in western Europe, then suspended whilst the birds migrate further and complete on the wintering grounds. Active wing moult in waders involves the simultaneous dropping and regrowth of several flight feathers and so may interfere with efficient flight (see e.g. Boere 1976; Pienkowski et al. 1976; Smit & Piersma 1989). Very few populations migrate during active moult. The different migration patterns and timings mean that wing moult takes place earlier on northern estuaries than in African wintering quarters, so that it is complete on estuaries in Britain and elsewhere around the North Sea by late October. Moult starts later, generally in September, in west Africa and takes longer, with new wing feathers not completely grown until December. A recent summary of moult timing and duration at different latitudes is given by Smit & Piersma (1989) and shown in Figure 8.6.12.

Many mouling waders concentrate in autumn on a few major estuaries in western Europe. The largest population is in the Wadden Sea, with other major
Moulting waders during their non-breeding seasons may need little additional food above their normal daily intake. Despite this, Smit & Piersma (1989) point out that there are some indirect additional energetic costs of moulting, notably a reduction in insulation that increases the costs of thermo-regulation when the ambient temperature is low and increased energy costs of flight using incompletely replaced wings.

**Moul in wildfowl**

Moulting wildfowl do not face these problems of flight energetics since during their main annual moults in late summer they become flightless, moulting all their flight feathers simultaneously. In this post-breeding moulting, wildfowl replace their body and flight feathers at sites usually on or near their breeding grounds, and before their migration to their wintering grounds. Some species do move from breeding areas and undergo a moult migration (Salomonsen 1969). For example, non-breeding pink-footed geese Anser brachyrhynchus migrate from Iceland to east Greenland to moult, before returning to Iceland to rejoin the breeding adults and their young before migrating to Britain (Taylor 1983). Another more recently developed moulting migration involving a British estuary is the movement of non-breeding and immature feral Canada geese Branta canadensis to the Beadnall Firth (the inner part of the Moray Firth review site). This moulting migration has developed since 1947. It involves mostly birds from Yorkshire and, more recently, a few from further south in the Midlands (Dennis 1984; Owen et al. 1986).

Another moulting migration for which British estuaries are of considerable significance is made by shelducks. This involves both breeding and non-breeding birds, most of which move in mid-July from all parts of north-west Europe to the Helgoland Bight in the West German part of the Wadden Sea. The flightless moulting flock here exceeds 100,000 birds. Several British estuaries have now been discovered to support smaller moulting flocks (Figure 8.6.13); there are no known moulting sites outside estuaries. The best known estuary is Bridgwater Bay, which can support up to 2,000 birds believed to be mostly Irish breeders. Elsewhere there are up to 3,000 birds on the Firth of Forth which certainly include locally-breeding birds, up to 1,800 birds on The Wash, a few hundred on the Humber Estuary, and a small flock on the Dee Estuary and North Wirral (Owen et al. 1986). These flocks on British estuaries probably represent at least 10% of the British wintering population and up to 3% of the international population. Furthermore Owen et al. (1986) consider that the use of British estuaries by moulting shelducks is spreading.

Most ducks moul their body feathers into an inconspicuous 'eclipse' plumage, and then again into winter plumage as their wing moult is completed. This rapid and extensive moulting period is then followed by the vegetative diet of many species makes moulting a costly process for wildfowl.
Shelduck moultng sites

![Shelduck moultng sites map](image)

No. of birds
- < 1,000
- > 1,000

Figure 8.6.13 Autumn moultng sites for shelducks on British estuaries

(Atkney 1979, 1984; Masman et al. 1986). Unlike waders, wildfowl do not, however, moult their body feathers again in spring before breeding. The presence of these moultng flocks accounts for the large proportion (17%) contributed by shelducks to the autumn wildfowl assemblage on British estuaries (Figure 8.6.10). After moult shelducks gradually disperse back to wintering areas during November and December.

Movements and site networks during the non-breeding season

The use of migratory staging sites in autumn has been described above. There is increasing evidence, derived from analysis of reports of ringed birds, systematic counts and observations of colour-marked birds, that in waders several further migrations occur within the general wintering area. The pattern of these movements can be complex, as an individual wader can depend on a network of several estuaries. In these birds that move, the first migration is in late autumn, or sometimes as late as midwinter, from a moultng site to a wintering site. Some remain, however, all winter on their British moultng sites, such as The Wash. Others move just once after moultng to spend all winter on one British estuary (see e.g. Evans & Pienkowski 1984; Pienkowski & Evans 1988; Townsend 1985). Yet others, particularly of some wader species, are more mobile and depend on a network of sites during the course of the winter.

These movement patterns are described and their signiﬁcance reviewed by Pienkowski & Pienkowski (1983), Evans & Pienkowski (1984) and Pienkowski & Evans (1985). Some of these movement patterns of waders involving British estuaries are described below.

Dunlins

The movements of alpina dunlins (the population which overwinters in western Europe) are described in detail by Pienkowski & Pienkowski (1983) and Pienkowski & Evans (1984). They are summarised in Figures 8.6.14 - 16. Figure 8.6.14 shows a complex pattern of dispersal in late autumn of birds moving from moultng to wintering areas, involving movements into Britain from elsewhere, particularly the Washen Sea and Dutch Delta, movements between estuaries in different parts of Britain, and movements out of Britain to estuaries further west in Ireland and further south in France, Spain and Portugal. Some British estuaries such as

![Dunlin late autumn movements](image)

Figure 8.6.14 Late autumn movements of dunlins Calidris alpina within their wintering range from Pienkowski & Pienkowski (1983) show that a complex network of sites is used by these internationally important populations. Arrows show known movements during a single autumn between different regions of the wintering area, shown shaded. Lines show links between sites, but are not intended to show actual migration routes.
The Wash are major net ‘exporters’ of dunlins at this time of year. Dispersal from moulting sites also involves northward movements in Britain from The Wash to as far north as the Moray Firth (Figure 8.6.14).

Another important feature of these autumn migrations is the movement to the same wintering estuaries of birds from different moulting sites; there is thus considerable intermixing of the populations at different times of year.

There is usually much less movement in the midwinter period between November and February. Nevertheless some dunlins move from estuaries in eastern England to others on the Irish Sea coast, and others move southwards to France and Iberia (Figure 8.6.15). In addition, counts of marked birds, particularly at small estuaries in Britain, have found that some movements occur throughout the winter. There are however no major influxes in midwinter into some sites such as the Firth of Forth (Symonds et al. 1984).

In late winter and early spring dunlins start moving to staging areas where they begin to moult and accumulate nutrient reserves before migrating to their wintering grounds. For alpina dunlins this generally involves a movement northwards and eastwards in March and early April from southern Europe to estuaries in eastern Britain, and elsewhere on the southern North Sea, and from Britain to the Wadden Sea (Figure 8.6.16). Some others, however, move southwards (i.e. away from their breeding grounds) down the east coast of Britain from estuaries such as the Firth of Forth.

**Figure 8.6.16** Late winter and early spring movements of dunlins Calidris a. alpina within their wintering range (from Pienkowski & Pienkowski 1983) show northward and westward movement between estuaries. Arrows show known movements during a single winter between different regions of the wintering area, shown shaded. Lines show links between sites, but are not intended to show actual migration routes.

**Grey plovers**

Other species have different movement patterns. More limited information from marked grey plovers shows that in late autumn and early winter some are known to move from moultng areas in The Wash and the Wadden Sea to the Medway and Stour Estuaries, from The Wash to the Severn Estuary and Taw-Torridge Estuary in south-west England, and from the Wadden Sea to Teesmouth (Figure 8.6.17). Grey plovers differ from dunlins in their movement pattern in that they do not seem to move northwards from moultng areas to wintering sites (Pienkowski & Evans 1984). Other adult grey plovers reach Teesmouth later in the winter, in late December and January, probably also from the Wadden Sea, and these displace some juveniles from Teesmouth further south to France. Other adults appear in February and may be starting to return towards their breeding grounds (Townshend 1985). In spring some grey plovers, like dunlins, return from Teesmouth to stage in the

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**Dunlin midwinter movements**

**Figure 8.6.15** Midwinter movements of dunlins Calidris a. alpina within their wintering range (from Pienkowski & Pienkowski 1983). Arrows show known movements during a single winter between different regions of the wintering area, shown shaded. Lines show links between sites, but are not intended to show actual migration routes.
Wadden Sea before returning to their Siberian breeding grounds.

Grey plover

![Map of grey plover movements](image)

**Figure 8.6.17** Autumn and winter movements of grey plovers within their wintering range (from Pienkowski & Evans 1984). Arrows show known movements during a single winter between different regions of the wintering area, shown shaded. Lines show links between sites, but are not intended to show actual migration routes.

### Knots

Knots use a more restricted number of estuaries during the non-breeding season than do most other species (see also Figure 8.6.47). Even so Dugan (1981) found that individual knots moved up the coastline of eastern Britain from their major moulting area on The Wash, reaching the Humber Estuary, Tees Estuary, Northumberland coast and the Firth of Forth. Timings suggested that individual birds may have used a network of more than one of these east coast estuaries during a single winter. Knots also disperse from The Wash to west coast estuaries including the Dee Estuary and North Wirral, the Ribble Estuary and the Clyde Estuary, as well as south to estuaries in north Kent (Dugan 1981; Cooper 1984). At the same time there is a movement into eastern British estuaries in November and December of knots that have moulted in the Wadden Sea (Dugan 1981; Prokosch 1988).

### Implications for survival of dependence on site networks

From these and other studies it is clear that many individual waders appear to follow the same movement patterns in different years, or predictably different patterns in different years. There is considerable evidence of strong wintering site fidelity in many species with internationally important wintering populations on British estuaries, including dunlin, sanderling Calidris alba, turnstone Arenaria interpres, ringed plover, grey plover, bar-tailed godwit and curlew (Evans & Pienkowski 1984). This strong site fidelity, coupled with evidence that shorebirds are best able to compete for food in the places to which they regularly return (Townshend 1985) and that for some species, such as grey plovers, many preferred wintering sites are at their capacity to support birds (Moser 1988), means that waterfowl using an estuary during the non-breeding season can be very vulnerable to loss of or damage to that site.

Loss of habitat on any one site in a network may threaten the survival of birds using it, since these birds will then be forced to try to find alternative areas for feeding so as to survive. But there is evidence that they are then at a competitive disadvantage with birds already regularly using and familiar with a site (Townshend 1985; Davidson & Evans 1985). The implications are particularly great with mobile species since a much higher proportion of a mobile waterfowl population will be affected than is present at any one time, and the loss of one site may threaten the survival of birds using much of the estuarine resource both in Britain and throughout their flyways.

### Local movements during winter

As well as these large-scale movements between estuaries in the wintering area, waders are known to move extensively within estuaries and estuarine complexes during the winter. Understanding such movements is important in determining the conservation needs and approach for wintering waterfowl.

### Movements to roosting sites

In some instances the movement is related to the tidal cycle and the location and availability of secure roosting sites. Many waders move considerable distances from feeding grounds to roosting sites on the Firth of Forth (Furness 1973; Symonds et al. 1984). In Essex oystercatchers are known to move from feeding on the Stour Estuary to roosting on the nearby Orwell Estuary (Davidson & Evans 1985). An extreme example is the change in roosting pattern of waders on the Dee Estuary and North Wirral. Since the mid 1970s the number of roosting waders on the Dee has declined by almost 60%, largely a reflection of major decreases in the numbers of roosting bar-tailed godwits, knots and dunlins. Mitchell et al. (1986) have found that many of the bar-tailed godwits and knots have continued to feed on the Dee but now fly over 20 km to roost on the Alt Estuary across Liverpool Bay. The declines in roosting numbers on the Dee have been attributed to increases in the amount of human disturbance to birds roosting on the
shoreline. Numbers of waders roosting on the Alt have increased dramatically since 1978/79 (Kirby et al. 1988), and numbers that remain to feed there are sometimes but not always substantial. Kirby et al.'s (1988) analyses suggest that the estuaries of the Alt, Firth of Deeside, and probably also the Mersey should be considered as a single intertidal complex in terms of their use by knots, bar-tailed godwits and dunlins.

**Movements between feeding areas**

A similar picture of high mobility of knots, bar-tailed godwits and dunlins during winter has been found within another major British estuarine complex, the Moray, Cromarty and Dornoch Firths and Loch Fleet in north-east Scotland (Symonds & Langslow 1986). For example knots marked when roosting in the Moray Firth and the Cromarty Firth in November were found widely distributed around all four review sites later in the winter, and a few also moved outside the estuaries onto open coasts (Figure 6.6.18). Symonds & Langslow (1986) found that turnstones, curlews, ringed plovers, oystercatchers and redshanks remained much more loyal to selected feeding areas. Wintering wigeon Anas penelope on the Moray Firth, like these waders, move very little between feeding sites (Mudge 1989).

These interspecific differences in the extent of mobility around large wintering sites appear to be general, since Symonds et al. (1984) found similarly high mobility around the various feeding areas within the Firth of Forth in knots, dunlins and bar-tailed godwits, but little movement in turnstones, grey plovers, oystercatchers and redshanks. Minton (1975) found similar mobility patterns for most of these species in The Wash. Dunlins move extensively between different feeding areas even on some much smaller estuaries such as the Tees (Davidson & Evans 1986a) and the Orwell (Davidson & Evans 1985).

Some intraspecific variation in mobility does, however, seem to exist at least in dunlins: since Clark (1963) found considerable site fidelity in parts of the dunlin population on the Severn Estuary, and Minton (1975) found that there was little movement of dunlins around The Wash in winter. This may, however, be related to differences in the scale of the movements, in that dunlins have a degree of mobility intermediate between the highly mobile knots and bar-tailed godwits and more sedentary species such as ringed plovers and oystercatchers.

In some waders different individuals have markedly different patterns of winter mobility. This is particularly so for sanderlings. Some wintering sanderlings in the population centred on Teesmouth remain all winter within the estuary and the coastal sandy beaches immediately nearby. In addition to these 'resident' there are 'transients' that move along tens of kilometres of coastline (Evans et al. 1980). This mixed pattern seems to be typical of wintering sanderling populations, since it has also been found by Myers et al. (1988) in both North and South America.

**Conservation implications of local movements**

There is considerable significance for the conservation of wintering wader populations in these mobility patterns. First the conservation approach needs to allow both for species and populations that depend on a localised feeding and roosting area and for those whose feeding depends on widely distributed feeding areas around estuaries and estuary complexes. Since the preferred winter feeding strategy of some species
such as knot, bar-tailed godwit and dunlin is to move around many or all feeding areas on such estuaries, the conservation approach must seek to avoid piecemeal loss of some parts of these intertidal feeding grounds.

Second, some estuaries must be considered as part of a linked estuarine complex. Identification of these movement patterns requires detailed marking and observation studies of the lands described above, which have as yet not been carried out on all estuarine complexes in Britain. The evidence of the intraspecific consistency of movement patterns of wintering waterfowl shows however that such linkages are likely to exist between all such estuarine complexes, some of which, for example the 'Greater Thames Estuary' of the Essex and Kent coasts, can be very large. The linking of such complexes forms part of the approach embodied in the designation of a network of sites of international importance under the Ramsar Convention and EC Wild Birds Directive (see Stroud et al. 1990).

Cold weather movements

It is clear that in mobile species such as migratory waders and wildfowl a site does not have to be of numerical importance at all times of the year, or even in every year, to be of major importance to the survival of the population (Stroud et al. 1990). Severe winter weather poses particular problems since the energetic costs of thermo-regulation are greatly increased during periods of low temperatures and strong winds (e.g. Dugan et al. 1981, Davidson & Morrison 1983). To meet these increased costs birds must either draw on energy reserves stored prophyllactically or find more food (Davidson 1981). Yet at these times their food usually becomes less available or completely inaccessible through changes in the behaviour of the prey (Evans 1979b; Pienkowski 1983a) or the freezing-over of the feeding grounds (e.g. Swennen & Duiven 1983). At these times waterfowl can adopt one of two alternative options: either remain where they are at the start of the cold spell, and draw on stored fat and protein reserves (e.g. Davidson 1981; Clark 1983; Pienkowski et al. 1984), or move to more sheltered areas. The effects of severe cold weather and wind which can affect waterfowl wintering in Africa are not an issue for British estuaries.

British estuaries as cold weather refugia

In severe weather estuaries and coasts become of increased importance as refuges for waterfowl since the buffering effect of sea temperature and salinity usually means that estuaries and coasts freeze over far less than inland and freshwater wetlands. British estuaries take on additional importance as severe weather refugia in western Europe since they are relatively milder than those of continental Europe in periods of severe weather (see Pienkowski & Evans 1984, and Chapter 6). In addition the interactions of wind and tide, that can exacerbate the impact of cold weather on estuaries with small tidal ranges, such as the Wadden Sea, affect British estuaries much less (Pienkowski & Pienkowski 1983; Pienkowski & Evans 1985).

Severe weather can result in almost all the intertidal areas of major continental European estuaries, such as the Wadden Sea, freezing over so that waterfowl are unable to feed for days or even weeks (Swennen & Duiven 1983). At these times there can be greatly increased mortality of waders, especially oystercatchers on the Wadden Sea (Swennen & Duiven 1983) and the Dutch Delta (F. Meininger pers. comm.).

Increased mortality of estuarine waders does also occur during periods of prolonged severe winter weather in Britain, despite the precautions of reserve storage or movement to milder areas (Dobinson & Richards 1984; Davidson 1982a; Davidson & Evans 1982; Clark & Davidson 1986). Severe weather mortality often affects redshanks and oystercatchers most seriously, although it is not clear why these species should suffer consistently greater mortality than other waders. Other waders, notably dunlins and grey plovers, can also be affected (e.g. Davidson & Clark 1985; Clark & Davidson 1986) and Davidson (1982b) found evidence from ringing recoveries of increased mortality in seven out of ten wader species during two periods of severe winter weather at Teessmouth.

The geographical pattern of severe weather and its effects on wildfowl differ considerably between years and cold spells (Davidson & Clark 1985; Clark & Davidson 1986). Hence the locations of effective estuarine refugia from severe weather also differ, although in general the more southern and western estuaries remain milder during spells of severe weather.

There are two types of movement related to severe weather. The most obvious is a movement directly in response to the onset of severe weather. Many of the regular westward and southward movements of post-moulting waterfowl described above are, however, also likely to have evolved as a response to the avoidance of areas in which severe weather is most likely later in the winter (Pienkowski & Evans 1984, 1985).

Responses of waders to cold weather

An analysis from ringing recoveries of the cold weather movements of waders and other waterfowl (Bailie et al. 1985) confirmed that most waders remain on their usual wintering grounds in severe weather and draw on their reserves of fat and protein to balance their energetic and nutritional budget (Davidson 1981). Bailie et al. (1986) found that some lapwings Vanellus vanellus, curlews and snipe Gallinago gallinago moved south out of Britain to France and Iberia in response to cold weather, and many lapwings and golden plovers Pluvialis apricariae are known to move from their inland feeding areas to estuaries and coasts in Britain (Dobinson & Richards 1984; Davidson 1981).
Although most estuarine waders in Britain remain on their wintering areas if cold weather begins, some do move from the more severely affected continental estuaries, many flying to Britain. For example van Eerden (1977) reported a movement of redshanks and oystercatchers out of the Dutch Wadden Sea at the start of cold weather, Davidson (1882a) reported a similarly timed movement of some redshanks from Ternmouth, and major influxes of dunlin into the Orwell Estuary in Suffolk coincided with the onset of particularly severe weather in continental Europe (Davidson & Evans 1985). Another severe weather influx on the eastern English coast is the arrival of some individual grey plovers at Ternmouth in midwinter only in years when there is severe weather in the Wadden Sea (Townshend 1982). In such years these birds return to regular sites, despite their irregular pattern of appearance.

Responses of wildfowl to cold weather

Wildfowl show a similarly complex pattern of movement in response to severe weather. Those wintering on freshwater habitats are particularly vulnerable to freezing conditions. Many then move to coasts and estuaries, and as with waders which areas the birds move to depends on the distribution of the most severe weather. For example Fox & Salmon (1988) reported major movements of pochard Aythya ferina to maritime habitats, especially the inner port of the Thames Estuary, during severe weather in January 1979. In severe weather in 1981/82 populations increased substantially on estuaries widespread around Britain, including Poole Harbour, the Severn Estuary, Hamford Water, Ternmouth and the Firth of Forth, although overall the movements involved less of the population than in 1979. Fox & Salmon (1988) considered this to be because in 1981/82 the very severe weather caused even many estuaries to freeze. Pintail Anas acuta are also very mobile and move westwards onto estuaries on the Irish Sea coast of Britain and further west into Ireland in response to severe weather, shelducks move from the Wadden Sea and northern Britain to estuaries in southern Britain and France (Baillie et al. 1986), and Ridgill & Fox (1990) have found evidence of movements in response to cold weather in seven common species of wildfowl.

Some geese also move in response to severe weather: most pink-footed geese move south from Scotland into the coastal regions of north-west England (Baillie et al. 1986; Owen et al. 1986). The winter distribution of the small vulnerable population of Svalbard light-bellied brent geese Branta bernicla hrota is strongly linked to winter weather conditions on their wintering grounds in Denmark (Madsen 1984). A larger proportion of the world population moves to the only major British wintering ground at Lindisfarne when winter weather is severe in Denmark, and the relationship is particularly strong in response to January temperatures.

Conservation implications of cold weather refugia on British estuaries

British estuaries are of major importance as severe weather refugia for many waterfowl, an importance that is additional to their very major international importance as waterfowl wintering areas during mild winters. This means that estuaries can assume a critical importance for the survival during severe weather of very much larger parts of waterfowl populations than are present at any time during mild weather. Even though such places may function as cold weather refugia, they often serve this purpose for only a few days or weeks and only in some winters. Ridgill & Fox (1990) point out that some sites assume national and international importance only during their critical function as cold weather refugia, and that such importance fails to show up through the application of the 1% criterion based on five-year average count values. This highlights the need to consider additional features of waterfowl usage of estuaries in identifying and developing conservation measures for waterfowl populations, in line with the requirements of international conservation measures.

It should be noted that the winter distribution analysis made below is based on the five-winter period from January 1983 to January 1987, when winters were generally mild. The population sizes and distributions described are therefore the baseline of importance which is considerably added to in severe winters.

It is often considered that it is the western British estuaries that are of increased importance during severe weather. Whilst they are of undoubted importance, particularly to birds moving from northern and eastern Britain, eastern British estuaries are also of significance, as refugia for waterfowl from continental European coasts. Other populations that use Britain in mild winters depend on cold weather refugia further south and west in Europe. Furthermore, the geographical location of the estuaries that provide effective refugia differs between spells of severe weather, depending on which parts of Britain are most affected by the severe weather. Since some waterfowl die during severe weather even with the precautions of energy reserves and refugia to which they move, it follows that without suitable feeding grounds in milder areas winter mortality would be much higher. Effective conservation of these mobile populations thus requires the maintenance of a network of estuaries throughout Britain so as to provide refugia wherever a cold spell strikes.

Peripheral feeding areas

In addition to these large-scale responses to severe weather, many waders using a single estuary alter their feeding behaviour in response to weather conditions and food availability. Waders that feed in intertidal habitats are time-limited by the period of exposure of the feeding grounds by the tide, in
some cases interacting also with the daylight period. When energy requirements increase, as for example in severe weather, the birds may need to increase their feeding period beyond the duration of exposure of their tidal feeding grounds. These birds then move to feed on habitats peripheral to the estuary. Pasture-feeding during high tide occurs widely in redshanks, oystercatchers and curlews around estuaries in various parts of Britain, from the Ythan Estuary in north-east Scotland to the Exe Estuary in south-west England.

On the heavily-industrialised Tees Estuary, where land-claim has restricted the period of tidal exposure of the main mudflats, Davidson & Evans (1986a) found that many waders fed on a variety of brackish-water and grassland habitats during high tide. Greatest use of this suite of peripheral habitats was by redshank and dunlin, and on some occasions by knot, curlew and grey plover. There was considerable interspecific variation in habitat choice (Figure 8.6.19). Choice of site, and the proportion of the populations involved, depended on both tidal and weather conditions, but curlews feed mostly on pastures, redshanks and grey plovers on sheltered brackish areas, and dunlins and knots on unsheltered high-level tidal flats. There were also seasonal differences related to weather conditions: most species fed more in sheltered areas in mid and late winter, during periods of high winds and low temperatures (Davidson & Evans 1986a).

Under some weather conditions some waders, particularly redshanks, dunlins and curlews, chose to leave the main mudflat feeding areas even when they were available as feeding grounds. These birds then fed on the peripheral areas during the low-tide period. Redshanks in particular moved from exposed mudflats to feed in sheltered creeks and pools when winds were very strong (Davidson & Evans 1986a).

Some parts of the wintering populations of waders depended more heavily than others on the peripheral feeding areas. For example at Teesmouth many juvenile grey plovers and dunlins fed on peripheral wetlands (Davidson & Evans 1986a). Curlews have a winter feeding distribution in which it was mainly males, which have shorter bills, that fed on peripheral pastures during the low-water period (Townshend 1981). These were joined over high water by some females that had been feeding on the main mudflats before they were covered by the tide. Townshend attributed this pattern to the main prey of curlews on the mudflats (the ragworm Hediste diversicolor) moving deeper into the mud in winter and so becoming less accessible to the short-billed males. These birds then shifted to feeding on earthworms on pastures, to be joined by the longer-billed females needing to extend their feeding time beyond the period of exposure of the main mudflats. In periods of severe weather, however, all curlews were forced to move back onto the mudflats as the pastures froze over.

Waterfowl are at risk from death by starvation during severe winter weather (e.g. Davidson 1982b; Davidson & Evans 1982). Even on estuaries where some additional feeding is possible, such as Teesmouth, winter mortality of several waders was higher in severe winters (Evans & Pienkowski 1984). Hence mortality in severe weather is likely to increase if those birds that remain on estuaries (rather than moving to milder areas) are unable to extend their feeding onto other areas when the main intertidal flats are covered, or cannot find sheltered feeding areas during periods of low temperatures and high winds (Dugan et al. 1981; Davidson & Evans 1986a).

Particularly for those estuaries where the intertidal feeding grounds have been restricted by land-claim and other developments (see Chapter 10), the effective conservation of waterfowl populations at times of stress such as severe weather may depend on the maintenance of a suite of peripheral habitats, as well as tidal flats. The varying habitat

![Figure 8.6.19](image-url)
preferences of different species, ages and sexes under different weather conditions means that variety of habitats are often needed to buffer waterfowl populations against the risks faced during severe weather, as well as at other times.

Population turnover

As mentioned briefly in describing autumn migration, many waders and wildfowl move extensively between estuaries during their non-breeding season. It is not usual for all of a population to move at once, so there is generally a turnover of individuals using one estuary. If the number of arriving birds equals the number of those departing then the total number present in a simple count will remain unchanged. If the numbers arriving and leaving differ, the presence of turnover can be detected. Sequential counts will, however, reveal only the net change in numbers and not the total number of individual birds involved. During migration periods in both spring and autumn there may be continual arrivals and departures of birds over a period of weeks with each individual remaining for a shorter time than the whole period over which birds of that population are present. Where several biogeographic populations, or sub-populations, with different migration strategies are involved the picture is particularly complicated, and even in winter there can be substantial population turnover. For example the turnover of shelducks using Teesmouth in winter was such that the total number of individuals using the estuary over the winter was several times the peak number present on any one day (Evans & Pienkowski 1982).

An understanding of turnover is valuable in two ways when implementing effective conservation of migrant waterfowl. Firstly, it helps in assessing the significance of particular estuaries in the migrations and annual cycles of waterfowl. Secondly, since turnover means that even peak counts will underestimate the proportion of a biogeographic population using an estuary, it is needed to qualify the data used to assess the basic 1% criterion used in the identification of estuaries of national and international importance. Turnover data, where available, are taken into account in conservation site assessments as well as in the formal guidelines for the identification of Ramsar sites (Stroud et al. 1990).

Assessing population turnover

A minimum assessment of turnover and the numbers of individual birds using an estuary can be made by summing all the increases in numbers between successive population counts during a season. Turnover is best assessed, however, from studies of individually marked birds that are sighted or recaptured during their staging time at a site. Unfortunately these studies are complex and time-consuming and have not been made at only a few estuaries and for only a few species.

Most studies of turnover have been on wintering or spring migrant waders (e.g. Dugan 1981; Symonds & Langslow 1981, 1985; Pienkowski 1983; Moser & Carrier 1983; Kersten et al. 1983; Kersten & Smit 1984; Symonds et al. 1984; Davidson & Evans 1986b; Prokosch 1988; Smit & Pietersma 1989). As well as assessing the total numbers of birds using an estuary, turnover studies yield information on the average stopover period for the migrant – information valuable in understanding the scheduling of migrations and the use of sites within the migratory network. The general findings on turnover are described below.

The extent of population turnover

Turnover studies have shown that the extent of turnover can differ in the same species at different estuaries on a migratory route, and between different species using an estuary at the same time. Thus at least twice the number of ringed plovers used the Solway Firth in spring than the number present on the peak count, but there was almost no turnover in the migrant turnstone population over the same period (Moser & Carrier 1983).

Kersten & Smit (1984), studying waders migrating north towards Britain and elsewhere in western Europe, found that the turnover of ringed plovers earlier in spring on the Sidi Mousa estuary in Morocco, like the redshank and dunlin, resulted in about 1.5 times the number of individual birds using the site than were present in early March. The average length of stay of ringed plovers at Sidi Mousa was only 6.3 days. Redshanks (8.5 days) and dunlin (12.3 days) stayed rather longer.

Turnover of between one and three times the maximum daily population seems general for waders on spring staging sites, since Prokosch (1985) reported over twice the number of grey plovers using the Wadden Sea in spring as were present in peak numbers. More knots and bar-tailed godwits also passed through the Wadden Sea than were present at any one time, although measures of turnover were not possible.

Even more rapid turnover in spring can, however, occur. Cronau (1988) reports that little stint Calidris minuta stayed an average of only 3.5 days during April and May at a wetland in Turkey, and estimated a turnover of at least eight times the number of individual little stints present in the peak count.

Arrivals and departures from late spring staging areas are often highly synchronous. For example nearctic-breeding knots from wintering grounds on British estuaries and the Wadden Sea pause for two weeks in May at Balsfjord in northern Norway. These birds almost all arrive over a period of five days and leave in late May over just three or four days (Davidson et al. 1986c; Utley et al. 1987). Observations of colour-marked birds in 1985 suggested little turnover. Recaptures of ringed birds confirmed that the total numbers of individuals using Balsfjord in May was less than 1.5
times the peak count (Davidson & Evans 1986b). So even here in such a highly synchronised population there is a small amount of turnover, and this is supported by counts and observations there and elsewhere in northern Norway in later years (Uttley et al. 1987; Strann in press).

The significance of population turnover in assessing estuary usage by waders is illustrated in Figure 8.6.20, with the example of the use of the Sidi Moussa estuary in Morocco by dunlins (largely the *calidris canutus* population) in early spring. This provides a clearer illustration of turnover than is available for waterfowl in migrating through Britain and many of the birds involved are likely to use British estuaries as their next staging site. The Moroccan example is derived from studies in 1981 and 1982 by Kersten *et al.* (1983), Kersten & Smit (1984) and Smit & Piersma (1989). Counts through the period from early March to late April found that the maximum population present on any day was 7,000 birds in early March. Counts during the two months showed a decline in numbers followed by an increase in early April and then a further decline. Analysis of these counts, and also observations of the proportions of marked birds in flocks, gave a cumulative count total over this period of 12,000 birds, almost twice the number present at any one time (Figure 8.6.20).

These analyses also permitted assessment of the turnover rate for the whole migration period from late February to early March at three times the number of birds present in early March. Thus about 21,000 individual dunlins used the estuary during their spring migration, almost double the number derived from even cumulative counts. In this case it means also that Sidi Moussa qualifies as of international importance for dunlins, since 1% of the population is 1,400 birds, although this was not apparent from counts since the population on any day was never more than one-third of the total using the site (Smit & Piersma 1989).

The extent of turnover for different species and estuaries will depend on the role of each site as a staging area in the migrations of waterfowl. The functions of these staging areas in spring are described further below. Detailed studies of migrant populations have all shown some degree of turnover. Hence any assessment of an estuary for conservation purposes should treat population counts as an indicator of minimum usage and importance. In general a larger and, sometimes a very much larger, proportion of each waterfowl population than is apparent at any one time depends on each estuary in the network used during the non-breeding season. This is particularly so for those sites which act as spring and autumn staging for migrants, but also applies to wintering sites. Overall the implication is that many estuaries which fall below the 1% criterion on the basis of peak monthly counts alone, in reality support more than 1% of the relevant populations during the course of a year and so will qualify as nationally or internationally important.

**Spring migration**

Most waders and waterfowl return to their breeding grounds between early March and May, depending on latitude. Breeding waterfowl generally reach temperate breeding areas such as Britain and western Europe beginning in March, some returning direct from the estuaries on which they have overwintered. At the same time populations breeding in arctic and sub-arctic regions such as Iceland and northern Scandinavia begin the return migration from African wintering areas. The timing of the spring migration of waders is summarised by Pienkowski & Evans (1984), but migration routes and migration strategies are generally poorly known (Piersma *et al.* 1987a).

Waders show a variety of strategies for making their spring migrations. These range from birds such as some terns that make their migration in a series of short stops, and so use several spring staging areas, to others such as *calidris canutus* and redshanks which fly longer distances between staging areas, with each individual using only a few staging areas. At the extreme are migrants such as knots and bar-tailed godwits that make very long jumps, generally using just one or two staging areas between wintering and breeding grounds (Piersma 1987).
British estuaries are vital staging areas for many spring migrant waterfowl populations. At the same time as more southerly wintering populations are arriving in Britain some of the British wintering populations of species such as alpina dunlins (Pienkowski & Pienkowski 1983, and Figure 8.6.16), islandica knots (Davidson & Wilson 1991) and dark-bellied brent goose (Owen et al. 1986) move east and south-east to the Wadden Sea. Britain and the Wadden Sea support the largest populations of spring migrant waterfowl in Europe (Prater 1981). The picture of use of a single Britain estuary is often complex, since there is continual change in the species and population composition of the assemblage due to differences in migration timing like those described above. In addition, there is also generally a substantial turnover of individuals within a population.

With such rapid spring movements, monthly BoE/NWC counts can give only a general representation of the size and distribution of spring migrant populations and can miss populations that pass rapidly through British estuaries, since many individuals stay for only a few days or weeks (see Turnover above). Understanding the complexities of the spring migration systems of waterfowl has required more detailed studies involving more frequent counts at staging areas, coupled with catching and observations of marked birds, to determine how individuals move along the flyway during a single migration.

There has been recent progress in clarifying spring migration patterns along the East Atlantic Flyway from detailed studies made at individual staging areas such as the Solway Firth (Moser & Carrier 1983), Mauritania (Ens et al. 1989), Morocco (Kersten & Smit 1984), the Wadden Sea (Prokosch 1988), Iceland (Morrison & Wilson 1972) and northern Norway (Davidson & Evans 1986b). In addition the collection of much information has depended on the organisation of international spring migration projects, often co-ordinated by the Wader Study Group (Dick 1979; Ferris 1980a, 1980b, 1981a, 1981b, 1981c; Pienkowski & Pienkowski 1983; Moser et al. 1985; Davidson & Piersma 1986). In Britain co-ordinated studies have concentrated particularly on establishing spring migration patterns on west coast estuaries (see Moser et al. 1985), although their findings are not yet fully available and the spring migration usage and importance of individual British estuaries, and of these estuaries for most species, cannot yet be described.

The general spring waterfowl species assemblages on British estuaries are summarised in Figures 8.6.21 and 8.6.22, derived from BoE/NWC counts.

The spring wildfowl assemblage

About 70,000 wildfowl use British estuaries in April. The species composition (Figure 8.6.21) shows an assemblage dominated by shelduck (36% of the total population). These are birds returning to breed around British estuaries, and the 27,000 birds in April must be most of the estimated British breeding population of 15,000 pairs (Stroud et al. 1990). The remainder of the assemblage is a mixture of some other species such as eider returning to breed around estuaries, with small remaining populations of late migrant arctic breeders such as dark-bellied brent goose and long-tailed ducks Clangula hyemalis. The majority of arctic-breeding ducks and geese have, however, already left Britain by April and moved to spring staging areas such as the Wadden Sea and Iceland (Owen et al. 1986). Long-tailed ducks form a larger proportion of the wildfowl assemblage than at other times of year. These birds are mostly in the firths of north-east Scotland, where there is a marked spring passage (Prater 1981).

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<th>April</th>
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<td>Shelduck</td>
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<td>Dark-bellied brent goose</td>
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<td>Common scoter</td>
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<td>Mute swan</td>
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<td>Red-breasted merganser</td>
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<td>Long-tailed duck</td>
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<td>8 other species</td>
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Figure 8.6.21 The spring (April) species assemblage of wildfowl on British estuaries, derived from Prater (1981)

The spring wader assemblage

As would be expected from the general patterns of migration and turnover of waders in spring, there are marked differences in the species composition of the wader assemblage on British estuaries in April and May (Figure 8.6.22).

In April, as at other times of year (Figures 8.6.10 and 8.6.33), the assemblage is dominated by dunlin, knot and oystercatcher. The wader population in April is a mixture of high-arctic breeders such as knots, alpina dunlins and bar-tailed godwits, and species such as redshanks, curlews and schinzii dunlins returning through Britain to breed at lower latitudes.
By May most individuals of some high-arctic breeders such as knots have left Britain for staging areas further north (Davidson & Wilson 1980). The assemblage is dominated by dunlins even more than at other times of year, and almost half the waders on British estuaries in May are dunlins, although the total population of dunlins present (c. 150,000 birds) is smaller than in April. Dunlins in May are predominantly the arctic-breeding alpina population, along with some late migrant Icelandic breeders and the small arctica population that breeds in Greenland. Other high-arctic breeders form a significant part of the May assemblage, notably the c. 30,000 sanderlings which form almost 10% of the assemblage. Some migrants heading for more temperate breeding grounds from southern wintering areas, notably whimbrels (9% of the assemblage), are passing through Britain at this time. Golden plovers also form a larger part of the spring assemblage in spring than at other times of year. The May assemblage is more diverse, with 11 species each forming more than 1% of the population, compared with nine species in April.

<table>
<thead>
<tr>
<th>April</th>
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<td>Dunnin</td>
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<td>Knot</td>
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<td>Grey plover</td>
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<td>Other species</td>
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Figure 8.6.22 The spring (April and May) species assemblage of waders on British estuaries, derived from Prater (1981)

Population size in spring

The total population of waders present in April and May is lower than in midwinter: c. 510,000 in April and 310,000 in May, compared with 1,160,000 in midwinter. These totals alone correspond to 7% and 4% respectively of the East Atlantic Flyway population. The rapid turnover of populations and individuals in spring (see above) means, however, that many more individuals depend on British estuaries in spring than the population counted on any one date in either April or May. It is not possible to determine precisely the total population involved since detailed turnover studies have not been made sufficiently widely. Turnover studies from elsewhere suggest that between 1.5 and three times the number of individuals may be involved. Based on the April population alone this suggests that between 765,000 and 1,530,000 waders used British estuaries in spring, so that in excess of 20% of the international flyway population may depend on British estuaries in spring.

Estuarine distribution of waders in spring

Although Prater (1981) indicated that estuaries on the west coast of Britain were particularly important as staging areas for spring migrant waders, it is now clear that many east coast estuaries also support important spring migrant populations. In eastern Britain most major staging areas are in the southern part of the region, notably the Essex coast, The Wash and the Humber Estuary. Nevertheless estuaries further north in eastern Britain, such as Teesmouth (Goodyer & Evans 1980; Davidson & Evans 1989) and the Moray Firth (Swann & Mudge 1989), also support passage populations of several wader species.

Populations of most wader species are concentrated on fewer estuaries during spring passage than in midwinter (Prater 1981). This generally more restricted distribution was further confirmed for estuaries in western Britain by Moser et al. (1985) who reported that sanderlings and ringed plovers concentrated in spring on a few large estuaries, and that there was no observable migration through many of the smaller west-coast estuaries. Figure 8.6.23 illustrates the spring distribution of four common migrant waders during the late 70s. Large numbers of sanderlings staged on just five estuaries (Dee and North Wirral, Alt, Ribble, Morecambe Bay, and Duddon). More frequent counts in the early 1980s have shown an apparent shift in spring distribution with lower peak counts on the Dee and the Duddon Estuaries, but larger numbers on the Solway Firth (Clark et al. 1982; Moser et al. 1985).

Detailed ringing studies on sanderlings at Teesmouth (Evans 1980) have found several components to the spring migrant population. Some from the wintering population leave in March and April and are known to move to Iceland later in the spring. These birds presumably breed in Greenland and Canada. Others pass through Teesmouth in early May, and yet others leave in late May (Davidson & Evans 1986). The destinations of these birds are less clear, but may be Siberia, since none of these spring passage birds has been seen in Iceland (PR Evans pers. comm.).

Ringed plovers occurred in large numbers in May 1984 on just four west coast estuaries: Severn, Ribble, Morecambe Bay and Solway Firth (Moser et al. 1985). Small numbers also occurred on all of the 18 review sites for which counts were made, although in some cases these may have been only locally-breeding birds. Figure 8.6.23 shows ringed
Figure 8.6.23 Spring distribution of ringed plovers, grey plovers, sanderlings and dunlins on British estuaries, from Prater (1981)
plovers to be amongst the most widespread of waders in spring.

Dunlins are also widespread in April and May (Figure 8.6.23) but again are concentrated onto major estuaries. In contrast to ringed plovers and sanderlings, there are some major staging areas in eastern Britain, with the largest population being on The Wash. East coast passage involves both the schinzi population heading for Iceland and alpina dunlins en route to northern Scandinavia and the USSR. Most dunlins staging in western Britain in spring belong to the Icelandic breeding population; there is a general movement of the wintering alpha population east and south-east in later winter and early spring to staging areas in eastern Britain and the Waddan Sea (Figure 8.6.18).

Crey plovers, which also breed in the Siberian arctic, are also concentrated chiefly on a few eastern British estuaries by May (Figure 8.6.23) and, like dunlins, are known to move east from eastern Britain to use the Waddan Sea as a spring staging area (Piepowskowsi & Evans 1984; Townshend 1985).

Likewise, many of the British wintering knots move in March to the Waddan Sea. Smaller numbers remain in Britain, chiefly on the major west coast estuaries of the Dee, Ribble and Morecambe Bay, with a few thousand on The Wash. All these birds leave their early spring staging areas in Britain, and the southern North Sea during the first week of May and fly to late spring staging areas in Iceland or northern Norway. There is mixing of birds from all parts of the wintering area and early spring staging sites on the latter spring sites (Davidson et al. 1986c; Davidson & Wilson 1991).

Moser et al. (1985) also cite examples of ringed plovers flying from early spring staging areas in western Britain to spend late spring at Teesmouth in eastern Britain. Thus although many waders heading for Iceland, Greenland and Canada use estuaries in western Britain in early spring, and many heading for Scandinavia and Siberia pass through eastern Britain, the division is by no means clear-cut.

**Patterns of spring estuary use by waders**

Colour-marking studies have helped to reveal the place of British estuaries in individual waders' use of the network of estuaries along the East Atlantic Flyway and their movements within Britain. International collaboration on dye-marking studies in spring 1985 showed that schinzi dunlins from the wintering population in the Banc d'Arguin (Mauritania), and from Portugal and western France, used British estuarine staging areas in spring (Figure 8.5.24). Most of these migrants used estuaries on the west coast of Britain from the Taw-Torridge Estuary in north Devon to as far north as the Outer Hebrides. Dunlins marked on the British west coast were subsequently seen in western Iceland later in the same spring. No dunlins were found to move between estuaries in western Britain in this study (Piersma et al. 1987a), and this accords with the findings of earlier co-operative studies of spring migration. Moser et al. (1985) reported very few movements of dunlins between British west-coast estuaries in 1984, although a few birds moved from the Severn Estuary in late April and early May to the Solway Firth in May. Ferns (1981b) also found little evidence of northwards spring movement between west-coast estuaries. Hence most individual schinzi dunlins use one, or at most two, of the network of British estuaries during their spring migration.

Figure 8.6.24 Movements to and through Europe of individual schinzi dunlins within a single spring migration period in 1984 or 1985. From Piersma et al. (1987a) with additional information from Moser et al. (1985).

Moser et al. (1983) found a similar pattern of dependence on a single British spring staging site by individual ringed plovers, sanderlings and turnstones, with at most a few individuals moving to a second British site, usually, but not always, further north. For ringed plovers and sanderlings this is similar to the earlier interpretation of counts and caught birds, but the pattern differs for turnstones (Ferns 1980a, 1980b, 1981a). Ferns describes a complex pattern for turnstones with some evidence that birds moved north in a series of small steps, often staging briefly at a sequence of sites. Some turnstones have been thought to pause in the Outer Hebrides as a final British staging area before flying
to Iceland, but the evidence for this as a regular feature remains equivocal (Pryj-Jones et al. 1988).

Two review sites form an important spring staging area for whimbrels Numenius phaeopus. About 2,000 whimbrels occur around the estuarine complex formed from the Severn Estuary and Bridgewater Bay during late April and early May, using the area as a final staging area before migrating to breed in Iceland (Ferns et al. 1979). These birds form about 1% of the Icelandic population, and few whimbrels occur in spring elsewhere in Britain (Prater 1981). Most of the Icelandic breeding population migrates through Belgium, The Netherlands and the Federal Republic of Germany in spring. Whimbrels roost at night in two places, one in Bridgewater Bay and the other on the Welsh shore of the Severn Estuary. During the day they disperse to feed on pastures on the Gwent Levels adjacent to the Severn Estuary and the Somerset Levels stretching inland from Bridgewater Bay.

Fidelity to spring staging sites

In most instances individual waders return to the same spring staging areas on the same migration schedule in successive years (e.g. Goodyer & Evans 1980; Utley et al. 1987; Prokosch 1988; Evans & Townshend 1989). They are thus dependent on the continued availability of these places to enable them to complete their migration. In a few circumstances waders use alternative staging areas in different years. One instance of this has been well documented in Siberian knots, which usually make a long non-stop migration from the Banc d’Arguin to the West German Wadden Sea in early May. In most years only a few knots appear at other estuaries along their migration route, in Portugal, France and The Netherlands. In a few years, however, a much larger number of knots appear at these ‘emergency staging areas’, particularly in western France. Knots that do appear at these places generally have low masses and stay a shorter time than their usual spring staging period; they seem to move on to their normal staging area in the Wadden Sea (Piersma et al. 1987b). Their appearance at emergency sites is linked to adverse weather conditions during their migration northwards, which force the birds to pause and replenish their energy reserves before completing their migration (Smit & Piersma 1989). Although it is not apparent from general counts, the continued availability of these alternative staging sites is thus critical in the long term for the survival of a large part of the populations of long-distance migrants.

Less explicable is the use of alternative spring staging areas by the other subspecies of knot, the islandica population, most of which overwinters in Britain. In late spring about two-thirds of the world population of these birds stage in west Iceland, with the remaining third using two fjords, Balsfjord and Porsangerfjord, in northern Norway (Davidson et al. 1986; Davidson & Wilson 1990). Numbers of knots in Balsfjord vary considerably from year to year and Strann (1981) suggests that this relates to the ice conditions in early May in Porsangerfjord, about 200 km further north than Balsfjord. Porsangerfjord usually holds the larger staging population. In years when spring is late, intertidal feeding grounds in Porsangerfjord remain ice-covered throughout May and under these circumstances it seems that a larger proportion of the population may return south to Balsfjord to stage before flying to their breeding grounds.

Even more unexpected is the apparent use by some islandica knots of a late spring staging area in Norway in one year and Iceland in the next year, revealed only by detailed marking studies (Utley et al. 1987). This implies that these birds must leave their early spring staging area in a quite different direction in different years, unlike the use of ‘emergency staging areas’ which lie on the same migration route. Evidently much remains to be understood about spring migration strategies of waterfowl and how this relates to their use of British estuaries.

Staging areas and nutrient reserve storage

Flight is an energetically costly activity. During flight energy is expended at a rate between seven and 10 times that of resting (Masman & Kalassen 1987). To fuel their migratory flights birds store reserves of fat, since fat has a high energy content for its mass and so is an economical way of carrying energy reserves. In general the size of reserves stored is related to the distance to be flown to the next staging area, and in some small waders can amount to half the total body mass just before departure on migration (Davidson 1984). Waders and wildfowl also increase the size of their thoracic muscles. This is to enable them to generate enough power from their muscles to fly efficiently with the large amounts of extra weight stored as fat (Davidson & Evans 1988). Recent studies on waders using the East Atlantic Flyway have shown that the 50-60% of the increase in mass before departure in long-distance migrants is fat and the remainder muscle protein (Smit & Piersma 1989).

In addition to the reserves of fat and protein needed for migratory flight, arctic-breeding waterfowl carry reserves of fat and protein that contribute to egg production and provide nutrients and energy for the incubating bird in early spring when food availability is poor (see Ankerney 1984; Mainguy & Thomas 1985; Murphy & Boag 1989). Waterfowl breeding further south generally carry smaller reserves into the breeding attempt and rely more on readily available food supplies on the breeding grounds. It has recently been established that arctic-breeding waders, like wildfowl, carry reserves of fat and protein to their breeding grounds and that these are sufficient to make a substantial contribution to egg formation (Davidson & Evans 1988).
Waterfowl arriving on arctic breeding grounds in late May and early June can face very hostile conditions of severe weather. This makes high energy demands for thermo-regulation at the same time that most feeding areas remain inaccessible under a blanket of snow. To survive these conditions at the start of the breeding season, waders need to draw on some of these reserves (Davidson & Morrison 1989, Morrison & Davidson 1990). Even so the weather can be sufficiently severe in some years to cause the death through starvation of many adults (Morrison 1975). Even if adults survive such severe weather they may later be forced to abandon their breeding attempt for lack of reserves. Thus it is very important for the survival and breeding of these species that they are able to accumulate sufficient nutrient reserves before they migrate to their breeding grounds.

Likewise the food obtained by geese on spring staging areas is important in determining the size of the clutch of eggs subsequently laid by the female on her arctic breeding grounds (e.g. Anney & MacInnes 1978, Thomas 1983; Anney 1984). Similarly the feeding conditions and reserves accumulated by dark-bellied brent geese on their spring staging areas in the Wadden Sea are important in determining their subsequent reproductive success (Ebbinge et al. 1982; Prokosch 1984); geese that departed in spring below a certain mass had a high probability of returning with no young in the following winter.

Arctic-breeding birds have a very short summer period in which to breed. Hence they must arrive on their breeding grounds, with sufficient nutrient reserves, immediately before conditions are suitable for breeding (Green et al. 1977; Meltofte 1985). Arrival too early can lead to death during severe weather or a serious depletion of reserves precluding egg laying. Arrival too late can mean that chicks cannot be hatched and fledged in time to take advantage of the peak abundance of food or to migrate south before the onset of winter. The use of spring staging areas reflects these needs; birds must arrive on staging areas and store sufficient nutrient reserves on the correct schedule so as to be able to leave their last staging area at precisely the optimum time to reach their breeding grounds. There generally appears to be more leeway in timing during the early stages of the return to the breeding grounds, and rates of accumulation of fat reserves are often lower on early spring staging sites than on late spring staging sites (e.g. Davidson & Wilson 1991).

Waterfowl sometimes change their diet and their foraging habitats during spring staging (e.g. Madsen 1985; Prins & Ydenberg 1985). These changes seem to be associated with the demands of accumulating large nutrient reserves before migration. The rate of spring accumulation of fat can depend on foraging habitat: greater snow geese staging in the Gulf of St. Lawrence in Canada gain fat faster when feeding on their traditional feeding grounds of freshwater marshes than on brackish marshes recently invaded by cord-grass Spartina (Gauthier et al. 1984). Changes in staging area habitat may therefore affect the ability of migrant waterfowl to store sufficient nutrient reserves for their migration and breeding.

Although rates of mass gain can be very rapid – often in excess of 5% of body mass per day (e.g. Davidson 1984; Piersma & van Brederode in press) – at least in waders they may not always be maximal. There is some evidence that waders can accelerate their rate of mass gain to compensate for delays in the migration schedule, such as weather-induced delays in movement between staging areas or arrival with lower than normal reserves as a consequence of adverse weather encountered during the migration (e.g. Piersma 1987; Piersma & Jukema 1990; Evans et al. in press). The precision of the amount of reserves accumulated, and of migration timing, is greatest on the late spring sites (Davidson & Wilson 1991). Smil & Piersma (1989) comment that feeding conditions on these final staging areas may be the most critical for migrants since they offer the last opportunity to bring reserves to the level needed for successful migration and breeding. Nevertheless the loss of any staging area in the sequence used may jeopardize the ability of waterfowl to make a successful migration to or from their breeding grounds, either because alternative areas have insufficient food supplies to permit the necessary reserve accumulation, or because the additional distance flown to other staging areas may delay the subsequent larger replenishing of reserves and so prevent birds reaching breeding grounds in time.

Staging areas with abundantly available food and free from disturbance allow the birds rapidly to accumulate reserves and are thus essential for the breeding strategy of migrant waterfowl, even though each site may be used for only very short periods of the year, or even sometimes only in some years. Hence many more staging areas, like cold weather refugia, may support nationally and internationally important populations of wildfowl than are currently apparent from 1% criteria based on average peak monthly counts.

The ability to ingest food in excess of daily requirements, so letting birds store fat and protein reserves, is also vital in early winter. Such reserves are used by waterfowl as an insurance against inability to find sufficient food during severe weather later in the winter (Hanson 1962; Pienkowski et al. 1979; Davidson 1981; Dugan et al. 1991). The size of fat and protein reserves stored by waders in Britain generally reflects the severity of the winter weather on each estuary (Pienkowski et al. 1979; Davidson et al. 1985a). Both the winter distribution of the birds and their reserve accumulation are adapted to ensure survival in winter. So the winter distributions described below reflect the presence of wintering sites where early winter reserve storage can be sufficient to ensure survival during severe late winter weather (e.g.
Wintering waterfowl distribution

General patterns of waterfowl distribution

British estuaries support very large numbers of wintering waterfowl. Total populations are summarised in Table 8.6.1. In January there are over 1,740,000 waterfowl present on review sites. This is almost 61% of the British wintering population and over 10% of the relevant international waterfowl populations (East Atlantic Flyway for waders, north-west Europe for wildfowl). The total waterfowl population on British estuaries divides between just over 581,000 wildfowl (38% of the British and 5% of the north-west European wintering population) and almost 1,159,000 waders: a massive 90% of the British coastal population and over 15% of the East Atlantic Flyway population. Over 38% of the waders wintering on the Atlantic coast of Europe are on British estuaries (Table 8.6.1). British estuaries are thus of very major national and international significance for their wintering waterfowl.

Total waterfowl distribution

Waterfowl are widely distributed around British estuaries. Some are present on each of the 142 review sites for which there are data on January numbers of waders and/or wildfowl (Figure 8.6.28). There are review sites in most parts of Britain with large numbers of wintering waterfowl, although sites in western and northern Scotland, and in south-west England generally, support regular midwinter populations of less than 10,000 birds. The largest midwinter populations are on The Wash (over 150,000 birds) and Morecambe Bay (over 140,000 birds). Five other review sites support in excess of 50,000 waterfowl in January: the Severn Estuary, the Dee Estuary and North Wirral, the Ribble Estuary, the Solway Firth and the Humber Estuary. Elsewhere there are major concentrations of waterfowl on the estuaries around the Solent in Sussex and Hampshire, in the firths of north-east Scotland and the complex of estuaries of the Suffolk, Essex and north Kent coasts. Taken together the stretch of almost continuous estuarine habitat from the Colne Estuary south to the Swale Estuary (effectively a 'Greater Thames Estuary') supports a substantial proportion of the wintering waterfowl populations in Britain: almost 229,000 birds (13.1% of the British estuarine waterfowl population).

Altogether 25 review sites each support more than 20,000 waterfowl. These sites hold the bulk of the estuarine wintering population: a total of 1,444,419 birds (83.2% of the January estuarine population (Table 8.6.1). Most review sites support much smaller populations than this; over half the review sites (84 sites) have wintering waterfowl populations of less than 5,000 birds, and 31 of these each support less than 500 birds. Taken together, however, all these sites with small populations make an important contribution to the waterfowl populations since almost 17% of the estuarine wintering population is on sites with less than 20,000 birds. As described above, however, although these are sites with small populations, they are often of additional significance as preferred feeding areas, migration staging areas and cold weather refugia.

Total wader distribution

The distribution of waders and wildfowl around review sites is broadly similar (Figures 8.6.28 & 8.6.27). By far the most numerically important estuaries for wintering waders are The Wash and Morecambe Bay, with almost 133,000 and 130,000 birds respectively. Other review sites important for their total populations are the three with more than 50,000 wintering waders: The Dee Estuary and North Wirral, the Solway Estuary and the Humber Estuary. There are a further 22 review sites each supporting January populations of more than 10,000 waders. Taken together these 27 review sites hold almost 925,000 waders, almost 60% of the British estuarine population. The 'Greater Thames
more than 20,000 wildfowl. Again the ‘Greater Thames Estuary’ is of major significance with over 89,000 wildfowl (18% of the British estuarine population) in January. 95 estuaries that each supports less than 10,000 wildfowl, taken together these have a total of 204,500 wildfowl, 2.2% of the international wintering population.

Total wildfowl

![Diagram of wildfowl distribution]

Figure 8.6.27 The distribution of wildfowl populations on review sites in January

Waterfowl distributions in Europe

Outside Britain there are few estuarine areas on the East Atlantic Flyway that support large numbers of wintering waders in midwinter (Figure 8.6.29). On the Atlantic coast of Europe the international Wadden Sea of Denmark, the Federal Republic of Germany and The Netherlands is by far the largest area of estuarine habitat in Europe, with about 4,000 km² of tidal flats (Chapter 6), but the Wadden Sea has a midwinter population of 760,000 waders (Smit & Pienaar 1989), only two-thirds of the British population. Elsewhere the Dutch Delta area is of major significance with 250,000 waders in January. Further south several parts of the African coast support very large numbers of wintering waders.
The Gulf of Gabes in the western Mediterranean has 267,000 waders. Of even greater significance are several parts of the West African coast, notably the coastline of the Democratic Republic of Guinea (400,000 waders) and the Archipelago dos Bijagos in Guinea-Bissau (980,000 waders). By far the most numerically important site on the East Atlantic Flyway in midwinter is the Banc d'Arguin in Mauritania, which supports an estimated 2,038,000 waders (27% of the flyway population) (Smit & Persma 1989).

The frequency of January wader, wildfowl and total waterfowl populations of different sizes on review sites.

Most wintering wildfowl in north-west Europe outside Britain are in the coastal wetlands of Denmark, the Federal Republic of Germany and The Netherlands, where the Wadden Sea is again of major significance, with over 500,000 wildfowl in midwinter (Pirot et al. 1989).

**Correlates of population size and density**

Figures 8.6.26 and 8.6.27 show that there are broadly similar patterns of distribution of waders and wildfowl around British estuaries. This link between the distributions of the two groups is further supported by Figure 8.6.30, which shows a highly statistically significant correlation between the numbers of waders and the numbers of wildfowl on each review site. Thus estuaries with large wintering populations of wildfowl also have large wader populations. Although this correlation explains over 80% of the variations in numbers, individual estuaries do diverge considerably from the average regression line. This is not surprising since waders and wildfowl tend to use estuaries in different ways, and have different food requirements. Furthermore there are many different species involved, each of which has different habitat and food needs. Nevertheless Figure 8.6.30 suggests an underlying common factor influencing waterfowl distribution around Britain.

![Figure 8.6.28](image1)

![Figure 8.6.29](image2)

A major determinant of wildfowl and wader population sizes on an estuary is its size. There are strong correlations between estuary size, both when measured as intertidal area and as total (intertidal and subtidal) area, and the January
example the average density of waders on an estuary with an intertidal area of 20,000 ha is 1.55 birds ha\(^{-1}\) but for a 200 ha estuary is 4.2 birds ha\(^{-1}\), a density 2.7 times higher. The difference for wildfowl is slightly less marked, with the equivalent figures being 1.02 birds ha\(^{-1}\) and 2.29 birds ha\(^{-1}\), a density 2.2 times larger on the smaller estuary. These figures also emphasize that densities of waders are higher than those of wildfowl throughout the size range of British estuaries.

**Figure 8.6.30** Estuaries that support large numbers of wintering wildfowl also support large numbers of wintering waders. Each symbol is a review site and the solid line shows the highly significant least-squares regression \(Y = 2.163X - 145.6, r = 0.781, n = 112, P<0.001\).

Wader, wildfowl and total waterfowl populations (Figure 8.6.31). The area of estuary accounts for between 49\% and 62\% of the between-site variation in bird numbers. The correlations account for slightly more of the variation in numbers of wintering waders than wildfowl, as might be expected since many waders are more closely tied to estuaries than are some wintering wildfowl. Those are strong correlates, considering that on some estuaries densities will be distorted by the movement of roosting birds to feed on other estuaries, and because some wildfowl only roost on estuaries.

If the density of birds is the same on estuaries of different sizes then the slopes of the least-squares regressions shown in Figure 8.6.31 will be unity. These statistical analyses show, however, that in all cases the slopes of the regressions are significantly (\(P<0.01\)) less than unity. This means that the densities of waders, wildfowl and total waterfowl are higher on small estuaries than on large estuaries. The differences are substantial. For

**Figure 8.6.31** Relationships between review site area (total area and intertidal area) and the January populations of a) waders, b) wildfowl, and c) total waterfowl. Solid lines show the least-squares regressions for intertidal area and dashed lines are for total area. For each regression the correlation coefficient (\(r\)) and the regression coefficient (\(b\) ± 1, standard error) are given. All correlations are highly significant (\(P<0.001\)).

These strong correlations do however mask a very considerable variation in waterfowl densities on different estuaries of similar sizes – see for
example Figure 8.6.32. This arises because some estuaries provide particularly good conditions for some species or assemblages for a variety of reasons such as location, diversity of habitats, weather conditions or food supply (e.g. Goss-Custard et al. 1977; Pienkowski & Evans 1984; Moser 1987). In addition different estuaries provide the most favourable conditions for different species assemblages.

![Graph showing the relationship between intertidal area and wader populations.](image)

**Figure 8.6.32** The relationship between intertidal area and January wader populations on review sites. The solid line is the least-squares regression, from Figure 8.6.31, and each symbol is a review site. Note that for review sites of a given size the wader population can vary up to one-hundredfold.

A similar pattern of increasing population size of individual wader species with increasing estuary size was found by Prater (1981) for estuaries in eastern England. From Prater's analysis it appears that most individual wader species occur at higher densities on smaller estuaries. Prater also found that the densities of total wader populations on eastern English estuaries were highest on small estuaries, which he attributed chiefly to the likely inclusion in large estuaries of more areas unsuitable for feeding.

Mudge (1989) has recently shown similar strong correlations between numbers of mallard, wigeon and teal and site area for a smaller number of estuaries, or parts of estuaries, in Britain. Mudge's analyses also found slopes consistently much less than unity for these regressions. Hence individual waterfowl species, as well as the total populations of the species assemblages, occur at lower densities on larger sites.

Since in general the highest densities of waterfowl occur on the most favourable estuaries, these results show that small estuaries can be of very considerable importance to wintering waterfowl even though individually they may support only relatively small populations. This has important consequences for approaches to conserving these populations since it emphasizes that numerical importance should not be used as the only measure for identifying key sites for waterfowl during their non-breeding seasons.

**Waterfowl assemblages on British estuaries**

26 species of wildfowl and 15 species of waders regularly occur on British estuaries in winter. These species, and their population sizes, are listed in Tables 8.6.2 and 8.6.3. Many of these species occur together on estuaries and often roost together as mixed species flocks, although they may use the estuary in different ways as each species has particular feeding requirements.

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of review sites¹</th>
<th>Review site population</th>
<th>British population²</th>
<th>% British population</th>
<th>International population³</th>
<th>% International population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oystercatcher</td>
<td>133</td>
<td>227,732</td>
<td>279,500</td>
<td>81.5</td>
<td>874,000</td>
<td>26.1</td>
</tr>
<tr>
<td>Avocet</td>
<td>13</td>
<td>474</td>
<td>500</td>
<td>94.8</td>
<td>67,000</td>
<td>0.7</td>
</tr>
<tr>
<td>Ringed plover</td>
<td>124</td>
<td>7,926</td>
<td>23,040</td>
<td>34.4</td>
<td>48,000</td>
<td>16.5</td>
</tr>
<tr>
<td>Golden plover</td>
<td>90</td>
<td>20,352</td>
<td>200,000</td>
<td>10.2</td>
<td>1,000,000</td>
<td>2.0</td>
</tr>
<tr>
<td>Grey plover</td>
<td>96</td>
<td>34,389</td>
<td>21,250</td>
<td>114.4</td>
<td>168,000</td>
<td>14.5</td>
</tr>
<tr>
<td>Lapwing</td>
<td>116</td>
<td>66,021</td>
<td>1,000,000</td>
<td>6.6</td>
<td>2,000,000</td>
<td>3.3</td>
</tr>
<tr>
<td>Knot</td>
<td>80</td>
<td>232,901</td>
<td>222,850</td>
<td>104.2</td>
<td>345,000</td>
<td>67.3</td>
</tr>
<tr>
<td>Sanderling</td>
<td>59</td>
<td>5,842</td>
<td>13,710</td>
<td>42.6</td>
<td>123,000</td>
<td>4.7</td>
</tr>
<tr>
<td>Purple sandpiper</td>
<td>31</td>
<td>1,234</td>
<td>19,140</td>
<td>7.6</td>
<td>50,000</td>
<td>2.5</td>
</tr>
<tr>
<td>Dunlin</td>
<td>130</td>
<td>383,332</td>
<td>430,000</td>
<td>67.0</td>
<td>1,373,000</td>
<td>37.4</td>
</tr>
<tr>
<td>Ruff</td>
<td>23</td>
<td>99</td>
<td>1,500</td>
<td>6.6</td>
<td>1,000,000</td>
<td>3.3</td>
</tr>
<tr>
<td>Snipe</td>
<td>93</td>
<td>2,483</td>
<td>–</td>
<td>86.9</td>
<td>65,000</td>
<td>6.3</td>
</tr>
<tr>
<td>Black-tailed godwit</td>
<td>40</td>
<td>4,146</td>
<td>4,770</td>
<td>86.9</td>
<td>65,000</td>
<td>6.3</td>
</tr>
<tr>
<td>Bar-tailed godwit</td>
<td>59</td>
<td>59,019</td>
<td>69,810</td>
<td>96.3</td>
<td>115,000</td>
<td>49.5</td>
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<tr>
<td>Curlew</td>
<td>234</td>
<td>52,654</td>
<td>91,200</td>
<td>56.0</td>
<td>345,000</td>
<td>18.5</td>
</tr>
<tr>
<td>Spotted redshank</td>
<td>15</td>
<td>39</td>
<td>200</td>
<td>19.8</td>
<td>6,500</td>
<td>0.6</td>
</tr>
<tr>
<td>Redshank</td>
<td>136</td>
<td>60,386</td>
<td>75,400</td>
<td>80.1</td>
<td>100,000</td>
<td>55.4</td>
</tr>
<tr>
<td>Greenshank</td>
<td>39</td>
<td>104</td>
<td>400</td>
<td>41.0</td>
<td>15,000</td>
<td>0.8</td>
</tr>
<tr>
<td>Turnstone</td>
<td>114</td>
<td>12,710</td>
<td>44,460</td>
<td>29.8</td>
<td>67,000</td>
<td>19.0</td>
</tr>
</tbody>
</table>

¹ Of 138 review sites with data
² From Moser (1987), Prater (1989), and Stroud et al. (1990)
³ From Smill & Pierson (1989)
⁴ Current estuarine population exceeds most recent British population estimate – see text.
Table 8.6.3 Populations of wildfowl species on review sites in January. Data are average populations for January 1983-1987, from BtoE/NWC counts.

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of review sites</th>
<th>Review site population</th>
<th>British population</th>
<th>% British population</th>
<th>International</th>
<th>% International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mute swan</td>
<td>94</td>
<td>3,113</td>
<td>18,000</td>
<td>17.3</td>
<td>100,000</td>
<td>1.7</td>
</tr>
<tr>
<td>Bewick’s swan</td>
<td>23</td>
<td>738</td>
<td>7,000</td>
<td>10.5</td>
<td>17,000</td>
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<tr>
<td>Whooper swan</td>
<td>26</td>
<td>616</td>
<td>6,000</td>
<td>10.3</td>
<td>17,000</td>
<td>3.6</td>
</tr>
<tr>
<td>Pink-footed goose (Grey goose)</td>
<td>18</td>
<td>33,672</td>
<td>110,000</td>
<td>30.6</td>
<td>110,000</td>
<td>30.6</td>
</tr>
<tr>
<td>European white-fronted goose</td>
<td>26</td>
<td>8,067</td>
<td>6,000</td>
<td>101.1*</td>
<td>300,000</td>
<td>2.0</td>
</tr>
<tr>
<td>Greenland white-fronted goose</td>
<td>3</td>
<td>157</td>
<td>10,000</td>
<td>1.6</td>
<td>22,000</td>
<td>0.7</td>
</tr>
<tr>
<td>Greylag goose</td>
<td>41</td>
<td>11,803</td>
<td>100,000</td>
<td>11.8</td>
<td>100,000</td>
<td>11.8</td>
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<tr>
<td>Barnacle goose</td>
<td>17</td>
<td>17,538</td>
<td>37,000</td>
<td>47.4</td>
<td>42,000</td>
<td>41.8</td>
</tr>
<tr>
<td>Light-bellied brent goose</td>
<td>17</td>
<td>2,417</td>
<td>3,000</td>
<td>80.6</td>
<td>4,000</td>
<td>75.0</td>
</tr>
<tr>
<td>Dark-bellied brent goose</td>
<td>59</td>
<td>90,996</td>
<td>90,000</td>
<td>101.1*</td>
<td>170,000</td>
<td>55.5</td>
</tr>
<tr>
<td>Shelduck</td>
<td>105</td>
<td>70,613</td>
<td>75,000</td>
<td>94.2</td>
<td>250,000</td>
<td>28.2</td>
</tr>
<tr>
<td>Wigeon</td>
<td>102</td>
<td>185,836</td>
<td>250,000</td>
<td>66.7</td>
<td>750,000</td>
<td>22.2</td>
</tr>
<tr>
<td>Garwall</td>
<td>46</td>
<td>673</td>
<td>6,000</td>
<td>113.3</td>
<td>12,000</td>
<td>5.6</td>
</tr>
<tr>
<td>Teal</td>
<td>96</td>
<td>42,996</td>
<td>100,000</td>
<td>42.9</td>
<td>400,000</td>
<td>10.7</td>
</tr>
<tr>
<td>Mallard</td>
<td>107</td>
<td>59,373</td>
<td>500,000</td>
<td>11.9</td>
<td>9,000,000</td>
<td>1.2</td>
</tr>
<tr>
<td>Pintail</td>
<td>73</td>
<td>21,493</td>
<td>25,000</td>
<td>86.0</td>
<td>70,000</td>
<td>30.7</td>
</tr>
<tr>
<td>Shoveler</td>
<td>57</td>
<td>1,384</td>
<td>9,000</td>
<td>15.4</td>
<td>40,000</td>
<td>3.5</td>
</tr>
<tr>
<td>Pochard</td>
<td>62</td>
<td>5,284</td>
<td>50,000</td>
<td>10.5</td>
<td>350,000</td>
<td>1.5</td>
</tr>
<tr>
<td>Tufted duck</td>
<td>74</td>
<td>5,571</td>
<td>60,000</td>
<td>9.8</td>
<td>720,000</td>
<td>0.8</td>
</tr>
<tr>
<td>Scopel</td>
<td>51</td>
<td>5,488</td>
<td>4,000</td>
<td>87.2</td>
<td>150,000</td>
<td>2.3</td>
</tr>
<tr>
<td>Eider</td>
<td>56</td>
<td>13,061</td>
<td>50,000</td>
<td>26.1</td>
<td>3,000,000</td>
<td>0.4</td>
</tr>
<tr>
<td>Long-tailed duck</td>
<td>34</td>
<td>7,489</td>
<td>20,000</td>
<td>3.7</td>
<td>2,000,000</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Common scoter</td>
<td>38</td>
<td>3,671</td>
<td>35,000</td>
<td>11.0</td>
<td>800,000</td>
<td>0.6</td>
</tr>
<tr>
<td>Velvet scoter</td>
<td>10</td>
<td>111</td>
<td>3,000</td>
<td>0.4</td>
<td>260,000</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Goldeneye</td>
<td>96</td>
<td>5,940</td>
<td>15,000</td>
<td>39.6</td>
<td>300,000</td>
<td>2.0</td>
</tr>
<tr>
<td>Smew</td>
<td>33</td>
<td>103</td>
<td>50</td>
<td>–</td>
<td>15,000</td>
<td>0.7</td>
</tr>
<tr>
<td>Red-breasted merganser</td>
<td>22</td>
<td>4,515</td>
<td>10,000</td>
<td>45.2</td>
<td>40,000</td>
<td>11.3</td>
</tr>
<tr>
<td>Goosander</td>
<td>33</td>
<td>1,767</td>
<td>5,500</td>
<td>32.1</td>
<td>10,000</td>
<td>17.7</td>
</tr>
</tbody>
</table>

1 Of 116 review sites with data
2 From Owen et al. (1986), and Stroud et al. (1990).
3 From Piot et al. (1986).
4 Biogeographic populations are combined in this analysis – see text.
5 Current estuarine population exceeds most recent British population estimate – see text.

The wintering wader assemblage

The numerical species composition of the midwinter wader and wildfowl populations on British estuaries (Figure 8.6.33) shows that the wader assemblage is dominated by three abundant species - dunlin, knot and oystercatcher - which together form 72.5% of the wader population. Five other wader species each form more than 1% of the assemblage. Comparison with the species composition of coastal waders on the whole East Atlantic Flyway (Figure 8.6.33) shows that some species including knot, oystercatcher and lapwing form a much larger proportion of the wader assemblage on British estuaries than on the flyway as a whole. In contrast estuaries elsewhere on the flyway, especially in west Africa, are used by populations of some other important flyway species such as curlew sandpiper and little stint. These are species that occur in Britain almost entirely only during migration.

The wintering wildfowl assemblage

The wintering wildfowl assemblage on British estuaries is, like the wader assemblage, dominated numerically by only a few species, notably wigeon *Anas penelope*, dark-bellied brent goose and shelduck, which together form over 56% of the total waterfowl population. A further 11 species each contribute more than 1% of the population.

Comparison with the north-west European waterfowl assemblage (Figure 8.6.33) shows that several species, including wigeon, dark-bellied brent goose, shelduck, teal *Anas crecca* and pintail, form substantially larger proportions of the estuarine assemblage in Britain than in north-west Europe as a whole.

Interspecific differences in estuarine dependence

The species of waders and wildfowl in these assemblages depend in varying degrees on estuaries in winter. The proportions of the British populations of waders and wildfowl that are found on estuaries in January are shown in Figure 8.6.34. For several species of waders, including grey plover, knot, avocet, recurvirostra avosetta, bar-tailed godwit and black-tailed godwit *Limosa limosa*, dunlin, oystercatcher and redshank, the wintering populations are almost entirely restricted to estuaries, with over 80% of the British population of each species on review sites. Note that these figures are approximate because of short-term population fluctuations since the last comprehensive national population estimates. For two species, grey plover and knot, this results in the estuarine population apparently exceeding the national 'total'. In the case of grey plovers this arises because the wintering population has been increasing rapidly in recent years (Moser 1988).
### January waders

<table>
<thead>
<tr>
<th>British estuaries</th>
<th>East Atlantic flyway</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of assemblage</td>
<td>% of assemblage</td>
</tr>
</tbody>
</table>

- **Dunlin**  
- **Knot**    
- **Oystercatcher**  
- **Lapwing**  
- **Redshank**  
- **Bar-tailed godwit**  
- **Curlew**  
- **Grey plover**  
- **Sanderling**  
- **Curlew sandpiper**  
- **Ringed plover**  
- **Little stint**  
- **Other species**

### January wildfowl

<table>
<thead>
<tr>
<th>British estuaries</th>
<th>North-west Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of assemblage</td>
<td>% of assemblage</td>
</tr>
</tbody>
</table>

- **Wigeon**  
- **Dark-bellied brent goose**  
- **Shelduck**  
- **Mallard**  
- **Teal**  
- **Pink-footed goose**  
- **Pintail**  
- **Barnacle goose**  
- **Eider**  
- **Greylag goose**  
- **Coot**  
- **European white-fronted goose**  
- **Goldeneye**  
- **Tufted duck**  
- **Long-tailed duck**  
- **Common scoter**  
- **Pochard**  
- **Velvet scoter**  
- **Mute swan**  
- **Other species**

**Figure 8.6.33** Species composition of January wader and wildfowl populations on British estuaries in comparison with their international populations – East Atlantic Flyway for waders, derived from Snit & Petersen (1989); north-west Europe for wildfowl, derived from Pirot et al. (1989).

Likewise the British knot population has increased slightly in recent years after a major decline during the 1970s (Salmon et al. 1989; Davidson & Wilson 1991).

Only small proportions of the British populations of some other waders such as lapwings and sanderlings occur on estuaries, despite being numerous there (Figure 8.6.34). Sanderlings, turnstones, ringed plovers and purple sandpipers Calidris maritima are predominately birds of open sandy and rocky coasts in winter (Moser & Summers 1987). Others such as lapwings and golden plovers mostly overwinter on inland pasture and arable fields, except during periods of severe weather.

Wildfowl have a similarly varying proportion of their wintering population on estuaries. Rather few species of wildfowl are substantially restricted to estuaries in midwinter: only eight wildfowl populations have more than half of their British wintering populations on review sites (Figure 8.6.34). These are four goose populations (dark-bellied and light-bellied brent goose, barnacle goose and European white-fronted goose Anser albirostris albirostris) and four species of duck (shelduck, scaup Aythya marila, pintail and wigeon). Note however that many barnacle goose and dark-bellied brent goose and wigeon feed on pasture and arable farmland in the environs of estuaries rather than on the estuaries themselves, returning to the estuaries chiefly for roosting.

Other species in the varied estuarine wildfowl assemblage overwinter chiefly elsewhere, either on freshwater wetlands (e.g. mallard, pochard and tufted duck Aythya fuligula) or marine coastal areas (e.g. eider Somateria mollissima, long-tailed duck and common scoter Melanitta nigra). Despite most of their populations overwintering elsewhere, some of these wildfowl, notably mallard and teal Anas crecca, form an important component of the estuarine assemblage because of their nationally large populations (Figure 8.6.33).

### Proportions of international wintering populations dependent on review sites

Populations comprising more than 1% of the relevant biogeographical population are generally considered to be of international significance on these simple numerical grounds. There are also additional reasons for international importance (see earlier, and Stroud et al. 1980). Fourteen species of waders and 21 species of wildfowl occur on review sites in midwinter in numbers exceeding 1% of their international population (Figure 8.6.35), even with the conservatism of using 1% of the January populations (see above).

British estuaries are of major international significance for some species. A total of 87% of neartic knots depend on British estuaries in midwinter, along with 55% of the East Atlantic Flyway population of redsharks, almost 50% of bar-tailed godwits, 27% of alpina dunlins, and 26% of oystercatchers. In addition British estuaries support more than 10% of a further four wader
### Figure 8.6.34

The percentages of the British populations of waders and wildfowl that occur on review sites in January. Total British population sizes are from Owen et al. (1986) and Stroud et al. (1990) for wildfowl, and from Moser (1987) for waders. For species marked * the current review site population exceeds the estimated British population – see text for explanation. For barnacle goose the shaded portion is the Svalbard population and the black portion is the Greenland population.
Figure 8.6.35 The percentage of international populations of waders and wildfowl that occur on review sites in January. Only species with >1% of the international population are shown. For barnacle goose the shaded portion is the Svalbard population and the black portion is the Greenland population.

species (turnstone, ringed plover, curlew and grey plover).

British estuaries are of great international importance for some wildfowl, especially barnacle and brent geese. Over 80% of light-bellied brent geese (which come almost entirely from the very small Svalbard breeding population) occur on British estuaries, chiefly at Lindisfarne in Northumberland. The precise proportion varies between years depending on how many birds move across the North Sea from their early winter Danish feeding grounds (Owen et al. 1986). In addition there are over 50% of dark-bellied brent geese and 100% of the Svalbard breeding population and c. 70% of the Greenland breeding population of barnacle geese on review sites. Other wildfowl with major international populations overwintering on review sites are pintail, pink-footed goose and shelduck, each with about one-quarter of the international population on such sites, and British estuaries support 10-25% of five other wildfowl species: wigeon, goosander *Mergus merganser*, grey-lag goose *Anser anser*, red-breasted merganser *Mergus serrator*, and teal.
Distribution of waterfowl within the British estuarine resource

The general dispersion pattern

Some wader species are very widely dispersed around British estuaries; others have a much more restricted distribution. The variation in dispersion has important consequences for the effective conservation of estuarine wader assemblages, as some species critically depend on the safeguarding of relatively few key sites, whilst the wintering populations of others depend on a much wider range of estuaries.

The dispersion of wintering wader on review sites is summarised in Figure 8.6.36. Many wader species are particularly widespread, and redshanks, curlews, oystercatchers, dunlins and dunlins can be found in winter on over 90% of British estuaries, including many small sites as well as the major estuaries. Others are less ubiquitous, but nevertheless altogether 12 of the 19 regularly occurring wintering waders each use over half the review sites. In comparison, most waterfowl have a more restricted distribution. This is particularly so for geese, many of which depend on just a few traditional wintering areas. The only widespread estuarine goose is the dark-bellied brent goose, but even this population occurs regularly on only half the review sites. Only 1.0 of the 24 regularly occurring estuarine wildfowl use more than half the review sites, and only the commonest wildfowl species, the mallard, uses more than 90% of the sites. The estuarine specialists, shelduck and wigeon, are also widespread.

The populations of each species are not, however, evenly distributed around the review sites on which they occur, and Moser (1987) has shown that in most species a large proportion of the wintering population occurs on just a few estuaries.

Examples of wildfowl distributions

Within this general dispersion pattern around British estuaries, different species are distributed very differently. This is illustrated in Figures 8.6.37 to 8.6.46 for a range of waterfowl species whose distributions in January are described below. These provide examples of different types of distribution pattern and are not intended to give a comprehensive description for each waterfowl species present on estuaries. Such species descriptions can be found in Prater (1981) for waders and Owen et al. (1966) for wildfowl.

Shelduck

Shelduck are one of the most widely distributed and characteristic waterfowl of estuaries, with 94% of the British population wintering on review sites, where they feed chiefly on a variety of small invertebrates on chiefly soft intertidal mudflats. Most wintering shelducks in Britain breed around British estuaries, although some probably come from breeding areas around the southern North Sea (Prater 1981). Although they are common (in waterfowl terms) throughout Britain they are particularly abundant on the east coast of Britain from the Eden Estuary southwards, on the south coast between Foulke Harbour and Flegham Harbour and in north-west England (Figure 8.6.37). The largest January population (over 12,000 birds) is on The Wash, but elsewhere midwinter numbers are less than 5,000 birds in any estuary.

Scaup

Other ducks are predominantly estuarine in Britain in winter but have a much more restricted distribution. Scaup breed in Iceland and the USSR and reach peak numbers in Britain in January, although the British total population is relatively small compared with those of the Netherlands and the Baltic. Scaup feed in shallow estuarine waters on mussels *Mytilus edulis* and other bivalves such as cockles and Baltic tellins *Macoma baltica* (Owen et al. 1986). In the 1970s scaup were concentrated mostly close to sewage outlets (Campbell 1978) or where distilleries discharged their grain waste. These areas had clearly enriched benthic communities which provided invertebrate food. Prater (1981) shows the largest population, sometimes up to 40,000 birds, in the Firth of Forth in the late 1960s. The sewage discharge there has since been reduced (Campbell 1984), and the population in the estuarine Firth of Forth is now very small (Figure 8.6.38). The national population

![Figure 8.6.36 The interspecific variation in dispersal of waders and wildfowl on review sites in January, shown as the number of review sites on which the population regularly occurs expressed as a percentage of the number of sites for which there are data (136 review sites for waders, 116 for wildfowl).](image-url)
has also declined overall. The largest wintering group, although at about 1,700 birds much smaller than in the past, is now in the Solway Firth. Elsewhere wintering populations exceed 50 birds on only five estuaries — on Islay, associated with domestic sewage discharge and to a lesser extent distillery discharges, in the Clyde Estuary, the Dornoch and Cromarty Firths and the Humber Estuary — although even smaller numbers are widespread around the British coastline (Figure 8.6.38).

Eider

Some other waterfowl also have a northern distribution in Britain. An example is the eider (Figure 8.6.39), which winters in large concentrations (>1,000 birds) only north from Morecambe Bay in the west and Lindisfarne in the east, although again much smaller numbers are scattered widely on estuaries throughout Britain. Eiders, almost entirely from the British breeding population, are not restricted to estuaries in winter, but review sites support over one-quarter of the British wintering population (Table 8.6.3), and

Figure 8.6.37 The January distribution of shelduck on review sites. Data are mostly from BoEE/NWC counts for 1983-1987.

Figure 8.6.38 The January distribution of scaup on review sites. Data are mostly from BoEE/NWC counts for 1983-1987.

eiders form a large component of the waterfowl assemblage on some northern estuaries.

Barnacle goose

Many wintering populations of geese are even more restricted in their wintering distribution, the most restricted being the barnacle goose. Two biogeographic populations of barnacle geese overwinter in Britain (Figure 8.6.40). The Svalbard population stages in autumn on Bear Island (Owen & Gullestad 1984), about 650 km south of the breeding grounds, and then flies non-stop the 2,500 km to the Solway Firth where the whole breeding population of about 12,100 birds overwinters.

The Greenland population breeds in east Greenland and reaches the islands of western Scotland, particularly Islay, in late October via a staging area in southern Iceland (Owen et al. 1986). Substantially the entire world population uses the Loch Gruinart review site as an autumn arrival and staging area before dispersing more widely to other parts of the wintering range (Easterbee et al. 1987). About 20,000 of the 27,000 British
population occurs on the two review sites on Islay, where they roost at night before spreading out to feed on nearby grasslands during the day. Very small numbers of barnacle goose occur in midwinter on a few other British estuaries (Figure 8.6.40). Their origins are uncertain but those in north-east England and Morecambe Bay are probably from the Svalbard populations whilst those on several estuaries in East Anglia may have moved from The Netherlands, where a third biogeographical population, from Siberia, overwinters (Owen et al. 1986). The few birds in southern and western England may be from feral flocks.

**Dark-bellied brent goose**

In contrast to these northern estuarine distributions, other geese depend heavily on estuaries in southern Britain. As for most other geese, the population of dark-bellied brent geese has increased very greatly since the 1950s. These birds feed on eel-grass *Zostera* on tidal flats and, increasingly, on pastures and arable farmland surrounding estuaries. The population decreased greatly in the 1930s, a decline generally attributed to a concurrent substantial disease-related decline in the abundance of *Zostera*, and has been increasing rapidly since the 1970s, possible as a consequence of the easing of hunting pressure in Europe. Since the 1980s the wintering distribution has become more southerly (Owen et al. 1986). The population overwintering in Britain breeds in northern Siberia, particularly on the Taymyr Peninsula, and reaches Britain via staging areas in the Wadden Sea.

Birds begin reaching Britain between September and November, when they congregate particularly on the tidal flats of Maplin Sands and Southend-on-Sea, before dispersing to estuaries in southern and eastern England (St. Joseph 1979). There are three main wintering areas: The Wash and North Norfolk Coast, the south coast from Pagham Harbour to the Exe Estuary and the estuaries of Essex and Kent. In recent years the Essex estuaries have declined in
relative importance whilst the proportions wintering in Norfolk and on the south coast have increased (Owen et al. 1986). The Wash holds the largest single part of the wintering population: 17,750 birds (almost 20% of the British population – Table 8.6.3). Away from their main wintering areas small numbers of dark-bellied brent geese overwinter on a number of south-coast and west-coast estuaries as far north as Morecambe Bay, with an average of 500 birds now occurring on the Loughor Estuary, and as far north as Lindisfarne in eastern England (Figure 8.6.41). Before the 1930s Lindisfarne was a major wintering ground for this population.

**Light-bellied brent goose**

The small (c. 3,000 birds) Svalbard-breeding population of light-bellied brent geese has not, unlike that of other arctic-breeding geese, increased greatly in recent years (Madsen 1987). It underwent a serious decline in the early 20th century, largely as a consequence of autumn shooting in Denmark and human disturbance in Svalbard (Madsen 1984; Owen et al. 1986). The absence of any subsequent increase is probably due to a number of factors, including high levels of nest predation and possibly also competition on their breeding grounds with the rapidly increasing Svalbard population of barnacle geese (Madsen et al. 1999). Many of these light-bellied brent geese overwinter in Denmark on just a few sites and some move to Lindisfarne in midwinter. The number reaching Lindisfarne generally depends on the severity of the winter weather in Denmark (Madsen 1984), but in recent years there has been a regular wintering flock at Lindisfarne, reinforced by influxes in severe weather. Between 1983 and 1987 an average maximum of three-quarters of the world population was at Lindisfarne (Table 8.6.3). Small numbers of light-bellied brent geese do occur elsewhere in two areas of Britain (Figure 8.6.41). Those in eastern Scotland, as far north as the Moray Firth (where many used to overwinter), are probably wanderers from the Svalbard population. There are also small numbers on eight review sites in south-western England and Wales. These may belong to the Greenland and Canadian breeding population which overwinters almost entirely in Ireland (Owen et al. 1986; O’Brien & Healy 1990). If they are all from the nearctic population these approximately 130 birds may be about 1% of the Irish-wintering population of that race in recent years.

**Examples of wader distributions**

Waders, like wildfowl, have major differences between species in their winter distributions. At the two extremes of distribution patterns are avocet (Figure 8.6.42) and dunlin (Figure 8.6.43).

**Avocet**

The wintering population of avocets is small but, like the breeding population (see later), is increasing rapidly. This has been documented recently by Cadbury et al. (1989). Avocets in winter are restricted to 13 review sites in southern and eastern England. Overwintering began in the early 1950s in Plymouth Sound and subsequently in the Exe Estuary, expanding in the mid-1980s to Pagham and Poole Harbours and soon afterwards also close to their breeding grounds in the Ore-Able-Butley Estuary in Suffolk. More recently, small numbers have begun to overwinter in Essex and Kent and winter counts in 1988/89 indicate a wintering population now exceeding 300 birds, about 1% of the East Atlantic Flyway population (Figure 8.6.42).

**Dunlin**

In contrast to avocets, the 380,300 dunlins wintering on British estuaries are widespread throughout Britain (Figure 8.6.43). In midwinter they are absent from only a few very small estuaries with little intertidal mud, scattered around Britain. Dunlins are the most abundant wader in Britain, but even so are relatively scarce compared with many
wintering British birds, since they depend almost entirely on estuaries, as do many other wintering waterfowl (Figure 8.6.34). Wintering dunlins belong almost exclusively to the alpina population that breeds in northern Scandinavia and the USSR and overwinters in western Europe (Cramp & Simmons 1983), and British estuaries support over 27% of the East Atlantic Flyway population (Table 8.6.2). Dunlins occur in large numbers on many British estuaries but are most abundant on large estuaries such as Morecambe Bay (over 28,000 birds), The Wash (over 24,000 birds) the Mersey Estuary (over 22,000 birds) and the Humber Estuary (21,000 birds), but the largest midwinter population is on the Severn Estuary where the over 34,000 dunlins in January comprise 5.5% of the international population. Elsewhere there are major concentrations of dunlins on Suffolk, Essex and north Kent estuaries, where there are in excess of 33,500 birds (almost 7.5% of the international population) between the Blyth and Swale Estuaries, and the Hampshire and Sussex estuaries from Pagham Harbour to the Lymington Estuary, where there are over 50,000 dunlins (3.7% of the international population) in January.

The distribution of dunlins, although still widespread, is that of a population that has declined substantially since the 1970s, a decline attributed by Goss-Custard & Moser (1988) to losses of feeding grounds, seemingly through the encroachment of *Spartina anglica* and its subsequent effects on mudflat character. This decline is a rain-influenced change, since *Spartina* arose through hybridisation with an introduced species and was subsequently deliberately planted in many estuaries for sea-defence and land-claim purposes (see Chapter 8.1 and Chapter 10).
Knots wintering in Britain are the *islandica* population that breeds in high-arctic Greenland and Canada. Knots make some of the longest non-stop flights of any waders, reaching Britain in autumn via staging areas in western Iceland. Some reach Britain in early winter after molting on the Wadden Sea. In spring they return via early spring staging areas chiefly in north-west England and the Wadden Sea. Birds from each of these sites fly to late spring staging areas in either Iceland or northern Norway, from where they fly up to 3,500 km direct to their high-arctic breeding grounds (Alerstam et al. 1986; Davidson & Evans 1986b; Davidson et al. 1986c). Knots are amongst the most highly migratory of waders. Some breed on the northernmost areas of land in the world within 600 miles of the North Pole in northern Canada, and some from the Siberian breeding population reach as far south as the southern tip of Africa in winter (Dick et al. 1987). The Siberian-breeding population (the *canutus* subspecies) migrates chiefly through the Wadden Sea in spring and autumn and overwinters in West Africa (Dick et al. 1987). None is thought to overwinter in Britain, although some Siberian knots do occur on migration, especially in eastern Britain in autumn.

The migrations and distribution of *islandica* knots have been recently reviewed by Davidson & Wilson (1991). These birds overwinter chiefly in Britain, the Wadden Sea, the Dutch Delta, and as far south as western France. Like *alpina* dunlins, this knot population has declined by about 40% since the early 1970s, but this seems to be largely because of a series of poor breeding seasons and adult mortality in the 1970s (Davidson & Wilson 1991; Boyd 1991).

Knots are heavily dependent on British estuaries in winter and over 67% of the international population occurs here in January (Table 8.6.2). Since the population decline, Britain has supported a larger proportion of the wintering population than previously. Knots overwinter in large numbers on rather fewer British estuaries than dunlins (Figure 8.6.44), but are very mobile and some move between a network of these sites during the course of the winter (Dugan 1981).

Knots occur chiefly on large estuaries, where they aggregate into flocks of many thousands of birds to feed mostly on small bivalve molluscs such as *Macoma balthica*. They occur in midwinter chiefly in four areas: the Essex and north Kent coasts, The Wash and the Humber Estuary, north-west England from the Dee Estuary to the Solway Firth, and east Scotland (Figure 8.6.44). The Wash is the major wintering site for knots: there are over 71,000 birds there in midwinter. This is over 20% of the world population of *islandica* knots. Elsewhere the largest wintering populations are on the Humber Estuary (25,700 birds; 7.4% of the international population) and the Alt Estuary (24,600 birds; 7.1% of the international population). The population on the Alt Estuary may not accurately reflect the distribution of feeding birds since, as described above, many knots now fly from feeding in the Dee Estuary to roost undisturbed on the Alt Estuary (Mitchell et al. 1988). In total this mobile Liverpool Bay population (from the Dee, Mersey, Alt and Ribble Estuaries) is an important part of the international distribution, amounting to over 46,700 birds (14.1% of the international population).

![Figure 8.6.44](image)

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Bar-tailed godwit

Bar-tailed godwits have a broadly similar distribution to that of knots (Figure 8.6.45), with small numbers scattered around many estuaries throughout Britain. Bar-tailed godwits are characteristic of muddy sand habitats on estuaries, where they feed chiefly on lugworms *Arenicola* and ragworms *Nereis* and *Hediste*. These muddy sand habitats are widespread on fairly exposed review sites such as those in western Scotland (see also Chapter 8.3), and this is reflected in the distribution of the birds. Britain supports almost 50% of the midwinter population overwintering in Europe (Table 8.6.2). These birds are thought to come from breeding populations in northern Scandinavia and the western USSR (Smit & Piersma 1989).
Although they are widely distributed in Britain, just four review sites together support over 50% (almost 28,000 birds) of the British estuarine population. These are the Alt and Ribble Estuaries, The Wash and Maplin Sands.

Black-tailed godwit

In contrast to the bar-tailed godwit, the distribution of the closely related black-tailed godwit is much more restricted, and it occurs in largest numbers on different estuaries from its congener (Figure 8.6.46). Wintering black-tailed godwits come from the Icelandic-breeding population which winters in Britain, Ireland and south along the Atlantic seaboard to Morocco (Smit & Pierma 1989). Increasing numbers of black-tailed godwits have overwintered in Britain since the 1940s (Prater 1981) and most of the small (c. 5,000 birds) British wintering population occurs on estuaries, where the birds generally feed on much saltier mud areas than bar-tailed godwits (Cramp & Simmons 1983). The stronghold of wintering black-tailed godwits is the Stour Estuary in Suffolk/Essex, where the January population exceeds 700 birds and is of international significance. The Suffolk and Essex estuaries are a major wintering area. Elsewhere black-tailed godwits winter around the Hampshire and Sussex estuaries, on the Exe Estuary, on the large estuaries of north-west England, and on the Eden Estuary in eastern Scotland. Elsewhere they are very scarce or absent (Figure 8.6.46).

Overall implications of waterfowl dispersion patterns

The dispersion pattern of all regularly occurring waders and wildfowl is further analysed in Figure 8.6.47. Here the British estuarine wintering population for each species is divided into two components: the proportion on major wintering sites (here defined as sites in which the January population exceeds 1% of the British estuarine wintering population), and the proportion on other sites each with less than 1% of this wintering population.

Several important distributional features emerge from this analysis. For wildfowl the number of sites each with more than 1% of the January estuarine
<table>
<thead>
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<th>British Estuarine Population</th>
<th>No. of Sites with 1%</th>
<th>British Estuarine Population</th>
<th>No. of Sites with &lt;1%</th>
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**Figure 8.6.47** The proportions of British estuarine populations of waders and wildfowl that occur in January on review sites each holding >1% of the British wintering population (shaded portion) and <1% (unshaded portion).

The patterns for waders are similar to those of wildfowl in that different species vary, from some, notably knot and the two godwit species, with almost their entire estuarine wintering populations on major sites each supporting more than 1% of the population, to widespread, often non-estuarine, species such as golden plover, lapwing and snipe with little or none of their populations on such major sites. The number of major (i.e. >1% of the population) sites used by many waders is much higher than for wildfowl: six of the 16 commonly occurring wader species each occur on more than 15 major sites, compared with only three of 28 wildfowl species. It is notable that even those widespread waders whose wintering populations are mostly non-estuarine (turnstone, ringed plover, purple sandpiper and sanderling) have more than 1% of their wintering population on some review sites. This is most marked in sanderlings with 13 major sites holding 71.5% of the wintering population (Figure 8.6.47).
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Figure 8.6.46: The percentages of international populations of waders and wildfowl in January on review sites each holding <1% of the British population of that species or biogeographic population. Only species where such sites support more than 1% of the international population are shown.

An important consequence of the widespread estuarine distribution of many wintering waders and wildfowl is illustrated in Figure 8.6.40, which shows that in excess of 1% of the international wintering population of 15 species of wildfowl and 13 species of waders are dispersed around the many estuaries that each hold only a small part of the wintering population. For many species, especially waders, this internationally important component of the wintering population is distributed over 100 of the 155 review sites. This emphasises the value of the network of sites formed by Britain’s estuaries, and also stresses the cumulative importance of the individually small estuaries.

For some species of waterfowl the percentage of the international wintering population on estuaries with only small numbers each is surprisingly large. A total of 17.9% of the East Atlantic Flyway population of redshanks is dispersed around 111 British review sites each supporting less than 500 birds. 12.3% of the international tern population is on 109 sites each with less than 127 birds, and 11.5% of ringed plovers are on 115 sites each holding fewer than 80 birds. Even in knots, which are well known for their concentration into large flocks on just a few wintering sites (Cramp & Simmons 1963), 4.4% of the flyway population uses 84 review sites, each with less than 2,300 birds. More than 5% of the international population of four other waders (curlew, dunlin, bar-tailed godwit, oystercatcher) occurs on between 84 and 119 review sites, each with a small population of that species.

Generally smaller proportions of international wildfowl populations are dispersed around review sites in small numbers. Most importantly, more than 5% of the international populations of three estuarine specialist wildfowl (wigeon, light-bellied brent goose and shelduck) depend on review sites with small populations, the largest being 7.8% of the north-west European wigeon population distributed around 83 review sites, each with less than 1,000 birds.

The spectacularly large flocks of wintering waders and wildfowl on major British estuaries, such as the Dee Estuary, the Solway Firth, the Humber Estuary, The Wash and Morecambe Bay, are well-known to be of very great national and international
importance in wildlife conservation. It is clear from this analysis that the network of estuaries throughout Britain, including the small estuaries each with relatively small waterbird populations, are also an important and vital component of the world's estuarine wildlife resource. Indeed some of the small estuaries, with their high densities of birds, may be the preferred wintering grounds for many species (see e.g. Moser 1988) and may thus be crucial to the long-term survival of these populations.

8.6.3 Other estuarine wintering birds

Several other groups of wintering birds occur on or close to British estuaries during their non-breeding seasons. These include seabirds, other waterbirds, raptors and passerines.

Seabirds

Many seabirds such as auks winter in coastal and inshore waters around Britain, but generally occur in areas outside the outer limits of the review sites. Distributions in the North Sea are reviewed by Tasker et al. (1987) and Tasker & Pienkowski (1987).

Some species, particularly seaducks such as common and velvet scoters and long-tailed ducks, occur both within review sites (with their distributions described above) and in outer parts of large firths such as the Moray Firth. These populations are of considerable national significance, with about 50% of the British population (3% of the north-west European population) of common scoters in the Dornoch/Firth Moray Firth area in midwinter. The largest long-tailed duck flock in the North Sea also occurs in this area, in and around six review sites (Loch Fleet, Dornoch, Cromarty and Moray Firths, Lossie Estuary and Spey Estuary), and has a total of about 20,000 wintering sea-ducks (Mudge & Allen 1980).

Other inshore species that are under-represented in BoED/NWC counts, but which occur in the outer parts of review sites, are divers, chiefly red-throated divers Gavia stellata and a few black-throated divers Gavia arctica and great northern divers Gavia immer. Red-throated divers are widespread along the North Sea coast of Britain in winter and occur also around estuaries in North Wales and parts of north-west England and Scotland (Lack 1986; Moser et al. 1986). The estimated early winter population is about 20,000 birds, of which about three-quarters are on the North Sea coast. Major concentrations are in the outer parts of the Moray Firth complex, with up to 1,500 birds at times (Barrett & Barrett 1985) and up to 1,000 divers in the outer parts of the 'Greater Thames Estuary' (Tasker & Pienkowski 1987).

Grebes and other waterbirds

Some other waterbirds, such as grebes, regularly occur in estuaries in small numbers in winter. Like divers, they are frequent in the outer parts of estuaries and so may be under-represented in counts. The commonest are the little grebe Tachybaptus ruficollis and great-crested grebe Podiceps cristatus, although both overwinter chiefly on inland freshwater sites. Prater (1981) reports about 1,500-2,000 little grebes on estuaries (about 10% of the British population). Great-crested grebes now breed widely on fresh water in Britain and Europe. In winter some move to estuaries and sheltered coasts, particularly in severe weather, and the 1,800 birds on estuaries reported by Prater (1981) is probably an underestimate. There are concentrations of wintering great-crested grebes on estuaries in north Wales and north-west England, the Firth of Forth, The Wash and the sheltered estuaries of Essex and around The Solent (Prater 1981).

Three other species of grebes occur in smaller numbers. About 200 red-necked grebes Podiceps grisegena overwinter in Britain, chiefly in estuarine and other coastal waters, with more moving from continental Europe in severe weather. The largest concentration is in the Firth of Forth, with up to 40 birds, and there are much smaller numbers scattered around the English coast at Lindsfarne, The Wash and North Norfolk Coast, Southampton Water and elsewhere (Prater 1981; Chandler 1986a). About 400 Slavonian grebes Podiceps auritus overwinter on sheltered coasts scattered around Britain. Wintering birds may come partly from the small British breeding population as well as from major breeding areas such as Iceland and Scandinavia. Many of the wintering population are on estuaries, with more than 10 wintering regularly on each of several widely scattered sites including the Dornoch Firth, Firth of Forth, Blackwater Estuary, Poole Harbour and Exe Estuary. Small numbers are also found in the estuaries of The Solent (Prater 1981; Chandler 1986b). There is just over 100 black-necked grebes Podiceps nigricollis overwintering in Britain, again mostly estuarine but with a more southerly and westerly distribution than the other two scarce grebes. The main estuary appears to be Langstone Harbour, with a few elsewhere in The Solent, Poole Harbour, The Fleet, the Teign Estuary, the Loughor Estuary and around Anglesey.

In winter cormorants Phalacrocorax carbo occur chiefly on coastal waters including estuaries around much of the coast of Britain. Dunnet (1986) estimates a British wintering population of 20,000-25,000 birds, of which there are at least 9,000 (38-45%) wintering on estuaries (Prater 1981).

Gulls

Most gulls are widespread throughout Britain in winter in both inland and coastal habitats (Prater 1981; Lack 1986). In addition to these widely distributed species small numbers of the artic and sub-arctic-breeding Iceland gull Larus glaucomelas and glaucous gull Larus hyperboreus occur on Britain's estuaries and coasts, particularly in
northern and eastern Britain (Hume 1986a, 1986b). Small but apparently increasing numbers of the more pelagic little gull Larus minutus also occur in winter round coasts in Britain, notably around the estuaries of Liverpool Bay (Prater 1981), although they are less frequent on estuaries in winter than in summer when juveniles are dispersing widely and occur on coastal lagoons and pools (Hutchinson 1986).

There has been no recent comprehensive assessment of the numbers and distribution of gulls on estuaries, but Prater (1981) found that the commonest estuarine gull in winter was the black-headed gull Larus ridibundus, which feeds on the intertidal flats alongside waders during the day (e.g. Curtis & Thompson 1985), as well as roosting on estuaries at night. Many black-headed gulls also feed on coastal grazing marshes and other grasslands in winter. Prater (1981) reported four estuaries with an average peak of over 20,000 black-headed gulls: the Severn Estuary, The Wash, the Clyde Estuary and the Solway Firth. Another five estuaries supported in excess of 10,000 birds. Many birds move from inland to estuaries during severe cold weather. Other widespread gull species (common gull Larus canus, herring gull Larus argentatus, lesser black-backed gull Larus fuscus and greater black-backed gull Larus marinus) chiefly use estuaries during winter as safe night-time roosts (Prater 1981). Several estuaries throughout Britain provide roosting areas for over 100,000 gulls in winter. These include the Thames Estuary, The Wash, the Mersey Estuary, Morecambe Bay and the Solway Firth.

Raptors

Two other groups of birds – raptors and some passerines – are characteristic of estuaries in winter. Several species of raptors hunt widely over saltmarshes and coastal grazing marshes. Between 200 and 300 hen harriers Circus cyaneus overwinter in Britain from breeding populations in Britain and continental Europe (Clarke 1986). Most are coastal and estuarine and gather in communal roosts in reed beds or marshes adjacent to estuaries such as The Wash and North Norfolk Coast, from which they radiate out to hunt during daylight. Although the wintering population is scattered widely around Britain there is an increasing population along the east coast of England from the Humber south to Kent (Clarke 1986). Short-eared owls Asio flammeus are widespread in England and southern Scotland in winter (Clive 1986) and some hunt over coastal saltmarshes and grazing marshes.

Two falcons, the merlin Falco columbarius and the peregrine Falco peregrinus, are particularly characteristic members of the winter bird assemblage on estuaries, as are sparrowhawks Accipiter nisus on some estuaries. Both species are found throughout Britain (Bibby 1986; Ratcliffe 1986), in the case of the peregrine mainly in western and northern Britain, but many move from upland breeding areas to prey on the large concentrations of wintering waterfowl on estuaries throughout Britain. The recovery of raptor populations in Britain since the major declines due to the effects of pesticides in the 1960s means that numbers hunting on estuaries may have increased recently, although only small numbers of raptors may still be involved. For example, at Teesmouth the estuary is hunted regularly by one merlin, with occasional visits from a peregrine and a sparrowhawk (Townshend 1984).

As top predators in estuarine systems, raptors depend on a variety of other bird species for food during winter. Merlins and sparrowhawks on estuaries feed on both small passerines and small waders such as dunlin, ringed plover and redshank. Peregrines take larger waders and ducks such as teal and wigeon as well as other birds such as wood pigeons Columba palumbus (Cram & Simmons 1983). Although raptor numbers may be small, Townshend (1984) suggested that they could take between 10% and 20% of the midwinter dunlin population on the Tees Estuary. Similarly, on Tynemouth Bay Whitfield (1985) estimated that raptors, mostly sparrowhawks but also peregrines and merlins, ate 15% of redshanks, 19% of ringed plovers and 4% of dunlins wintering there. Even larger proportions of a wintering population of redshanks were eaten by raptors, mostly sparrowhawks, on a nearby stretch of narrow rocky and sandy shore.

Passerines

Large flocks of some passerines, chiefly finches and buntings, congregate on estuaries in winter to feed on the abundant seed stock on upper saltmarshes, and along strand-lines. These flocks include some widespread species such as linnet Carduelis cannabina, greenfinch Carduelis chloris and chaffinch Fringilla coelebs and others that are largely restricted to coasts and estuaries. Lapland bunting Calcarius lapponicus and chalcothorax Eremophila alpestris are largely restricted to the coasts of eastern Britain in winter. Snow buntings Plectrophenax nivalis also have a wintering bias to eastern coasts but some also overwinter in the uplands of Scotland and northern England (Lambert 1986a). Snow buntings feed on both saltmarshes and sandy shores and so are not restricted on the coast to estuaries, although large flocks of several hundred birds are characteristic of the outer parts of many estuaries in eastern Britain. Shorelarks come from a breeding population in northern Scandinavia and the USSR, and the small wintering population (c. 300 birds) is largely restricted to a few estuaries in eastern Britain including the Firth of Forth, Tynemouth Bay, Lindisfarne, the Tees Estuary, the Humber Estuary, The Wash, the North Norfolk Coast and several estuaries in Essex and Kent (Lambert 1986b). On estuaries they depend on areas of developing saltmarsh, where they feed chiefly on glasswort Salicornia seed during low tide, and on adjacent dune systems, where they feed at high tide (Lambert 1986b).
Lapland buntings are more widespread on the east coast from the Firth of Forth south to north Kent (Lambert 1986c), where they feed, often in association with skylarks *Alauda arvensis*, on coastal arable and pasture fields and on saltmarshes. Lambert (1986c) estimated the wintering population at 200-500 birds, but Davies (1987) has recently found a wintering population of over 500 Lapland buntings on saltmarshes of The Wash, substantially increasing the total wintering population and making The Wash the most important estuary for Lapland buntings in Britain. Davies (1987) suggests that these birds come from the Norwegian-breeding population. Wintering populations of skylarks can be very large on estuaries and Davies (1987) estimated 28,000-32,000 birds on the saltmarshes of The Wash, although these still form a small proportion of the estimated 25 million skylarks wintering in Britain (Green 1986).

Twites *Carduelis flavirostris* are also mainly coastal and estuarine in winter, although Lambert (1986c) shows a scattered distribution elsewhere in Scotland and northern England. Their main wintering strongholds are, however, the extensive saltmarshes of The Wash and the Essex estuaries. Davies (1987) estimated that up to 17,000 twites overwinter on The Wash and showed from ringing recoveries that these come from the isolated breeding population of the southern Pennines. In some winters the Wash birds probably comprise almost all this breeding population (Davies 1988). Numbers vary between years, however, and the birds may move elsewhere, reappearing across the southern North Sea, in years when the seed production by saltmarsh plants is low.

Fassarines and raptors further enhance the varied and abundant assemblages of wintering waders, wildfowl and other waterbirds which contribute very substantially to the great national and international significance of Britain’s estuaries for wildlife. Indeed, raptors as well as waterfowl are two (the other being seabirds – see Section 8.6.1) of the three groups of birds for which Britain is most internationally important.

### 8.6.4 Breeding Birds

**Introduction**

Breeding birds are an important and vulnerable feature of the conservation interest of estuaries. The mosaic of habitats surrounding estuaries provides suitable nesting sites for important numbers of various bird species, notably waders and seabirds. For many waders, especially, estuaries support nationally and internationally important breeding populations. The abundant macrobenthic fauna in the intertidal mudflats nearby provide rich feeding grounds for both adults and young of waders and wildfowl, for example shelduck. The major breeding habitats associated with British estuaries are coastal wet grasslands, beaches and shingle systems, sand-dunes and saltmarshes.

Important assemblages of breeding birds occur on saltmarshes and the shingle, machair and lowland grasslands associated with estuaries. Such assemblages, with their complex behavioural and ecological links, are of particular scientific and conservation importance, in addition to that of the individual species involved (Stroud et al. 1990). Estuarine breeding assemblages are characteristically dominated by their breeding wader populations. Typical assemblages on lowland wet grasslands include redshank, lapwing, snipe *Gallinago gallinago* and curlew, with more rarely ruff and black-tailed godwit. On coastal grasslands the association often includes oystercatcher and ringed plover and, on the machair of the Outer Hebrides, ringed plover and dunlin. The rich breeding wader assemblages of the Outer Hebrides are described in detail by Fuller et al. (1986). A typical saltmarsh assemblage includes redshank, lapwing, oystercatcher and ringed plover.

Assemblages of estuarine breeding waders also often include other birds; for example, on wet grasslands, breeding waders are often associated with passerines including yellow wagtail *Motacilla flava*, skylark, meadow pipit *Anthus pratensis* and reed bunting *Emberiza schoeniclus*, and wildfowl such as mallard, pochard, and sometimes garganey *Anas querquedula* and shoveler *Anas clypeata* (e.g. Mitchell 1983; Williams et al. 1983; Everett 1987). Similarly Fuller (1982) showed that among the particularly abundant saltmarsh breeding species were (in addition to waders) skylark, reed bunting, meadow pipit and mallard, and also sometimes yellow wagtail and colonial gulls and terns. Estuarine shingle systems are characterised by breeding ringed plover, oystercatcher and little tern *Sterna albifrons*, as well as colonies of gulls and terns in some places.

Although the breeding assemblages on estuaries, particularly on saltmarshes and shingle, are often species-poor compared with those of such habitats as woodland and farmland (Green 1987), breeding populations can be very large, especially when they involve colonial-breeding seabirds.

The precise habitat requirements vary between species. Most species depend, however, on the continuity of a generally similar breeding habitat and are affected similarly by damaging changes such as the drainage of wet grasslands and excessive human recreational disturbance of breeding bird assemblages on beaches. The distribution, abundance and conservation needs of the characteristic and important breeding birds of British estuaries are described below.

**Breeding waders**

**Background and data sources**

The major wader breeding habitats associated with British estuaries are shingle systems and beaches, sand-dunes and saltmarshes. In addition, avocets are particularly associated with brackish lagoons. The coastal grazing marshes and other wet
grasslands close to the upper reaches of tidal estuaries also support substantial breeding wader populations. The assemblages of breeding waders on and adjacent to estuaries are a major component of the national and international conservation importance of estuaries. The Wader Study Group's compilation of information on population sizes of breeding waders in Europe (Piersma 1986), published with the support of the NCC and the Netherlands national conservation authorities, and other national compilations encouraged by the Wader Study Group (Dominguez et al. 1987; Hromadkova 1987; Bartovský et al. 1987; Tinarelli & Bacetti 1989; Nankinov 1989), have emphasised the major international importance of Britain for temperate breeding wader populations.

Several extensive surveys of breeding waders in the last 10 years have shown that important breeding areas for breeding waders are distributed throughout Britain. The widespread and continuing loss of wet grasslands through land drainage, agricultural intensification and conversion to arable cultivation has, however, fragmented and much reduced the area of suitable breeding habitat for waders. An extensive survey in 1988 assessed the breeding populations of five wader species (lapwing, snipe, curlew, redshank and oystercatcher) on almost 1,300 lowland wet grassland sites in England and Wales (Smith 1983), and a related survey covered Scottish agricultural land in 1982 and 1983 (Callbrath et al. 1984). The breeding wader populations of saltmarshes have received less comprehensive survey coverage. The most widespread survey was made for the NCC in 1988 (Allport et al. 1986). This covered 77 sample plots on saltmarshes throughout mainland Britain and on Mull, including plots on 34 review sites. A national census of ringed plovers Charadrius hiaticula was carried out by the British Trust for Ornithology in 1973/74 (Prater 1976b) and repeated in 1984 (Prater 1989).

Other surveys have covered one or more wader breeding habitats on a smaller geographical scale. Among the more comprehensive was the extensive survey of the very important breeding populations of waders on the machair and associated land of the Outer Hebrides, undertaken jointly by the Wader Study Group and the NCC (Fuller et al. 1986). Review sites in Orkney were covered as part of a survey of wetland areas (Campbell et al. 1988). Other regional surveys covering counties or estuaries include Greenhalgh (1989, 1971, 1973), Williams et al. (1983), Murfit & Weaver (1983), Mitchell (1983) and Holzer et al. (1985). Other such surveys have revealed major concentrations of breeding waders on machair and associated habitats in other places such as Coll and Tiree, where they are not directly associated with estuaries (Stroud 1990).

The distribution and size of the various breeding populations in Britain are described below using data extracted from these surveys. Wherever possible data are from surveys conducted in the 1980s so as to minimise any differences due to historical changes in the size of the breeding populations. For saltmarshes, comparable data on densities of breeding pairs are available for sample areas on 38 review sites from Allport et al. (1986), Campbell et al. (1988) and Roberts (1988). Maximum densities for each review site have been used in comparisons. Similar maximum breeding densities for wet grasslands have been derived from the data collected during Smith's (1983) survey and from the Outer Hebrides and Orkney surveys (Fuller et al. 1986; Campbell et al. 1988). The latter two surveys covered a wider range of habitats than just wet grassland: the Hebrides surveys covered both wet and dry machair grassland and associated habitats including dunes (Fuller et al. 1986). Altogether there are data on grassland-breeding waders for 85 review sites. Review sites for which there are data on grassland and/or saltmarsh-breeding waders are shown in Figure 3.6.49. As the grassland surveys covered most or all suitable habitat in each area, population sizes have also been calculated for each review site. For ringed plovers only population sizes are available, except for sites on the Outer Hebrides.

![Figure 3.6.49 Review sites for which there are data on breeding waders on wet grasslands and/or saltmarshes](image-url)
and Orkney. Sources for scarce or rare species of breeding waders are described separately.

Total British population estimates were made by Reed (1985) and set in their European context by Pierson (1986). These, modified and updated where appropriate by Stroud et al. (1989), have been used to assess the national and international importance of British estuaries for breeding waders.

The frequency of occurrence of common breeding waders on British estuaries is summarised in Table 8.6.4, and population estimates for waders breeding on wet grasslands adjacent to estuaries are given in Table 8.6.5.

<table>
<thead>
<tr>
<th>Table 8.6.4 The frequency of occurrence of breeding waders on review sites in Britain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saltmarshes</td>
</tr>
<tr>
<td>No.</td>
</tr>
<tr>
<td>Estuaries with data</td>
</tr>
<tr>
<td>Redshank</td>
</tr>
<tr>
<td>Oystercatcher</td>
</tr>
<tr>
<td>Lapwing</td>
</tr>
<tr>
<td>Curlew</td>
</tr>
<tr>
<td>Snipe</td>
</tr>
<tr>
<td>Dunlin</td>
</tr>
<tr>
<td>All species</td>
</tr>
</tbody>
</table>

Redshank

Redshanks are one of the most characteristic and widespread of waders breeding on British estuaries. They breed predominantly on saltmarshes and wet grasslands, occurring on saltmarshes on 86.1% of review sites studied and on grasslands on 80.0% of review sites (Table 8.6.4). Redshanks were the most widespread breeding wader found by Allport et al. (1986) and they occur on estuarine saltmarshes throughout Britain, except that they are largely absent from south-west England (Figure 8.6.50). Breeding densities are highest in eastern Britain and on marshes where there is medium grazing pressure (Allport et al. 1986). Where there is little or no grazing, vegetation grows too high to provide suitable habitat, and at high grazing pressure many nests are destroyed by trampling and the absence of cover leads to high predation levels. Redshanks nest chiefly on upper saltmarshes where the risk of tidal inundation is low and usually where there is considerable diversity of saltmarsh vegetation (Allport et al. 1986; Cadbury et al. 1987).

Redshanks breed at very high densities on some saltmarshes and on many are the most abundant breeding wader. Allport et al. (1986) found highest densities on part of the west side of the Wash (110 pairs km⁻²), with densities exceeding 100 pairs km⁻² on parts of the Colne (Essex), Beaulieu (Hampshire), and Morecambe Bay. Figure 8.6.50 shows that major areas for saltmarsh-breeding redshanks are in Lancashire, The Wash and North Norfolk, Suffolk and Essex, and Hampshire. Saltmarsh densities are generally lower in Wales.

Figure 8.6.50 The distribution of redshanks breeding on review sites. a) Maximum densities (pairs km⁻²) on estuarine saltmarshes; b) maximum densities (pairs km⁻²) on wet grasslands adjacent to estuaries; and c) total numbers of pairs on wet grasslands.
**Table 8.6.5** Breeding populations of waders on grasslands adjacent to estuaries in Britain. Grasslands are wet grasslands and coastal grazing marshes in England and Wales, and machair and associated habitats in Orkney and the Outer Hebrides.

<table>
<thead>
<tr>
<th>Species</th>
<th>Estuarine popn. (pairs)</th>
<th>% Outer Hebrides</th>
<th>% Ouse &amp; Nene Washes</th>
<th>% Norfolk Broads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redshank</td>
<td>2,194</td>
<td>27.5</td>
<td>13.3</td>
<td>12.6</td>
</tr>
<tr>
<td>Oystercatcher</td>
<td>1,143</td>
<td>64.6</td>
<td>2.0</td>
<td>10.3</td>
</tr>
<tr>
<td>Lapwing</td>
<td>4,170</td>
<td>23.3</td>
<td>12.6</td>
<td>16.0</td>
</tr>
<tr>
<td>Curlew</td>
<td>57</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Snipe*</td>
<td>1,037</td>
<td>13.1</td>
<td>71.1</td>
<td>5.0</td>
</tr>
<tr>
<td><strong>Total waders</strong></td>
<td><strong>9,239</strong></td>
<td><strong>36.2</strong></td>
<td><strong>13.5</strong></td>
<td><strong>12.2</strong></td>
</tr>
</tbody>
</table>

Sources: NCC/ITO/RSPB Survey of Breeding Waders in Wet Grasslands, WSG/NCC surveys of breeding waders in the Outer Hebrides, and Campbell et al. (1988)

* Surveyed as number of displaying males

and Scotland. Cadbury et al. (1987) made a preliminary estimate of 17,500 pairs of saltmarsh-breeding redshanks based on the area of saltmarshes in Britain.

Redshanks are widespread breeders in grasslands adjacent to estuaries, although densities in England and Wales are consistently lower than those on saltmarshes on the same estuaries (Figure 8.6.51). Redshanks are either absent or breed only in densities of less than 50 pairs km\(^{-2}\) on estuarine grasslands in western and northern England and in Wales, but densities are consistently higher in East Anglia and Kent (Figure 8.6.50). Highest densities occur on the Ouse and Nene Washes adjacent to the upper tidal reaches of The Wash, the marshes of the Norfolk Broads and the Swale in Kent (53.7 pairs km\(^{-2}\)). Densities are high also on the machair grasslands of the Outer Hebrides, and also in parts of Orkney adjacent to estuaries, although there the area of wet grassland is small and hence total populations are low (Figure 9.6.50).

Although densities are generally low on estuarine grasslands, the large areas of grasslands in the Outer Hebrides, Norfolk Broads, Ouse and Nene Washes and the Swale Estuary mean that these areas support substantial numbers of breeding redshanks. Together they have 53.4% of the total of 2,194 pairs of redshanks breeding on estuarine wet grasslands on review sites for which there are data (Table 8.6.5). Away from these areas adjacent to estuaries the only other lowland wet grasslands in England and Wales with comparable numbers are the Derwent Ings in Yorkshire and the Somerset Levels, with a joint total of 8.1% of the England and Wales population. Wet grasslands adjacent to estuaries are very important for breeding redshanks, supporting 68.8% of the breeding pairs (1,523 pairs) found on all wet grassland in England and Wales. Similarly areas of machair adjacent to estuaries support 23.2% (604 pairs) of redshanks breeding in the Uists.

Since data are not available for some review sites, notably mainland estuaries in Scotland, the total British estuarine breeding population is difficult to assess but must be in excess of 18,700 pairs. Britain, Norway and The Netherlands are the strongholds of breeding redshanks in Europe, together supporting over 70% of the breeding population of the nominate t. t. subspecies (Piersma 1986), 12% of t. t. redshanks breed in Britain (Stroud et al. 1990). Hence a minimum of 60.6% of the British-breeding population and 73% of the north-west and central European population breeds on or adjacent to British estuaries. Smith's (1983) survey showed redshanks in England and Wales to have been largely restricted to a few, mostly coastal, sites and to have declined as an inland-breeding species in the last few decades. Subsequent monitoring has found further declines in the redshank populations of wet grasslands (Smith 1988), so in future saltmarshes and associated estuarine grasslands are likely to

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**Figure 8.6.51** The densities of breeding redshanks on estuarine saltmarshes are consistently much higher than the densities breeding on wet grasslands on the same estuaries. The solid line shows equal densities in the two habitats.
become even more important for breeding redshanks.

**Oystercatcher**

Oystercatchers are the second most common breeding wader in Britain with a total population of 38,000 pairs (17% of the north-west and central European population) (Stroud et al. 1990). Most of the rest of the European population breeds in Norway and The Netherlands (Piersma 1986). Although many oystercatchers are coastal breeders they also breed in increasing numbers inland in Scotland and in northern England, and even on rooftops in Aberdeen. Coastal pairs breed in a variety of habitats, chiefly sand and shingle beaches, saltmarshes and grasslands. There are no recent comprehensive data on the distribution and population sizes on sand and shingle, but oystercatchers nest widely on saltmarshes on estuaries throughout Britain, occurring on 77.8% of review sites for which there are data. Breeding on coastal and adjacent wet grasslands is less frequent, but even so oystercatchers nested on grasslands on over half the review sites for which there are data (Table 8.6.4). The distribution and densities of breeding pairs (Figure 8.6.52) shows that densities on grassland are generally low (<20 pairs km⁻²) in England and Wales and that oystercatchers are largely absent from grasslands in western England and Wales. Grassland breeding in England is most frequent in East Anglia (on 75% of review sites between Norfolk and Kent). Although over 60% of grassland-breeding oystercatchers in England and Wales are adjacent to estuaries, the total number of breeding pairs (342) is small.

In contrast to the low breeding densities on English and Welsh grasslands, densities in Scotland are much higher (Figure 8.6.52), reaching up to 83 pairs km⁻² on the small wetlands adjacent to Orkney review sites, and 103 pairs km⁻² on the machair grasslands of the Uists. The Uists are an important breeding area for oystercatchers, with 740 pairs (1.9% of the British breeding population) occurring adjacent to review sites alone. Elsewhere the major grassland sites in terms of size of total breeding population are the Solway and the wet grasslands of the Norfolk Broads (Figure 8.6.52).

Oystercatchers breed widely on saltmarshes around Britain, but as on grasslands they are scarce or absent from south-west England and Wales (Figure 8.6.52). Elsewhere they were found breeding on all 21 review sites surveyed except for Kenneth Bay in north-west Scotland. Highest densities were on the Solway (72 pairs km⁻²), with other dense populations on the Duddon Estuary and Morecambe Bay in north-west England, the firths of north-east Scotland, around the Solent and on the North Norfolk Coast. Densities on saltmarsh were consistently higher than on adjacent grasslands on the same estuaries.

Although coastal-breeding oystercatchers are often considered to be largely associated with shingle beaches, Figure 8.6.52 shows them to be widespread breeders on other habitats in Britain. Those nesting on beaches are, like ringed plovers, vulnerable to human disturbance where there is public access. This may account for the scarcity in some areas of oystercatchers breeding on shingle rather than saltmarshes and grasslands. For example the Ore/Alder/Butley (Suffolk) has the extensive shingle systems of Orfordness, but

![Figure 8.6.52](image_url) The distribution of oystercatchers breeding on review sites. a) Maximum densities (pairs km⁻²) on estuarine saltmarshes; b) maximum densities (pairs km⁻²) on wet grasslands adjacent to estuaries; and c) total numbers of pairs on wet grasslands.
although 47% of oystercatchers breeding on Suffolk estuaries were on this estuary, only 18% nested on shingle compared to 47% on saltmarsh and 34% on grassland (Holzer et al. 1989).

Lapwing

Lapwings are the most abundant breeding wader in Europe and breed in large numbers over much of northern Europe (Piersma 1986). Britain supports the largest breeding population in Europe: an estimated 315,000 pairs, 25% of the north-west and central European population (Stroud et al. 1990). Lapwings nest widely throughout Britain and in particularly high densities on low-intensity farmland and traditionally-managed grasslands (e.g. Galbraith et al. 1984; Baines 1989). Smith (1983) found a pronounced coastal bias in the distribution of wet grassland-breeding lapwings in England and Wales, and lapwings bred on grasslands on a higher percentage (83.4%) of review sites than any other species (Table 8.6.5). As for other breeding waders, lapwings are scarce or absent from grasslands on most estuaries in south-west England and Wales (Figure 8.6.53). On wet grasslands adjacent to estuaries densities are highest in East Anglia and Kent (up to 75 pairs km\(^{-2}\) on the South Thames Marshes, Pagham Harbour (79 pairs km\(^{-2}\)) and the Mersey (59 pairs km\(^{-2}\)). Lapwings breed abundantly also on the machair grasslands of the Uists, where the 978 pairs recorded on machair and associated habitats adjacent to review sites was 22.5% of the total lapwing population of the area (Fuller et al. 1986). In total, 4,170 pairs (1.9% of the British population) of lapwings bred on grasslands adjacent to review sites for which there are data (Table 8.6.5). In addition to the Uists other major breeding sites are the The Wash (Ouse and Nene Washes), Breydon Water (the Norfolk Broads) and the Swale Estuary. These four areas support 64.8% of the lapwings breeding on grasslands adjacent to estuaries.

Although lapwings breed on saltmarshes they are less widespread there than on grasslands, occurring on saltmarsh on 47.2% of review sites surveyed (Table 8.6.4). On only seven of these 17 review sites does the breeding density exceed 20 pairs km\(^{-2}\); these are mostly in western England and eastern Scotland (Figure 8.6.53). In addition to their almost complete absence as a breeding bird on the estuarine saltmarshes of south-west England and Wales, breeding lapwings were also absent from East Anglian saltmarshes. Despite this more restricted distribution on saltmarshes, breeding densities are higher there than on the adjacent grasslands on three (Beaulieu, Dudmaston and Solway) of the five estuaries for which there are comparable data (Figure 8.6.54).

Curlew

The estimated 35,500 pairs of curlews breeding in Britain breed mainly in upland areas, preferring moist, poorly drained moors and heaths and low-intensity farmed grasslands (Baines 1989). The British population is about 28% of the European population; curlews breed abundantly elsewhere only in Fife, Sweden and Finland (Piersma 1986). In Britain curlews have a largely western and northern distribution, although they are scarce in north-west Scotland and have spread extensively into lowland areas during the 20th century (Sharrock 1976).

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**Figure 8.6.53** The distribution of lapwings breeding on review sites. a) Maximum densities (pairs km\(^{-2}\)) on estuarine saltmarshes; b) maximum densities (pairs km\(^{-2}\)) on wet grasslands adjacent to estuaries; and c) total numbers of pairs on wet grasslands.
Curlows are an uncommon breeding bird on estuaries in Britain, occurring on only 18.5% of review sites for which there are grassland data, and 19.4% of surveyed saltmarsh review sites (Table 8.6.4). Curlows breed on estuarine saltmarshes only in north-west England, between Morecambe Bay and the Solway, and in eastern Scotland and always at low density (<10 pairs km\(^{-2}\)) (Figure 8.6.55). Grassland-breeding curlows occur on scattered sites in England and Wales and on Orkney, again at low densities and in small numbers (Figure 8.6.55). Highest breeding densities are on small wetlands adjacent to review sites in Orkney (up to 45 pairs km\(^{-2}\)).

Snipe

There are an estimated 30,000 British breeding pairs of snipe (4% of the European population), although this figure must be treated with caution, since snipe are a particularly difficult species to census. Snipe nest mostly in wet grasslands, bogs and fens. They are particularly vulnerable to the drainage, agricultural intensification and
conversion to arable of lowland wet grasslands (Smith 1983; Stroud et al. 1990). The extensive losses of these traditional breeding habitats have resulted in a major population decline in England and Wales in recent years (Smith 1983). There is evidence that the decline is continuing (Smith 1983).

During the surveys of saltmarsh-breeding waders, snipe were found breeding on only one estuarine saltmarsh, at Aberlady Bay on the Firth of Forth. They are more widespread on wet grassland adjacent to estuaries, breeding there on 32 review sites (38.2% of sites for which there are data) (Table 8.6.4). These estuarine grasslands hold 52.4% of the 1,979 pairs of snipe estimated to be breeding in lowland wet grasslands in England and Wales (Smith 1983). Like most other breeding waders, snipe are absent or breed only at very low densities (<10 pairs km⁻²) over most of England and Wales (Figure 8.6.56). Highest nesting densities (up to 60 pairs km⁻²) were on the The Wash (Ouse and Nene Washes), adjacent to Otitir Mhor in the Outer Hebrides (42 pairs km⁻²) and in a small wetland adjacent to Deer Sound in Orkney (83 pairs km⁻²). By far the most important review site for breeding snipe is the Ouse and Nene Washes, where the 797 breeding pairs recorded in Smith's (1983) survey are over 70% of the snipe breeding on grassland adjacent to surveyed review sites. A further 13% breeds on the machair adjacent to the Uists review sites.

Dunlin

Dunlins breed widely in arctic and subarctic regions but are a much scarcer breeding bird in temperate areas. The approximately 9,150 pairs of dunlin breeding in Britain are 83% of the schinzii race that breeds in temperate Europe (Piersma 1986; Stroud et al. 1990). This population is believed to overwinter in west and north Africa and has been greatly reduced in range and numbers elsewhere in western Europe (Jonasson 1986). Dunlins breed widely in upland Britain, but the main concentrations are on the peatlands of Lewis, Caithness and Sutherland, and the machair of the Outer Hebrides (Fuller et al. 1986; Stroud et al. 1987, 1990).

On estuaries, Allport et al. (1996) found dunlins breed at low density (maximum 6 pairs km⁻²) on
Dunlin

Grassland density

pairs km
2
0

1-10
11-20
>20

Figure 8.5.57 The distribution and density (maximum pairs km
2) of dunlins breeding on saltmarshes and wet grasslands adjacent to review sites

saltmarshes on only five estuaries (13.9% of review sites surveyed). All are in north-west England/south-west Scotland (Ribble Estuary to the Solway) and north-east Scotland (Dornoch and Cromarty Firths). The only estuaries in Britain with substantial numbers of breeding dunlins are Baghnan Faoilean, Oir Mhor and Vallay/Oronsay in the Outer Hebrides (Figure 8.5.57). Here dunlins breed at much higher densities (up to 46 pairs km
2) on saltmarshes and damp machair grasslands adjacent to the review sites. Overall densities in the Outer Hebrides were 53 pairs km
2 on saltmarsh and even higher (66 pairs km
2) on damp machair (Fuller et al. 1988). The estimated 602 pairs adjacent to the Outer Hebrides review sites are 18% of the total breeding on the Outer Hebrides, 6.6% of the British breeding population and 5.4% of the European population of temperate-breeding schinzii dunlins.

Ringed plover

Britain supports 64% of the small temperate-breeding population of the nominate hystrix race of ringed plovers. There are also subarctic

hystrix birds breeding in Iceland, and a further arctic population in Greenland and northeastern Canada (Piersma 1986). National surveys in Britain in 1973/74 (Prater 1976b) and 1984 (Prater 1989) found that whilst most breeding ringed plovers are coastal, there is a small but increasing inland breeding population, especially in England and Wales. The main coastal-breeding habitats in most of Britain are shingle and sand beaches, with breeding success in some areas being higher on shingle (Pienkowski & Pienkowski 1989). 48.2% of coastal-breeding ringed plovers in the 1984 survey were on beaches. The other major coastal habitat for breeding ringed plovers is the machair grassland of the Outer Hebrides, with 27.5% of the coastal population (Prater 1989).

Estuaries provide breeding habitat for about half of the ringed plovers breeding in Britain. The 1984 survey (Prater 1989) found a total of 2,509 pairs of ringed plovers breeding on a minimum of 78 review sites (50.3%) distributed around much of the British coast (Figure 8.5.58). Ringed plovers are absent, or present only in low numbers, in south-west England, Wales and the north-west Scottish mainland, although in Scotland this finding may have been partly due to incomplete survey coverage (Prater 1989).

Figure 8.5.58 The distribution (no. of pairs) of breeding ringed plovers on review sites
Major breeding areas on estuaries are the machair grasslands adjacent to the sounds and open shores of the Uists, and the eastern English coast including the Humber Estuary, The Wash and North Norfolk Coast. The Uist review sites together support a total of 487 pairs (19.4% of the coastal population) and the extensive shingle and dune systems of the North Norfolk Coast support 433 pairs (17.3%). In all, these three east coast and four Uist review sites have 1,208 breeding pairs, or 48.1% of the British estuarine population. Only six other estuaries (Firth of Firth, Tees, Colne, Lynemouth, Morecambe Bay and Solway Firth) support more than 50 breeding pairs each. In total 43% of coastal-breeding ringed plovers, and 29.8% of the total British breeding population, occur on estuaries. Overall British estuaries are of major international importance for breeding ringed plovers, with 19.8% of the north-west and central European *Charadrius hiaticula* population.

Breeding ringed plovers are very vulnerable to human disturbance where there is public access to the beaches on which they breed, and where such pressure is high few pairs nest successfully (Pienkowski 1984). Prater (1989) notes that most of the large breeding populations in eastern and southern England are now restricted to protected areas such as nature reserves, and anticipates that such localisation of the breeding population will continue.

**Avocet**

Avocets ceased to breed regularly in Britain in the early 19th century. They began to recolonise the east Anglian coast in the early 1940s when a few pairs started breeding at Minimere in Suffolk and on Haverigg Island in the Ouse/Alde/Butley Estuary further south in Suffolk. Since then the breeding population has steadily increased and expanded its range (Figure 8.6.59) (Cadbury et al. 1989). In 1988 the breeding population totalled 365 pairs (2% of the north-west and central European population) (Stroud et al. 1990). Most of the European population breeds on the coasts of the Wadden Sea (Piersma 1986).

In 1988 avocets bred at 18 localities, all of which are on the English east coast between Tho Wash and north Kent. About 75% of British breeding avocets are on nine review sites in this region. Away from estuaries the only major breeding site is the coastal brackish lagoon system at Minimere, where 55 pairs bred in 1988. Other major colonies are the up to 132 pairs at Haverigg Island (Ouse/Alde/Butley) and those at Titchwell and Cley (North Norfolk Coast) and Elmley (Swale). Most avocets breed on brackish lagoons adjacent to estuaries, and breeding adults feed on the nearby mudflats. A few pairs have now begun breeding on coastal wet grasslands (C Beardall pers. comm.).

**Other breeding waders**

In addition to the eight breeding wader species described above, four other scarce breeding waders occur adjacent to review sites. Black-tailed godwits *Limosa limosa* formerly bred widely in wet grasslands in East Anglia and Yorkshire but ceased regular breeding there in the 1830s, probably owing to loss of habitat and persecution by shooting and egg-collecting (Cottier & Lea 1969). Breeding began regularly again in 1952 on the Ouse Washes (The Wash) and this remains the stronghold of breeding black-tailed godwits in Britain. Small numbers breed adjacent to at least two other review sites in eastern England. The total British breeding population remains small (in 1986 it was up to 47 pairs), all are associated with review sites. The British population is less than 1% of the European breeding population, where the stronghold of the nominate race is in the Netherlands (Piersma 1985).

Like the black-tailed godwit, the ruff *Philomachus pugnax* ceased to breed regularly in Britain in the late 19th century, as a result of drainage of its wet grassland breeding areas. Breeding began regularly again on the Ouse Washes in the 1960s (Cottier & Lea 1969) and since then the number of females believed to be breeding in Britain has fluctuated between 0 and 32, and is usually less than 10 (Stroud et al. 1990). Rufes in Britain breed on coastal grazing marshes and on upper salmarches, and most of the British population is associated with at least two review sites in eastern England.

Most European whimbrels *Numenius phaeopus* breed in the subarctic of Iceland and northern Scandinavia (Piersma 1986). Whimbrels are a scarce breeding species in Britain and are restricted to northern Scotland, with most of the population of about 465 pairs on the moorland and maritime heaths of Shetland (Stroud et al. 1990). Between 5-10 pairs (1-2% of the British population) of whimbrels breed on coastal grasslands adjacent to one north-east Scotland review site.

Temminck's stint *Calidris temminckii* are a very rare breeding bird in Britain, with regular breeding by up to nine birds in Scotland since 1971 (Stroud et al. 1990). Since 1987 up to six adults have nested adjacent to one northern Scottish review site. The adults feed on the nearby Scottish review site.
Total estuarine-breeding wader populations

The overall density of all breeding waders on estuaries is shown in Figure 8.6.60. This emphasises that estuaries with high densities of waders breeding on saltmarsh are widely distributed around Britain. Eight estuaries have areas of saltmarsh with waders breeding at a density in excess of 100 pairs km\(^{-2}\), including estuaries on south, east and west coasts from Beaulieu in the south, with the highest density of 160 pairs km\(^{-2}\) at Montrose Basin in the north. Allport et al. (1988) derived a 'weighted wealth index' for saltmarshes with breeding wader populations, based on the density of breeding pairs, the species diversity and the relative size of the national breeding populations. They found that the 15 estuaries with the highest conservation importance for saltmarsh waders were likewise widely distributed throughout Britain, from the Dornoch Firth south to the Isle of Wight (Newtown Estuary), with the highest indices on the Solway Firth, Beaulieu River, Morecambe Bay and Duddon Estuary. Four of the 15 estuaries were, however, in north-west England and another five in eastern Scotland.

The pattern for grassland-breeding populations is different. Highest breeding densities occur in two widely separated parts of Britain: in south-east England, notably at Elmley on the Swale Estuary (117 pairs km\(^{-2}\)) and at Fasfham Harbour (116 pairs km\(^{-2}\)), and in northern Scotland. Here there are exceptionally high densities (a maximum of over 300 pairs km\(^{-2}\)) on small wet grassland areas in Orkney, and total densities exceeding 100 pairs km\(^{-2}\) on machair adjacent to each of three Uist review sites (Figure 8.6.60). The exceptional importance of the machair of the Outer Hebrides is emphasised by the high total numbers of breeding waders in these areas (Figure 8.6.60); breeding populations adjacent to each of two review sites (Bagh nam Failean and Oliph Mhor) exceeded 1,000 pairs, only rivaled by the populations breeding on the Ouze and Nene Washes and on the extensive wet grasslands of the Norfolk Broads (Breydon Water). Total wader densities are, however, consistently higher on saltmarshes than on the adjacent grasslands of the same estuaries (Figure 8.6.61), and in the case of at least one species (redshank) the estimated total saltmarsh-breeding population appears to be about eight times larger than that on grasslands adjacent to estuaries. Population sizes on saltmarsh cannot yet be calculated for other breeding waders so the numerical importance of the two types of breeding habitat cannot be assessed. Likewise total numbers of breeding waders on estuarine shingle cannot be assessed as there are comprehensive data only for ringed plovers.

In some parts of Britain, notably southern England, estuaries and their adjacent habitats support almost all the breeding waders of the region. In Suffolk most of the breeding redshanks and oystercatchers are estuarine. Even in such a widespread species as the lapwing, 12% of the Suffolk population bred on estuaries (Holzer et al. 1989). In Sussex 81% of redshank and 64% of snipe were associated with estuaries (Mitchell 1983). Such trends towards coastal breeding may become even more widespread as inland breeding habitats continue to disappear.

Twelve wader species breed regularly on estuaries in Britain and an average of 3.8 species

![Figure 8.6.60](image_url) - The distribution of total waders breeding on review sites. a) Maximum densities (pairs km\(^{-2}\) on estuarine saltmarshes; b) maximum densities (pairs km\(^{-2}\) on wet grasslands adjacent to estuaries; and c) total numbers of pairs on wet grasslands.
per estuary breed on the 75 review sites for which there are reliable data. For at least four of these species (redshank, dunlin, ringed plover and avocet) the network of British estuaries provides breeding habitat for a population of international importance, since populations are in excess of 1% of the north-west and central European breeding population (Stroud et al. 1980). Even with incomplete data, minimum estimates of the British estuarine breeding population are: redshank – 7.3% of the north-west and central European population, dunlin – 6.4%, ringed plover – 19.2% and avocet – 1.5%.

No single review site supports breeding populations of all 12 of the breeding wader species, but three sites (Dornoch Firth, The Wash and the North Norfolk Coast) each have assemblages of eight species (Figure 8.6.63). Diverse estuarine assemblages also occur consistently in East Anglia and south-east England, in north-west England, the Outer Hebrides and Orkney. In general only small numbers of wader species breed on review sites in Wales, north-east England and south-east Scotland. Breeding waders are largely absent from south-west England (Figure 8.6.61).

Although these assemblages of breeding waders on an estuary, or on a particular habitat within an estuary, often mean that different species regularly breed in association with each other, no two species have precisely the same habitat preferences even when all are nesting at high densities (e.g. Fuller et al. 1985). Hence sites favoured by one species may support only low densities of another. For example there is no correlation between the peak densities of breeding oystercatchers and redshanks on saltmarshes on the 34 review sites for which there are comparable data, or between lapwings and redshanks on the same sites (Figure 8.6.63). Waders generally breed in higher densities where conditions are most favourable for the successful rearing of young, so the absence of density correlations between species means that different parts of the network of breeding habitats on British estuaries are most important for different species. This is apparent also from the differences in distribution patterns around Britain (Figures 8.6.58 – 8.6.59). Effective conservation of estuarine breeding waders in Britain must therefore take into account the distribution, density and habitat preferences of each species, as well as the diversity and density of the wader assemblages.
Breeding seabirds

General estuarine distribution

Britain is of major international importance for breeding seabirds. It holds more than half the European Community population of 14 species of seabirds and more than half the world population of four of these (Lloyd et al. in press). Many species are colonial nesting that breed in the safety of the steep cliffs and slopes of the islands and mainland coasts of northern and western Britain. These safe breeding sites are within range of rich coastal and offshore feeding grounds. Other coastal species, particularly terns, nest on shingle beaches and flat sites such as island platforms. Some gulls are predominantly coastal breeders in a variety of habitats, although some, such as the lesser black-backed gull *Larus fuscus* and common gull *Larus canus*, also nest in large inland colonies.

Although many of Britain's seabirds breed on the exposed rocky coasts and islands of northern and western Britain, information collected between 1985-1988 on the NCC Seabird Group Seabird Colony Register shows that in the mid-1980s 75 estuaries (48.4% of review sites) had one or more pairs of breeding seabirds. These estuaries are widely distributed around the British coast (Figure 8.6.64), although this and Figure 8.6.65 show that there are only a few generally small colonies on the estuaries of Wales and south-west England. Many of these are small colonies of roof-nesting gulls, chiefly herring gulls *Larus argentatus*, in towns adjacent to estuaries. Some other colonies in western and northern Britain comprise small numbers of cliff-breeding species on cliffs and rocky islands at the outer edges of the review sites. Nevertheless some British estuaries, notably Morecambe Bay, the Ribble, the North Norfolk Coast, parts of Suffolk, Essex and Kent and the Solent, support very large breeding seabird populations (Figure 8.6.65).

British estuarine breeding seabird populations are summarised in Table 8.6.6. Sixteen species breed on British estuaries and for some of these British estuaries are of considerable importance. For six of these species (black-headed gull *Larus ridibundus*, lesser black-backed gull, herring gull, Sandwich tern *Sternula sandvicensis*, common tern *S. hirundo* and little tern *S. albifrons*) the network of British estuaries supports breeding populations in excess of 1% of the west and central European breeding population. A further two species (common gull and arctic tern *S. paradisaea*) breed in numbers in excess of 1% of their British coastal breeding population. Numbers of common gulls are, however, very small. The distributions of
Breeding seabird population size

Figure 8.6.65 The total number of breeding seabirds (number of pairs) on review sites

Black-headed gull

Figure 8.6.66 The distribution of breeding pairs of black-headed gull on review sites

Table 8.6.6 British estuarine breeding populations of seabirds in 1986-88

<table>
<thead>
<tr>
<th>Species</th>
<th>British estuarine popn. (pairs)</th>
<th>% British coastal popn.</th>
<th>% W &amp; Central European popn.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fulmar</td>
<td>2,082</td>
<td>0.4</td>
<td>0.4*</td>
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<td>Cormorant</td>
<td>52</td>
<td>0.8</td>
<td>+</td>
</tr>
<tr>
<td>Shag</td>
<td>25</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Arctic skua</td>
<td>1</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Black-headed gull</td>
<td>40,957</td>
<td>93.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Common gull</td>
<td>216</td>
<td>1.4</td>
<td>+</td>
</tr>
<tr>
<td>Lesser black-backed gull</td>
<td>18,560</td>
<td>30.1</td>
<td>10.5</td>
</tr>
<tr>
<td>Herring gull</td>
<td>17,893</td>
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<td>1.9</td>
</tr>
<tr>
<td>Greater black-backed gull</td>
<td>165</td>
<td>0.9</td>
<td>+</td>
</tr>
<tr>
<td>Kittiwake</td>
<td>1,334</td>
<td>0.2</td>
<td>&lt; 0.1</td>
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<td>Sandwich tern</td>
<td>6,446</td>
<td>46.2</td>
<td>13.8</td>
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<tr>
<td>Common tern</td>
<td>4,910</td>
<td>37.2</td>
<td>4.6</td>
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<tr>
<td>Arctic tern</td>
<td>1,100</td>
<td>1.4</td>
<td>0.6**</td>
</tr>
<tr>
<td>Little tern</td>
<td>1,783</td>
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<td>12.9</td>
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<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Black guillernot</td>
<td>40*</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Source: Lloyd et al. in press; NCC/Seabird Group, Seabird Colony Register

+ Less than 0.1%
* Excludes Iceland
+ Excludes Iceland and the Faeroes

253
breeding seabird species for which British estuaries are important are shown in Figures 8.6.66 – 8.6.72 and are described below.

**Black-headed gull**

Almost 50,000 black-headed gulls nest on 35 review sites (Figure 8.6.66). Large estuarine colonies are typically found on saltmarshes and dune systems. Most are in east and south-east England, notably on The Wash, the North Norfolk Coast, the Suffolk, Essex and Kent coasts, the Rother Estuary and in parts of The Solent and in Poole Harbour. In western Britain the only estuarine colonies of over 1,000 pairs are on Morecambe Bay and the Ribble Estuary. One of the largest colonies, numbering 10,480 pairs in 1973, was on the Esk Estuary in north-west England (Gribble 1976), but this has since undergone a dramatic decline and became extinct in 1988. There is little evidence of the displacement of these breeding birds to Morecambe Bay, but many birds have moved elsewhere, primarily northwards and inland. The largest colony on the British coast is now on the Ribble Estuary: 20,000 pairs. This colony alone holds over 37% of the British coastal-breeding total and 1.7% of the west and central European-breeding population. Elsewhere the largest estuarine colony is currently the 7,000 pairs breeding on the Beaulieu River in Hampshire. Here, as typically elsewhere, black-headed gulls breed as part of a mixed-species colony with several tern species and sometimes other gulls.

**Lesser black-backed gull**

30% of the British coastal-breeding population is estuarine, but lesser black-backed gulls have a breeding distribution restricted to 13 review sites. Only five sites hold more than 100 breeding pairs (Figure 8.6.67). Most of the estuarine population breeds in a colony of c. 10,000 pairs (5.7% of the western and central European population) on Walney Island on Morecambe Bay, along with various tern species and similar numbers of herring gulls. Here, and at the smaller colony on Orfordness in Suffolk (Ore/Alder/Bulley Estuary), breeding numbers have greatly increased in recent years.
**Herring gull**

Although herring gulls often breed in mixed colonies with lesser black-backed gulls and the total numbers breeding on estuaries are similar, herring gulls are more widespread and breed on 29 review sites. These are mostly in northern and western Britain (Figure 8.6.68). Total numbers on British estuaries form a smaller proportion (15.2%) of the British coastal-breeding population, but, as for the lesser black-backed gull, the main breeding colony of c. 10,000 pairs is on Morecambe Bay and this site alone supports c. 1% of the international population. The only other colonies exceeding 1,000 pairs are on shingle and dune systems, on the Ythan Estuary in north-east Scotland and Orfordness (Oare/Alde/Butley Estuary). Elsewhere small colonies are on roofs, cliffs and rocky islands.

**Sandwich tern**

Britain is important as a breeding area for Sandwich terns, with the British breeding population totalling about 15,000 pairs – more than any other European country and about 32% of the European population (Table 8.6.6). Over 65% of the British breeding population occurs in just six main colonies, four of which are on these review sites (Figure 8.6.69). Sandwich terns breed on shingle ridges and islands, usually amongst common or arctic terns. The largest colonies are on the Ythan Estuary (1,000 pairs) and the North Norfolk Coast (4,090 pairs) and Morecambe Bay (550 pairs). Smaller concentrations are restricted to 11 other estuaries, most of which are in south-east and southern England. Altogether estuaries are important for Sandwich terns, supporting 46.8% of the British coastal-breeding population and almost 14% of the European population.

**Common tern**

Common terns are more widespread than Sandwich terns and their estuarine colonies are scattered on 35 estuaries around most parts of Britain. They are largely absent, however, from north-west Scotland, south-west England and Wales (Figure 8.6.70). Common terns mostly breed near the coast on shingle and sand-dune systems, saltmarshes and islands. Although they breed...
widely in Europe. 37% of British common terns breed on estuaries, and these comprise 4.6% of the European population.

**Arctic tern**

The arctic tern is a circumpolar breeding species. Britain has about 44% of the European breeding population. In Britain most breed in Orkney and Shetland, and most of the British breeding range is in the north of the country (Figure 8.6.71). Arctic terns breed mostly on low, often rocky, islands as well as sand and shingle. They are less strongly associated with estuaries than other British terns, with only about 1.4% of the British coastal population present on 22 review sites. All but two sites are in Scotland - there are small numbers breeding on Morecambe Bay and the North Norfolk Coast, in mixed colonies of terns.

![Arctic tern distribution map](image)

**Figure 8.6.71** The distribution of breeding pairs of arctic terns on review sites

Recently there have been repeated breeding failures in the main British populations on the Shetlands, which have been attributed to the failure of the terns' main food supply, sand-eels *Ammodramus* spp. (Heubeck 1989; Monaghan et al. 1989).

**Little tern**

Breeding colonies of little terns are widely scattered around the coasts of Britain on shingle and sand ridges, beaches and islands. The British-breeding population of about 2,500 pairs is internationally important and most (c. 74%) of the British population is on estuaries. The breeding population on British estuaries amounts to almost 13% of the European population (Table 8.6.6). Although this estuarine-breeding population is spread over most parts of Britain there are few little terns in western Britain, apart from small breeding colonies in north Wales and north-west England and north and west Scotland. The stronghold of the British population is in eastern and southern England (Figure 8.6.72). The largest colonies are on the Humber, North Norfolk Coast, the Suffolk and Essex estuaries and the harbours and estuaries of the Solent. The extensive shingle and sand-dune systems of the North Norfolk Coast are particularly important, with a breeding population amounting to over 20% of the British and 2.6% of the European population. The Humber Estuary also has a breeding population of more than 1% of the European population.

![Little tern distribution map](image)

**Figure 8.6.72** The distribution of breeding pairs of little terns on review sites
Other seabirds

Most other seabirds breeding on review sites are cliff- and rock-nesting species, with a few pairs on the outer parts of some of the rockier fringes and bays. These colonies are insignificant compared with the large and internationally important populations elsewhere on the coasts of Britain (Table 8.6.5). Kittiwakes breeding on estuaries are, however, worthy of note. Although the populations are small (0.2% of the British coastal population), two small breeding colonies are located, unusually, on the artificial habitat of window ledges of buildings on the Tyne Estuary in north-east England. One has been the subject of intensive long-term population studies (Coulson & Thomas 1985).

Other breeding birds

Besides seabirds and waders, several other species of breeding birds are characteristic of estuaries and their surroundings or breed in substantial numbers in such areas.

Reedbed-breeding species

One group comprises species characteristic of reedbeds. Large reedbeds are now scarce in Britain. Major concentrations are on Anglesey, the south coast of England and in East Anglia. The only extensive coastal reedbeds in Scotland are on the Tay Estuary. Many of the remaining reedbeds are small, with only 15 exceeding 40 ha (Everett 1989). Many reedbeds are associated with estuaries. Some, such as at Blacktoft Sands on the Humber, and on the north shore of the Tay, are on tidal estuaries; others, such as on the Norfolk Broads, are on lowland river floodplains, adjacent or close to tidal rivers; and some are on coastal floodplains protected by sea defences from natural incursion by the sea. Some of these, such as at Leighton Moss on Morecambe Bay, are adjacent to estuaries.

Some breeding species, notably the reed warbler Acrocephalus scirpaceus, are common and widespread and particularly associated with reedbeds. Other warbler species, such as the common sedge warbler A. schoenobaenus and much rarer Savi’s warbler Locustella luscinioides and Cetti’s warbler Cettia cetti, often include reedbeds in their breeding territories (Everett 1989). Reedbeds are also important for warblers in autumn as places in which they accumulate fat reserves before migration. Bearded tits Parus biarmicus are almost entirely confined to reedbeds as breeding sites. Yearly numbers are greatly affected by severe winter weather, and bearded tits presently have a largely coastal-breeding range from Yorkshire to Dorset, including many of the major reedbeds associated with estuaries in these regions (Batten et al. in press).

Wildfowl

One species of British wildfowl, the shelduck, is particularly associated with estuaries for breeding. Shelducks breed widely around the coast of Britain wherever there are suitable sandy or muddy shores close to nesting habitats. Shelducks nest in a wide variety of places, usually under cover, in old buildings, haystacks, banks and often in old rabbit burrows in sand-dunes (Owen et al. 1988). Most nests are on dunes and grazing marshes adjacent to sheltered estuaries (Sharrock 1976). Shelducks often nest colonially in places such as dune systems, although studies on the Firth of Forth have found that their breeding success in colonies may be much lower than in pairs nesting in isolation (Pienkowski & Evans 1982). Soon after hatching broods are led to nearby saltmarshes and intertidal mudflats to feed. Where these are close to colonized broods often aggregate into crotchet, although their survival is better on linear shores and where creches are not found (Evans & Pienkowski 1982).

Shelducks breed in north-west Europe, parts of the Mediterranean and the Middle East. Although the size of the north-west European breeding population is not known, the wintering population there and in the western Mediterranean is estimated at 285,000 birds (Pirot et al. 1993). By comparison an estimated 15,000 pairs of shelducks breed in Britain (Stroud et al. 1990). Britain is therefore of considerable international importance as a breeding area for shelducks, supporting at least 11% of the European population and, since not all shelducks present will breed, probably considerably more than this figure. Most of the British-breeding population utilizes estuaries, and at least 35% of review sites (257%) throughout Britain are used by breeding shelducks (Figure 8.6.73). Information from 29 review sites (from Allport et al. 1986; Roberts et al. 1986) shows that densities present on saltmarshes are generally less than 50 pairs.
km², and that highest densities are on Morecambe Bay and the Duddon Estuary where densities can be up to 102 pairs km² (Figure 8.6.73). Nevertheless, Evans & Henkowsk (1982) found that most of the production of young may be from low density populations breeding on linear shores outside estuaries: a good example of where density is not a good measure of importance.

Figure 8.6.73 The distribution of shelducks breeding on review sites. Densities are shown as maximum estimated breeding pairs km², and presence records are from Sharrock (1976).

In Britain, eider ducks Somateria mollissima also breed extensively on estuaries, almost exclusively in Scotland (Figure 8.6.74). Eiders are a very numerous species with an estimated wintering population of 3,000,000 birds in the western palaearctic (Stroud et al. 1990). The British-breeding population is much smaller, currently 20,000 pairs (Stroud et al. 1990). Eiders are common in west Scotland, Orkney and Shetland but the largest colonies are on the east Scottish coast, particularly on estuaries such as the Ythan, where c. 2,000 pairs bred in the 1970s, and on the Fife and Kincardine coasts, including the Eden and Tay Estuaries and Montrose Basin (holding up to 3,000 pairs).

Figure 8.6.74 The distribution of breeding eiders on review sites, derived from Sharrock (1976).

8.6.5 Conservation of British estuarine birds

Estuarine birds comprise a major feature of estuarine wildlife. Most are at the top of their food chains and provide sensitive indicators of the health of estuaries, since they are vulnerable to the accumulation of pollutants and depend on areas safe from human disturbance where they can breed, feed and roost. Britain's estuaries are host to large and important populations of many breeding, migrant and wintering bird species. The dependence of these birds on estuarine ecosystems for their survival is recognised in international treaties to which Britain is a party (see Chapter 9). Much of the conservation of estuarine habitats and wildlife is currently initiated as a result of the identification of areas as of international importance for birds.

Whilst the general approach to the conservation of birds in Britain, through the selection and notification of SSSIs, is similar to that for other wildlife, the high mobility of birds, especially those such as the migrant and wintering waterfowl that
use estuaries, adds a further dimension to the safeguarding of birds during each part of their life (NCC 1989). Furthermore the mobility of birds results in their dependence on a complex mosaic of habitats for their survival, both the short term such as during a tidal cycle, and the longer term such as during migration and whilst on wintering grounds. In addition established distribution patterns can be modified by environmental stresses such as severe winter weather, so that some sites vital for a bird’s survival may be used only very short periods. This means that site selection needs to be based on population sizes as well as distribution patterns.

Birds, including many important estuarine bird species, are mobile on an international scale as well as a national one, as described in Section 8.6.2. This has led to birds becoming the subject of several international government agreements on wildlife conservation. Two are particularly significant. The first is the Convention on the Conservation of Wetlands especially as Waterbird Habitat, often known as the ‘Ramsar Convention’, for which signatory states place wetland sites on a list of Wetlands of International Importance. The other is the Council of the European Communities’ Directive 79/409/EEC on the Conservation of Wild Birds, which requires member states to undertake special protection measures for all migratory and some other vulnerable bird species. Among these measures is the designation of Special Protection Areas. Both these international agreements are of particular relevance to estuarine conservation.

The Ramsar Convention concerns the conservation of wetlands and their waterbird populations. The EEC Wild Birds Directive places emphasis on the need to conserve habitats as a means of maintaining populations of all species of birds, and also focuses particularly on two main categories of birds. These are vulnerable species (listed in Annex I of the Directive) and all other regularly occurring migratory species. The Directive identifies the need to protect migratory species on their breeding, moulting and wintering areas and the staging posts along their migrations, and places particular emphasis on the protection of wetlands, particularly wetlands of international importance. Hence for the conservation of estuarine birds, particularly migrant and wintering populations, the EEC Wild Birds Directive and the Ramsar Convention are usually linked in the designation of sites. The operation and functioning of these and other international measures in Britain has recently been reviewed by Stroud et al. (1990), and their application to estuarine wildlife is described further in Chapter 9.

The functioning of the 1% of population size threshold for selection of sites has been outlined in Section 8.6.2. The 1% level has become widely accepted as a basis of the site selection component of bird conservation, since it covers both the rare and the more common, but localised, species. It forms an important element of both national and international site selection criteria (NCC 1989). As described in Section 8.6.2, use of a 1% criterion needs to be linked, however, with other approaches designed to ensure safeguarding of, for example, important bird assemblages and sites where large numbers of birds occur, such as breeding colonies. Thus a wetland is considered as internationally important under the Ramsar Convention if it regularly supports 20,000 waterfowl, or 1% of the individuals in a biogeographic population, or substantial numbers of individuals from particular groups of waterfowl indicative of wetland values, productivity or diversity. Recent guidelines also explicitly recognise the need to consider population turnover, and Ridgill & Fox (1980) emphasise the need to incorporate, in the national and international site network, sites that usually support lower numbers of waterfowl but which are critical for the survival of many more birds during periods of severe weather.

The descriptions in this review of the use of estuaries by birds have highlighted the many ways in which populations link habitats within the estuarine complex. Examples include the species that nest in one habitat such as grassland or sand-dunes and feed in another such as mudflats, and wintering populations that move between mudflats, saltmarshes, grasslands and shingle ridges during a tidal cycle of feeding and roosting. This interdependence highlights the need to conserve entire estuaries since loss of an area of habitat can have substantially graveer consequences for the birds which depend on it as part of their mosaic than appears from the size of the area (e.g. Davidson & Evans 1985). The aim of safeguarding the entire estuarine complex is incorporated in international measures such as Article 2.1 of the Ramsar Convention. This recognises that the boundaries of wetlands designated under the convention may incorporate riparian and coastal zones adjacent to the wetlands and islands or bodies of marine water deeper than 6 m at low tide lying within the wetlands, especially where these have importance as waterbird habitat.

In addition to safeguarding populations through the establishment of SPAs, the EEC Directive on Wild Birds also places an obligation (under Article 4.2) on Britain as an EEC member state to implement special protection measures elsewhere so that bird habitats in the wider countryside, outside the specially designated Ramsar/SPA sites, can be safeguarded. This follows from the requirement of the Directive that international conservation measures cover both the maintenance of the traditional geographic ranges of birds and the sustenance of levels of productivity. Furthermore the EEC Directive on Wild Birds indicates the need for special conservation measures for all species of birds to ensure their survival and reproduction in their area of distribution.

In considering the conservation measures appropriate for estuarine birds it is important to recognise that although many species appear widespread and abundant, where they occur, many
are largely restricted to estuarine areas. In reality the populations of these estuarine species are generally small in comparison with those of many other birds. For example, estimated British wintering populations include 37 million starlings *Sturnus vulgaris*, 30 million chaffinches, 20 million dunnocks *Prunella modularis* and 25 million skylarks (Lack 1986). In comparison, the most abundant wintering wader in Britain is the lapwing, with a population of 1 million, and the most abundant predominantly estuarine wader is the dunlin, with a midwinter population of 433,000. No other wader and only one duck – the very widespread mallard – exceeds a wintering population of 300,000 birds in winter.

For many waterfowl even international populations are much smaller than this, and are much less than 100,000 for many waterfowl for which Britain has an international responsibility (Tables 8.6.3 and 8.6.4). Hence conservation of estuarine birds concerns generally scarce and localized species. Nevertheless considerable proportions of the populations of some species are scattered around sites which individually fall below the 1% criterion for importance (Figures 8.6.47 and 8.6.48), and so the wider countryside approaches embodied in Britain’s international obligations are also relevant to the conservation of estuarine birds.

**Conservation of breeding birds**

The saltmarshes on estuaries and the grasslands, shingle and dunes associated with estuaries provide breeding habitat for breeding wader assemblages of major national and international importance, although estuaries are not the only key places in Britain for some of these species. Of particular significance are the over 60% of British redshanks and 30% of ringed plovers breeding on estuaries, and the large and diverse assemblages of breeding waders and other birds on many estuaries throughout Britain especially those adjacent to the review sites in the Outer Hebrides, the Norfolk Broads and the Ouse and Nene Washes alongside the tidal rivers of the Wash. Many of the breeding waders and other birds of saltmarshes and grazing marshes that occur in nationally and internationally important numbers on estuaries are, however, widespread in their breeding distribution.

Thirty-three estuarine sites containing saltmarsh and other coastal grassland bird habitats, and a further seven seasonally flooded neutral grasslands, are included within the designated and proposed Ramsar/SPA site network as internationally important ornithological sites. Machair areas adjacent to five review sites on the Outer Hebrides and Orkney are also included in the international site network because of their breeding bird populations (Stroud et al. 1990).

The saltmarshes, sand-dunes and shingle banks of estuaries are of considerable national and international conservation importance for their breeding seabirds. For seabirds the very large proportion of Britain’s little tern population that breeds on estuaries is of particular national and international significance. British estuaries also support more than 10% of the western and central European breeding populations of lesser black-backed gulls and sandwich terns. Many of the largest gull and tern colonies in Britain, for example at Walney Island on Morecambe Bay, Blakeney Point and Scolt Head on the North Norfolk Coast, Orfordness on the Orin/Alde/Blyth in Suffolk, and the Sands of Forvie on the Ythan estuary, are on estuaries.

Eighteen estuarine sites within the proposed Ramsar/SPA site network contain major seabird colonies (Stroud et al. 1990). In all 55 estuaries included in the proposed Ramsar/SPA site network contain saltmarsh and grassland-breeding bird assemblages and/or seabird colonies (Figure 8.6.75). (Note that in some places, for example the Stour and Orwell Estuaries in Suffolk, two or more review sites together form a single Ramsar/SPA site and that, because of resource constraints, the precise boundaries have yet to be determined for some proposed Ramsar/SPA sites (Stroud et al. 1990).) Sixteen review sites feature among the internationally important sites with both saltmarsh/saltmarsh-breeding species and assemblages, and seabird colonies (Figure 8.6.75). All review sites that fall wholly or partly within the proposed Ramsar/SPA site network are shown in Chapter 9.

Although many seabird colonies are occupied consistently for long periods of years, some species, particularly terns, sometimes abandon formerly traditional breeding sites and move elsewhere. Such moves may be induced by local food shortages or by excessive disturbance to the breeding colony. (The presence of good inshore and coastal feeding grounds close to a safe breeding colony is important for successful breeding.)

Many seabird colonies, especially estuarine colonies on mainland sand-dunes and shingle systems, are very vulnerable to predation from ground predators such as foxes and human disturbance from beach recreation such as bathing and dog-walking. Shingle and beach-breeding waders such as oystercatchers and ringed plovers are also at risk from predation and human disturbance, particularly in areas where beach recreation is extensive such as in much of southern Britain. Many colonies are now closed to public access during the breeding season so as to minimize disturbance, and this protection has probably been instrumental in the increases in the breeding populations of some species such as Sandwich and little terns during the last few decades (e.g. Thomas 1982). There is a trend, however, for increasingly large proportions of the breeding populations of shingle-breeding terns to become concentrated in these lower sites, as noted by Prater (1989) for ringed plovers in eastern and southern England.
There are very much higher overall breeding densities of waders (Figure 8.6.62), and of individual species such as redshanks (Figure 8.6.51), on saltmarshes than on wet grasslands. This implies that the very widespread and extensive past conversion of saltmarsh to coastal grazing marsh on estuaries, for example on the Ribble Estuary and The Wash (Doody 1987), has already resulted in major reductions in the total British breeding populations of redshanks and other waders.

The subsequent destruction of these coastal grazing marshes and lowland wet grasslands, through drainage and arableisation and agricultural intensification, is of major concern for the internationally important assemblages of breeding birds on such habitats. Change from low intensity traditional agricultural practices also reduces the suitability of wet grassland for breeding waterfowl. Reductions have been both extensive and recent.

For example, Williams et al. (1983) have documented a 49.8% reduction in the area of grazing marshes in north Kent (South Thames Marshes, Medway and Swale Estuaries) between 1935 and 1982. Major losses are not restricted to Britain (e.g. Bontema 1983; Nairn et al. 1988). Reduction and fragmentation of these habitats in Britain in the second half of this century has coincided with marked declines in grassland breeding populations of waders such as snipe and redshank (Mitchell 1983; Smith 1983). Changes to lowland grasslands and coastal grazing marshes are still occurring and there is recent evidence that the declines in lowland grassland breeding populations of redshank and snipe are continuing (Smith 1988; Holzer et al. 1999). Sympathetic farming and management of these habitats in Environmentally Sensitive Areas (ESAs) such as the Norfolk Broads, on SSSIs under management agreements with the NCC and on nature reserves, are, however, proving beneficial in some areas (e.g. Everett 1987; Stroud 1989; D Henshfield in litt.).
Conservation of migrant and wintering birds

The very considerable importance of Britain's estuaries for migrant and wintering birds is reflected by the fact that 68 review sites are currently included in the proposed Ramsar/SPA site network as sites containing migrant and wintering estuarine bird habitats (Stroud et al. 1990). Many review sites individually qualify as internationally important for several different reasons in respect of the Ramsar Convention and the EEC Wild Birds Directive. For example, 24 review sites each support in excess of 20,000 waterfowl in just January, qualifying by virtue of this alone as wetlands of international importance (Figure 8.6.76). As described above the January totals under-represent the total number of individuals using each site, so additional review sites qualify when such turnover is taken into account in conservation assessments, as for example by average peak monthly counts (e.g. Prater 1981; Salmon et al. 1989). Many more review sites qualify as nationally and internationally important for supporting in excess of 1% of a relevant population: Prater (1981) identifies 82 review sites that each support nationally important populations of one or more migrant waterfowl species or subspecies (Figure 8.6.77). Fifty-four of these support internationally important populations of individual species of waterfowl (Figure 8.6.77), with many estuaries supporting nationally and internationally important numbers of 10 or more biogeographic populations.

The high mobility of individual birds and their dependence for survival during the non-breeding season on a network of different estuaries have also to be taken into account in fulfilling the international obligations to safeguard these populations. The movements of waterfowl around estuarine complexes is recognised in the setting of boundaries to Ramsar/SPA sites, some of which link several review sites where there is evidence of short-term movements between them of the bird populations which depend on them. The high proportions of some of these populations that overwinter on review sites other than those identified by the 1% criterion as individually important (Figures 8.6.47 and 8.6.48), and the known use by individuals of networks of sites during migration, moult and overwintering, mean that fulfilling international conservation obligations requires conservation measures to be applied to
these wider estuarine areas, as well as to the sites supporting large populations, if the size and geographical range of populations are to be maintained, as embodied in the EEC Wild Birds Directive. This is particularly important in view of the evidence presented in Section 8.6.2 that many small estuaries may be the preferred sites for many waterfowl in winter, and that these sites provide the most favourable conditions for survival.

An example of the extent to which migrant and wintering waterfowl treat British estuaries as a single network is shown in Figure 8.6.78. This shows some of the known movements between review sites made by individual dunlins, based on reports of ringed birds and observations of colour-marked birds. This illustrates that the great majority of British estuaries are already known to be involved in the network upon which the internationally important populations of dunlins depend. It is important to note, however, that the pattern shown in this illustration represents a minimum of movements, since it is based on a selection of records and is dependent on where large numbers of birds have been caught and ringed. Thus absence of a link can represent lack of knowledge rather than lack of movement of dunlins. For example, very large numbers have been ringed on The Wash, and this is reflected in the many links between The Wash and other estuaries. Similarly, the relative paucity of links in northern and western Britain is more a reflection of the smaller numbers of birds marked there, coupled with the remoteness of the estuaries leading to fewer reports, rather than the absence of links. Even with these limitations, however, the figure demonstrates links between 93 (90%) of the 155 review sites.

The complex pattern of use and the distribution of estuarine birds means that many are vulnerable to the piecemeal loss of estuarine habitat resulting from land-claim for a wide variety of purposes (see Chapter 10). Such land claims prior to 1986 have been widespread in the past and have resulted in very substantial reductions in the remaining available habitat on some estuaries such as The Wash (e.g. Doody 1987) and the Tees Estuary (Evans & Pienkowski 1983; Davidson & Evans 1986a). There are, however, many current activities on British estuaries that are causing further loss or severe degradation of estuarine habitats, and many further such episodes are proposed (Chapter 10). Some affect the intertidal and subtidal parts of estuaries, others the surrounding marine and subtidal habitats. Each can affect waterfowl populations because of their complex patterns of use of the estuarine habitat mosaic. Those species that are highly concentrated onto a small number of estuaries are at high risk from habitat loss on those few sites; more widespread species are also at risk; however, because land-claim is simultaneously affecting many different estuaries. This piecemeal loss of habitat is of particular concern since it results in a continued decline in the area of remaining habitat and there is evidence that habitat loss is implicated in the recent decline of at least one wader species, the dunlin, overwintering in Britain (Goss-Custard & Moser 1988).

Figure 8.6.78 An example of a waterfowl site network within Britain some of the known links between review sites for individual dunlins, from reports of ringed and colour-marked birds. Each line joins two review sites between which there is at least one reported individual movement. Information is taken largely from studies on The Wash (Cooper 1984, Brasson 1989), Suffolk and Essex coasts (Davidson, Evans & Pienkowski 1986), Humber Estuary (Edwards 1988), Firth of Forth (Symonds & Langslow 1981), Moray Firth (Symonds & Langslow 1985), Severn Estuary (Clark 1983), and from reports listed in Wader Study Group Bulletins. Note that the pattern of known movements partly reflects the distribution of these studies.

Declines in populations of estuarine waterfowl are not restricted to Britain and Europe. Howe et al. (1989) report substantial declines in the migrant populations of whimbrels, short-billed dowitchers Limnodromus griseus and sanderlings in eastern North America, which may be a consequence of the major wetland losses that have occurred in North and South America.

The actual impact on bird populations of any particular loss of habitat is seldom in direct
proportion to its area, as a consequence of the fact that more individuals use an area than are present at any one time (e.g. Evans & Pienkowski 1983, Davidson & Evans 1985). Thus even a small loss in a particularly sensitive place can have a major impact on waterfowl populations.

Loss of habitat takes on a further significance if the area is used as a cold weather refuge, or as a migration staging area. Loss of or damage to, migration staging areas can be particularly critical, since loss of these ecological bottlenecks may seriously affect the chances of waterfowl populations reaching their breeding grounds or breeding successfully (Smid & Persmenna 1989).

One consequence of habitat loss is the focussing of all use of estuaries by wildlife and man into smaller areas, so increasing pressure on those remaining areas. A number of pressures can affect waterfowl using remaining areas of estuarine habitats. Human disturbance to feeding waterfowl can reduce the amount of time birds are able to feed in preferred feeding areas, so reducing their food intake. Such disturbance can be from a specific human activity such as wildfowling at night (Mudge 1989) or from a wide variety of causes during the day (e.g. Belanger & Bedard 1989). Similar effects of disturbance, affecting the distribution of waterfowl, occur also on inland waters, associated chiefly with watersports (e.g. Tuite et al. 1984). Effects of disturbance can be cumulative from different sources. For example, wildlife conservation on many estuaries has involved the establishment of wildfowl refuge areas in which wildfowling is not permitted. However, in one such refuge, at Buckie Bay, Scotland, disturbance from increasingly large numbers of bait diggers in recent years prevented birds from using the refuge area for feeding.

Human disturbance can also affect roosting birds. This can be a particular problem during severe weather when birds already face an energy deficit from high energy expenditure and low food availability. At such times disturbance causing birds to fly – an energetically very costly activity – will increase their rate of nutrient reserve loss. Disturbance to roosting birds can be severe and is implicated in the movement of waders tens of kilometres from the Dee Estuary to roost on the Alt Estuary in north-west England (Mitchell et al. 1988).

In spring waterfowl at migration staging areas need to accumulate fat and protein reserves rapidly if birds are to reach their arctic breeding grounds in time to breed and with sufficient reserves to both survive and assist in egg formation (e.g. Davidson & Evans 1988; Davidson & Morrison 1986). Disturbance that affects this reserve accumulation on spring staging areas is of particular concern. Belanger & Bedard (1989) have documented just such an instance where human disturbance caused significant energetic consequences for staging snow geese.

Pollution has a variety of impacts on estuarine waterfowl, depending on its nature and magnitude. For example organic pollutants can cause serious eutrophication and oxygen depletion in the water at some times of year in estuaries. This enrichment, often causing general ecological deterioration of an estuary, can, however, increase the biomass of some macroinvertebrates that provide food for estuarine waterfowl. This may permit the numbers of birds using the area to increase (e.g. van Impe 1985), although such heavy pollution of systems can result in a reduction in the diversity of the estuarine system. Conversely reductions in organic pollutant levels can increase the range of plants and animals able to tolerate the estuarine conditions but may alter the overall species composition and size of the wintering waterfowl assemblages using the area (e.g. Campbell 1978, 1984; Furness et al. 1986).

Heavy metal pollution often accompanies organic enrichment in polluted estuaries. Heavy metals are known to accumulate in substantial concentrations in waterfowl on polluted estuaries in Britain (NRDC 1983; Evans et al. 1987), but their effects appear to be generally chronic rather than rapidly fatal. One instance of high mortality attributed to heavy metal pollution was caused by poisoning by alkyl lead compounds in the Mersey Estuary (Bull et al. 1983). Waterfowl can also ingest fatally high levels of lead in the form of spent lead pellets from wildfowling (Mudge 1983).

Oil pollution generally causes fewer problems for estuarine birds than for seabirds in inshore waters, but oil spills within the confines of an estuary can be very serious, particularly outside the waterfowl breeding season. At such times oiling of many wildfowl and waders can occur, as in the Medway Estuary in the 1970s and the Firth of Forth in 1975 (Campbell et al. 1978). More recent incidents in the Mersey Estuary and the Humber Estuary have, largely by chance, avoided serious direct impacts on waterfowl.

The continued maintenance of the nationally and internationally important bird populations of estuaries thus depends on ensuring the effective conservation of all the remaining areas of estuarine habitat and at least the maintenance of the quality of these areas as waterfowl feeding, roosting, migration staging, moult and breeding grounds.

8.6.6 References


DAVIDSON, N.C., & EVANS, P.R. 1986a. The role and potential of man-made and man-modified wetlands in the enhancement of the survival of overwintering shorebirds. Colonial Waterbirds, 2, 176-188.


EBBINGE, B.S. 1987. In hoeverre bepalen lemmingen het broedresultaat van Rotgrazen Branta bernicla Limosa, 60, 147-149.


EVANS, P.R., DAVIDSON, P.R., PIERSMA, T., & PIENKOWSKI, M.W. In press. Effects of habitat loss at migration staging posts on shorebird populations. *Proceedings of the XX International Ornithological Congress*.


GOODER, I.R., & EVANS, P.R. 1980. Movements of shorebirds into and through the Tees estuary, as revealed by ringing, County of Cleveland Bird Report 1979, 45-52.


Corax, 12, 274-442.


8.7 Mammals

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8.7.1 Introduction

Three groups of mammals are relevant to estuarine wildlife conservation: cetaceans, seals and otters. Although none is entirely dependent on estuaries, such places provide important feeding and breeding areas for otters and for seals, particularly common seals. The use of estuaries by cetaceans, chiefly dolphins, is less well understood, but some species are known to occur regularly in the outer parts of some British estuaries and so information on their known locations in review sites is included.

8.7.2 Cetaceans

Introduction

Twenty-four species of whales and dolphins have been recorded in British and Irish waters and most have been seen from the shore. Of these, 12 species are regularly seen close to our coasts. These include not only smaller species such as the harbour porpoise Phocoena phocoena but also larger whales including the 20-metre fin whale Balaenoptera physalus which has been seen mainly off western coasts. The small cetaceans characteristic of more inshore waters include the harbour porpoise, the bottle-nosed dolphin Tursiops truncatus and Risso's dolphin Grampus griseus. Amongst the larger species, the minke whale Balaenoptera acutorostrata and the killer whale Orcinus orca are regularly seen from headlands and offshore islands.

A study of the status and distribution of British cetaceans is being carried out by the Cetacean Group, established in 1973 within the UK Mammal Society. A network of some 350 observers distributed throughout Britain and Ireland has contributed substantially to our knowledge of cetaceans in European seas. There is still much to learn, however, about the movements of cetaceans in British waters, and many of the early data have been drawn from records of strandings collected by the British Museum (Natural History).

Two species of cetacean are frequently found in enclosed coast Estuaries Review sites. These are the harbour porpoise Phocoena phocoena and the bottle-nosed dolphin Tursiops truncatus. Other species occur only infrequently and data for these species in review sites are very sparse.

Common or harbour porpoise

The harbour porpoise is the smallest British cetacean, measuring not more than two metres in length. It is a short, stout and robust-looking cetacean, with a black back, white belly and varying amounts of grey on the sides. It has a short blunt head; a snout or beak is absent. It is a slow swimmer and accordingly does not normally leap clear of the water as do dolphins (Furves 1977).

Porpoises are present in coastal waters throughout the year, favouring shallow calm waters, and the harbour porpoise has a very wide distribution in the North Atlantic. Adults with calves assemble in coastal waters on both sides of the North Atlantic from July to October, but breeding locations are unknown. The harbour porpoise is by far the most common cetacean species recorded from both strandings and sightings, although the frequency of its occurrence within review sites is not specifically documented. Between 1913 and 1978 there were 723 strandings, nearly four times as many as for the second most commonly stranded species, the bottle-nosed dolphin (Evans 1980). Porpoises are essentially coastal in occurrence, although individuals have been seen from time-to-time long distances up-river, notably in the estuaries systems feeding The Wash (R Mitchell pers. comm.).

Bottle-nosed dolphin

The bottle-nosed dolphin is a small cetacean which can grow to just less than four metres long. It has a robust slate grey or light brown body. The head
possesses a distinct beak; the lower jaw of which protrudes beyond the tip of the snout. Streaks of lighter coloration stretch from the base of the beak to the blowhole located on the top of the head. The throat and belly are white or pale pink. There is a prominent dorsal fin which slopes backwards and has a concave hind margin (Purves 1977).

Bottle-nosed dolphins appear to be mainly coastal, often occurring in estuaries. Regular watching in recent years has revealed that certain estuaries and coastal areas either hold resident bottle-nosed dolphin populations or are visited regularly each year.

There are two main resident populations of bottle-nosed dolphins in British waters and one population can be found within or near to two review sites, the Moray and Cromarty Firths, whilst the other population is in Cardigan Bay in west Wales (outside review sites). Outside these areas most records of sightings are from south-west Britain and Ireland (Evans 1976). The Cardigan Bay population appears to be smaller than the population present in the Moray Firth. Research is currently under way to provide more information on both populations. Other places from which bottle-nosed dolphins are known include the Clyde Estuary and the hot water outflow from Dungeness Power Station on the Kent coast. Such areas are frequently used throughout the summer months.

In the Clyde, bottle-nosed dolphins have been observed in March feeding amongst herring shoals, and they have been seen feeding on salmon in the Cromarty and Moray Firths in the summer. Their diet, however, rather poorly known. They are believed to feed mainly on inshore bottom-living fish including mullet, but will also take herring, mackerel and cod.

Bottle-nosed dolphins have been recorded most commonly in summer, earliest in the north of Britain and later further south. It is not clear whether apparent absence at other times of year is real or a consequence of varying intensity of observation.

Dolphins give birth mainly in spring/summer in lower latitudes, after mating 10-12 months before. After giving birth to their young, they move into higher latitudes to feed during the summer months. In Britain bottle-nosed dolphins can be occasionally seen with calves. For example, there were two sightings of herds with young in Scotland in 1974, one of 40 adults and 10 small calves in April in the Cromarty Firth, the other on the Ballantrae Bank (outside review sites) in south-west Scotland in March, and groups in the Irish Sea have often been seen with attendant calves (C T S Rees pers. comm.).

Status and threats

The status of many species of cetaceans, especially the smaller species of dolphins and the larger species of whales, is of major concern. The harbour porpoise, although still the most frequently recorded species, is thought to have declined in recent years. Since 1980 noticeable declines have occurred in the southern North Sea, the English Channel and the Irish Sea (Evans 1980). This species was formerly very common near the French coast but is now one of the least common species there. The bottle-nosed dolphin seems to have become less common than formerly in the northern Irish Sea. It was seen frequently in parts of the North Sea until the late 1950s but had virtually disappeared from this area by the late 1960s (Gubbay 1986). Pollution, disturbance from ships and boats and over-exploitation of fish stocks have all been put forward as possible contributing factors, along with the incidental catching of cetaceans during fishing operations. High residues of chemicals, for example chlorinated hydrocarbon insecticides, have been found in the fat of porpoises from the North Sea (Holden & Marden 1967), while drastic declines in planktonic stages of teleostean fish in the English Channel between 1933 and 1937 have been linked to an increase in stranding of porpoises (Russell 1973; Corbin 1948, 1949). Large incidental catches of cetaceans during fishing operations are thought to have been a major factor in, specifically, the decline of the harbour porpoise (Kayes 1985).

Conservation

As a result of the 1986 Quinquennial Review of the Wildlife & Countryside Act 1981, all cetaceans are afforded total protection. Prior to this only the harbour porpoise, common dolphin and bottlenosed dolphin were so protected, although all species have been protected since 1934 from commercial whaling up to 200 miles from the English and Welsh coasts. Protection was extended because it was realised that the difficulties of differentiating threatened from unthreatened species as sea were so great that only protection of all would be effective. This also complied with international obligations under the Bern Convention (A Whitten pers. comm.).

Conclusions

Both harbour porpoises and bottle-nosed dolphins favour calm, shallow inshore waters, and clearly a number of the enclosed coast Estuaries Review sites provide such conditions. These areas also support populations of fish on which the species feed (see also Chapter 8.4). Data on the numbers of individuals which use these areas are limited, and the overall significance of review sites for both species is not understood, but individual locations such as the Moray Firth and Cardigan Bay are obviously of high conservation importance. The Moray Firth holds the largest known population of resident bottle-nosed dolphins in Europe.

8.7.3 Seals

Two species of seal, the grey seal Halichoerus grypus and the common seal Phoca vitulina, occur commonly and breed around the coasts of Britain.
Other species, including harp seal Phoca groenlandica, ranged seal Phoca hispida and hooded seal, have been recorded very occasionally in British waters, including some estuaries.

**Grey seal**

The world population of grey seals is distributed in three breeding groups, one in the Baltic Sea and the others in the western North Atlantic and eastern North Atlantic. 1985 surveys by the Sea Mammal Research Unit (SMRU) of the Natural Environment Research Council estimated the British population at about 92,000 grey seals (NERC 1987). This is about 40% of the world population. Grey seals favour exposed shores for their breeding sites, so breeding grey seals occur largely outside estuaries. Major breeding sites are in Shetland, the Orkneys, the Outer Hebrides, the Isle of May in the mouth of the Firth of Forth and the Farne Islands off the Northumberland coast. Grey seals also breed around some review sites in the far north of Scotland. Elsewhere there are a total of about 3,000 grey seals breeding in western Britain (on Angelsey, in Dyfed and in Cornwall) and grey seals also at Donna Nook on the Humber Estuary (Northridge 1980). Pups are born in autumn (December at Donna Nook) and remain on shore for several weeks. Grey seals do, however, regularly appear in estuaries throughout Britain, especially in the north and west, when they are away from their breeding sites. Individuals can move considerable distances along coasts and into estuaries for short periods; for example, Harwood (1986) describes a grey seal tracked by radio telemetry from the Farne Islands north up the east coast, into the inner Firth of Forth and north as far as the mouth of the Firth of Tay. Some estuaries are regularly used as haul-out sites: a non-breeding group using the Dee Estuary & Wirral has increased from a few seals in the 1950s to over 300 individuals by the late 1980s. A recent review of seals in the Irish Sea (Northridge in press) notes that small numbers of grey seals are regularly recorded in the Mersey, Ribble, Morecambe Bay and Duddon Estuaries. A similar pattern of appearance occurs in most other estuaries within the breeding range of grey seals.

**Common seal**

Common seals are less abundant than grey seals in Britain but their population is important in international terms. The estimated minimum population size of common seals in the early 1980s was 24,500 (NERC 1987), about 25% of the east Atlantic subspecies of common seal (Summers 1979). Common seals occur much more in sheltered inshore areas such as estuaries and sounds, where they use sand-banks and islands as haul-out sites. Estuaries therefore provide important areas for common seals in Britain. In contrast to grey seals, common seal pups can leave their sand-banks within a few hours of their birth in the summer. Two adjacent British estuaries, The Wash and North Norfolk Coast, are of very major importance for common seals. Until recently these review sites supported about 6,800 common seals (27% of the British population and 7% of the east Atlantic subspecies), although numbers have now declined owing to viral disease (see below). A similar number breed on the sheltered shores, including review sites, of Orkney, so over half the British population breeds in these two breeding areas.

Elsewhere much of the rest of the population occurs on the west coast of mainland Scotland and the Inner and Outer Hebrides (5,800 seals), including the various sheltered review sites in these areas. There are 1,000 common seals breeding on the east coast of Scotland, mostly on the review sites of the Forth, Cromarty and Moray Firths and further south in the Firth of Tay and Eden Estuary (J Harwood pers. comm.). Common seals breed also at Donna Nook on the Humber Estuary (Northridge 1990). There are also small groups on some other east coast estuaries such as Teesmouth (D Jackson pers. comm.), where breeding is now being attempted again after the breeding population disappeared over a century ago, and also in North Wales (EIS Rees pers. comm.). Hence at least one-third, and probably considerably more, of the British population bred on estuaries before the spread of the virus (see below).

Outside the breeding season common seals, like grey seals, range widely around the coastlines of Britain and occur in most estuaries in northern and eastern Britain. They are however scarcer in the south and the west, occurring only occasionally in western England and Wales.

**Recent population changes**

Seal populations have been substantially reduced in Britain and in other major breeding areas such as the Wadden Sea since 1987 as a consequence of phocine distemper virus. This virus, similar to the canine distemper virus, was first noted in the Kattegat in April 1988. During the summer of 1988 it spread rapidly through the populations of the Wadden Sea and seals began dying in large numbers in Britain in August 1988. Common seals were much more seriously affected than grey seals, although there has also been concern about the effects that even a lesser impact of the virus may have on the small world population of grey seals, since most of the European population breeds in Scotland.

All of the British populations of common and grey seals are thought to have been exposed to the virus, but different parts of the population have been affected to quite different extents. Extensive surveys of common seals in August 1989 found that numbers have decreased by 50-60% since before the epidemic in the Kattegat, the Wadden Sea, and on the east coast of England, including the major breeding area of The Wash, but that there has been only a 30% decline in the Irish Sea and little change in the Scottish common seal populations (Harwood...
Conservation of seals

Adults and pups used to be killed in most places where they bred, mostly for commercial hunting and to prevent damage to fisheries, especially salmon fisheries. Although the 1914 and subsequent Grey Seals Protection Act imposed a closed season for hunting during the seal's breeding season, common seals had no such protection. Concern over the impact of extensive hunting of common seals on the Th Wash, in Orkney and western Scotland led to the Conservation of Seals Act 1970, which imposed a closed season for grey seals from 1 September to 31 December and for common seals from 1 June to 31 August. The Conservation of Seals (Scotland) Order 1973 afforded protection to common seals in Shetland all year. The Conservation of Seals Act permits licensed culling of seals for fisheries protection, population management and research. There has, however, been no hunting of common seals on the Wash since 1973 nor in Orkney or the west coast of Scotland since 1982. Similarly hunting of grey seal adults and pups in various parts of Scotland ceased in the early 1980s, and there has also been sporadic control of the adult grey seal population on the Farne Islands.

Seals can cause serious damage to fisheries and since the early 1980s licences have been issued mostly to fish farmers and salmon fishermen in Scotland to kill seals in the vicinity of their gear. In 1987 17 licences for common seals and 19 licences for grey seals were issued (Gubbay 1988) and in 1988 a total of 97 common seals were reported shot under licence. There is also concern over unlicensed killing in the vicinity of fishery operations, so the numbers killed may be well in excess of these figures. Since the viral epidemic the close season has been extended to give protection all year until 1990 to common seals throughout Britain and protection all year to grey seals in England and Wales.

The possible effects of pollutants on marine mammals in general and seals in particular were widely publicised as a possible contributor to the severity of the seal virus. It has been suggested that in particular polychlorinated biphenyls (PCBs) can affect mammalian immune systems, so rendering the animal more susceptible to disease, although no evidence is yet known to link pollution to the seal virus. PCBs are, however, known to be able to affect the reproduction of seals, and are of particular current concern, although recent studies of seals on the east coast of England found levels of PCBs and other organochlorines mostly at the lower end of the range known for seals in the North Sea and Baltic Sea (Law et al. 1989). In general Irish Sea seal populations appear to have been less affected by pollution than those in the Baltic and the Wadden Sea (Northridge 1990 in press).

8.7.4 Otters

Introduction

The European otter Lutra lutra is a widespread largely fish- and shellfish-eating mammal that occurs in river systems, lakes and coasts throughout Europe and Asia. In Britain and Ireland it was formerly widespread and common throughout the country, but during the latter half of the twentieth century the distribution of otters has been substantially reduced in Britain and elsewhere in western Europe. In many parts of their European range otters remain scarce.

Many causes may have contributed to the decline in population and range of otters in Britain and Europe, but major factors were probably habitat loss associated with land drainage schemes that straightened and cleared rivers of the overhanging trees and other vegetation that provided cover for the otters, increasing pressure from waterborne and bankside recreation, and pollution (Lenton, Chann & Jeffries 1960). Chann & Jeffries (1978) have, however, identified persistent organochlorine pesticides as the key factor in the major decline in the otter population, as it was for the declines in populations of birds of prey. Other forms of pollution such as that from polychlorinated biphenyls (PCBs) and agricultural run-offs that kill invertebrates and fish may also now be involved (Andrews & Crawford 1986).

Concerns about the declining status of otters led to standardised surveys of the distribution of otters being made during 1977–79 over much of England (Lenton, Chann & Jeffries 1960), Wales (Crawford et al. 1979) and Scotland (Green & Green 1980). These confirmed that otter distribution in England and Wales was very restricted, with only 6% and 20% respectively of surveyed sites showing signs of otters. The surveys found, however, that otters were widespread in Scotland. Because of the possibility of continuing declines in the British otter population, nationwide surveys were repeated during 1984–85 (Andrews & Crawford 1986; Green & Green 1987; Strachan et al. 1990). These have shown that there have been recent further declines in the populations of otters in two parts of Wales (Anglesey and mid-Glamorgan), but also that in some parts of England and Wales and in eastern Scotland there have been marked increases.

Otter surveys have concentrated on the freshwater parts of river systems, and otters are difficult to survey in tidal areas because signs such as spraints are rapidly washed away by the tide. Otters can,
Table 8.7.1 Numbers and percentages of review sites on which otters have been recorded recently

<table>
<thead>
<tr>
<th>Country/region</th>
<th>On estuary</th>
<th>Upstream of estuary only</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotland*</td>
<td>42 (88.4%)</td>
<td>7 (13.7%)</td>
<td>2 (3.9%)</td>
</tr>
<tr>
<td>W England/Wales</td>
<td>4 (10.0%)</td>
<td>16 (40.0%)</td>
<td>20 (50.0%)</td>
</tr>
<tr>
<td>S England</td>
<td>5 (17.6%)</td>
<td>8 (23.5%)</td>
<td>20 (58.9%)</td>
</tr>
<tr>
<td>E England</td>
<td>7 (21.9%)</td>
<td>7 (21.9%)</td>
<td>18 (56.2%)</td>
</tr>
<tr>
<td>Total</td>
<td>59 (38.1%)</td>
<td>36 (23.2%)</td>
<td>80 (38.7%)</td>
</tr>
</tbody>
</table>

* Includes Solway Firth

Percentages are of the total number of sites in that country/region

however, move considerable distances during a single night so although they are nocturnal and hence seldom seen in many parts of their range, and although signs of otters are difficult to find on estuaries, it is likely that otters regularly visit the tidal parts of many of the rivers on which they occur. They probably avoid, however, the heavily industrialised and polluted estuarine parts of river systems such as some of those in north-east England.

Distribution on British estuaries

Much of the information presented below on the distribution of otters on British estuaries has been gathered from otter surveyors past and present. Where appropriate this has been supplemented with information from the published surveys.

Otters have been recently recorded on 59 (38.1%) review sites (Table 8.7.1). In addition they are known to be present upstream of the tidal limit of a further 36 (23.2%) sites; in all otters are thus likely to occur on 61.3% of review sites. As would be expected from the general distribution of otters in Britain, otters are most frequently recorded on estuaries in Scotland, where 49 (96.1%) of sites have otters present or nearby (Figure 8.7.1; Table 8.7.1). There are only three estuaries in Wales on which otters are currently known to occur, although a further 10 review sites have recent records from above their tidal limits. Likewise there is only a scattered distribution in England, where most sites on which otters have recently been recorded are in Devon and Cornwall, and in eastern England between the Humber and north Suffolk. In all only 14 (17.7%) English review sites are currently known to support otters, and on only a further 21 sites are otters known to be present upstream. Otters are largely absent from the estuaries of south-east England, southern England east of Devon, south Wales, north Wales and north-west England (Fig 8.7.1).

In general there is a pattern of otters spreading back onto rivers in England and Wales so that both their range and their numbers are increasing. On some rivers such as the Severn otters are expanding their ranges downstream so that their use of estuaries is undoubtedly increasing. Otter populations remain high or are currently expanding throughout most of Scotland – there has been a recent range expansion in southern Ayrshire, and the expansion in Fife noted by Green 

Figure 8.7.1 The distribution of otters on review sites

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The ways in which otters use British estuaries seems to differ regionally. Over much of England, Wales and eastern Scotland otters are largely nocturnal, but in northern and western Scotland they are much more active by day. In south-west and west Scotland otters are widespread over much of the coastline, and use open coasts as well as estuaries, although in Dumfries and Galloway the sheltered estuaries and firths are preferred. Similarly otters are widespread and common on the sheltered coasts, including the review sites, of the mainland and islands of western Scotland. Otters are also widespread on Orkney and although the three review sites on Sanday have not been surveyed they, like the rest of the coastline of the Orkneys, are believed to be used by otters. On the north coast of Scotland otters mainly use the sheltered estuaries and bays and avoid the exposed open coasts between. In eastern Scotland otters are present chiefly in the estuaries and firths, and the river systems that feed into them. There is a similar distribution pattern over much of England and Wales, but in some places such as parts of the North Norfolk Coast the coastal marshes and reedbeds currently appear to be more important to otters than the adjacent rivers (H. Smith, pers. comm.).

Estuaries in Britain evidently support an important part of the British otter population throughout the year. In winter coasts and estuaries become additionally important to otters as refuges from severe weather. During these times when lakes and rivers freeze over making feeding difficult otters may move considerable distances to the tidal shores to find ice-free areas (Laidler 1982).

8.7.5 References


