



# **An inventory of UK estuaries**

## **Volume 1 Introduction and methodology**

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Professor Peter Evans

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# 1 Foreword

Professor Peter Evans

Chairman, Department of Biological Sciences, University of Durham

Viewed worldwide, estuaries are a scarce natural resource, even though some in the deltas of great rivers are of immense size. The British Isles is fortunate in holding a large number and variety of types of estuary, particularly when compared with the rest of temperate and Mediterranean Europe. Yet we have not used most of our estuaries either wisely or sustainably, probably for two reasons: first a lack of knowledge of the natural resources they contain and second a lack of understanding of the effects of the human uses to which they have been, or are being, put.

Pollution problems up-river have readily been apparent to anglers and recreational users alike and there have been long-standing campaigns to improve water quality in many of our rivers. These have begun to bear fruit. Many of the larger estuaries have not attracted such concern from the general public in relation to their water quality. People have increasingly turned their backs on the river corridors as they near the sea and looked further afield for clean recreational areas. As a result discharges of industrial and domestic wastes into estuaries have continued on a large scale, though restrictions are gradually being introduced (or even self-imposed by environmentally aware industrial concerns).

Even less obvious to the general public has been the steady loss of intertidal land within estuaries, to land-claim for industrial development and to dredging for the creation of wider and deeper shipping channels and berths needed to accept the larger vessels in which we import more raw material as our own accessible resources of many minerals and chemicals decline. Intertidal and even permanent shallow-water areas of estuaries have been buried under domestic rubbish and other solid wastes, or sometimes permanently flooded for water storage schemes. To these established, though often not sustainable, uses are being added new demands: barrage schemes for power generation, harbour developments for pleasure craft and many others.

Knowledge of the natural resources of the British estuaries has been slow to accumulate. Even one of the most obvious of the biological resources, the bird populations, had not been counted in more than a few of the smaller estuaries before the "Birds of Estuaries Enquiry", now organised by the BTO, WWT, RSPB, and JNCC, was launched in 1969<sup>1</sup>. The very idea of attempting a count of all the birds using the shores of the Wash in Lincolnshire and Norfolk was considered impractical before a Cambridge Bird Club team, of which I was a member, attempted the task in the mid-1950s. Quantification of other resources has proven even more difficult: fishery catch statistics do not necessarily permit identification of spawning and nursery areas, yet for several species these lie in estuaries and are vital for the continued health of our fish stocks. The role of algae and other plants in stabilising estuarine shores against erosion is only now

becoming understood in a more quantitative way though it had been appreciated for more than half a century that planting of the cord-grass *Spartina* provided an extra line of defence against erosion of soft shores.

Now we are faced with the reality of sea level rise and the need for rethinking coastal defences. People have come to appreciate the value of the wildlife resources of estuaries, and industries located on estuaries increasingly appreciate the advantages of developing a 'green image' backed by actions such as the reduction of waste discharges to confirm it. This, therefore, is a particularly appropriate time to launch this *Inventory of UK estuaries*, building on the excellent publication *Nature conservation and estuaries in Great Britain* which appeared in 1991. That book, edited by Dr Davidson, who is a co-author of several of the chapters in these present inventory volumes, was the last major review published by the former Nature Conservancy Council. I am proud to have persuaded my fellow Council members in the mid-1980s to commission that work which has, I believe, influenced attitudes to estuary use in a most positive way.

I well recall, during the Examination in Public of the Teesside Structure Plan in 1975, appealing for a national planning policy to be developed for estuarine use. It was considered impossible at that time. But today there is great enthusiasm including guidance from government for coastal conservation and management, in part as a result of our growing international responsibilities for example in relation to the management of the North Sea, the implementation of the Ramsar Convention on Wetlands of International Importance and the acceptance of the EC Directives on the Conservation of Wild Birds (1979) and Habitats and Species (1992). The need for detailed information to enable sensible estuarine management plans to be formulated not only in a local but also a national and international context has never been greater. I commend these volumes to all interested in the planning, sustainable development, management and conservation of UK estuaries. It is an authoritative base-line from which to prepare for the 21st century.

Peter Evans

Durham, January 1993

<sup>1</sup>now organised as the Wetland Bird Survey (WeBS)

## 2 Contributors and acknowledgements

### 2.1 The Estuaries Review team and Coastal Conservation Branch

The compilation of *An inventory of UK estuaries* began as part of the Nature Conservancy Council's Estuaries Review and was continued by the JNCC through its Coastal Conservation Branch.

The Estuaries Review was established in September 1988 as part of the NCC's Chief Scientist Directorate. A team of three - Dr N.C. Davidson, Dr D. d'A. Laffoley and L.S. Way - undertook a data collection, collation and analysis exercise, initially published as *Nature conservation and estuaries in Great Britain* (Davidson *et al.* 1991). The resulting data, much of it accessible through L.S. Way's development of a major computer database, provided certain information used in the inventory. We would like to thank C. Manners and particularly E. Leck for providing invaluable clerical assistance during the work of the Estuaries Review.

Since April 1991 the inventory formed part of the work of JNCC's Coastal Conservation Branch under the direction of Dr J.P. Doody. During the JNCC phase of the work we are grateful for the ever-cheerful clerical support of E. Leck and T. Crowson, for the invaluable computing assistance of J.H. Barne and M. Jones, and for the continued support of Dr M. Vincent throughout the project.

The compilation of the Northern Ireland volume of the inventory was a joint project between the JNCC, the Department of the Environment (Northern Ireland) and the Royal Society for the Protection of Birds. We are grateful for financial assistance for part of this work from DoE (Northern Ireland). Much of the data collation for Northern Ireland estuaries was undertaken by A. Donaghy, and the authors would like to thank R. Bleakley and M. Bradley (DoE (Northern Ireland) Environment and Heritage Service) and to Dr P. Bradley, Dr R.A. Brown, P.I. Rothwell, L. Campbell and K. Peck (RSPB) for their help in the establishment of this part of the project.

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# 3 Background and rationale

## 3.1 Background

Many of the United Kingdom's estuaries have changed a great deal over the last few centuries, not just through the natural changes brought about by the effects of tides, winds and shifting sea-levels, but also through the activities of people using and manipulating estuaries for many different purposes. Just as many people have depended on healthy estuaries for their livelihood, others have regarded them as wastelands, suitable chiefly for refuse and waste disposal, or for converting to dry land and so removing the intertidal flats that are considered by some to be unsightly.

The coastline of the UK is particularly well-endowed with estuaries and these vary greatly in their geomorphological origin, size, shape, extent of freshwater influence and their variety of marine and coastal habitats. Overall, the UK's estuaries form almost one-third of the West European resource and they are of great importance for the survival of a wide variety of wildlife. These estuaries are now recognised as a great natural asset in the UK. Effective conservation of estuaries for their wildlife requires not only the sustainable management of individual estuaries but also the maintenance of the diversity of the estuarine network throughout the UK and internationally. Yet the pressures of multiple use of estuaries continue, with remaining parts of many estuaries, especially those in urban and industrial areas, facing further degradation or loss.

Wildlife conservation has been delivered largely through the designation of key parts of estuaries under a variety of local, national and international measures. Whilst this remains a key feature of wildlife safeguard, there is increasing recognition that such designated areas need to be a part of more integrated management of whole estuarine systems. Such integrated management depends on co-operation between the wide range of user groups, coastal managers and decision-makers for its success and this is increasingly being sought through a variety of processes under the general term of coastal zone planning and management (CZM). Such approaches operating at a variety of geographical scales are increasingly seen as the way forward for delivering future sustainable use of coasts and estuaries and maintaining coastal biodiversity.

With such a great number of activities and pressures on estuaries there has, over the last few years, been an increasing impetus for initiatives aimed at encouraging co-operation and partnerships in coherent estuary management. These include a variety of local authority-led coastal groups in Wales, English Nature's Estuaries Initiative, Scottish Natural Heritage's Firths Initiative, and in Northern Ireland the establishment of the Strangford Lough Management Committee.

To develop estuary management plans and implement them through informed decision-making, sound baseline

information is needed on both the natural resource and how it is being used. Such information is required in detail for the estuary under consideration and also more broadly, so as to set a particular feature or site in its wider regional, national or international context.

To provide this national context as a baseline, in the late 1980s the then Nature Conservancy Council (NCC) undertook an 'Estuaries Review'. This culminated in the publication of *Nature conservation and estuaries in Great Britain* (Davidson *et al.* 1991) which provided a national overview of estuaries, their conservation and human uses. During the Estuaries Review consultations with many people and organisations involved in coastal conservation identified that, whilst there is a great deal known about some estuaries, much of the information is scattered through many, often largely inaccessible sources, and that for only a very few estuaries was there a compilation of simple, widely-available information describing the estuary.

## 3.2 An inventory of UK estuaries

*An inventory of UK estuaries* aims to provide a short, standardised summary of the key features of an estuary that are of interest or significance for estuary management from a nature conservation perspective. There is an entry for all of the 163 estuaries in the UK. For each site, a set of maps and brief text descriptions indicate the location and size of the estuary and its key features. An inventory entry is designed to give initial summary information about a site and to help identify sources of more detailed information should this be required. It is beyond the scope of the inventory to provide detailed listings of features such as all plant and animal species recorded on the estuary, nor can it provide more than the initial basis for the development of practical coastal management initiatives on specific sites - more detailed information on site-specific key issues is also needed for these initiatives.

The inventory does not attempt to provide a detailed review of the complex physical, chemical and biological processes of each individual estuary. Indeed, such processes are generally poorly understood for most UK estuaries, except those that have been the subject of intensive scientific study. Further general information on estuarine hydrology, geomorphology and ecosystem processes can be found in many texts such as Steers (1964, 1973), Dyer (1979), McLusky (1971, 1981), Barnes & Hughes (1982), Barnes (1984), Pethick (1984), Head (1985), Kennish (1986) and Day *et al.* (1989).

Taken together with the national overview *Nature conservation and estuaries in Great Britain* (Davidson *et al.* 1991) the information presented in the inventory can be used to set a particular estuary in its national and international context - an important stage in the identification of management issues. The inventory is intended also to promote the understanding of the great

importance of the UK estuarine resource; it provides a readily-available single source of summarised information for use in development planning and control. In addition, the snapshot information in each summary provides an easy-to-use basis for broad-scale monitoring of change in the estuarine resource and its human uses.

*An inventory of UK estuaries* provides part of the development of a sound information base for coastal planning and management being produced by the Joint Nature Conservation Committee on behalf of country conservation agencies and other bodies. These include *The Directory of the North Sea Coastal Margin* (Doody *et al.* 1993); the 17 volumes of the *Coastal Directories* series summarising coastal information at a regional scale (e.g. Barne *et al.* 1995); a series of national coastal vegetated habitat inventories, covering saltmarshes (Burd 1989), sand dunes (Dargie 1993, 1995; Radley 1994) and vegetated shingle structures (Sneddon & Randall 1993a, 1993b, 1994a, 1994b). Europe-wide coastal habitat inventories are also being developed (e.g. Doody 1991).

### 3.3 Structure of the inventory

*An inventory of UK estuaries* covers 163 UK estuaries; the 155 estuaries in England, Scotland and Wales identified by the Estuaries Review, and the eight estuaries in Northern Ireland that meet the same criteria (see section 4.2). The inventory is published as six regional volumes, with most including 25-35 estuaries (see Figure 3.1). Boundaries for the regional volumes have been chosen largely on topographical grounds so as to provide reasonably distinct geographical zones; these coincide broadly with divisions of major coastal sediment cells (see Motyka & Brampton 1993).

Each regional volume includes a brief introduction, a general description of the features of estuaries in that region, a short key to understanding the information in the site reports, followed by the individual site reports themselves.

### 3.4 Objectives of this introductory volume

This introductory volume details the rationale, methods and definitions used in the inventory. It is strongly recommended that the relevant parts of this volume are consulted before making detailed interpretation of the site reports. Key features of the introductory volume are that it:

- brings together descriptions of source and data handling methods - such information was previously dispersed through the different chapters of *Nature conservation and estuaries in Great Britain*;
- describes where different or additional data handling methods are used for site-specific information;
- updates, amends and clarifies some definitions given in *Nature conservation and estuaries in Great Britain* in the light of comments received since its publication;
- provides summary tabulations of estuary size and characteristics, by inventory report region and by

country, to aid wider context-setting of individual estuaries;

- extends descriptions of methods, definitions and numerical listings to cover Northern Ireland as well as Great Britain; and
- corrects and updates some numerical errors discovered since publication of *Nature conservation and estuaries in Great Britain*.

# Defining an estuary

## 4.1 Definition of an estuary

There are many ways in which estuaries have been defined and described, not by their very nature or pieces of evidence but by what they are not. An estuary is usually defined usually for all types of estuaries.

Furthermore, many definitions have been proposed over the course of a century, and it is not clear that each definition is equally useful. In particular, it is the common practice to use the word 'estuary' to describe a body of water which is partially enclosed by a land mass and which is characterized by a large tidal range.

NERC (1975) defines an estuary as a body of water which is partially enclosed by a land mass and which is characterized by a large tidal range. This means that estuaries are usually found in coastal areas and are usually partially enclosed by a land mass.

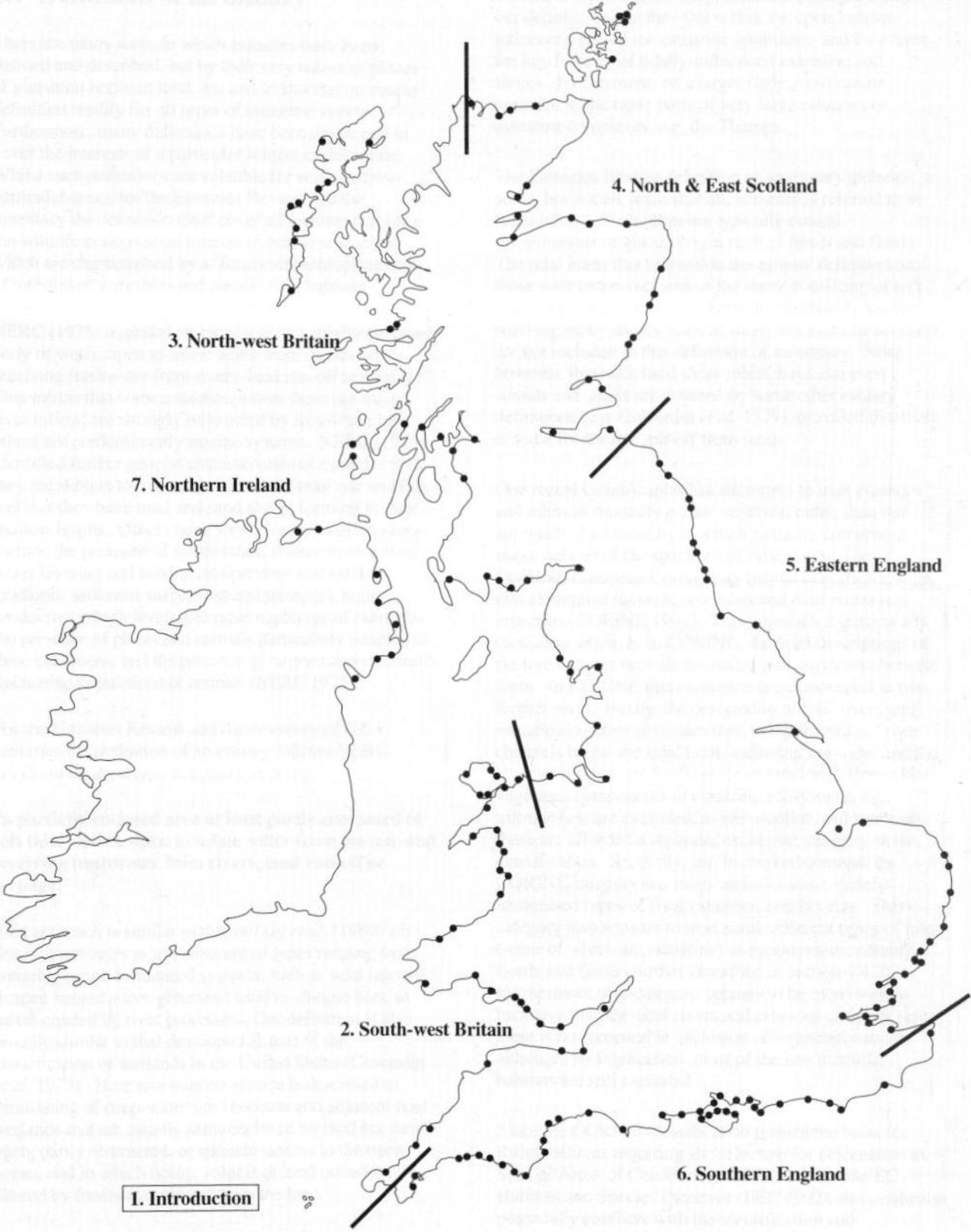
It is important to note that the definition of an estuary is not always clear-cut. Some estuaries are more open to the sea than others, and some are more enclosed than others. The definition of an estuary is therefore a matter of degree.

The present volume is a comprehensive survey of the estuaries of the United Kingdom. It is based on a detailed study of the estuaries of the United Kingdom, and is intended to provide a comprehensive survey of the estuaries of the United Kingdom.

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**Figure 3.1** The regional volumes comprising *An inventory of UK estuaries*. Each of the 163 estuaries is marked by its centre grid reference.

# 4 Defining an estuary

## 4.1 Definition of an estuary

There are many ways in which estuaries have been defined and described, but by their very nature as places of transition between land, sea and freshwater no simple definition readily fits all types of estuarine system. Furthermore, many definitions have been developed to cover the interests of a particular subject or discipline. Whilst such definitions are valuable for work in those particular areas, for the Estuaries Review and the inventory the definition must cover all features that form the wildlife conservation interest of estuarine systems which are characterised by a 'functional ecological unit' of interlinked terrestrial and aquatic tidal habitats.

NERC (1975) regarded an estuary as "a partially enclosed body of water, open to saline water from the sea and receiving freshwater from rivers, land run-off or seepage". This means that some estuaries, where there is a major river inflow, are strongly influenced by freshwater but others are predominantly marine systems. NERC (1975) identified further general characteristics of estuaries: that they are subject to a usually twice-daily tidal rise and fall, and that they have mud and sand shoals forming in their shallow basins. Other characteristic features of estuaries include the presence of saltmarshes, shelter from waves, water layering and mixing, temperature and salinity gradients, sediment suspension and transport, high productivity, high levels and rapid exchange of nutrients, the presence of plants and animals particularly adapted to these conditions, and the presence of migrant and seasonally fluctuating populations of animals (NERC 1975).

For the Estuaries Review and *An inventory of UK estuaries* the definition of an estuary follows NERC (1975) in taking a typical estuary as being:

**"a partially enclosed area at least partly composed of soft tidal shores, open to saline water from the sea, and receiving freshwater from rivers, land run-off or seepage."**

This approach is similar to that of Day *et al.* (1989) who describe estuaries as a continuum of types ranging from entirely marine-influenced systems, such as tidal lagoons formed behind wave-generated sand or shingle bars, to deltas created by river processes. Our definition is also broadly similar to that developed as part of the classification of wetlands in the United States (Cowardin *et al.* 1979). Here an estuarine system is described as "consisting of deep-water tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater run-off from the land."

The conditions of large supplies of sediment and shallow seas surrounding parts of the UK have led to some extensive areas of soft tidal flats developing outside river

mouths on open coasts. Such areas are included within our definition since they fall within the open, marine-influenced part of the estuarine continuum and they have the key features of tidally-influenced extensive soft shores. Furthermore, on a larger scale, most can be regarded as the outer parts of very large estuaries or estuarine complexes, e.g. the Thames.

The Estuaries Review definition of an estuary includes some, but not all, areas that are sometimes referred to as 'tidal inlets'. Such inlets are typically coastal invaginations of glacial origin such as fjords and fjards. The tidal inlets that fall within the estuary definition are those with extensive parts of the shore consisting of soft sediments. Tidal inlets that have predominantly steeply-shelving rocky shores, such as many sea lochs in Scotland, are not included in this definition of an estuary. Note, however, that such hard shore inlets, bays and even sounds and straits are covered by some other estuary definitions (e.g. Cowardin *et al.* 1979), provided that there is some freshwater run-off from land.

One recent classification has attempted to treat estuaries and inlets as mutually exclusive terms, rather than our approach of a hierarchy in which estuaries comprise a major sub-set of the spectrum of tidal inlets. The CORINE European Community habitat classification has two alternative habitats: *sea inlets* and *tidal rivers and estuaries* (CORINE 1991). This approach is particularly confusing when, as in CORINE, the brief descriptions of the two habitats provide an inadequate distinction between them. In CORINE this confusion is compounded in two further ways. Firstly, the description of tidal rivers and estuaries is extremely restrictive, being limited to "river channels below the tidal limit, including the water and the channel bed but not the fringing vegetation." Hence key vegetated components of estuarine ecosystems, e.g. saltmarshes, are excluded, as are mudflats and sandflats - these are afforded a separate, exclusive, category in the classification. Secondly, and in marked contrast, the CORINE category *sea inlets* includes some widely-recognised types of river estuaries, notably rias. This category also appears to treat some different types of inlet (some of which are estuarine) as synonymous, notably fjords and fjards (further described in section 4.4.2). Furthermore, this category appears to be more widely inclusive than the tidal rivers and estuaries category since there is no comparable exclusion of vegetated habitats although, by implication, most of the key intertidal habitats are still excluded.

Since the CORINE classification formed the basis for listing habitats requiring site selection for designation as Special Areas of Conservation (SACs) under the EC Habitats and Species Directive (EEC 1992), this confusion potentially conflicts with the identification and designation of the appropriate parts of key sites representing the range and variety of estuarine ecosystems as integrated functional units.

It should be noted that, to cover the wide range of features that combine to form estuaries, the NERC and Estuaries Review treatment of estuaries is broader than some other estuarine definitions used widely by some disciplines of estuarine researchers. Fairbridge's (1980) definition - "an inlet of the sea reaching into a river valley as far as the upper limit of tidal rise" - does include the tidal, freshwater, upper reaches of a river mouth and also its outer parts under strong marine influence, but still excludes some areas, notably those without major river influence, where marine-dominated estuarine ecosystems have developed. Pritchard's (1967) definition - "an estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which seawater is measurably diluted with freshwater derived from land drainage" - makes no direct mention of the rise and fall of the tide, and excludes the freshwater tidal reaches of estuaries; zones which can be extensive in the flat lowlands of eastern Britain. Furthermore the zone of measurably reduced salinity in an estuary is constantly changing, both on a tidal cycle as saline water moves up- and downstream and seasonally with variations in the amount of freshwater inflow from rivers and other run-off. The complex mobility of this reduced salinity zone means that its limits are poorly known for some estuaries. So although Pritchard's definition is widely used by marine benthic ecologists since it delimits the ecological zone characterised by particular estuarine benthic communities, it is less useful for disciplines such as geomorphology where features such as transport patterns are of key interest; nor can it delimit a geographical zone needed to present the multidisciplinary information in this inventory.

## 4.2 Site selection and delimitation

The definition of an estuary used here (a partially enclosed area at least partly composed of soft tidal shores, open to saline water from the sea, and receiving freshwater from rivers, land run-off or seepage) permits the general location of estuaries around the coast to be established. However, to compile information on the wildlife usage, conservation and human uses of each estuary, the more precise delimitation of characteristics and boundaries of estuaries is necessary.

### 4.2.1 Criteria for site selection

Based on the broad definition of estuaries given above, areas were selected for inclusion as an estuary if they had predominantly soft shores and either:

- a) a tidal channel of 2 km or longer; or
- b) intertidal soft sediment shores of 0.5 km or wider at low tide, along a shoreline of 2 km or longer.

This excluded several types of soft coastline, notably narrow, exposed sandy or shingle beaches, small stream and river outflows, and most Scottish sea lochs. These sea lochs have predominantly narrow shingle or rocky shorelines with steeply-shelving beaches, although some have small areas of saltmarsh and tidal flats where rivers flow into the head of the loch.

The size selection criteria exclude parts of the coastline where small streams and rivers discharge over rocky or boulder shores, or into short, steeply-shelving estuaries.

Such freshwater discharges over exposed marine shores often exhibit features of typical estuarine habitats and are of physiographical and marine biological interest, but are outside the scope of this inventory. The exclusion of these small estuarine systems has little effect on the overall size distributions of estuaries and their wildlife conservation features. Their inclusion would, however, have further emphasised the size distribution pattern, described in Davidson *et al.* (1991), of Britain's estuarine resource being composed of a few very large and many small estuaries.

A few estuaries have been so heavily modified by human activities such as land-claim that they no longer strictly fulfil the size selection criteria and/or have had their natural estuarine form entirely changed. Such sites have been included where they are known to have been functional estuaries in the past, since they are pertinent to considerations of estuarine habitat loss and other patterns of human activities.

### 4.2.2 'Core sites' and associated habitats

In its narrowest sense, an estuary comprises solely the intertidal and subtidal zones. Intertidal (or 'shore' or 'littoral') features occur in the area between terrestrial vegetation and low water spring tides. Subtidal (or sublittoral) features occur below the level of tidal exposure. Although these parts form the focus of attention for many types of estuarine wildlife and for human activities, the estuarine environment is more complex and consists of a mosaic of maritime and sub-maritime habitats, which, whilst not directly influenced by the tidal waters of the estuary, are nevertheless intricately linked to the estuary in a variety of ways (Ratcliffe 1977). For example, terrestrial coastal habitats, such as sand dunes, receive sediments from estuaries and adjacent coastlines, and the hydrology of other habitats such as coastal grazing marshes can be affected by tidal movements of water in the adjacent estuary. Furthermore the natural transitions between intertidal habitats and fringing terrestrial habitats are of particular wildlife interest (e.g. Burd 1989).

Many estuarine birds depend on both intertidal parts of an estuary and adjacent terrestrial habitats. For example, many waders feed on intertidal mud- and sandflats during periods of low water, and once these feeding grounds are covered by the rising tide, the birds fly to roost on a variety of adjacent habitats such as shingle ridges and coastal grasslands. Conversely many wildfowl feed on such grasslands but fly to roost on the estuary at night. In addition, human activities affecting tidal parts of estuaries often take place wholly or partly on the adjacent land.

Since the inventory is intended to provide information for those developing integrated management of the coastal zone, it is vital that it covers both the subtidal and intertidal parts of each site and the terrestrial habitats surrounding them. Therefore we have treated each estuary as a functional unit and have collected data on estuaries for a *core site* that covers the intertidal and subtidal parts of the estuary, and on the associated terrestrial habitats surrounding this core site. It is difficult to define standard geographical zones for the inclusion of terrestrial habitats associated with estuaries, as such parts of a coastal zone vary greatly between sites depending, for example, on topography and historical land use patterns. For this

reason the information on the terrestrial zone varies between sites and includes functional units of maritime-influenced wildlife habitat and areas of human uses that directly or indirectly affect the core estuary.

#### Associated intertidal areas

Some shorelines outside the mouth of an estuary lack the characteristics for direct inclusion within a core site (for example, where the intertidal zone is <500 m wide) but are inextricably linked to the estuary in some way by, for example, the geomorphological functioning of the site; the tidal feeding movements of their bird populations (see e.g. Davidson & Evans 1986); or they may form part of an estuarine complex at a larger scale than that chosen for the inventory. In Davidson *et al.* (1991) these areas were included as part of the estuary but distinguished as *associated intertidal (AI)*.

To simplify analysis for the inventory, any associated intertidal measurements identified in Davidson *et al.* (1991) are incorporated within the 'core site' of the estuary. However, there were three sites (Ythan, Tees and Swale Estuaries) where it was felt necessary to keep these areas separate for the following reasons:-

1. The Ythan is a bar built estuary whose mouth is constricted by a sand spit. This spit extends south-westwards from the Sands of Forvie and is still prograding, further altering the mouth and dominating the geomorphological processes of the lower estuary. It was felt necessary to consider the seaward side of this spit, as it is such an important feature of the estuary. The dunes of Foveran Links on the other side of the estuary mouth are less influential and so have not been included.
2. The present mouth of the Tees Estuary is constricted by two large breakwaters which separate the estuary from Coatham Sands to the east and Seaton Sands and Hartlepool Bay to the west. These sandy beaches were part of the once-larger Tees Estuary, which has diminished greatly due to successive land-claims. Although once an integral part of the estuary, these outer bays have been isolated by the breakwaters, and so have been included as 'associated intertidal' flats.
3. The core site of the Swale Estuary extends north-westwards along the northern shore of the Isle of Sheppey to Warden Point. Beyond here the intertidal flat narrows considerably, becoming a mixture of sand and shingle. As these (only very narrow) intertidal flats are quite distinct from the adjacent Medway Estuary but form part of a Greater Thames Estuary complex, they have been included as 'associated intertidal'.

### 4.3 Setting estuary boundaries

The upstream limits (for estuaries with river inflows) and shoreline boundaries were defined consistently for all sites. The great variability of estuarine form has, however, meant that the placing of the outer limits of estuaries varies between sites, and any such delimitation in a dynamic and changing system must inevitably be arbitrary. It is, nevertheless, essential that information is collected in relation to boundaries identified for each site

so that valid comparisons can be made. The types of boundary are illustrated in Figure 4.1 and are described further below.

#### 4.3.1 Upstream limits

For sites with a river inflow, the upstream limit is the Normal Tidal Limit (NTL) as shown on the 1:50,000 Ordnance Survey (OS) map, except where local information established a substantially different limit to the tidal influence. This means that the core site includes the rivers flowing into upper parts of estuaries that are above the influence of saline water but which are subject to tidal movements. On some sites such as the Wash the upstream limit is more than 20 km above the influence of saline water. For open coast sites where there is no river discharge and freshwater influence is restricted to seepage a shoreline boundary was used (see 4.3.2).

#### 4.3.2 Shoreline boundaries

Mean High Water (MHW) is not useful in defining estuaries biologically as it excludes the upper zones of estuarine habitats such as saltmarshes. Consequently the upper shoreline boundary of each estuary was taken as the High Water limit of the Highest Astronomical tides (HWHA), which corresponds closely to the seaward limit of wholly terrestrial vegetation and the landward limit of tidally-influenced vegetation such as saltmarsh. (However, where High Water Mark is set by vertical features such as sea defences or cliffs, HWHA is

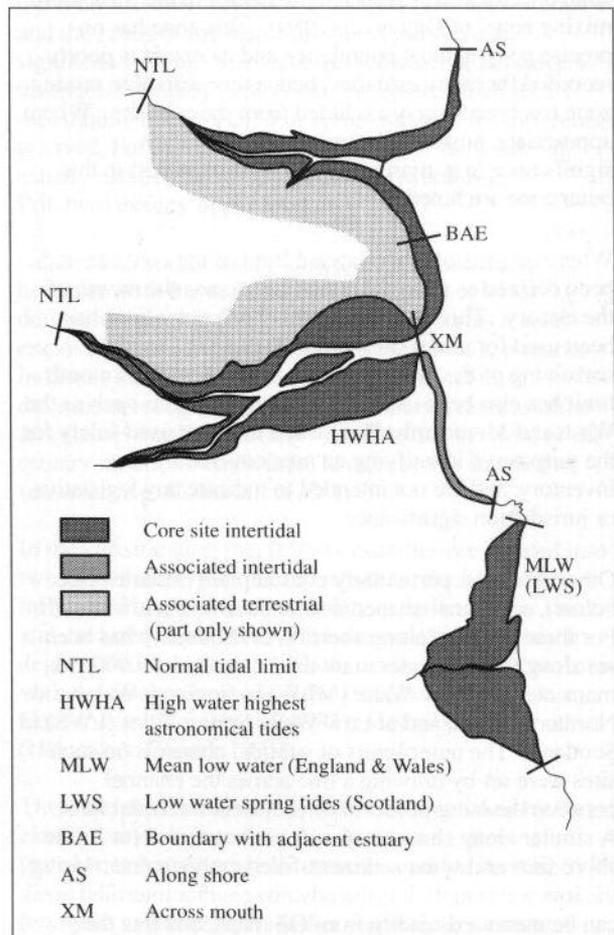


Figure 4.1 Types of boundary used to define site limits.

effectively the same as MHW.) HWHA is not a mapped feature on most OS maps, which usually show Mean High Water (MHW) or High Water Spring tide (HWS) in Scotland, so to define the boundary of each estuary HWHA was interpreted from 1:25,000 OS maps and then marked on 1:50,000 maps. For shorelines with more gently sloping transitions to terrestrial areas HWHA was interpreted as the upper boundary of mapped saltmarsh, sand, mud, rock or shingle symbols or shading. Where the transition is to sand dunes, HWHA was taken as the outer limit of sand dune symbols.

Note that in Davidson *et al.* (1991) the HWHA boundary was erroneously titled extreme high water spring tides (EHWS).

For sites in Northern Ireland 1:25,000 maps were not available for all sites in order to interpret HWHA. In the absence of other supporting information, the landward limit for these sites was defined as MHW mark on 1:50,000 scale maps.

### 4.3.3 Seaward limits

The diversity of estuarine form and the seasonal variability in the influence of some estuarine features such as salinity means that the location of a boundary at the seaward limits of estuaries depends greatly on the particular geography of each site. In river estuaries the freshwater discharge plume can extend a considerable distance out to sea, and the extent of its influence varies with seasonal variations in river discharge. This outer zone of estuarine influence corresponds to the 'nearshore mixing zone' of Day *et al.* (1989). This zone has no precise geographical boundaries and its extent is poorly recorded for many estuaries, hence this nearshore mixing zone has been largely excluded from the core site. Where appropriate, however, features of conservation significance (e.g. marine wildlife communities) in this outer zone are noted.

Wherever possible the seaward limit of the core site had been defined as a 'bay closing line' across the mouth of the estuary. This 'across mouth' (XM) outer limit has been used for many sites in which there is a marked narrowing of the estuary at its mouth. An across mouth limit has also been used for large embayments such as the Wash and Morecambe Bay. Such lines are used solely for the purpose of identifying an area covered by the inventory, and are not intended to indicate any legislative or jurisdiction significance.

Other estuaries, particularly coastal plain estuaries (see below), are funnel-shaped and so have no narrow mouth. For these sites an 'along shore' (AS) boundary has been set along the low water mark as shown on 1:50,000 OS maps at Mean Low Water (MLW) in England, Wales and Northern Ireland and at Low Water Spring Tides (LWS) in Scotland. The outer limits of subtidal channels on such sites were set by drawing a line across the channel between the outer points of the adjacent intertidal flats. A similar along shore treatment has been used for linear shore sites and some sediment-filled embayments. Using the low water mark has the advantages that intertidal areas can be measured readily from OS maps, and that the seaward limits to the intertidal parts of many sites coincide with those of statutory conservation sites. Its disadvantage

is that it underestimates the total extent of the intertidal zone, especially in England, Wales and Northern Ireland, by excluding the lowest parts of the intertidal shore. Such infrequently-exposed areas can be of considerable nature conservation interest.

The outer parts of the large firths in Scotland have largely not been covered since they are effectively non-estuarine in character. On these sites an outer boundary has been set in which there is an across mouth delimitation of the inner part of the site, outside which is an along shore boundary. Hence the core site covers both the intertidal and subtidal zones in the inner parts of these estuaries, but in the outer parts only the intertidal zone.

In most cases the along shore boundary is continued along the coastline to a natural boundary, for example a rocky promontory. However, some sites have no such natural geographical limit. For these, the along shore boundary has been set where the intertidal zone narrows to a width of less than 500 m.

### 4.3.4 Site boundaries within estuarine complexes

Most estuaries on the UK coastline are discrete sites separated from their neighbours by stretches of rocky shore or narrow, sandy beaches. Some coastlines, however, are not so simple and have several river discharge estuaries or bays joined by broad expanses of intertidal sediments, all of which qualify for inclusion in this review. Between such contiguous sites we have set an arbitrary 'boundary with adjacent estuaries' (BAE), usually at either the mid-point of the shore between the sites, or where the intertidal area is at its narrowest.

Large estuaries and embayments, for example the Severn Estuary and Morecambe Bay, are often complex and composed of features which can be treated as estuaries at several levels of scale. The rivers flowing into such large estuaries (e.g. the Avon, Wye and Taff/Ely on the Severn Estuary; the Wyre, Lune, Keer, Kent and Leven in Morecambe Bay) each have an estuarine structure. These 'sub-estuaries' have smaller streams joining their tidal reaches which also show features definable as estuaries in their own right. For the scope and objectives of this review such large complexes have been treated as single sites. Similarly Carmarthen Bay, with its three confluent river estuaries, is treated as a single site. The topography of no two estuaries is, however, identical and for some it has proved more feasible to treat them as separate sites, the most complex being the region of the Thames Estuary, described below. Boundaries of such sites have been set so that between them the sites include all relevant intertidal areas, either in core sites or as 'associated intertidal', enabling the information from them to be combined as a larger-scale site, in this case as a 'Greater Thames Estuary'.

In the Thames Estuary there is a continuous and extensive intertidal area that reaches as far north as Colne Point in mid-Essex and on the southern shore as far as Whitstable on the north Kent coast. This 'Greater Thames Estuary' encompasses the discharges of five large rivers (Medway, Thames, Crouch, Blackwater and Colne), with broad areas of soft intertidal shores between them. We have chosen here to treat the various components of this area as separate sites, so as to give proper consideration to the

distribution of wildlife interest and human activities in the area. Boundaries between sites have been set with regard to administrative and statutory conservation boundaries, as well as the geography of the areas. At the scale of individual sites some, e.g. Dengie Flats, Maplin Sands, are classified as open shores, but at a larger scale these form the outer parts of a large coastal plain estuary. Similarly each estuary flowing into Morecambe Bay would individually be classified as a coastal plain estuary, but in our larger-scale treatment they form parts of the whole Morecambe Bay embayment.

#### 4.3.5 Review sites and statutory site boundaries

Wherever possible site boundaries have been set to encompass the estuarine parts of statutory wildlife sites, notably Sites of Special Scientific Interest (SSSIs) notified under the Wildlife & Countryside Act 1981 and its subsequent amendments. As described above, site boundaries between contiguous sites have, wherever possible, been set to coincide with statutory site boundaries. Many SSSIs that encompass intertidal areas also include a variety of other terrestrial habitats, so the relationship between estuaries in the inventory and statutory wildlife sites is complex. For example, it is not yet possible to calculate the precise overlap between estuary sites and SSSIs.

### 4.4 Estuary classification: geomorphology and tidal range

Numerous attempts have been made to define and classify estuaries, taking account of: tides and tidal range; sediment availability, transport and distribution; salinity; and sea-level change. One method of classifying estuaries is through their morphology and origin. However, as estuaries are active systems undergoing continuous change it is difficult to apply a simple geomorphological classification. Some estuaries inevitably do not fit readily into a single category since, for example, their geological history involved several phases such as glaciation, sea-level rise and reworking of sediments. Estuaries may also exhibit features of different estuary types at different levels of scale, for example river discharge estuaries of coastal plain type flowing into a large embayment.

Thus, a simple classification cannot embrace all the attributes of every estuary. Nevertheless it can provide a useful framework for understanding the characteristics of estuaries in general, why they occur where they do, what features they share and, most importantly, how they function. More specifically, as part of the Estuaries Review, a classification allowed an assessment of the distribution of the main types of British estuaries and how this relates to the many features of wildlife and human use of estuaries.

#### 4.4.1 Geomorphological classification of estuaries

For the Estuaries Review a geomorphological classification was adopted, based partly on that of Fairbridge (1980) who described an estuary in geomorphological terms as "an inlet of the sea reaching into a river valley as far as the upper limit of tidal rise". Fairbridge proposed a morphological classification of estuaries which included elements of the regional history

of sea level, tectonic factors, climatic factors and freshwater and sediment supply.

Other classification schemes for estuaries have been suggested. For example, Pethick (1984) advocated a classification using present-day processes, which allows the dynamic and changing nature of estuaries to be understood. Sufficiently detailed information on these features is, however, incomplete or absent for many UK estuaries and so could not provide a consistent UK-wide classification for this inventory. These more process-based classifications do, however, serve to illustrate the complexity of estuarine systems.

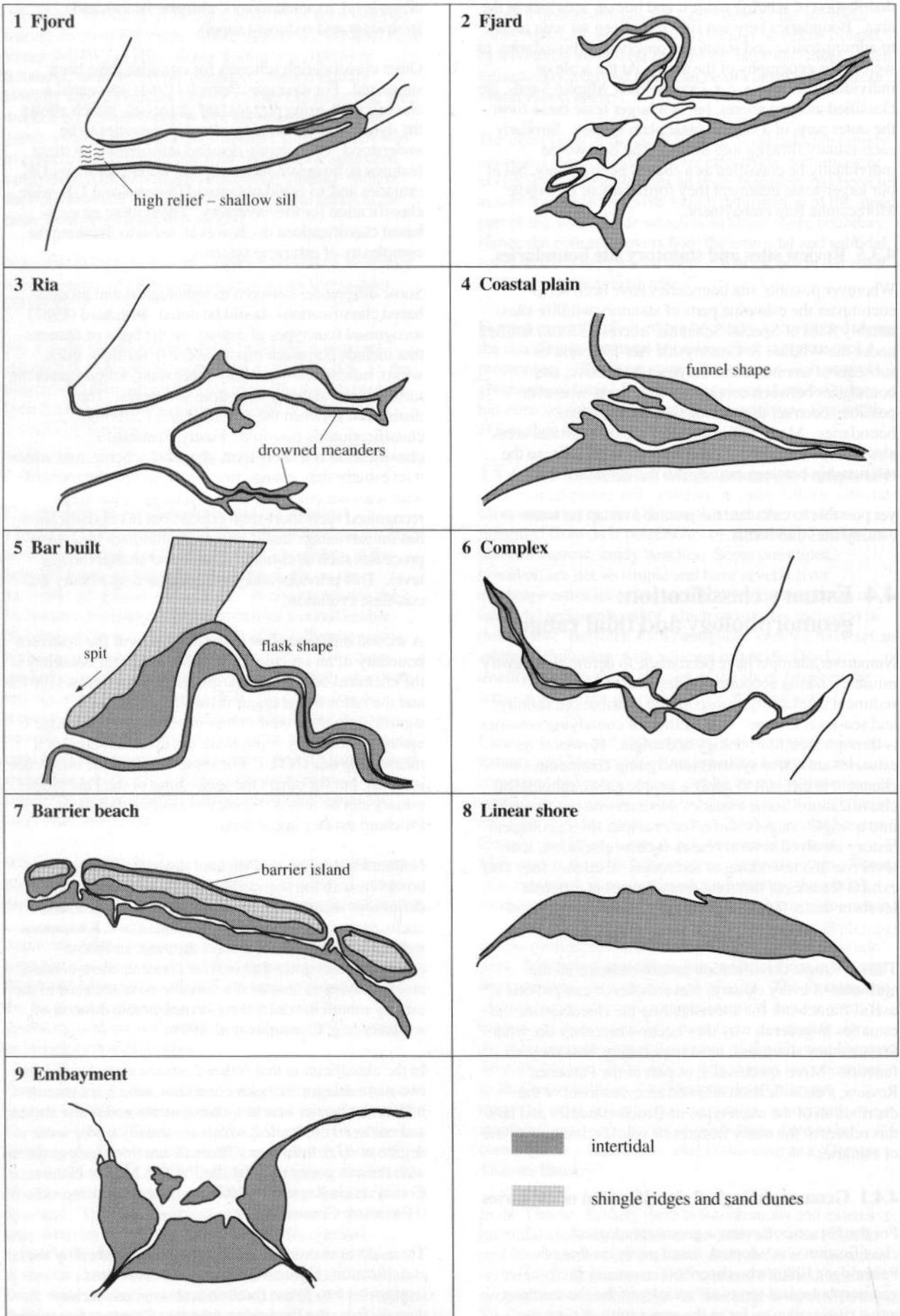
Some differences between morphological and process-based classifications should be noted. Pritchard (1967) recognised four types of estuary on the basis of features that include dominant mixing force (river flow, tides, wind), mixing energy, width-depth ratio, salinity gradient, turbidity and stability of bottom sediments. The distinction between the Pritchard and Fairbridge classifications is two-fold. Firstly, Pritchard's classification is a short-term, dynamic scheme, and within it an estuary may change frequently in type, for example with seasonal change in river discharge. Fairbridge recognised such short-term effects, but his classification has the advantage that it also accommodates long-term processes such as climatic change and changes in sea level. This provides a key to understanding estuary and coastline evolution.

A second difference lies in the definition of the upstream boundary of an estuary. Pritchard's upstream boundary is the chemical one, where the chlorinity falls below 0.001‰ and the ratios of the major dissolved ions change significantly from their values in seawater. Fairbridge's upstream boundary is physical: the upstream limit of a measurable tide (NTL). For some estuaries the difference is trivial, but for others the upper limit of the Fairbridge estuary can be tens of kilometres landward of the Pritchard estuary upper limit.

Neither Fairbridge nor Pritchard deals definitively, however, with the seaward boundary, although both definitions assume that the basic estuary forms a semi-enclosed basin or inlet. Our assessment of UK estuaries indicates that this is not always the case, and most definitions recognise that in river estuaries there is often an extensive and temporally variable zone seaward of the estuary mouth in which there is measurable dilution of seawater (e.g. Cowardin *et al.* 1979).

In the classification that follows estuaries are divided into two main categories: open coast sites, which are marine-influenced barrier beaches, embayments and linear shores, and enclosed coast sites, which are usually under some degree of river influence. These distinctions are consistent with the categories used by the JNCC's Marine Nature Conservation Review (MNCR) to describe marine sites (Hiscock & Connor 1991).

There are nine estuarine categories distinguished by the classification (Figure 4.2). Enclosed coast sites (categories 1 to 5) are river estuaries and are derived directly from the Fairbridge scheme. Category 6 estuaries (complex estuaries) are another form of river estuaries. Three further categories of estuaries (categories 7 to 9) are



**Figure 4.2** The categories of estuary used in the Estuaries Review morphological classification of estuaries.

open coast sites with extensive expanses of soft sediments. Lagoons are not considered here as a separate estuary type; most are treated as a coastal habitat, although tidal lagoons (i.e. those with openings to the open sea) are treated as bar built estuaries.

As is inevitable with evolving structures subject to change, some estuaries in Britain currently have morphological characteristics of more than one estuary type. Such sites are classified here according to their dominant features at the scale of their inclusion in the inventory.

In addition to Fairbridge's morphological classification, we have further classified estuaries according to their tidal range as microtidal, mesotidal and macrotidal (see section 4.4.3). The geomorphological and tidal range classification for all UK estuaries is listed in Appendix 1.

#### 4.4.2 Geomorphological categories of estuary

The nine categories of estuary in our classification are described briefly below. More details of their distributions are given in Davidson *et al.* (1991).

**1 Fjord.** Fjords are drowned glacial troughs often associated with major lines of geological weakness. They are characteristic of areas once covered by Pleistocene ice-sheets where glacial erosion was intense or selective in its operation. Erosion by ice further deepened existing river valleys and the movement and scouring action of the ice has left characteristic shallow rock bars, particularly at fjord mouths. As a result of glacial overdeepening fjords have a close width-depth ratio, steep sides and an almost rectangular cross-section. Their plan outline is typically also rectangular, with any sharp bends usually reflecting underlying geological structures. Fjords generally have rocky floors or a thin veneer of sediment, with sediment deposition restricted to the head of the fjord in association with major rivers. River discharge is small compared to total fjord volume but, as many fjords have restricted tidal ranges, the river flow is often large in relation to the tidal prism (the water volume between high and low water levels). Most fjords in the UK do not meet the definition of an estuary; those that do are secondarily filled with soft sediments.

**2 Fjard.** Fjards are typical of glaciated lowland coasts and are more complex than fjords, with a more open and irregular coastline and often have no main tidal channel. Their form frequently reflects the underlying geological structure and, although ice-scoured rock basins and bars are characteristic features, fjards are nevertheless relatively shallow. Although fjards are more exposed to wave action than fjords they are sheltered in their upper reaches.

**3 Ria.** Although rias have some features superficially in common with fjords and fjards they have not been shaped by glacial processes. Rias are drowned river valleys formed by tectonic subsidence of the land, a rise in sea level or a combination of both. Sedimentation has not kept pace with inundation and the estuarine topography still resembles a river valley. Rias are relatively deep, with narrow, well-defined channels that are substantially marine-influenced. They have no entrance sill or ice-scoured rock-bar and are shallower than fjords. The substratum is predominantly rocky but the sheltered parts

of bays and inlets contain soft sediments. Elsewhere secondary sedimentation masks the bedrock.

**4 Coastal plain estuary.** Coastal plain estuaries were formed during the Holocene transgression by the flooding of pre-existing valleys in both glaciated and unglaciated areas. Maximum depths in these inlets are generally less than 30 m and the central channel is often sinuous. The channels have a triangular cross-section, similar to that of terrestrial valleys, and the cross-section usually has a large width-depth ratio. In outline coastal plain estuaries are often funnel-shaped, widening towards the mouth, which may be modified by spits. Unlike rias, coastal plain estuaries have extensive mudflats, sandflats and saltmarshes. These estuaries are usually flooded by varying thicknesses of recent sediments, often muddy in the upper reaches and becoming increasingly sandy towards the mouth. Coastal plain estuaries are generally restricted to temperate latitudes, where the amount of river-borne sediment is relatively small. River flow in large coastal plain estuaries is small in comparison with tidal prism volume, so salinity in much of the estuary is little reduced from that of sea water.

**5 Bar built estuaries.** These estuaries are also in part drowned river valleys that were incised during ice ages and subsequently inundated. They are distinguished by recent sedimentation that has kept pace with the inundation such that they are sediment-filled and have developed a characteristic bar (or spit) across their mouths. The bar or spit usually forms where waves break on the beach. For a bar or spit to develop, tidal range must be small and large volumes of sediment available; consequently bar built estuaries are mostly associated with depositional coasts. Sediment sources vary: on some estuaries bars or spits develop from material carried down the coast by longshore drift; in others they develop as shingle storm beaches made up chiefly of reworked offshore glacial deposits. Bar built estuaries are only a few metres deep and often have extensive lagoons and shallow waterways just inside their mouths. Many naturally-formed coastal lagoons have developed from an extreme form of bar built estuary in which the bar or spit has entirely, or almost entirely, closed off a bay or inlet.

**6 Complex estuaries.** Some UK river estuaries do not easily fit the description of one of the five categories above. Such estuaries have resulted from the influence of a mixture of glaciation, river erosion, sea-level change and geological constraints such as hard rock outcrops. There are two distinct types of complex estuary in the UK: the large firths, all in Scotland, have similar hydrodynamics to coastal plain estuaries but are set apart by their size and geomorphological complexity; the second type are narrow estuaries which reflect the influence of geological controls, glaciation and incision into relatively hard rock types during periods of Quaternary relative sea-level change.

**7 Barrier beaches.** Barrier beaches are open coast systems which develop as soft shores in shallow water where the dissipation of wave and current energy offshore leads to the development of bars and barriers. Abundant sediments are present in these coastal systems. The North Norfolk Coast is a classic barrier beach system in which saltmarshes, tidal flats and creeks have developed behind a shingle and sand dune barrier. The only other such

system in the UK, at Lindisfarne, is a barrier system that has developed in the shelter of an island (Holy Island) and its associated sand dunes.

**8 Linear shores.** These are stretches of the coast where broad areas of soft sediments have deposited in shallow seas, where there are abundant sediments and low wave and current strengths, but little indentation of the coast. Coastal outline on linear shores is convex, linear or at most only slightly concave. Most linear shores in the UK are, at a larger geographical scale, parts of large estuarine complexes such as the Greater Thames Estuary.

**9 Embayments.** Embayments are formed where the line of the coast follows a concave sweep between rocky headlands. Soft sediments accumulate in the shelter of these bays. Many embayments have one or more rivers and streams discharging into them; at a smaller scale these components often individually exhibit characteristics typical of coastal plain estuaries.

#### 4.4.3 Tidal range classification of estuaries

Tidal range (the height difference between low tide and high tide) exercises an important influence on estuarine processes for, in conjunction with estuary size and morphology, it determines tidal current and residual current velocities and consequently the rates, amounts and patterns of sediment movement. We have followed Davies (1973) and Hayes (1975) in classifying estuarine tidal ranges into three categories:

- microtidal = tidal range less than 2 m;
- mesotidal = tidal range between 2 m and 4 m; and
- macrotidal = tidal range greater than 4 m.

In microtidal estuaries processes in the upper reaches of the estuary are dominated by freshwater discharge and in the lower reaches of the estuary by wind-driven waves from outside the mouth. Wind-driven waves can produce spits and barrier islands which enclose bar built estuaries. Microtidal estuaries tend to be wide and shallow.

Mesotidal estuaries are dominated by strong tidal currents rather than freshwater inflows. The limited tidal range means, however, that the tidal flow does not extend far upstream and so mesotidal estuaries are often short and wide (see Pethick 1984).

In macrotidal estuaries strong tidal and residual currents can extend far inland. These estuaries do not have the ebb-flow deltas characteristic of mesotidal estuaries, instead the central channel near the estuary mouth is occupied by long, linear sand bars parallel with the tidal flow. These estuaries are distinctively funnel-shaped, that typical of coastal plain estuaries (Pethick 1984).

To enable comparison between estuaries, and to minimise the effects of the estuary's individual morphology on the tide, the mean spring tidal ranges given for each estuary are those measured from a site as close as possible to the defined estuary mouth. These are listed in Appendix 2. The classification by tidal range for all UK estuaries is listed in Appendix 1.

# 5 Data sources and methods

## 5.1 Background

The objective in compiling the inventory has been to achieve, as far as possible, a standard approach to data handling and presentation for each estuary. We have therefore concentrated on using consistent data on a national scale, so as to present estuarine features in their wider context. The basic data used for British estuaries comes chiefly from 1989 and 1990 as a snapshot in time (see Davidson *et al.* 1991). Where the feature is unlikely to have changed substantially since that time, these data have been used. However some features, such as migratory waterfowl whose populations can vary substantially from year to year, and many types of human activity, can be subject to rapid changes. In such instances more recent data or updated information have been incorporated, and these are noted in the relevant sections.

To extend the inventory to cover the UK the work was expanded in 1992 to incorporate the eight estuaries lying wholly or partly within Northern Ireland. Data for these estuaries were compiled during 1992 and 1993. Some information was collected at this time, whilst other parts of the material were drawn from work carried out during 1991/92 for the RSPB's Estuaries Inventory project (Davidson 1991; Peck 1993). Many conservation datasets for Northern Ireland have been collected independently from those in Great Britain, such that it has not been possible to compile all data in a fully compatible form across the whole of the UK. Data on some features in Northern Ireland, e.g. areas of saltmarsh, were not accessible during the time available for our data collection.

This chapter provides brief descriptions of features to explain the handling of data in particular ways or to clarify the coverage of the feature. General descriptions of many British estuarine features, their size, distribution or significance for nature conservation, are given in Davidson *et al.* (1991), which should be consulted for national contextual information.

For each estuary a site map shows the location of the estuary, delimited according to the criteria set out above, and shows the locations of upstream and seaward limits. A four-figure OS grid reference for the centre of the site is given, together with lists of counties, Scottish regions, local authority districts and the country conservation agency region(s) in which the estuary falls. There is also a brief general description of the estuary and its main features.

## 5.2 Areas and lengths

### 5.2.1 Measuring estuary areas and lengths

For each site, the area of the estuary and the lengths of the shoreline and the longest tidal channel have been measured. For estuaries in Great Britain measurements

were digitised from the interpreted shoreline boundaries (see section 4.3) on 1:50,000 Second Series OS maps onto the NCC's Intergraph Geographical Information System (GIS). As noted in section 4.3.2, information on the interpreted High Water of the Highest Astronomical tide was not available for Northern Ireland, hence the measurements for the eight sites in Northern Ireland were made at Mean High Water mark from 1:50,000 OS maps. The measurements for all sites are listed in Appendix 2. It should be noted that for some sites this includes areas of 'associated intertidal' noted separately in Davidson *et al.* (1991); see section 4.2.2 for further details.

All areas are given in hectares, rounded to the nearest 1 ha, and all lengths are in kilometres, rounded to the nearest 0.1 km. The following measurements were made:

**total area** of the estuary including both the intertidal and subtidal parts, below the interpreted HWA (MHW in Northern Ireland) and the Normal Tidal Limit;

**intertidal area** of the core site (i.e. all tidal flats, saltmarshes and rocky outcrops) from the interpreted HWA to MLW in England and Wales, and from HWA to LWS tides in Scotland;

**shore length** of the core site, including the shores of major islands, measured along the interpreted HWA (MHW in Northern Ireland); and

**channel length**: the length of longest tidal channel, measured along the mid-channel line from NTL to the defined estuary mouth.

Where a site has an area of 'associated intertidal' (AI) habitat two additional measurements were taken:

**associated intertidal area** from the interpreted HWA to MLW (or LWS in Scotland); and

**associated intertidal shore length** measured along the interpreted HWA.

These measurements for all sites are listed in Appendix 2.

### *Accuracy of measurements*

Accuracy of measurements depends in part on the scale at which the areas are made. For area measurements, precision improves with increasing scale of measurement. Our choice of 1:50,000 scale for measurements was determined by the availability in the UK of up-to-date maps, since at larger scales shoreline and intertidal features have generally been surveyed and revised at less frequent intervals than terrestrial features. Also, with land-claims made on many estuaries during the last 30 years shoreline boundaries have altered over this period; most such land-claims are mapped on Second Series OS maps.

These measurements seem to provide a reliable area estimate for measurements made at this scale. For example, measurements of the Exe Estuary made independently by the Royal Society for the Protection of Birds' Estuaries Inventory produced areas that differed by only 0.85% (total estuary area) and 1.15% (intertidal area). Note, however, that the percentage accuracy of such measurements will be lower for small sites.

The measurement of the length of an irregular feature such as a shoreline is highly dependent on the scale of measurement and coastline lengths have provided a major example of this mathematical phenomenon (Mandelbrot 1967). This means that the larger the measurement scale the longer the measured length. Hence any comparison of shoreline and channel lengths from different sources is valid only for measurements made at the same scale.

### 5.2.2 Human populations

The size of the human population living close to an estuary greatly influences the ways in which the estuary has been and is being used, for large local populations generally lead to extensive industrial, urban and sometimes recreational use of an estuary. The human population total tabulated for sites in England, Scotland and Wales is derived from the 1981 population census figures listed in Bartholomew's Gazetteer, which excludes small towns, villages, hamlets and farms but provides an overall picture of the British population around estuaries. For Northern Ireland the figures are taken from the 1991 population census. The figure shown for each site is the total population living in towns and cities that are within 1 km of the core estuary. Note, therefore, that where a conurbation is adjacent to more than one estuary its population is included in the figure for each adjacent estuary. Hence the total estuarine human population for a region is not necessarily the sum of the figures listed for each estuary. Figures are rounded to the nearest 1,000 where the population exceeds 5,000; populations smaller than 5,000 are listed as <5,000.

### 5.2.3 Water quality

Some domestic and industrial effluents are discharged into most UK estuaries. The consequent water quality can have a major influence on the functioning of the estuarine ecosystem and can affect a variety of human uses such as shellfisheries. Estuarine water quality is monitored regularly by the Environment Agency (formerly the National Rivers Authority) in England and Wales and the River Purification Boards in Scotland. A graded water quality assessment for each estuary or part of an estuary is published periodically as maps.

Water quality assessments given in the general description are derived from National Rivers Authority (1991) for England and Wales and Scottish Development Department (1987) for Scotland. The quality assessment system combines an evaluation of the biological and aesthetic quality of the water with the measurements of the minimum levels of dissolved oxygen. At the time of press, no comparable information was available for Northern Ireland.

The grading is a four point scale:

Quality	Grading for Scotland	Grading for England and Wales
Good	1	A
Fair	2	B
Poor	3	C
Bad	4	D

Water quality grades were not available separately for some sites, e.g. open coast sites, treated as estuaries in this inventory. Furthermore a new system is under development for England and Wales, aimed at minimising subjectivity and providing a scheme suitable for Statutory Water Quality Objectives.

## 5.3 Coastal habitats

Estuaries are a complex mixture of distinctive habitat types that are linked physically, chemically and biologically. Some are characteristic of and almost entirely restricted to estuaries; some are widespread around the coast of the UK; some others occur mostly outside estuaries but nevertheless contribute to the diversity of the estuarine matrix.

The inventory tabulates the occurrence of subtidal and intertidal habitats, and the main maritime and sub-maritime terrestrial habitats (see Ratcliffe 1977). Intertidal habitats are saltmarsh, sandflats, mudflats, intertidal shingle and rocky shores. Terrestrial habitats are sand dunes (including machair), shingle, lagoons and lowland grasslands. A category for 'other' permits the inclusion of other habitats such as cliffs and maritime heathland. A brief description of each habitat category is given in Table 5.3.1. The characteristic features, distribution, and conservation importance of these habitats are described in Davidson *et al.* (1991).

Habitat presence was derived from several sources including mapped features on OS maps, information from detailed habitat surveys (e.g. Burd 1989; Radley 1994; Dargie 1993, 1995) and consultation with regional conservation agency staff.

For each habitat, its presence is shown as a major habitat or a minor habitat. In general, a minor habitat coding indicates a feature forming less than 5% of the relevant area or shore length. However, in some cases a small area of a habitat is coded as a major habitat where it makes a significant contribution to the conservation significance of the estuary.

Where possible, the areas of some habitats are also given. All habitat area measurements are rounded to the nearest 1 ha. Subtidal habitat area is derived from the measurements of total and intertidal estuarine area, and includes both areas below low water mark and channels and pools that remain filled with water at low tide. Areas of intertidal flats (mudflats and sandflats) are derived from measurements of the intertidal area minus the areas of saltmarshes (see below). It was not possible to determine the areas of mudflats and sandflats separately, for such intertidal areas are often mixtures of these sediments, which can range from silty muds, through sandy muds, muddy sands, to pure sand. In some sites the intertidal

**Table 5.3.1** Scope of tabulated coastal habitats

Habitat category	Definition
Subtidal	Areas below Mean Low Water mark (Low Water Spring tides in Scotland). Includes river channels and other areas remaining covered by water at low tide.
Sandflats	Intertidal soft sediments composed chiefly of sand (may include some muddy sand sediments).
Mudflats	Intertidal soft sediments composed chiefly of fine muds and silts (may include some sandy mud sediments).
Saltmarsh	Intertidal vegetation on soft sediments, consisting of communities of halophytic plants, i.e. salt-tolerant and able to withstand regular submersion by sea water. Includes 'saltings', 'merse', 'carselands' and other natural landward transitions, but excludes splash zones on cliffs.
Rocky shores	Intertidal rocks and boulders.
Shingle	Intertidal and terrestrial shingle deposits. Includes shell banks and intertidal gravel beds, which are often unvegetated, and shingle structures and shorelines, which may support annual and perennial vegetation.
Sand dunes	Wind-blown sand deposits, often supporting open vegetation communities (e.g. dune grassland, dune heath and dune slack). Includes machair grasslands.
Lowland grassland	All lowland wet grasslands and marshes, including coastal grazing marshes (often formed by the enclosure of saltmarshes), hay meadows and washlands.
Lagoons	Natural lagoons (including freshwater lagoons) formed behind sand and shingle barriers; and artificially-constructed coastal ponds under maritime influence.
Other	Includes: Cliffs: vegetated and non-vegetated hard and soft cliffs, cliff and cliff-top vegetation, notably maritime heath and acidic, neutral and calcareous grasslands. Heathlands: areas of maritime heaths not forming cliff or cliff-top vegetation. Fens: emergent wet lowland vegetation (other than wet grasslands). Peatlands: peat-based vegetation including both upland and lowland mires and bogs. Woodlands: areas of trees, including fen carr. Includes woodland and scrub growing on dunes.

flats change rapidly with time; hence it is only possible to give an indication of which types of intertidal sediments form major or minor habitats. Note that these areas also include the generally small areas of rocky shores found on estuaries, and intertidal shingle.

Saltmarsh areas were derived from the *Saltmarsh survey of Great Britain* (Burd 1989), based on surveys undertaken during the 1980s. The Blyth Estuary (Suffolk) was not covered by these surveys but the figure presented is calculated from 1991 aerial photography (Burd, pers. comm.). Saltmarsh areas were not available for estuaries in Northern Ireland, but the presence of saltmarshes on these estuaries is noted in the text. The areas of saltmarsh for all estuaries in England, Scotland and Wales are listed in Appendix 2.

Using the data from Burd (1989), most discrete areas of saltmarsh lay within a single estuary. However, this was not the case for the Crouch-Roach Estuary and Maplin Sands. For the saltmarsh survey, the Crouch Estuary was surveyed as a separate site (468 ha), and the Roach Estuary and Maplin Sands (Foulness) were surveyed as one site (590 ha). Hence the areas of saltmarsh for the Crouch-Roach Estuary and Maplin Sands sites in the inventory were not readily available.

However, maps and the areas of saltmarsh in each 10 x 10 km grid square are available (Fojt 1975). For the most part, the saltmarsh falls within one or other of the estuary sites, so it was possible to allocate the areas of saltmarsh to an estuary. The exception is grid square TQ98, where the map indicates that the saltmarsh lies approximately half in one site and half in the other; hence

the area of saltmarsh in this square was divided equally between the sites. The approximate area of saltmarsh in the Crouch-Roach Estuary and Maplin Sands inventory sites was thus calculated.

National surveys of sand dunes and shingle have also been undertaken, summarised in the *Sand dune survey of Great Britain* (Dargie 1993, 1995; Radley 1994) and *Vegetated shingle structures of Great Britain* (Sneddon & Randall 1993a, 1993b; 1994a, 1994b). Total areas for these habitats are not given, as the surveys covered only parts of the total national resource (further surveys are underway to complete coverage of sand dunes), and also because often only minor parts of sand dune systems or shingle structures lie within the identified estuarine site. For many individual sand dune systems, vegetation reports have been published separately and these are listed in the Further Reading section of each estuary.

## 5.4 Aquatic estuarine communities

This classification of benthic estuarine communities was developed in 1988-90, based on the methodology being developed by the NCC/JNCC's Marine Nature Conservation Review (MNCR). This was a first attempt to describe the distribution of the major estuarine benthic communities and their known conservation importance. The classification is preliminary and is being further developed and incorporated into the MNCR as subsequent estuarine and other open coast survey work is completed - for methods see Hiscock (1990). The MNCR classification is described by Hiscock & Connor (1991); it is developed from typical benthic plant and animal

**Table 5.4.1** Names of aquatic estuarine communities

Soft substrates	Hard substrates
1. Gravel/shell gravel community	17. Exposed rocky shore community
2. Maerl beds	18. Moderately exposed rocky shore community
3. Exposed sand community	19. Sheltered rocky shore community
4. Clean sand community	20. Variable salinity rocky shore community
5. Common mussel beds	21. Reduced (variable) salinity rocky shore community
6. Horse mussel beds	22. Reduced salinity rocky shore community
7. European oyster beds	23. <i>Sabellaria</i> reef community
8. Surface algal community	24. Current-exposed sheltered rocky shore community
9. Current-swept sand community	25. Exposed rock community
10. Sand/muddy sand community	26. Sheltered rock community
11. Muddy gravel community	27. Hydrozoan/bryozoan turf community
12. Muddy 'offshore' sand community	28. Slipper limpet beds
13. Normal/variable salinity muddy community	29. Artificial substrata community
14. <i>Zostera</i> and <i>Ruppia</i> beds	30. Variable salinity rock community
15. Variable/reduced salinity mud community	31. Variable salinity clay community
16. Reduced salinity mud community	32. Reduced (variable) salinity rock community
	33. Reduced salinity rock community

communities occupying sites described by a range of physical and chemical features such as salinity, wave exposure and tidal stream strength. Such communities are often typical of a particular substrate type and some community names reflect this.

The coverage of the MNCR classification includes both inshore subtidal areas and intertidal shores where these are not vegetated by vascular plants, i.e. saltmarshes are excluded. Coverage is restricted to those parts of the estuary where there is measurable penetration of saline water, so freshwater parts of the tidal estuary are excluded.

The classification used here is described in more detail in Davidson *et al.* (1991), and its further refinements by Laffoley & Hiscock (1993). It shows the presence of 33 major aquatic estuarine communities on many of the estuaries in Great Britain (Table 5.4.1). For each site the presence of communities is tabulated, based on information from publications and MNCR and equivalent surveys. Note that this listing is derived from a preliminary compilation of mostly published information, so that the recorded diversity and distribution of communities in part reflects the distribution of detailed survey work. For example, more recent surveys by JNCC's MNCR team have been undertaken on sites in Eastern and Southern England, but in the time available it has not been possible to incorporate these data. Consequently communities additional to those shown may be present in the estuaries. For Northern Ireland the known presence of benthic estuarine communities was compiled from information available in 1992.

It should also be noted that a community is listed only when there is recorded information of the benthic plants and animals characteristic of that community - the known presence of a suitable substrate and set of physico-chemical conditions alone is not sufficient for the inclusion of a community in the tabulation.

## 5.5 Birds

Estuarine birds can be highly mobile and they depend on a network of sites during their annual cycle. The use of a particular estuary varies from bird to bird, species to species and year to year. Key features of their use and distributions around British estuaries are described in detail in Davidson *et al.* (1991).

### 5.5.1 Wintering waterfowl - sources of data

The information presented focuses on wintering waterfowl (waders, ducks, geese, swans and coots), since consistent and long-term information on wintering waterfowl is available for most UK estuaries. Prior to October 1993 data were derived chiefly from the Birds of Estuaries Enquiry (BoEE), co-ordinated by the British Trust for Ornithology, and the National Wildfowl Count (NWC) operated by the Wildfowl & Wetlands Trust (WWT). However, not all estuaries covered by the inventory were counted regularly under the BoEE/NWC schemes. For most of these sites, some data are available from the 1984-1985 BTO/Wader Study Group Winter Shorebird Count (WSC), a single midwinter survey that covered non-cliff shores outside estuaries (Moser & Summers 1987). In volumes 2-4 of the inventory, the data sources used (BoEE, NWC or WSC) are noted for each site.

Since October 1993 these schemes have been amalgamated into the Wetland Bird Survey (WeBS) - operated jointly by BTO, WWT, RSPB and JNCC. For volumes 5-7 of the inventory, WeBS is the single source of information on wintering waterfowl. Since 1992/3 the estuaries covered by WeBS have matched closely those boundaries of the estuaries used here. However, in a few areas, notably around the Thames Estuary, in parts of Essex and the Severn Estuary, the areas counted under WeBS are slightly different and so the numbers presented here may differ from those given in published WeBS reports.

The behaviour of some waterfowl species, notably geese which feed on surrounding land during high tide, means that their numbers are underestimated in WeBS counts. For these species some additional information is drawn from supplementary surveys which are noted in the text.

### 5.5.2 Wintering waterfowl - data presentation

Information for wintering waterfowl is presented as the average peak monthly counts (APMC) for the most recent five-year period available at the time of compilation; the years from which the data are used is noted. As the numbers of wintering waterfowl fluctuate from year to year, more recent and/or more detailed information should be sought from the WWT (for wildfowl) or BTO (for waders).

The average peak monthly count is widely accepted as the most appropriate measure for assessing the importance of individual estuaries for mobile waterfowl since it takes better account of the timing of peak occurrence in different species and in different years than do other measures. Note, however, that the APMC indicates the usage and importance of a single site only; it should not be used to analyse national and international distributions (see Davidson *et al.* 1991 for further explanation).

The data presented in the inventory are:-

**Total wintering waterfowl:** this figure shows the total number of birds that use the estuary during the winter.

**Species assemblage:** this pie-chart indicates the diversity of wintering species on the site and the proportion of species that winter on the estuary. Each species forming more than 5% of wintering waterfowl numbers is shown separately.

**% Internationally/nationally important populations:** a species is considered to be of national or international importance if its numbers exceed 1% of its national or international population respectively, over the five-year period shown. (Note that where 1% of the national population is less than 50, 50 is normally used as a minimum qualifying level.) A bar-chart shows the percentages of national and international populations for each species exceeding the 1% population threshold. For sites in Northern Ireland, the % 'national' population refers to the all-Ireland context.

### 5.5.3 Breeding birds

Information on breeding seabirds comes from the JNCC/Seabird Group *Seabird Colony Register* which holds information collected for all known seabird colonies (Lloyd *et al.* 1991). As the numbers of breeding birds changes from year to year, only a brief summary of breeding seabirds is given. A colony referred to as small, medium-sized or large is not an indication of absolute numbers, but corresponds to the relative size of colonies of that species in Britain. For example, a breeding colony of 100 pairs of uncommon birds such as the little tern *Sterna albifrons* is of particular note within the British Isles, whereas 100 pairs of a more numerous species such as herring gull *Larus argentatus* is of less significance.

Information on numbers of breeding waders is geographically patchy and/or provide coverage of only one habitat or parts of a habitat. Other information comes from sample surveys of single habitats. However, some information is available for breeding waders on saltmarshes on 36 British estuaries and for grassland-breeding waders on 55 British estuaries. Most data are derived from surveys undertaken in the early 1980s, notably Smith (1983) for lowland grasslands, Allport *et al.* (1986) for saltmarshes, Murfitt & Weaver (1983) for Norfolk, Mitchell (1983) for Sussex, Fuller *et al.* (1986) for the Outer Hebrides, Campbell *et al.* (1988) for Orkney, and Holzer *et al.* (1989) for Suffolk. National survey data are available from 1984 for ringed plovers *Charadrius hiaticula* (Prater 1989). No information is currently available for Northern Ireland.

As much of the available information on breeding waterfowl dates from the early 1980s, and as populations can change from year to year, no precise numbers of breeding pairs are given. However, as with seabirds, an indication of the numbers or densities of the breeding species is given, corresponding to the known breeding status of that species in Britain.

### 5.5.4 Other

This section notes where an estuary is known to be important during spring and autumn for migrant waterfowl, and/or during autumn for feather moult, or for any other features of ornithological note. Information on these topics is patchy and obtained from regional conservation agency staff or from site-specific reports and papers. Important published sources are listed under 'Further reading'.

## 5.6 Additional wildlife features

### 5.6.1 Vascular plants

The coastal habitats fringing the estuaries of the UK support a number of rare and scarce vascular plants. Information on such species known to be associated with an estuary comes from the JNCC Rare Plants Database, with additional information from regional conservation agency staff. Data for Northern Ireland was supplied by DoE (Northern Ireland) Environment and Heritage Service. However, the status of vascular plant species in GB and Northern Ireland has been undergoing review; where recent changes in status are known, the more recent information has been incorporated.

Nationally rare plant species in England, Scotland and Wales are those occurring in 15 or fewer 10 x 10 km squares and these species are named. Nationally scarce plant species are those occurring in 16-100 10 x 10 km squares; due to the very large number of nationally scarce plants associated with some estuaries, these are not named but the number of such species is given to indicate the importance of the site for the conservation of plants. A further category, that of 'Red List' species, was adopted by JNCC in 1995 as a national standard, based on the 1994 IUCN threat criteria (World Conservation Union 1994). Subsequent volumes of the inventory (volumes 5-7) use this category in addition to those of nationally rare and nationally scarce.

**Table 5.6.1** Status categories for terrestrial invertebrate species in Britain

Status	Definition
Red Data Book	known from 15 or fewer 10 x 10 km grid squares
RDB 1 'Endangered'	in danger of extinction and whose survival is unlikely if the causal factors continue operating
RDB 2 'Vulnerable'	believed likely to move into the endangered category in the near future if the causal factors continue operating
RDB 3 'Rare'	small populations that are not at present endangered or vulnerable, but are at risk
Nationally scarce	known from 16-100 10 x 10 km grid squares

Note: for some species apparent RDB status has emerged after the preparation of the Red Data Book for insects (Shirt 1987). Such species are currently afforded provisional RDB status (pRDB).

For Northern Ireland, the status of the plant species is considered in an all-Ireland context, based on Curtis & McGough (1988).

### 5.6.2 Marine benthic species

Criteria to assess the rarity of marine benthic species have been developed only very recently (Sanderson 1996), and hence information on rare or scarce marine benthic species has been available only for volumes 5 and 6 of the inventory. Information on the presence of such species in estuaries is drawn from the *Coastal Directories* series (Barne *et al.* 1995, *et seq.*) which includes a first attempt to summarise the known occurrence of rare and scarce species in Great Britain. 'Nationally rare' marine benthic organisms are those that occur in eight or fewer of the 10 x 10 km national grid squares containing sea within the 3-mile territorial limit for GB, and 'nationally scarce' are those occurring in nine to 55 such squares. As more data become available or populations change, the status of the species noted here will require re-evaluation.

Equivalent data for species in Northern Ireland were not available at the time of compilation.

### 5.6.3 Terrestrial invertebrates

Information on terrestrial invertebrates was supplied from JNCC's Invertebrate Site Register (ISR) and generally includes only recent (i.e. from 1970) records. Note that data compilation and analysis is continuing such that terrestrial invertebrate importance may be under-represented for some sites, particularly those in Scotland. The ISR and Red Data Books uses different categories to indicate the status of terrestrial invertebrates in Britain (Ball 1986; Shirt 1987); those relevant to the inventory are defined in Table 5.6.1. Records of Red Data Book (RDB 1 to RDB 3) species from 1970 onwards are named, but due to the very large number of Notable species associated with some estuaries, these are not named but the number of such species is given to indicate the importance of the site for the conservation of invertebrates.

Equivalent data for species in Northern Ireland were not available at the time of compilation.

### 5.6.4 Fish

Information on estuarine fish is patchy and the inventory records only certain known features of interest. For example, some estuaries have records of rare or uncommon fish or are spawning and/or nursery areas for commercially important species. Where an estuary is noted as being a major nursery for sea bass *Dicentrarchus labrax*, this indicates that part of the estuary has been designated as a statutory sea bass nursery under the Bass (Specified Sea Areas) (Prohibition of Fishing) Order 1990, with certain restrictions on fishing for bass in order to conserve stocks.

### 5.6.5 Amphibians & reptiles

Of the 12 species of amphibians and reptiles native to the UK, one species, the natterjack toad *Bufo calamita*, is both rare and largely restricted to coastal areas (chiefly sand dunes) associated with estuaries. The presence of natterjack toads and other rare and scarce amphibians and reptiles is derived from Davidson *et al.* (1991) and from information provided by regional country conservation agency staff.

### 5.6.6 Mammals

Information on mammals focuses on seals and otters, with some information on dolphins, and is derived from Davidson *et al.* (1991), a variety of published scientific papers, and information provided by regional country conservation agency staff. Information on the presence of otters has been drawn largely from national otter surveys (Andrews & Crawford 1986; Chapman & Chapman 1982; Green & Green 1987; Strachan *et al.* 1990).

## 5.7 Conservation status

the types of protected site relevant to Northern Ireland estuaries are shown in Table 5.7.2.

As with most habitats in the UK, the safeguard of much of the wildlife and landscape value of estuaries is achieved through the identification and designation of sites of importance. There are a large number of different conservation designations on UK estuaries. Some are statutory, i.e. enacted by law, while others are voluntary; some are international and others national or local; some are designated for wildlife and others for their landscape, leisure or amenity value. Together they create a complex overlapping suite of areas afforded varying degrees of safeguard.

### 5.7.1 Presentation of conservation status information

In the inventory, each estuary account provides a tabulation of the presence and number of each type of protected site present. Information has been updated from that used by Davidson *et al.* (1991), since for many estuaries the pattern of conservation designation has changed considerably since 1989/90, particularly through the renotification of SSSIs in Great Britain under the Wildlife & Countryside Act 1981. For most types of site only those designated, notified or present are listed. However, known proposals for further designation of NNRs, SSSIs, LNRs, Ramsar sites and SPAs are listed; in Northern Ireland sites that meet the criteria as Ramsar sites or SPAs are shown.

As the geographical relationships between these conservation sites are complex, often involving partial or complete overlap, it is not always possible to show clearly the boundaries of all conservation sites on estuaries. Consequently only the boundaries of National Nature Reserves and Sites (or Areas) of Special Scientific Interest are shown on the maps. Note that for many intertidal SSSIs the seaward boundary is notified as the Mean Low Water mark (or Low Water Spring tides in Scotland); such boundaries are mapped with a broken line. The approximate central locations of County Wildlife Trust reserves, RSPB reserves and some other types of protected sites are shown.

During publication of the inventory the EC 'Habitats and Species Directive' (EC Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora) was adopted by member states. This involves the identification of sites in the UK for designation (with European Commission agreement) as Special Areas of Conservation (SACs). Where parts of estuaries were identified as potential SACs, these are also noted in the tabulation, but note that this information was available only for the later volumes of the inventory (volumes 5-7). As there are various stages in the identification of SACs, e.g. 'possible', 'candidate', or 'proposed' SACs, to simplify the inventory these sites are noted simply as 'proposed' SACs.

### 5.7.2 Types of protected site

The types of protected site and the abbreviations used in the inventory are listed in Table 5.7.1. A more detailed description of each type and its distribution in Britain is given Davidson *et al.* (1991). Statutory site designation is delivered under separate legislation in Northern Ireland, so

**Table 5.7.1** Types of protected site on estuaries in Great Britain (England, Scotland and Wales)

Abbreviation	Type of site	Status	Description
NCR	Nature Conservation Review site	non-statutory; identified by statutory conservation agencies	Identified as the key areas in Britain for statutory nature conservation (see Ratcliffe 1977) and periodically updated. The NCR series helps to identify suitable candidates for designation as biological NNRs (see below).
GCR	Geological Conservation Review site	non-statutory; identified by statutory conservation agencies	The earth science equivalent of the NCR, to identify all British sites of national and international earth science importance. Includes both geological and geomorphological features. All GCR sites are potential SSSIs (see below).
NNR	National Nature Reserve	statutory	Nationally important wildlife sites managed by the conservation agencies or on their behalf. NNRs are declared by the statutory conservation agencies under the Wildlife & Countryside Act 1981, as amended, and are managed specifically for wildlife conservation purposes.
SSSI	Site of Special Scientific Interest	statutory	<p>The major statutory designation for site-based wildlife and earth science conservation in Britain. Sites are identified by the conservation agencies. After a consultation period with owners, occupiers, local planning authorities, the Secretaries of State, water authorities and drainage boards, SSSIs are notified under the Wildlife and Countryside Act 1981, as amended. Once notified, consultation on proposed activities that might damage the conservation interest of the SSSI is required. Biological sites are selected using a suite of guidelines (NCC 1989; Hodgetts 1992); earth science sites are selected through the GCR process.</p> <p>In the inventory tabulation the numbers of SSSIs are listed in three categories:</p> <p>SSSI(B): site notified for biological interest;</p> <p>SSSI(G): site notified for earth science interest; and</p> <p>SSSI(M): 'mixed' site notified for both biological and earth science interest.</p>
LNR	Local Nature Reserve	statutory	LNRs are designated by local authorities (District Councils in England and Wales; Regional, Island or District Authorities in Scotland) under the National Parks and Access to the Countryside Act 1949. LNRs are established in consultation with the conservation agencies for the same purposes as NNRs but for their local rather than national interest.
Ramsar	Ramsar site - wetland of international importance	statutory	<p>Designated by the UK government under the 'Ramsar Convention' (the Convention on wetlands of international importance especially as waterfowl habitat) on the advice of the conservation agencies. Contracting parties (of which the UK is one) are required to designate wetlands of international importance and to promote their conservation and 'wise use'. Criteria for identifying such wetlands are internationally agreed by contracting parties, the most widely applied criteria so far relating to migratory waterfowl populations. These are:</p> <ul style="list-style-type: none"> <li>• where a wetland regularly holds 1% of the individuals in a population of one species or subspecies of waterfowl; and</li> <li>• where a wetland regularly holds a total of 20,000 or more waterfowl.</li> </ul>
SPA	Special Protection Area	statutory	The 1979 EC Directive on the conservation of wild birds (the 'Birds Directive') requires member states to take conservation measures for certain rare or vulnerable species and for regularly-occurring migratory species of birds. In part this is achieved through the designation of SPAs. The UK government designates SPAs on the advice of the statutory conservation agencies; all SPAs must first have been notified as SSSIs under the Wildlife and Countryside Act 1981 (see above). On estuaries most SPAs are designated for migratory waterfowl and so are closely linked with 'Ramsar' sites.
SAC	Special Area of Conservation	statutory	Amongst other measures, the 1992 EC Directive on the conservation of natural habitats and wild fauna and flora (the 'Habitats and Species Directive') requires member states to designate areas of importance for particular habitats and species as SACs. Such habitats include: estuaries (specifically the subtidal channel); intertidal mudflats and sandflats; various types of saltmarsh, sand dune and shingle vegetation; and lagoons. In the UK the Directive is implemented through the Conservation (Natural Habitats &c.) Regulations 1994 (DoE 1994).
AONB	Area of Outstanding Natural Beauty	statutory	AONBs are designated primarily to conserve their natural landscape beauty, and to meet the demands of recreation as far as possible whilst maintaining the natural beauty and other land uses. AONBs are designated under the National Parks and Access to the Countryside Act 1949, in England by the Countryside Commission and since 1991 in Wales by the Countryside Council for Wales. AONBs do not apply to Scotland. Responsibility for local administration of an AONB lies with local authorities at county and/or district level.

**Table 5.7.1** Types of protected site on estuaries in Great Britain (England, Scotland and Wales) (continued)

Abbreviation	Type of site	Status	Description
CWT	County Wildlife Trust reserves	non-statutory	Nature reserves owned, leased or managed by the Wildlife Trusts, which in England and Wales generally each cover a county or small group of counties. Scotland is covered by the Scottish Wildlife Trust. Wildlife Trusts are promoted and represented at national level by a central body, The Wildlife Trusts (formerly RSNC). Some CWT reserves are partly or wholly NNRs managed on behalf of conservation agencies; others are LNRs managed on behalf of local authorities.
RSPB	Royal Society for the Protection of Birds reserves	non-statutory	The RSPB manages over 130 reserves in Britain, which are generally in areas of high wildlife value and most are wardened and open to the public (a few have restricted access to avoid disturbing sensitive bird populations). Reserves are mostly purchased or on long leases with appropriate management rights.
ESA	Environmentally Sensitive Area	statutory	ESAs are designated by the UK government under the Agricultural Act 1986 to encourage sensitive farming practices in areas where traditional farming helps to create important wildlife habitat and attractive landscapes. ESAs provide incentives, including payments, to encourage favourable low-intensity farming practices.
NP	National Park	statutory	The National Parks were established under the National Parks and Access to the Countryside Act 1949, to promote and enhance an area's natural beauty and to promote public enjoyment of it, taking into account the needs of park residents. The Countryside Commission (in England) and CCW (in Wales) advise government on National Parks, each of which is administered by a Park Authority. The Norfolk Broads and the New Forest have similar status to National Parks. National Parks do not apply to Scotland.
WWT	Wildfowl & Wetlands Trust reserves	non-statutory	The Wildfowl & Wetlands Trust maintains wildfowl collections (used extensively for education) and reserves in a number of key wintering areas for migratory wildfowl. Reserves and refuges are mostly owned or on long leases.
NT	National Trust properties	non-statutory	The National Trust and the National Trust for Scotland are independent charities covering the UK and are the largest private landowners in the UK. The National Trust has major coastal land-holdings in the UK funded particularly through its Enterprise Neptune appeals. Although much is on open sandy and cliffed coastlines there are important estuarine properties particularly in eastern and southern England and Northern Ireland.
NSA	National Scenic Area	statutory	NSAs are designated by Scottish Natural Heritage as the best examples of Scotland's landscape and natural heritage. They fulfil parts of the approach embodied in National Parks and AONBs in England and Wales.
HC	Heritage Coast	non-statutory	Areas of largely undeveloped coastline of high scenic quality, selected by the Countryside Commission (in England) and CCW (in Wales) as an aid to local authorities in planning and managing their coastlines. Local authorities develop management plans for Heritage Coasts, including sensitive management for land use and protection, public enjoyment and nature conservation.
<i>Other:</i>			
AoSP	Area of Special Protection	statutory	AoSs are designated under the Wildlife and Countryside Act 1981, with the agreement of the landowner or occupier, to afford strong legal protection for particular bird species throughout the year.
MCA	Marine Consultation Area	non-statutory	Areas identified by Scottish Natural Heritage as areas of marine nature conservation significance, to encourage consultation on activities in these areas.
SMA	Sensitive Marine Areas	non-statutory	Areas identified by English Nature as nationally important and notable for marine communities. Their identification aims to raise awareness of their importance, to be taken into account in estuarine and coastal management planning.
VMCA (also known as vMNRs)	Voluntary Marine Consultation Areas (voluntary Marine Nature Reserves)	non-statutory	Established by local users of a subtidal area or shoreline to initiate management of the area. Management may have a variety of purposes, from conservation of a biologically important marine area to educational purposes.
CP	Country Parks	non-statutory	A local authority designation under the Countryside Act 1968. Country Parks are designed primarily for recreation and leisure, but are often in areas of semi-natural habitat.
MoD	Ministry of Defence	non-statutory	Many areas of land, owned by the Ministry of Defence and Territorial Army Volunteer Reserves and used for a variety of purposes, are of considerable wildlife conservation significance. The long-term restrictions on public access affords considerable protection to these areas.

**Table 5.7.2** Types of protected site on estuaries in Northern Ireland

Abbreviation	Type of site	Status	Comments
NNR	National Nature Reserve	statutory	NNRs are nationally important wildlife sites declared by the DoE (Northern Ireland) and are managed specifically for wildlife conservation purposes and to provide special opportunities for research. Prior to 1985 they were designated under the Amenity Lands Act (Northern Ireland) 1965 as 'Nature Reserves'. From April 1985 new sites were designated as 'National Nature Reserves' under the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985, as amended in 1989.
ASSI	Area of Special Scientific Interest	statutory	<p>The major statutory site designation for site-based wildlife and earth science conservation in Northern Ireland (equivalent to SSSIs in GB). After a consultation period with owners and occupiers, ASSI designation is confirmed under the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985 and its 1989 amendments. Once notified, consultation on proposed activities that might damage the conservation interest of the site is required.</p> <p>In the inventory tabulation the numbers of ASSIs are listed in three categories:</p> <p>ASSI(B): site notified for biological interest;</p> <p>ASSI(G): site notified for earth science interest; and</p> <p>ASSI(M): 'mixed' site, notified for both biological and earth science interest.</p>
ASI	Area of Scientific Interest	statutory	Under the Amenity Lands Act (Northern Ireland) 1965 Areas of Scientific Interest (ASIs) were declared as a mechanism for ensuring assessment of the nature conservation implications of planning applications. ASIs and the more recently designated ASSIs frequently overlap; where an area has been declared as both an ASSI and an ASI, the ASSI is shown on the map in the inventory.
MNR	Marine Nature Reserves	statutory	MNRs are created under Article 20 of the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985 to conserve marine flora, fauna or features of geological, physiographic or other scientific or special interest, while providing special opportunities for research. MNRs can include the open sea, seashore up to highest astronomical tide and the sea bed; they can be protected by bylaws where no alternative protection measures under other legislation are available.
Ramsar	Ramsar site - Wetland of international importance	statutory	<p>Sites designated by the UK government under the 'Ramsar Convention' (the Convention on wetlands of international importance especially as waterfowl habitat) on the advice of DoE (NI) Environment &amp; Heritage Service. Contracting parties (of which the UK is one) are required to designate wetlands of international importance and to promote their conservation and 'wise use'. Criteria for identifying such wetlands are internationally agreed by contracting parties, the most widely applied criteria so far relating to migratory waterfowl populations. These are:</p> <ul style="list-style-type: none"> <li>• where a wetland regularly holds 1% of the individuals in a population of one species or subspecies of waterfowl; and</li> <li>• where a wetland regularly holds a total of 20,000 or more waterfowl.</li> </ul>
SPA	Special Protection Area	statutory	The 1979 EC Directive on the Conservation of Wild Birds (the 'Birds Directive') requires member states to take conservation measures for certain rare or vulnerable species and for regularly-occurring migratory species of birds. In part this is achieved through the designation of SPAs. Sites in Northern Ireland are identified by DoE (NI) Environment & Heritage Service. Implementation of the Birds Directive in Northern Ireland is achieved through the Nature Conservation and Amenity lands (NI) Act 1985 - all SPAs must first have been declared as ASSIs. On estuaries most SPAs are designated for migratory waterfowl and so are closely linked with 'Ramsar' sites.
SAC	Special Area of Conservation	statutory	Amongst other measures, the 1992 EC Directive on the conservation of natural habitats and wild fauna and flora (the 'Habitats and Species Directive') requires member states to designate areas of importance for particular habitats and species as SACs. Such habitats include: estuaries (specifically the subtidal channel); intertidal mudflats and sandflats; various types of saltmarsh, sand dune and shingle vegetation; and lagoons. In Northern Ireland the Directive is implemented through the Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995.
AONB	Area of Outstanding Natural Beauty	statutory	AONBs are designated primarily to conserve their natural landscape beauty, and to meet the demands of recreation as far as possible whilst maintaining their natural beauty and other land uses. In Northern Ireland AONBs are designated by DoE (NI) Environment & Heritage Service under the Nature Conservation & Amenity Lands (NI) Order 1985 (formerly under the Amenity Lands Act (NI) 1965).

**Table 5.7.2** Types of protected site on estuaries in Northern Ireland (continued)

Abbreviation	Type of site	Status	Comments
ESA	Environmentally Sensitive Area	statutory	Designated by the UK government under the Agricultural Act 1986 to encourage sensitive farming practices in areas where traditional farming has helped to create important wildlife habitat and attractive landscapes. ESAs provide incentives including payments to encourage favourable low-intensity farming practices.
CWT	County Wildlife Trust reserves	non-statutory	Nature reserves owned, leased or managed by the Wildlife Trusts; Northern Ireland is covered by the Ulster Wildlife Trust. Wildlife Trusts are promoted and represented at national level by a central body, The Wildlife Trusts (formerly RSNC). Some UWT nature reserves are also partly or wholly ASSIs.
RSPB	Royal Society for the Protection of Birds reserves	non-statutory	The RSPB manages over 150 reserves in the UK, which are generally in areas of high wildlife value and most are wardened and open to the public (a few have restricted access to avoid disturbing sensitive bird populations). Reserves are mostly purchased or on long leases with appropriate management rights.
WWT	Wildfowl & Wetlands Trust reserves	non-statutory	The Wildfowl & Wetlands Trust maintains wildfowl collections (used extensively for education) and reserves in a number of key wintering areas for migratory wildfowl. Reserves and refuges are mostly in ownership or on long leases.
NT	National Trust properties	non-statutory	The National Trust and the National Trust for Scotland are independent charities and are the largest private landowners in the UK. The National Trust has major coastal land-holdings in the UK funded particularly through its Enterprise Neptune appeals. Although much is on open sandy and cliffed coastlines there are important estuarine properties in Northern Ireland. The National Trust own or manage large areas of land in Northern Ireland that are NNR/ASSI.
<i>Other:</i>			
MoD	Ministry of Defence land	non-statutory	Many areas of land owned by the Ministry of Defence and Territorial Army Volunteer Reserves and used for a variety of purposes, are of considerable wildlife conservation significance. The long-term restrictions on public access affords considerable protection to these areas.
CP	Country Park	non-statutory	Country Parks are primarily intended for recreation and leisure, but are often in areas of semi-natural habitat. In Northern Ireland there is no legislation providing for the designation of areas as Country Parks, but the Nature Conservation and Amenity Lands (NI) Order 1985 provides for the acquisition and management of 'Amenity Lands'. Several coastal sites acquired as Amenity Lands are managed as Country Parks.

## 5.8 Features of human use

### 5.8.1 Data sources

There are a great many different types of human activity taking place on many estuaries. The presentation of comprehensive and detailed information on the distribution, intensity and effects of each activity on estuaries in the UK is outside the scope of this inventory. Such assessments are best undertaken either for a type of activity over a range of estuaries or for a suite of activities on a single estuary, for example to provide baseline information during the development of estuary management initiatives (e.g. English Nature 1992).

The information presented in the inventory is largely based on that collected during 1989/90 by the NCC Estuaries Review, revised and updated where appropriate. For the earlier volumes of the inventory the data presented are from 1989/90, with more recent information on proposals, etc. noted in the text. However, over the timescale taken for publication of the inventory, for later volumes this information was revised and updated by regional country conservation agency staff and the appropriate date of the 'Human activities' information is shown. Any subsequent developments or proposals are noted in the 'Features of human use' text.

The primary sources of information on activities were the NCC's regional staff, particularly those with site casework responsibility for areas including estuaries. The knowledge of these staff and the material held in their regional files provided an unparalleled source of comparable and comprehensive information available within the short timescale of the Estuaries Review. However, where some data were not available, additional information was obtained from other local sources, organisations or published sources. Information for sites in Northern Ireland was compiled from material collected from a variety of sources by the RSPB's Estuaries Inventory project in 1992/1993.

To collect data for each estuary a standard questionnaire was devised covering more than 250 separate activities. At the most basic level the presence or absence of these activities on the estuary was recorded. Where possible additional numerical information, varying in type depending on the nature of the activity, was also collected. The information ranged from the number of locations of an activity (e.g. the number of dock sites or complexes) or individual features (e.g. the number of marina berths), to the area (in hectares) of the estuary on which the activity is known to occur. For some activities, for example coastal defences, it was more appropriate to use the length (in kilometres) or percentage of the shoreline affected. Active proposals for activities were also noted.

The data for each site were collected through the standard questionnaire, supplemented by maps on which the locations of features were marked, with ancillary material extracted from locally-held files. For estuaries where responsibility was divided between two or more regional members of staff, the information from all sources was combined. The data were entered into the Estuaries Review Database, now held at JNCC, and formed the basis of the human activities information in the inventory.

### 5.8.2 Presentation of Features of human use information

#### *Human activities*

The human activities information presented in the inventory is a much-simplified version of the original data that were collected during the Estuaries Review and that are held on the Estuaries Review Database. To summarise the occurrence of the great range of human uses of the estuary, the list of activities was simplified by combining the original 250 separate activities into 121 more general types. These are presented as a standard tabulation with a symbol indicating which activities were present and/or proposed, as a 'snapshot' in time.

Those activities listed as 'present' include not only those activities taking place at the time of data collection but also those under construction or for which consent had been granted. Activities noted as 'proposed' encompasses a range of proposals including initial publicity for development plans or firm proposals under pre-application discussion or environmental impact assessment. The date of this information is either 1989/90 (as in earlier volumes of the inventory) or as otherwise stated; subsequent proposals or activities are noted in the 'Features of human use' text.

#### *Features of human use*

The text summarises the key features and locations of the main human uses of the estuary. The urban or industrial shorelines and the main areas of leisure and recreation use are mapped, with the locations of other key features also shown, e.g. ports and harbours, marinas and industrial sites. Any proposals are summarised and a final paragraph highlights major changes subsequent to the data shown.

#### *Categories of human use*

The pattern of human activities is presented also as a histogram to illustrate the diversity of uses on the estuary. For this analysis the activities were further combined into six major groups. For each major category, the number of types of activity currently occurring on the estuary is expressed as a percentage of the total number possible in that category. For example, a value of 33% in the 'Leisure/recreation' grouping means that 33% (i.e. 10) of the total of 30 leisure and recreational activities take place on the estuary. The major categories and total numbers of activities grouped for this analysis are shown in Table 5.8.1.

#### *Land-claim*

Historically land-claim (sometimes known as 'reclamation') has greatly changed the size, shape and appearance of many UK estuaries. Land-claim continues or is proposed on many estuaries for a variety of purposes - for a more detailed analysis see Davidson *et al.* (1991), and Davidson *et al.* (1995). Information on the historical patterns of land-claim is patchy, but for some estuaries this is summarised.



# 6 A summary of the UK estuarine resource

The distribution of estuaries in Great Britain and an analysis of their main features is summarised in Davidson *et al.* (1991). Here the data are extended to cover the whole of the United Kingdom by the inclusion of Northern Ireland estuaries, and to incorporate corrections of some measurement and classification errors detected after the publication of *Nature conservation in Great Britain* (Davidson *et al.* 1991). The areas, lengths and characteristics for each estuary are listed in Appendices 1 and 2.

163 estuaries were identified for inclusion in the Estuaries Review and the inventory and these estuaries are distributed widely around the coastline of Britain (see figure 3.1). There are 26 estuaries in Wales plus two major estuaries - the Severn, and the Dee Estuary and North Wirral - which are shared with England. 48 sites are wholly in Scotland, plus the Inner Solway Firth that straddles the border between England and Scotland; the upper reaches of the Tweed Estuary are also in Scotland. A further 77 estuaries are wholly within England, with the aforementioned four estuaries shared with Wales or Scotland. Eight estuaries lie wholly or partly within Northern Ireland.

## 6.1 Distribution of estuaries classified by geomorphological types and tidal range

Tables 6.1.1 and 6.1.2 show the numbers of the different geomorphological types and tidal range types of estuaries in the UK, broken down by inventory regions and by country. For details of the geomorphological classification of estuaries, and the measurement and classification of tidal ranges, see section 4.4.

Associated with glaciated coasts, the fjords and fjards occur in the west and north of Scotland, with the exception of a single site on Anglesey in Wales. In contrast, rias are found in the south-west of the UK, mostly on the coasts of Devon and Cornwall with two rias in South Wales. Coastal plain estuaries are widely distributed in England and Wales, occurring particularly in south-east England, the south coast of England, the south coast of Wales and the Liverpool Bay area. Bar built estuaries are the most numerous type in the UK and are also widespread, but are predominant on the west coast of Wales, the south coast of England and the eastern coast of

**Table 6.1.1** Geomorphological types of estuaries in the UK

a. Geomorphological type by country

Country	Fjord	Fjard	Ria	Coastal plain	Bar built	Complex	Barrier beach	Linear shore	Embayment	Total
England	0	0	13	28	23	5	2	4	6	81
Scotland	6	19	0	2	10	7	0	2	4	50
Wales	0	1	2	7	14	0	0	1	3	28
Northern Ireland	0	0	0	3	2	2	0	0	1	8

N.B. Figures shown are for estuaries falling partly or wholly within a country. As some estuaries fall within two countries, the totals exceed that for the UK.

b. Geomorphological type by inventory region

Inventory region	Fjord	Fjard	Ria	Coastal plain	Bar built	Complex	Barrier beach	Linear shore	Embayment	Total
South-west Britain	0	1	4	5	16	0	0	1	5	32
North-west Britain	4	14	0	6	2	1	0	2	4	33
North & East Scotland	2	5	0	2	9	5	0	0	1	24
Eastern England	0	0	0	12	7	4	2	4	2	31
Southern England	0	0	11	10	13	0	0	0	1	35
Northern Ireland	0	0	0	3	2	2	0	0	1	8
<i>Total</i>	6	20	15	38	49	12	2	7	14	163

**Table 6.1.2** Numbers of tidal range types of estuary in the UK

a. Tidal range type by country

Country	Microtidal (spring tide <2m)	Mesotidal (spring tide 2-4 m)	Macrotidal (spring tide >4 m)
England	5	17	59
Scotland	1	26	23
Wales	0	0	28
Northern Ireland	2	3	3

N.B. Figures shown are for estuaries falling partly or wholly within a country. As some estuaries fall within two countries, the totals exceed that for UK.

b. Tidal range type by inventory region

Inventory region	Microtidal (spring tide <2m)	Mesotidal (spring tide 2-4 m)	Macrotidal (spring tide >4 m)
South-west Britain	0	0	32
North-west Britain	1	11	21
North & East Scotland	0	15	9
Eastern England	2	9	20
Southern England	3	8	24
Northern Ireland	2	3	3
<i>Total</i>	8	46	109

Scotland. Complex estuaries occur mainly on the east coast of Scotland and the only two barrier beach systems in the UK are present on the Eastern England coast. Linear shores occur mainly in south-east England with a small number scattered on the west coast of Britain. Embayments are widely distributed around the coast of the UK.

Tidal ranges in the UK are generally much larger than those on most other parts of the European coast (Davidson *et al.* 1991). Table 6.1.2 shows that over two-thirds of the estuaries in the UK are macrotidal, including all the estuaries on the west coast of England, in Wales and south-west Scotland. The tidal ranges of Blue Anchor Bay, Bridgwater Bay, the Severn Estuary and the Thaw Estuary are exceptionally large, and the Severn Estuary has one of the largest tidal ranges in the world. Around the remainder of the Scottish coast and on Eastern England, tidal ranges are mostly mesotidal or macrotidal. There are few microtidal estuaries in the UK, most in East Anglia and on the south coast of England.

## 6.2 The size of the UK estuarine resource

The distribution and total area of estuaries in the UK (updated since Davidson *et al.* 1991) is shown in Figure 6.1. The total areas and shoreline and channel lengths of estuaries are summarised in Tables 6.2.1 and 6.2.2. The proportional distributions of the resource by country and by inventory region are shown in Figures 6.2 and 6.3. The largest areas of the UK's estuarine resource are in North-west Britain and Eastern England, which together contain over 56% of the total area of estuarine habitat in the UK. These regions contain many of the largest estuaries in the UK, such as the Wash, Morecambe Bay, the Severn Estuary and the Greater Thames Estuary. In contrast, whilst Southern England has the largest number of estuaries (35 in total - 21% of the UK total) of any region, estuaries on this coastline are generally small and form less than 6% of the UK area. However, it is important to note that, like those elsewhere on the UK, many of the small estuaries on this coastline have many features of nature conservation importance.

**Table 6.2.1** Areas and shoreline and channel lengths of estuaries for each country of the UK.

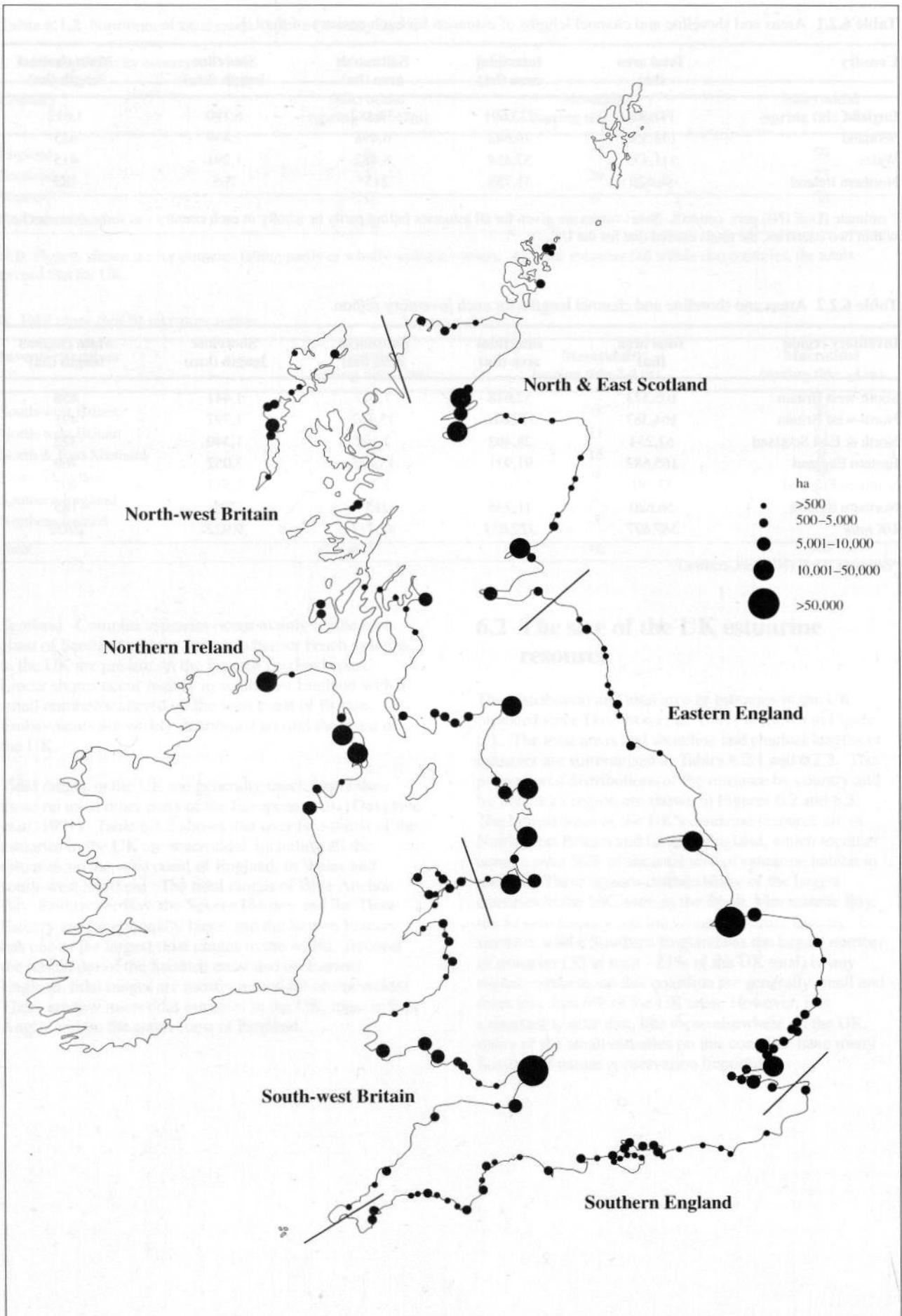
Country	Total area (ha)	Intertidal area (ha)	Saltmarsh area (ha)	Shoreline length (km)	Main channel length (ha)
England	398,504	233,691	33,482	6,190	1,612
Scotland	135,358	76,642	6,498	2,439	625
Wales	111,435	57,454	8,482	1,291	415
Northern Ireland	56,620	11,735	215*	705	185

\* estimate (DoE (NI) pers. comm.). Note: values are given for all estuaries falling partly or wholly in each country - as some estuaries lie within two countries, the totals exceed that for the UK.

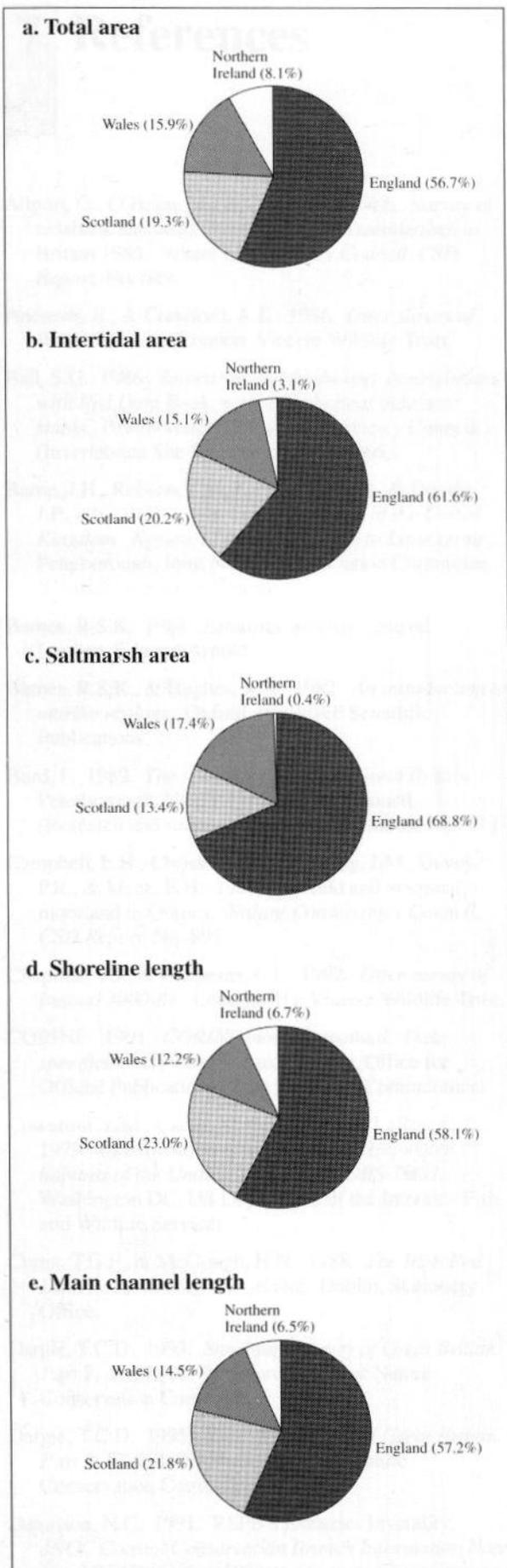
**Table 6.2.2** Areas and shoreline and channel lengths for each inventory region.

Inventory region	Total area (ha)	Intertidal area (ha)	Saltmarsh area (ha)	Shoreline length (km)	Main channel length (ha)
South-west Britain	105,573	52,618	7,147	1,441	458
North-west Britain	164,387	119,616	13,462	1,797	491
North & East Scotland	62,234	28,462	2,167	1,340	322
Eastern England	165,682	91,931	15,425	3,052	769
Southern England	33,381	17,671	4,296	1,587	407
Northern Ireland	56,620	11,735	215*	705	185
<i>UK total</i>	<i>587,877</i>	<i>322,033</i>	<i>42,712</i>	<i>9,922</i>	<i>2,632</i>

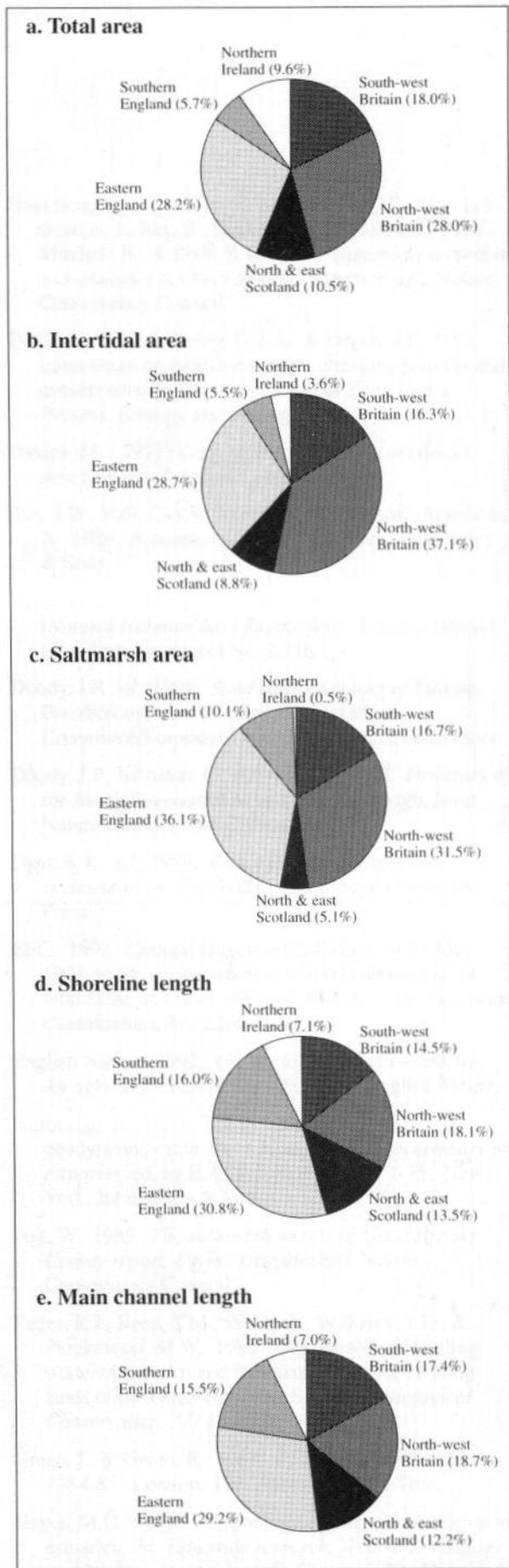
\*estimate (DoE (NI) pers. comm.)



**Figure 6.1.** The distribution and size of the UK estuarine resource. Areas shown are the total areas of sites as covered in the inventory.



**Figure 6.2** The proportional distribution of the UK estuarine resource by country. Note the area of saltmarsh for Northern Ireland is an estimate.



**Figure 6.3** The proportional distribution of the UK estuarine resource by inventory region. Saltmarsh area for Northern Ireland is an estimate.

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## Appendix 1 Geomorphological classification of UK estuaries

The geomorphological and tidal range categories of the estuaries classification are described in section 4.4. Note that this classification lists the only major

geomorphological type of each estuary and that some estuaries also exhibit features of other geomorphological types.

Estuary	Central grid ref.	Geomorph. type	Tidal range type
1. Hayle Estuary	SW5538	Bar built	Macrotidal
2. Gannel Estuary	SW8061	Ria	Macrotidal
3. Camel Estuary	SW9375	Ria	Macrotidal
4. Taw-Torridge Estuary	SS4631	Bar built	Macrotidal
5. Blue Anchor Bay	ST0244	Embayment	Exceptionally large
6. Bridgwater Bay	ST2947	Embayment	Exceptionally large
7. Severn Estuary	ST4080	Coastal plain	Exceptionally large
8. Thaw Estuary	ST0366	Coastal plain	Exceptionally large
9. Ogmore Estuary	SS8776	Coastal plain	Macrotidal
10. Afan Estuary	SS7588	Bar built	Macrotidal
11. Neath Estuary	SS7292	Ria	Macrotidal
12. Tawe Estuary & Swansea Bay	SS6694	Embayment	Macrotidal
13. Loughor Estuary (Burry Inlet)	SS4897	Coastal plain	Macrotidal
14. Carmarthen Bay	SN3408	Embayment	Macrotidal
15. Milford Haven (Cleddau Estuary)	SM9403	Ria	Macrotidal
16. Nyfer Estuary	SN0540	Bar built	Macrotidal
17. Teifi Estuary	SN1648	Bar built	Macrotidal
18. Aberystwyth	SN5980	Bar built	Macrotidal
19. Dyfi Estuary	SN6495	Bar built	Macrotidal
20. Dysynni Estuary	SH5802	Bar built	Macrotidal
21. Mawddach Estuary	SH6416	Bar built	Macrotidal
22. Arthro Estuary	SH5725	Bar built	Macrotidal
23. Traeth Bach (Glaslyn/Dwryd Estuary)	SH5736	Bar built	Macrotidal
24. Pwllheli Harbour	SH3835	Bar built	Macrotidal
25. Foryd Bay	SH4559	Bar built	Macrotidal
26. Traeth Melynog (Braint Estuary)	SH4364	Bar built	Macrotidal
27. Cefni Estuary (Malltraeth Estuary)	SH4067	Bar built	Macrotidal
28. Alaw Estuary	SH3081	Fjord	Macrotidal
29. Traeth Dulas	SH4888	Bar built	Macrotidal
30. Traeth Coch (Red Wharf Bay)	SH5380	Linear shore	Macrotidal
31. Traeth Lavan	SH6375	Embayment	Macrotidal
32. Conwy Estuary	SH7976	Coastal plain	Macrotidal
33. Clwyd Estuary	SJ0080	Coastal plain	Macrotidal
34. Dee Estuary & North Wirral	SJ2674	Coastal plain	Macrotidal
35. Mersey Estuary	SJ4180	Coastal plain	Macrotidal
36. Alt Estuary	SD2903	Coastal plain	Macrotidal
37. Ribble Estuary	SD3424	Coastal plain	Macrotidal
38. Morecambe Bay	SD3668	Embayment	Macrotidal
39. Duddon Estuary	SD1977	Coastal plain	Macrotidal
40. Esk Estuary (Cumbria)	SD0896	Bar built	Macrotidal
41. Inner Solway Firth	NY2762	Complex	Macrotidal
42. Rough Firth & Auchencaim Bay	NX8451	Fjord	Macrotidal
43. Dee Estuary (Dumfries & Galloway)	NX6747	Fjord	Macrotidal
44. Water of Fleet	NX5753	Fjord	Macrotidal
45. Cree Estuary	NX4655	Fjord	Macrotidal
46. Luce Bay	NX1855	Linear shore	Macrotidal
47. Garnock Estuary	NS3039	Bar built	Mesotidal
48. Hunterston Sands	NS1953	Linear shore	Mesotidal
49. Inner Clyde Estuary	NS3675	Fjord	Mesotidal
50. Ruel Estuary (Loch Riddon)	NS0079	Fjord	Mesotidal
51. Loch Gilp	NR8687	Fjord	Mesotidal
52. Tràigh Cill-a-Rubha (Bridgend Flats)	NR3362	Embayment	Microtidal
53. Loch Gruinart	NR2971	Fjord	Mesotidal

Estuary	Central grid ref.	Geomorph. type	Tidal range type
54. Loch Crinan	NR7993	Fjard	Mesotidal
55. Kentra Bay	NM6469	Fjard	Macrotidal
56. Loch Moidart	NM6873	Fjard	Macrotidal
57. Tràigh Mhór	NF7005	Embayment	Mesotidal
58. Bagh nam Faoilean	NF7948	Fjard	Macrotidal
59. Oitir Mhór	NF8158	Fjard	Macrotidal
60. Tràigh Vallay	NF7875	Fjard	Macrotidal
61. Oronsay	NF8575	Fjard	Macrotidal
62. Scarista	NF9992	Embayment	Mesotidal
63. Tràigh Luskentyre	NG0798	Fjord	Mesotidal
64. Camus Uig	NB0433	Fjard	Mesotidal
65. Laxdale Estuary	NB4434	Fjard	Macrotidal
66. Kyle of Durness	NC3766	Fjord	Mesotidal
67. Kyle of Tongue	NC5858	Fjord	Macrotidal
68. Torrisdale Bay	NC6962	Fjard	Macrotidal
69. Melvich Bay	NC8964	Fjard	Macrotidal
70. Otters Wick	HY6843	Fjard	Mesotidal
71. Cata Sand	HY7041	Bar built	Mesotidal
72. Kettletoft Bay	HY6739	Fjard	Mesotidal
73. Deer Sound & Peter's Pool	HY5404	Fjard	Mesotidal
74. Loch Fleet	NH7996	Bar built	Mesotidal
75. Dornoch Firth	NH7087	Complex	Mesotidal
76. Cromarty Firth	NH6667	Complex	Mesotidal
77. Inner Moray Firth	NH7152	Complex	Macrotidal
78. Lossie Estuary	NJ2470	Bar built	Macrotidal
79. Spey Bay	NJ3465	Bar built	Mesotidal
80. Banff Bay	NJ6964	Embayment	Mesotidal
81. Ythan Estuary	NK0026	Bar built	Mesotidal
82. Don Estuary	NJ9509	Coastal plain	Mesotidal
83. Dee Estuary (Grampian)	NJ9405	Coastal plain	Mesotidal
84. St Cyrus	NO7362	Bar built	Macrotidal
85. Montrose Basin	NO6957	Bar built	Macrotidal
86. Firth of Tay	NO3527	Complex	Mesotidal
87. Eden Estuary	NO4819	Bar built	Mesotidal
88. Firth of Forth	NT0182	Complex	Macrotidal
89. Tynninghame Bay	NT6480	Bar built	Macrotidal
90. Tweed Estuary	NT9853	Complex	Macrotidal
91. Lindisfarne & Budle Bay	NU1141	Barrier beach	Macrotidal
92. Alnmouth	NU2410	Bar built	Mesotidal
93. Warkworth Harbour (Coquet Estuary)	NU2605	Bar built	Mesotidal
94. Wansbeck Estuary	NZ3085	Coastal plain	Macrotidal
95. Blyth Estuary (Northumberland)	NZ3082	Bar built	Macrotidal
96. Tyne Estuary	NZ3466	Complex	Macrotidal
97. Wear Estuary	NZ3958	Complex	Macrotidal
98. Tees Estuary	NZ5326	Coastal plain	Macrotidal
99. Esk Estuary (Yorkshire)	NZ9010	Complex	Macrotidal
100. Humber Estuary	TA2118	Coastal plain	Macrotidal
101. The Wash	TF5540	Embayment	Macrotidal
102. North Norfolk Coast	TF8946	Barrier beach	Mesotidal
103. Breydon Water	TG4907	Bar built	Microtidal
104. Oulton Broad	TM5192	Bar built	Microtidal
105. Blyth Estuary (Suffolk)	TM4776	Bar built	Mesotidal
106. Ore/Alde/Butley Estuary	TM4357	Bar built	Mesotidal
107. Deben Estuary	TM2945	Coastal plain	Mesotidal
108. Orwell Estuary	TM2338	Coastal plain	Mesotidal
109. Stour Estuary	TM1833	Coastal plain	Mesotidal
110. Hamford Water	TM2325	Embayment	Mesotidal
111. Colne Estuary	TM0617	Coastal plain	Macrotidal
112. Blackwater Estuary	TL9507	Coastal plain	Macrotidal
113. Dengie Flat	TM0504	Linear shore	Macrotidal

Estuary	Central grid ref.	Geomorph. type	Tidal range type
114. Crouch-Roach Estuary	TQ9694	Coastal plain	Macrotidal
115. Maplin Sands	TR0087	Linear shore	Macrotidal
116. Southend-on-Sea	TQ8984	Linear shore	Macrotidal
117. Inner Thames Estuary	TQ6675	Coastal plain	Macrotidal
118. South Thames Marshes	TQ8180	Linear shore	Macrotidal
119. Medway Estuary	TQ8471	Coastal plain	Macrotidal
120. Swale Estuary	TR0066	Coastal plain	Macrotidal
121. Pegwell Bay	TR3563	Embayment	Macrotidal
122. Rother Estuary	TQ9419	Bar built	Macrotidal
123. Cuckmere Estuary	TV5198	Coastal plain	Macrotidal
124. Ouse Estuary	TQ4402	Coastal plain	Macrotidal
125. Adur Estuary	TQ2105	Coastal plain	Macrotidal
126. Arun Estuary	TQ0103	Coastal plain	Macrotidal
127. Pagham Harbour	SZ8796	Bar built	Macrotidal
128. Chichester Harbour	SU7600	Bar built	Macrotidal
129. Langstone Harbour	SU7002	Bar built	Macrotidal
130. Portsmouth Harbour	SU6203	Bar built	Macrotidal
131. Southampton Water	SU4506	Coastal plain	Mesotidal
132. Beaulieu River	SU4100	Bar built	Mesotidal
133. Lymington Estuary	SZ3395	Coastal plain	Mesotidal
134. Bembridge Harbour	SZ6388	Coastal plain	Mesotidal
135. Wootton Creek & Ryde Sands	SZ5592	Coastal plain	Mesotidal
136. Medina Estuary	SZ5093	Coastal plain	Macrotidal
137. Newtown Estuary	SZ4191	Bar built	Mesotidal
138. Yar Estuary	SZ3489	Coastal plain	Mesotidal
139. Christchurch Harbour	SZ1791	Bar built	Microtidal
140. Poole Harbour	SZ0189	Bar built	Microtidal
141. The Fleet & Portland Harbour	SY6181	Bar built	Microtidal
142. Axe Estuary	SY2591	Bar built	Mesotidal
143. Otter Estuary	SY0782	Bar built	Macrotidal
144. Exe Estuary	SX9883	Bar built	Macrotidal
145. Teign Estuary	SX9172	Ria	Macrotidal
146. Dart Estuary	SX8753	Ria	Macrotidal
147. Salcombe & Kingsbridge Estuary	SX7441	Ria	Macrotidal
148. Avon Estuary	SX6745	Ria	Macrotidal
149. Erme Estuary	SX6249	Ria	Macrotidal
150. Yealm Estuary	SX5449	Ria	Macrotidal
151. Plymouth Sound	SX4356	Ria	Macrotidal
152. Looe Estuary	SX2554	Ria	Macrotidal
153. Fowey Estuary	SX1255	Ria	Macrotidal
154. Fal Estuary	SW8334	Ria	Macrotidal
155. Helford Estuary	SW7626	Ria	Macrotidal
156. Lough Foyle	C5630	Coastal plain	Microtidal
157. Bann Estuary	C8235	Bar built	Microtidal
158. Larne Lough	D4300	Coastal plain	Mesotidal
159. Belfast Lough	J3982	Coastal plain	Mesotidal
160. Strangford Lough	J5660	Complex	Mesotidal
161. Killough Harbour	J54360	Embayment	Macrotidal
162. Dundrum Bay	J4137	Bar built	Macrotidal
163. Carlingford Lough	J2013	Complex	Macrotidal

## Appendix 2 Area, shoreline, channel length and tidal range measurements for UK estuaries

This table provides an updated and amended listing of estuary measurements to that given in *Nature conservation and estuaries in Great Britain* (Davidson *et al.* 1991); hence the figures listed here should be used instead of the 1991 listing. Amendments include the correction of typographical errors and some misinterpretation of the site boundaries which came to light in the production of the inventory. In addition, following a review of the consistency of the identification of areas of 'associated intertidal' habitat, many of these areas have now been included as part of the core estuary. However, for three estuaries (Ythan, Tees and Swale

Estuaries), areas of 'associated intertidal' have been retained separately (see 4.2.2).

This listing differs from that in Davidson *et al.* (1991) also by the inclusion of measurements of saltmarsh (where available) and by the inclusion of comparable measurements for Northern Ireland estuaries. Saltmarsh areas are derived from surveys by Burd (1989) unless otherwise stated - see section 5.3 for further details. These surveys covered only Great Britain and so saltmarsh areas are not available for estuaries in Northern Ireland.

Estuary	Area (ha)	Intertidal area (ha)	Saltmarsh (ha)	Shoreline (km)	Channel length (km)	Tidal range (m)
1. Hayle Estuary	358	321	19	19.5	2.4	5.0
2. Gannel Estuary	122	85	20	9.2	3.7	6.4
3. Camel Estuary	839	610	49	43.0	15.3	5.9
4. Taw-Torridge Estuary	2,463	2,018	240	87.9	20.8	7.3
5. Blue Anchor Bay	350	350	0	8.9	0	9.7
6. Bridgwater Bay	6,529	5,147	487	109.4	46.3	11.1
7. Severn Estuary	55,684	16,890	933	353.0	111.2	12.3
8. Thaw Estuary	160	160	8	4.7	0	10.5
9. Ogmore Estuary	187	173	15	8.0	1.6	8.9
10. Afan Estuary	38	18	0	4.9	2.5	8.6
11. Neath Estuary	1,129	1,079	159	26.9	10.6	8.6
12. Tawe Estuary & Swansea Bay	785	748	0	22.8	6.5	8.6
13. Loughor Estuary (Burry Inlet)	9,524	6,553	2,187	84.7	30.2	7.1
14. Carmarthen Bay	8,295	5,360	910	115.7	30.7	7.5
15. Milford Haven (Cleddau Estuary)	5,448	1,710	385	170.7	35.4	6.3
16. Nyfer Estuary	100	75	10	6.1	3.1	4.0
17. Teifi Estuary	302	181	46	21.0	10.0	4.1
18. Aberystwyth	18	5	1	7.1	2.4	4.3
19. Dyfi Estuary	1,954	1,524	546	52.2	19.6	4.3
20. Dysynni Estuary	117	69	22	9.9	4.4	4.3
21. Mawddach Estuary	1,159	976	219	37.7	13.8	4.3
22. Arthro Estuary	120	114	10	7.4	1.7	4.4
23. Traeth Bach (Glaslyn/Dwryd Estuary)	2,050	1,750	348	54.0	15.7	4.4
24. Pwllheli Harbour	85	60	3	4.6	2.4	4.5
25. Foryd Bay	343	285	123	9.4	4.5	4.7
26. Traeth Melynog (Braint Estuary)	365	314	66	10.9	5.4	4.7
27. Cefni Estuary (Malltraeth Estuary)	744	614	111	26.1	12.7	4.7
28. Alaw Estuary	1,085	721	63	38.2	10.4	5.0
29. Traeth Dulas	103	103	21	5.2	2.9	6.4
30. Traeth Coch (Red Wharf Bay)	583	583	31	10.0	4.4	6.4
31. Traeth Lafan	3,040	2,932	9	16.1	2.9	6.9
32. Conwy Estuary	1,494	1,081	105	55.8	24.7	7.1
33. Clwyd Estuary	422	386	43	19.1	8.1	6.7
34. Dee Estuary & North Wirral	16,101	12,981	2,108	108.5	36.8	7.6
35. Mersey Estuary	8,914	5,606	847	102.9	45.6	8.9
36. Alt Estuary	1,413	1,413	1	14.0	5.2	8.0
37. Ribble Estuary	11,924	10,674	2,184	107.5	28.4	7.9
38. Morecambe Bay	45,462	34,339	3,253	266.5	40.3	8.4
39. Duddon Estuary	6,092	5,056	537	65.5	22.6	8.1
40. Esk Estuary (Cumbria)	1,134	1,049	158	42.2	11.4	7.7
41. Inner Solway Firth	42,056	27,550	2,925	213.6	46.3	8.4
42. Rough Firth & Auchencraig Bay	1,290	1,289	135	44.4	14.4	6.7

Estuary	Area (ha)	Intertidal area (ha)	Saltmarsh (ha)	Shoreline (km)	Channel length (km)	Tidal range (m)
43. Dee Estuary (Dumfries & Galloway)	1,144	825	77	28.6	11.7	6.7
44. Water of Fleet	790	790	28	19.9	7.2	6.7
45. Cree Estuary	4,728	3,340	445	24.3	63.2	6.7
46. Luce Bay	1,228	1,196	36	27.5	8.5	5.3
47. Garnock Estuary	204	161	30	14.7	5.6	3.2
48. Hunterston Sands	291	291	0	16.4	0	2.9
49. Inner Clyde Estuary	5,485	1,841	67	129.7	41.9	3.0
50. Ruel Estuary (Loch Riddon)	426	184	7	15.4	6.7	3.0
51. Loch Gilp	245	143	0	6.8	3.4	3.1
52. Tràigh Cill-a-Rubha (Bridgend Flats)	639	288	40	8.6	3.0	1.5
53. Loch Gruinart	973	876	51	18.7	8.1	3.1
54. Loch Crinan	280	168	47	15.3	6.2	3.7
55. Kentra Bay	338	313	41	13.4	4.9	4.3
56. Loch Moidart	881	469	24	34.9	10.1	4.3
57. Tràigh Mhór	242	210	0	6.5	0	3.7
58. Bagh nam Faoilean	2,144	1,264	35	37.5	10.9	4.1
59. Oitir Mhór	5,519	4,028	144	292.4	13.3	4.1
60. Tràigh Vallay	1,113	823	15	22.9	6.9	4.1
61. Oronsay	1,278	825	6	29.9	6.3	4.1
62. Scarista	290	290	40	7.5	0	3.8
63. Tràigh Luskentyre	344	344	32	11.5	4.1	3.8
64. Camus Uig	438	214	10	18.0	5.5	3.6
65. Laxdale Estuary	559	390	96	12.8	4.7	4.1
66. Kyle of Dumess	1,328	561	6	28.9	12.7	4.0
67. Kyle of Tongue	1,818	422	8	37.2	14.2	4.3
68. Torrisdale Bay	200	139	11	9.8	2.9	4.3
69. Melvich Bay	78	33	4	6.9	3.0	4.3
70. Otters Wick	553	310	5	12.0	2.6	2.8
71. Cata Sand	218	204	7	7.9	1.3	2.8
72. Kettleoft Bay	191	122	6	6.7	1.9	2.8
73. Deer Sound & Peter's Pool	1,287	305	7	25.4	6.4	3.2
74. Loch Fleet	695	522	34	20.7	6.6	4.0
75. Dornoch Firth	11,663	4,397	400	284.5	42.8	3.4
76. Cromarty Firth	9,232	3,642	227	120.5	32.7	3.7
77. Inner Moray Firth	11,150	4,783	516	169.6	32.3	4.1
78. Lossie Estuary	56	30	2	13.3	4.4	4.1
79. Spey Bay	49	29	22	4.9	0.9	3.4
80. Banff Bay	102	16	1	8.6	2.8	3.1
81. Ythan Estuary	282	201	25	28.2	10.9	3.7
82. Don Estuary	23	9	1	5.5	2.4	3.7
83. Dee Estuary (Grampian)	97	7	0	18.7	5.8	3.7
84. St Cyrus	156	136	8	12.8	2.1	4.1
85. Montrose Basin	842	739	58	21.9	8.0	4.1
86. Firth of Tay	12,265	5,720	502	170.3	53.7	3.7
87. Eden Estuary	1,041	937	32	27.7	11.1	3.7
88. Firth of Forth	8,401	4,798	173	272.5	54.8	4.8
89. Tynninghame Bay	507	400	112	25.8	5.9	4.5
90. Tweed Estuary	199	68	0	27.7	9.9	4.1
91. Lindisfarne & Budle Bay	3,364	2,931	218	36.3	8.5	4.2
92. Alnmouth	135	111	24	12.7	4.4	3.3
93. Warkworth Harbour (Coquet Estuary)	75	45	15	12.9	5.0	3.3
94. Wansbeck Estuary	102	37	0	12.3	5.8	4.2
95. Blyth Estuary (Northumberland)	168	90	<0.5	21.5	6.6	4.2
96. Tyne Estuary	792	60	3	83.1	32.7	4.3
97. Wear Estuary	200	29	6	37.5	17.0	4.4
98. Tees Estuary	1,347	471	34	121.4	38.3	4.8
99. Esk Estuary (Yorkshire)	30	9	0	8.5	3.8	4.6
100. Humber Estuary	30,357	13,521	1,419	675.5	144.7	6.0
101. The Wash	66,654	29,770	4,228	359.0	90.2	6.5

Estuary	Area (ha)	Intertidal area (ha)	Saltmarsh (ha)	Shoreline (km)	Channel length (km)	Tidal range (m)
102. North Norfolk Coast	6,292	5,874	2,217	70.2	6.0	2.6
103. Breydon Water	1,534	769	<0.5	317.0	46.8	1.9
104. Oulton Broad	129	30	0	6.8	20.1	1.9
105. Blyth Estuary (Suffolk)	311	235	791 <sup>1</sup>	25.4	10.8	2.1
106. Ore/Alde/Butley Estuary	1,821	1,332	562	73.2	28.0	2.2
107. Deben Estuary	1,007	687	461	49.8	19.7	3.2
108. Orwell Estuary	1,786	576	119	50.7	20.1	3.6
109. Stour Estuary	2,531	1,637	297	48.1	19.6	3.6
110. Hamford Water	2,377	1,570	863	54.0	8.3	3.8
111. Colne Estuary	2,335	2,002	671	89.6	16.2	4.6
112. Blackwater Estuary	5,184	3,315	1,103	107.5	21.2	4.6
113. Dengie Flat	2,986	2,986	405	17.5	0	5.0
114. Crouch-Roach Estuary	2,754	1,536	8,382 <sup>2</sup>	158.5	29.6	5.0
115. Maplin Sands	11,519	9,443	2,212 <sup>2</sup>	18.2	0	4.6
116. Southend-on-Sea	2,737	2,528	395	71.7	8.8	5.2
117. Inner Thames Estuary	4,745	1,126	0	232.0	82.5	6.5
118. South Thames Marshes	2,487	2,439	78	30.6	4.7	5.2
119. Medway Estuary	6,441	4,008	754	143.4	40.9	5.1
120. Swale Estuary	3,283	2,696	414	79.3	18.4	4.9
121. Pegwell Bay	863	709	99	79.9	35.1	4.5
122. Rother Estuary	376	344	54	23.0	6.6	5.3
123. Cuckmere Estuary	47	15	10	16.7	8.4	6.5
124. Ouse Estuary	124	6	0	49.2	20.3	6.1
125. Adur Estuary	153	46	9	46.5	20.6	5.5
126. Arun Estuary	171	3	0	80.3	37.1	5.3
127. Pagham Harbour	266	245	33	9.8	2.6	4.9
128. Chichester Harbour	2,946	2,342	1,077	80.6	8.1	4.2
129. Langstone Harbour	1,925	1,513	100	43.0	7.7	4.2
130. Portsmouth Harbour	1,593	964	181	55.2	10.8	4.1
131. Southampton Water	3,975	1,376	355	109.8	20.2	4.0
132. Beaulieu River	546	417	185	31.3	10.4	3.2
133. Lymington Estuary	1,367	589	506	18.1	4.2	2.5
134. Bembridge Harbour	158	130	0	7.7	2.3	3.1
135. Wootton Creek & Ryde Sands	475	466	14	18.5	1.8	3.8
136. Medina Estuary	219	101	13	19.6	7.4	4.2
137. Newtown Estuary	332	296	120	30.0	3.3	2.9
138. Yar Estuary	110	97	66	7.9	3.2	2.5
139. Christchurch Harbour	239	122	50	21.4	6.6	1.2
140. Poole Harbour	3,805	2,050	697	102.9	16.3	1.4
141. The Fleet & Portland Harbour	1,617	278	51	47.5	16.7	1.9
142. Axe Estuary	79	62	34	8.1	3.8	3.7
143. Otter Estuary	36	19	19	6.1	1.1	4.1
144. Exe Estuary	1,874	1,201	66	47.8	16.7	4.1
145. Teign Estuary	370	219	13	20.4	9.1	4.2
146. Dart Estuary	863	313	25	60.5	19.8	4.0
147. Salcombe & Kingsbridge Estuary	674	446	4	48.6	8.3	4.6
148. Avon Estuary	214	146	26	19.8	7.8	4.7
149. Erme Estuary	145	72	21	17.1	6.0	4.7
150. Yealm Estuary	446	154	2	28.1	7.7	4.7
151. Plymouth Sound	3,962	1,809	359	208.6	34.1	4.7
152. Looe Estuary	56	43	6	12.6	4.1	4.8
153. Fowey Estuary	305	146	3	39.2	11.1	4.8
154. Fal Estuary	2,482	746	93	126.8	18.1	5.3
155. Helford Estuary	568	186	5	44.3	9.2	4.7
156. Lough Foyle	20,692	4,097	n/a	180.8	60.5	1.8
157. Bann Estuary	281	128	n/a	32.9	11.4	1.8
158. Larne Lough	1,189	393	n/a	34.0	11.3	2.4
159. Belfast Lough	13,480	554	n/a	100.0	28.4	2.9
160. Strangford Lough	14,513	3,930	n/a	242.7	35.8	3.2

161. Killough Harbour	213	106	n/a	8.5	2.7	4.6
162. Dundrum Bay	1,117	1,037	n/a	43.1	7.9	4.6
163. Carlingford Lough	5,135	1,490	n/a	63.4	26.7	4.1
<b>GB Total</b>	<b>531,257</b>	<b>310,298</b>	<b>42,496</b>	<b>9,217.5</b>	<b>2,446.9</b>	-
<b>NI Total</b>	<b>56,620</b>	<b>11,735</b>	-	<b>705.4</b>	<b>184.7</b>	-
<b>UK Total</b>	<b>587,877</b>	<b>322,033</b>		<b>9,922.9</b>	<b>2,631.6</b>	

<sup>1</sup> = measurement taken from aerial photographs; <sup>2</sup> = estimates based on data from Burd (1989) - see section 5.3 for details;  
n/a = areas for Northern Ireland saltmarshes not available.

**Additional measures: estuaries with 'associated intertidal' habitats** (see section 4.2.2).

Estuary	Associated intertidal area (ha)	Associated shoreline (km)
81. Ythan Estuary	83	2.8
98. Tees Estuary	454	19.1
120. Swale Estuary	244	12.3