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Conserving international coastal habitat networks on migratory waterfowl flyways

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Abstract. Migratory waterfowl depend on habitat networks at local, national and international scales for their survival. Coastal habitats are key areas for many waterfowl. Different species use different biotopes and in different places, so overall many parts of the coastal resource are important. As well as national conservation efforts, waterfowl conservation is increasingly focussed worldwide on collaborative international conservation, catalysed by several measures e.g. the Ramsar Convention, the EC Conservation of Wild Birds Directive, and the Bonn Convention Agreement on the Conservation of African/ Eurasian Migratory Waterbirds. Several international conservation plans are under development for single species, but a more effective approach may be to develop plans for assemblages of migratory birds with similar habitat requirements. All such plans must incorporate future sustainable use of the habitats on which the birds depend. Yet migratory bird and coastal habitat conservation is still often approached separately, despite the two being now closely linked to the development of the Natura 2000 site network in the European Community. Implementing the 1992 EC Habitats Directive requires the selection of coastal habitat sites for designation, set in national and international contexts of resource distribution. International coastal habitat inventories are needed to underpin this process. Combining such inventories with assessment of the flyway habitat requirements of waterfowl species and assemblages offers great potential for identifying international coastal habitat networks that meet the objectives of both habitat and migratory waterfowl conservation.

Keywords: Biotope classification; Convention; European Union; Habitat directive; Shorebird; Wildfowl.

Introduction

Migratory waterfowl (shorebirds and wildfowl)[1] undertake some of the longest and most spectacular migrations of any wildlife, with some species flying in just a few stages from breeding grounds on the northernmost land of the Arctic to the southern tips of South America, Africa and Australasia. As one of the great biological wonders of the world these migratory species and their migrations are widely recognised as a global conservation priority and are the subject of a wide variety of local, national and international conservation measures (Davidson et al. 1995).

In moving to and between its breeding, moulting and wintering areas each waterfowl population uses a network of sites on which it depends for its survival. Each waterfowl species and population has particular migration strategies and different habitat preferences and so migrates in a different way and uses a different suite of sites. This leads to many migration systems that overlap in space and time. From extensive research of these various migration systems it has been possible to group the migration routes into broad flyways, each of which is used, often in a similar way, by many species during their annual migrations. There are, for example, five widely recognised shorebird flyways covering shorebird species throughout Europe and Asia (Anon. 1992) (Fig. 1).

There are no distinct separations between flyways and their use is not intended to imply major biological significance. Rather the use of the flyway concept is valuable for the convenience of its approach in permitting the biology and conservation of migratory waterfowl, as with other migratory species, to be considered in broad geographical units into which the migrations and populations of species can be grouped.

This paper reviews key features of different scales of site and habitat networks used by migratory waterfowl as they move along flyways and summarises coastal habitat use by these birds. International agreements for migratory waterfowl conservation are largely based on measures to safeguard the birdsÕ habitats. We describe current international initiatives for waterfowl flyway conservation and relate these to developments in inter-

[1]In this paper we follow Rose & Stroud (1994) in using the term *waterfowl*, covering *shorebirds* and *wildfowl*, but excluding other *waterbirds* such as herons, storks and cranes. *Shorebirds* is a term synonymous with *waders*, and includes plovers e.g. Lapwing (*Vanellus vanellus*) and Grey Plover (*Pluvialis squatarola*), sandpipers e.g. Knot (*Calidris canutus*) and Redshank (*Tringa totanus*) and oystercatchers e.g. *Haematopus ostralegus*. Wildfowl are ducks e.g. Wigeon (*Anas penelope*), geese e.g. Brent Goose (*Branta bernicla*) and White-fronted Goose (*Anser albifrons*), and swans e.g. Tundra swan (*Cygnus bewickii*).

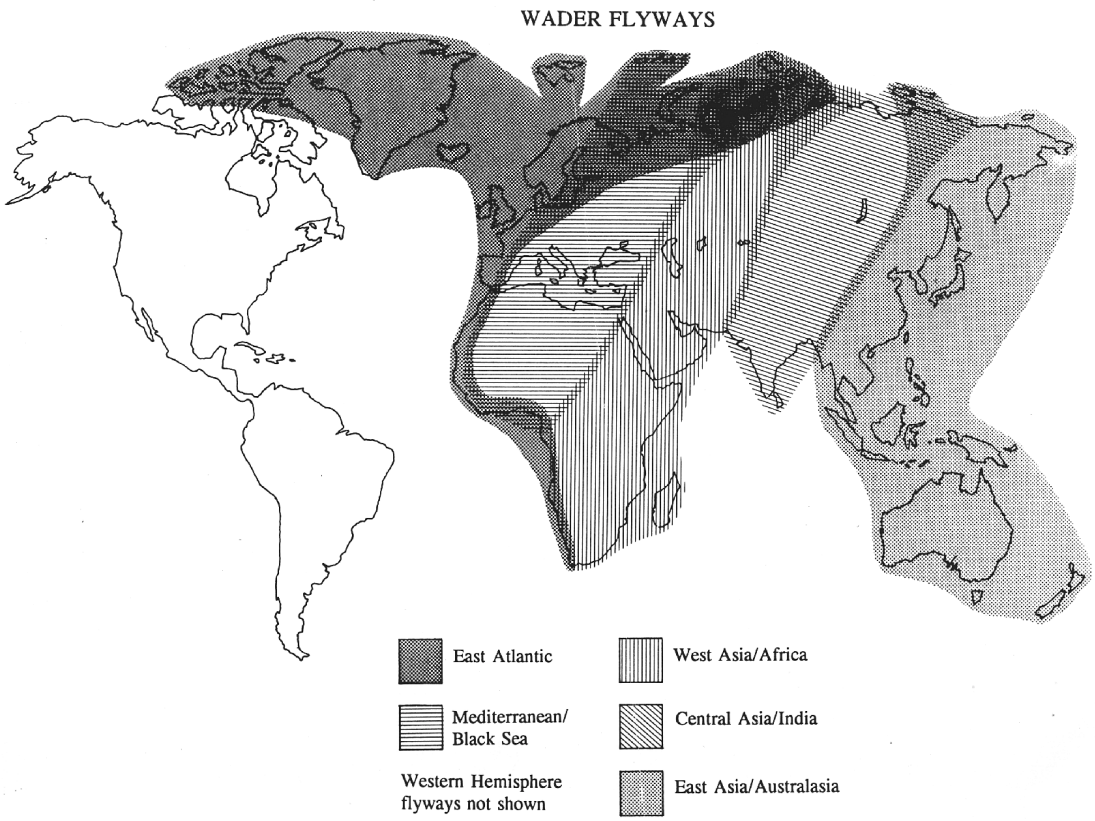

Fig. 1. Shorebird migration flyways involving Europe and Asia (from Wader Study Group 1992).

national habitat conservation in the coastal zone. For simplicity we draw our examples from site-based conservation but it is important to note that many waterfowl are highly dispersed at some times of year, e.g. when they are breeding, so that broader-based land-use planning consistent with maintaining wildlife also is an essential component of the conservation of migratory waterfowl. The underlying aim of the paper is to stress the benefits to be gained by ensuring that national and international habitat and bird conservation measures are more fully integrated.

Scales of coastal waterfowl movement

There are several geographical scales over which migratory waterfowl move during their year. Examples to illustrate these are given below. An understanding of each of these scales of movement and the site and habitat needs shown by the birds is important in developing international conservation measures. Identification of individual sites for conservation safeguard of migratory waterfowl has been largely achieved through regular counting of the numbers of birds using each site and the assessment of site use compared to national (e.g. Cranswick et al. 1992) and international (e.g. Pirot et al. 1989; Smit & Piersma 1989) population sizes. In supporting these conservation measures it is also important to understand why the birds use these sites and how they reach them. Knowledge of migration systems is, however, more patchy than knowledge of the distribution of populations (Davidson & Piersma 1992).

International flyways: large-scale movements through the annual cycle

Examples of the different scales of movements given below are chiefly for coastal waterfowl using the East Atlantic flyway. One of two major flyways crossing Europe, the East Atlantic flyway covers birds breeding over very large areas of arctic, boreal and temperate habitats from north-west Canada to mid-Siberia and moving to and through the Atlantic coastal habitats of Europe and Africa (Fig. 1).

Although flyways cover broad areas of the globe, many species of migratory waterfowl typically move

from being dispersed widely and sparsely over often non-coastal breeding grounds to much more localised and coastal overwintering areas. In doing so, many populations fly long distances non-stop, pausing at just a few key staging areas in which to store the fat and protein reserves they need both to power migratory flight and survive harsh conditions on arctic breeding grounds. These places, along with other areas where birds are preparing for migration, are particularly important parts of migratory networks since there can be few alternative places in suitable locations and with a sufficiently abundant food supply for birds on time-limited migrations (Evans et al. 1991).

Fig. 2a illustrates such an international migration system for one subspecies of the Knot (*Calidris canutus islandica*), a shorebird species whose global migrations are better known than most (Piersma & Davidson 1992). This population concentrates on a very few early spring areas on large British estuaries and in parts of the Wadden Sea, and then flies north to either one of a few areas of western Iceland or one of two fjords in northern Norway. There the birds feed intensively for two to three weeks before making another long flight to their breeding grounds. In autumn their migratory site use is even more localised, with almost all the population passing briefly through western Iceland, then a direct flight to a few major British estuaries and the Wadden Sea where they undergo a major body and wing feather moult. Note also in Fig. 2a that despite this species being more extensively studied than most, and having a rather simple migration system involving a small number of sites, the links between sites are not all understood.

Like most shorebird species the Knot depends on several quite different habitats during its annual cycle: it breeds only on high arctic tundra, feeding on seeds and insects, but on migration and in the wintering grounds it occurs chiefly on large muddy estuaries where it feeds almost entirely on marine molluscs.

Fig. 2b shows a similarly simple migration system for a wildfowl species: the three biogeographical populations of the Barnacle Goose (*Branta leucopsis*) using the East Atlantic flyway. These populations use even more localised staging areas than the Knot, and the Svalbard-breeding birds are particularly restricted on their wintering grounds, depending on only one estuary, the Solway Firth. They too breed on arctic tundra, but depend largely on grasslands on staging sites, and use saltmarshes, peatlands, grasslands and arable farmland in winter.

These two species show one extreme of migratory strategy: making long flights (sometimes over 3000 km) between a few coastal staging sites but waterfowl have evolved many different ways of moving between breeding and wintering grounds. Other species have evolved migratory strategies that involve a rapid flight over short distances (several 100 km) with many brief stops, while others use an intermediate strategy of fewer stops between 500-1000 km (Piersma 1987). There is also some evidence that several different migration strategies may exist within a single biogeographic population.

These few examples illustrate several important features of flyway migrations that need to be incorporated into effective conservation for both waterfowl and coastal habitats:

¥ some individuals, populations or species depend on just a few key places during their annual migrations, others require a network of many places at relatively short distances apart;

¥ key migratory staging areas are often used for only very short (days or weeks) periods of the year;

¥ many different migratory strategies can occur in populations using the same flyway;

¥ migratory waterfowl depend on very different biotopes at different times of year, e.g. Knots breeding on arctic tundra and overwintering on large estuaries;

¥ different species and populations depend on many different locations and different habitats within the flyway;

¥ even for some well-studied species there remain considerable gaps in our knowledge of migratory routes, many of which will be difficult to fill.

Movements and site networks within a non-breeding season

As well as their long-distance flights between breeding and wintering grounds many waterfowl, especially shorebirds, are highly mobile over shorter distances and over shorter time-periods. Research has identified a wide variety of these within-season movements. Some patterns are very complex and their elucidation has depended on international research collaboration. An example is the autumn and winter movements of the Dunlin subspecies (*Calidris alpina alpina*) that winters in western Europe (Pienkowski & Pienkowski 1983). In this population late autumn post-moulting movements are typically flights of several hundred km westwards into the British Isles and south-westwards to the Atlantic coast of south-west Europe (Fig. 3). Analyses showed that the sites could be grouped into several zones within which movements to and from individual sites were similar - the overall pattern of movement generated by the many different itineraries of individual Dunlins is thus even more complex.

Although the midwinter period is generally when waterfowl are least mobile, Pienkowski & Pienkowski (1983) found that even then there were some inter-estuarine movements by Dunlins. Other species are

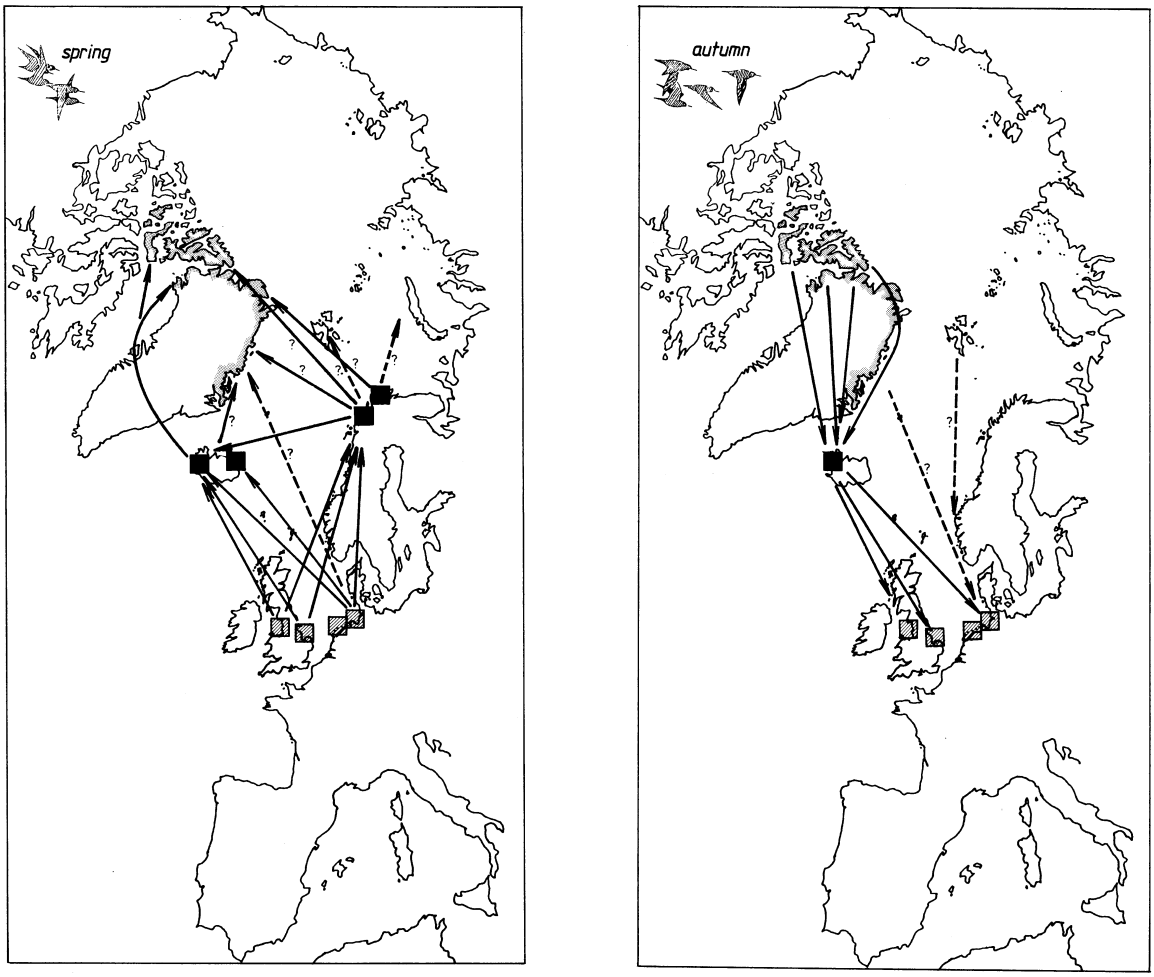

Fig. 2. a. The spring and autumn migration systems of a subspecies of Knot (*Calidris canutus islandica*) which overwinters chiefly on large estuaries in the British Isles and southern North Sea (from Davidson & Wilson 1992); and **b. (**overleaf**)** the autumn migration systems of three populations of Barnacle Goose (*Branta bernicla*) using the East Atlantic flyway (from Stroud et al. 1990).

more mobile: for example Knots move during a single winter between several estuaries in eastern Britain (Dugan 1981), and other species such as the Sanderling (*Calidris alba*) move up and down several tens of km along sandy coastlines during winter (e.g. Roberts 1991). These more mobile species are thought to be those whose food supply is unpredictable and so their movement patterns can differ from year to year. An implication here is that more than one site in an area needs to be conserved if the birdsÕ feeding requirements are to be met in all years.

Several studies have found that some estuarine species including Knot, Dunlin and Bar-tailed Godwit (*Limosa lapponica*) are consistently more mobile than others (e.g. Symonds et al. 1984; Symonds & Langslow 1986; Mitchell et al. 1988). During short periods (days or weeks) of the winter, individuals of such species can move between feeding and roosting areas in different parts of large estuarine complexes. Hence site safeguard depends on maintaining each part of this linked resource if it is to meet the requirements for these mobile species.

Another, episodic, winter mobility that requires site safeguard for places used in only some years is the response to cold weather. Many waterfowl move westwards from continental Europe into Britain, and from eastern Britain to the western British Isles and southwest Europe during periods of prolonged severe weather (Ridgill & Fox 1990). Under such circumstances a coastal area used only briefly every few years can be critical for the survival of these long-lived birds.

These movement patterns and their significance are reviewed further by Pienkowski & Evans (1985), Stroud et al. (1990) and Davidson et al. (1991).

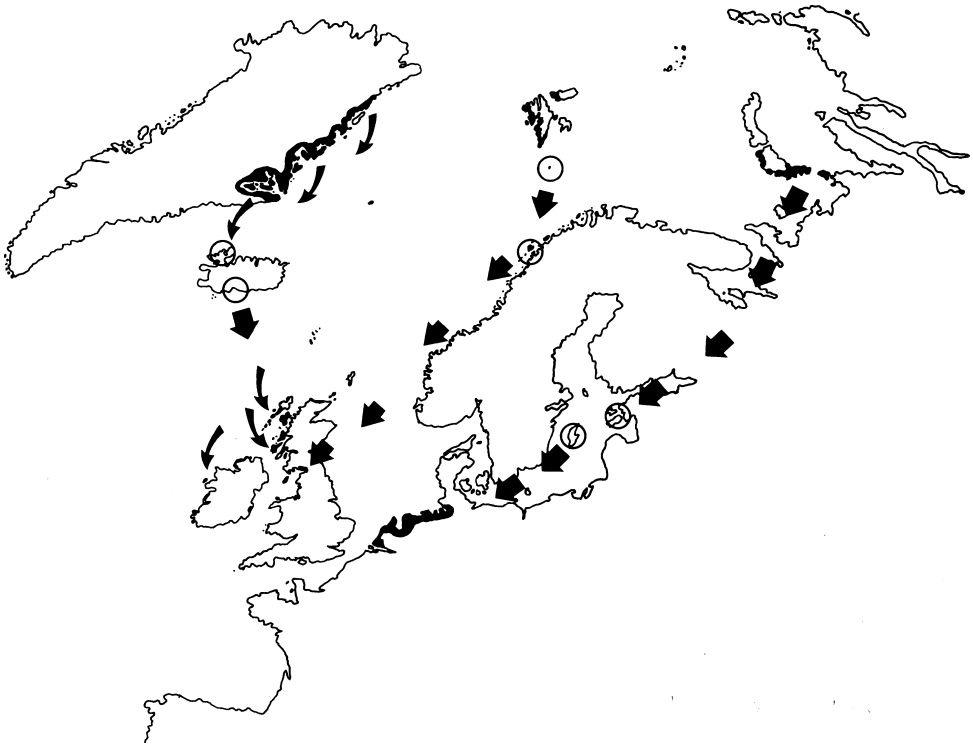

Fig. 2. (*continued*)

Using habitat mosaics within a site - movements during the tidal cycle

Coastal-wintering waterfowl typically utilise several coastal habitats during a single tidal cycle, but habitat choice and the pattern of use varies interspecifically, and sometimes geographically. For example, estuarine shorebirds typically feed on soft tidal flats when these are exposed by the tide, and then move to saltmarshes and a variety of terrestrial maritime habitats to roost during the high tide period. Whilst some north-west European wildfowl feed on saltmarshes and marine grasses (e.g. *Zostera)* on a tidal cycle, others feed during daytime on grasslands and farmland, returning to roost at night on an estuary or other water body. In contrast, on Mediterranean coasts, where there is little tidal movement, many wildfowl appear for daytime roosts and feed intensively in fresh and brackish water marshes at night.

Within a single tidal cycle shorebirds may move several times to exploit the food supply as it is exposed and covered by the tide. For example Knots wintering on the Tees estuary in eastern Britain feed at low tide on rocky shores outside the estuary mouth, move to estuarine mudflats during mid-tide, and then to high tidal level sandflats as the tide rises further, before moving to roost on sand dunes and low islands at high tide (Davidson & Evans 1986). On the same estuary other species e.g. Curlew (*Numenius arquata*) move from feeding on tidal flats at low tide to feeding and roosting on coastal grasslands at high tide (Davidson & Evans 1986).

Coastal habitat use by migrant waterfowl

Table 1 summarises the pattern of coastal habitat use by shorebirds and wildfowl using the East Atlantic flyway. Non-breeding season use includes habitats used on wintering grounds, moulting areas and migratory staging sites. Habitat availability differs geographically: some habitats e.g. mangrove are restricted to tropical coastlines, others occur in both southern Europe and Africa (rice fields, salinas), and some (e.g. mudflats and sandflats) are widely distributed throughout the Atlantic coastline.

Table 1 emphasises that almost all Atlantic coastal habitats support shorebird or wildfowl (or both) during stages of their annual cycle. The only major coastal habitat type on the Atlantic coast that is not used by migratory waterfowl is cliffs. Cliffs, however, are of

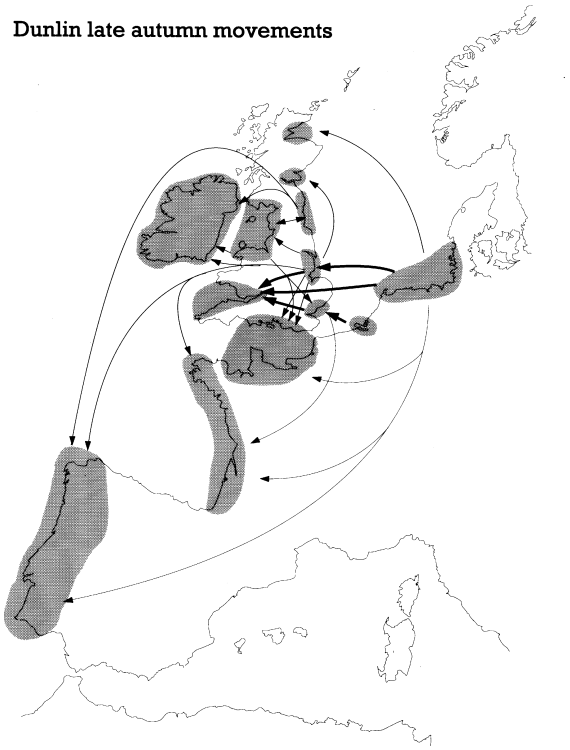

Fig. 3. Late autumn movements of Dunlin (*Calidris alpina alpina*) show a complex network of site use. Arrows show known movements during a single autumn between different regions (shown shaded) of the wintering area. Lines show links between sites but not actual migration routes. From Davidson et al. (1991) after Pienkowski & Pienkowski (1983).

great importance as habitat for other groups of birds for which there are international conservation commitments, notably for many species of breeding seabirds (Stroud et al. 1990).

Individual species and populations on the East Atlantic flyway have different habitat preferences and so each uses a subset of the range of habitats listed in Table 1. An analysis of the waterfowl assemblages using each habitat (Table 2) shows that many habitats are used by large percentages of the total species assemblage, but that the extent of use of any particular habitat varies between wildfowl and shorebirds, and during different stages of the annual cycle. For example the most diverse assemblages of feeding shorebirds during their non-breeding season are on mudflats and sandflats, with rocky shore, lagoons and salinas also providing feeding habitat for many species. Similarly many species of wildfowl feed on mudflats and lagoons, but there are also diverse assemblages on saltmarshes, wet grasslands and floodlands and arable farmland.

Rather few wildfowl species commonly nest on the coast but important assemblages of coastal breeding shorebirds are spread across a variety of habitats, especially saltmarshes, maritime heathlands, dry grasslands and machair, and wet grasslands (Table 2).

International conservation measures need to be applied to each of these individual species contributing to these assemblages, to ensure that each species flyway network as well as that for the overall waterfowl assemblage is covered.

A major implication to be drawn from Tables 1 and 2 for the development of effective coastal habitat conservation for migratory waterfowl on the East Atlantic flyway is the need to safeguard mosaics of inter-related habitats within sites, as well as across the national and international networks of each habitat. Furthermore Tables 1 and 2 include several habitats that are created or extensively managed by people (salinas, rice fields,

Table 1. The main coastal (marine waters, intertidal and maritime terrestrial) habitats utilised by East Atlantic waterfowl (shorebirds and wildfowl) on the Atlantic seaboard of Europe and Africa. Habitat use was derived from Cramp & Simmons (1977 & 1983) since these provide a standard source for all species. Species and habitats excluded from this summary are a) species using chiefly inland and freshwater habitats during the non-breeding season, and b) breeding habitats used by arctic, subarctic and boreal species (e.g. tundra, freshwater marshlands, forest and peatlands). Habitats marked * are listed as one or more habitat types in Annex I of the EC Habitats Directive.

Habitat	Non-breeding season feeding	Non-breeding season roosting	Breeding season nesting	Breeding season feeding
Tidal waters *	wildfowl	wildfowl		wildfowl
Lagoons *	shorebirds & wildfowl	shorebirds & wildfowl	shorebirds	shorebirds & wildfowl
Salinas	shorebirds & wildfowl	shorebirds & wildfowl	shorebirds	shorebirds
Mudflats *	shorebirds & wildfowl	shorebirds & wildfowl		shorebirds & wildfowl
Sandflats *	shorebirds & wildfowl	shorebirds & wildfowl		shorebirds & wildfowl
Saltmarshes *	wildfowl	shorebirds & wildfowl	shorebirds	shorebirds & wildfowl
Mangrove		shorebirds		
Shingle *		shorebirds	shorebirds	
Rocky shores *	shorebirds	shorebirds	shorebirds	shorebirds
Cliffs *				
Sand dunes *			shorebirds	
Wet grasslands	shorebirds & wildfowl	shorebirds & wildfowl	shorebirds & wildfowl	shorebirds & wildfowl
Arable farmland	wildfowl	shorebirds & wildfowl		
Rice fields	shorebirds			

Key:
shorebirds
wildfowl
shorebirds & wildfowl

arable farmland). These are used extensively, especially by wintering wildfowl and breeding shorebirds, but are not generally the subject of coastal habitat conservation measures, which are usually concerned with those habitats and areas least affected by anthropogenic change. The r™le and importance of these more artificial habitats needs to be considered in developing waterfowl flyway conservation.

Conserving waterfowl flyways

There are many international statutory commitments and some non-statutory agreements that are used to safeguard migratory waterfowl populations around the world. Some of the main measures are listed in Table 3. The terms and implementation of many of these have been recently described by SalathŽ (1991). In addition to these international measures there are many domestic designations and legislation that include safeguards for migratory waterfowl and coastal habitats - see e.g. Davidson et al. (1991) for a review of coastal habitat and waterfowl protective measures for Great Britain. These often provide the mechanism through which international conservation measures are delivered. The key measures for conserving waterfowl and their habitats on the European coastline are described below, as are some current and future initiatives.

Table 2. The percentages of watefowl (shorebird and wildfowl) species commonly occurring on the Atlantic coasts of Europe (excluding Iceland) and North Africa that utilise each coastal habitat at different stages of their annual cycle. Total numbers of species included in the analysis are: feeding wildfowl (non-breeding season) 24; feeding shorebirds (non-breeding season) 27; and nesting shorebirds 17. Infrequent habitat uses by each species were not scored. Habitats marked * support between 9-27% of the 11 species of breeding wildfowl commonly occuring on the coast. Habitat use was derived from Cramp & Simmons (1977 & 1983) since these provide standard sources for all species.

Coastal habitat	Feeding (non-breeding season) wildfowl (%)	shorebirds (%)	Nesting shorebirds (%)
Inshore marine/ tidal channels	12	1	0
Lagoons *	38	37	12
Salinas	17	33	2
Mudflats	38	81	0
Sandflats/sandy shores	8	48	0
Saltmarshes	25	15	41
Rocky shores/rocks	4	30	3
Terrestrial shingle/sand	0	2	24
Sand dunes *	0	0	3
Dry grasslands/ machair *	8	15	29
Maritime heathlands *	0	0	41
Wet grasslands/ floodlands *	38	19	29
Peatlands	4	4	18
Arable farmland	42	11	24
Rice fields	8	7	0

Table 3. Main international conservation measures and agreements relevant to waterfowl and their habitats (from Davidson et al. 1995). Dates in parentheses give date of declaration or implementation. Note that some measures, e.g. Ramsar Convention, are given only as their abbreviated title.

Worldwide
- ¥ Ramsar Convention (1971)
- ¥ World Heritage Convention (1972)
- ¥ CITES (1973)
- ¥ Bonn Convention (1979)

Europe/Africa/West Asia
- ¥ Bern Convention (1979)
- ¥ EEC Wild Birds Directive (1979)
- ¥ African Convention (1968)
- ¥ EC Habitats and Species Directive (1992)

East Asia/Australasia

Bilateral agreements between USA, Japan, China, Australia, India, (former USSR), e.g.:
- ¥ JAMBA (Japan-Australia Migratory Birds Agreement)

Americas
- ¥ Protection of Migratory Birds Convention (1916)
- ¥ Protection of Migratory Birds & Game Mammals Convention (1936)
- ¥ Western Hemisphere Convention (1940)
- ¥ US-Japan Migratory Birds Convention (1976)
- ¥ US-USSR Migratory Birds Convention (1976)
- ¥ Western Hemisphere Shorebird Reserve Network (WHSRN) (1985)
- ¥ North American Waterfowl Management Plan (NAWMP) (1986)

International agreements

Two international agreements have provided the impetus and framework for the conservation of migratory waterfowl on parts of the East Atlantic flyway. The first is the *Convention on wetlands of international importance especially as waterfowl habitat*, for convenience usually called the ÔRamsar ConventionÕ after the Iranian town in which it was adopted in 1971. In EC countries delivery of site safeguard of international wetland and waterfowl through the Ramsar Convention has been facilitated by the requirements of the EEC Directive on the conservation of wild birds (Directive EEC/79/409) adopted in 1979, and often known as Ôthe EEC Birds DirectiveÕ.

The Ramsar Convention requires contracting parties to take steps to stem the progressive encroachment on and loss of wetlands, to promote the wise use of wetlands and to identify and list wetlands of international importance. The EEC Birds Directive includes a number of

broad conservation policies for maintaining and enhancing naturally occurring bird populations, including the designation of Special Protection Areas (SPAs) as well as wider countryside measures for dispersed species. Member states are required to take special measures for two groups of birds: certain listed rare or vulnerable species, and regularly occurring migratory species. In a link to the Ramsar Convention the Directive stresses that particular attention shall be paid to the protection of wetlands and particularly to wetlands of international importance. In practice this means that many coastal wetlands are designated under both the Ramsar Convention and EEC Birds Directive in Britain (Davidson et al. 1991) as elsewhere in Europe.

A key feature of both these measures lies in the way they link the conservation of areas of habitat with the conservation of birds, notably migratory waterfowl, dependent on these places. Some of the criteria for site selection under the Ramsar Convention specifically concern the assemblages of plants and animals in wetlands, although in practice the numerical criteria for site selection for migratory waterfowl populations have proved most widely and readily applicable. Likewise the Birds Directive stresses the safeguard of wetlands of international importance and requires member states to take appropriate steps to avoid pollution or deterioration of habitats. The link was made particularly strongly in a Council Resolution issued at the same time as the Birds Directive, in which member states were called upon to take account of the need to protect biotopes and flora and fauna in the designation of Special Protection Areas (Stroud et al. 1990). Hence SPAs can provide a mechanism for the protection of biotopes where these are used by internationally important bird populations.

The Ramsar Convention and the Birds Directive lead to the designation of a suite of sites, each of which supports an important component of migratory bird populations. Implicit in this is the need for co-ordinated action between countries on migratory flyways so as to conserve a shared resource. Such co-operation forms the basis of the 1992 Odessa Protocol on International Co-operation on Migratory Flyway Research and Conservation (Anon. 1992), has been stressed by the recent meetings of the Parties to the Ramsar Convention (Anon. 1990, 1993a) and is explicit in the Bonn Convention on the Conservation of Migratory Species of Wild Animals.

The Bonn Convention includes a mechanism for establishing Agreements between groups of Range States for the conservation and management of migratory species, with such agreements covering all aspects of the speciesÕ conservation including habitat conservation. Of particular relevance is the Agreement on the Conservation of African/Eurasian Migratory Waterbirds (Anon. 1995a). This Agreement, expanded from the earlier proposals for a Western Palearctic Waterfowl Agreement (Anon. 1991), provides a mechanism for co-ordinating and linking conservation action on the two major flyways involving Europe, and provides a framework for developing consistent site safeguards and co-ordinated species/population conservation strategies. Consistent action may prove of great value since there is currently great variation in the level and extent of safeguards applied in different parts of a flyway. This means that the degree of habitat safeguard for a species varies considerably between countries, flyways and seasons (for an example see Davidson & Piersma 1992).

There is an increasing variety of other international developments, described in SalathŽ (1991). Not all are based around statutory designations. One highly successful non-statutory mechanism operates in the Americas to raise support and awareness of the importance of key wetland sites on shorebird flyways: the Western Hemisphere Shorebird Reserve Network (WHSRN), now operates as part of the Wetlands for the Americas programme. Since its establishment in 1985 WHSRN has linked 16 reserves covering about 1.5 million ha throughout the Americas. Central to the network is the understanding that the conservation and management of shorebird habitat remains the responsibility of the inhabitants of the region in which the reserve is located (Hunter et al. 1991). Such voluntary initiatives may have considerable potential for complementing statutory coastal designations on the East Atlantic flyway (Davidson et al. 1995).

Flyway conservation and management plans

An increasingly-used approach to international flyway conservation is the production of co-ordinated plans (variously called action, recovery, conservation or management plans). Plans fall into two broad types.

First there are expert analyses of conservation requirements that provide a strategic review useful for conservation agencies but at most provide a blueprint for future action by a wide range of governmental and non-governmental bodies. Synoptic reviews of the conservation needs of populations or along migratory flyways fall into this category. Coastal examples include Lane & Parish (1991) for the Asian-Australasian flyway; Davidson & Piersma (1992) for the Knot; Davidson et al. (1995) for shorebirds world-wide.

Second are plans resulting from the working together of parties responsible for initiating actions. These provide both a statement of need and some, usually more formalised, commitment towards actions to deliver flyway conservation (Stroud 1993). Examples include the North American Waterfowl Plan; the Bonn Convention Agreement on the Conservation of African/

Eurasian Migratory Waterbirds; and the Greenland White-fronted Goose (*Anser albifrons flavirostris*) international conservation plan currently being finalised (Stroud 1993). Such plans will be required for some species (and urged for others) under the Bonn Convention migratory waterbird agreements.

In view of this requirement under waterbird agreements the International Waterfowl & Wetlands Research Bureau (IWRB) (now Wetlands International) is using the experience of developing plans such as that for the Greenland White-fronted Goose to provide an agreed protocol for use as a model for further plan development. The Greenland White-fronted Goose plan has been developed jointly by the five countries (Greenland and Denmark, Iceland, Ireland and the UK) on the birdsÕ flyway, and a draft plan (Stroud 1992) is now under revision. The plan sets an agreed agenda for action based on an analysis of flyway use and conservation needs. It formulates broad goals at an international level, the achievement of which will be developed at a national level, considers constraints to the achievement of the goal ideals and identified specified limits to change based on an understanding of the population dynamics of the species. Mechanisms are established to trigger action under the plan if there is divergence from these limits e.g. if there is a rapid continuing population decline. The implementation of the plan is based on the maintenance and management of those areas used by the geese. Key to the international conservation of this species is the understanding of, and management of, anthropogenic pressures, e.g. hunting and habitat loss, on a long-distance migrant with a highly localised distribution. For further information about international management plan development see Stroud (1992, 1993, 1994).

Information needs and availability

Underpinning the development of international flyway plans is knowledge of the distribution and biology of the species concerned. It can, however, be difficult to establish the level of detail at which information is essential to putting in place effective conservation measures, in relation to what is currently known. This issue is reviewed generally for migratory shorebirds by Davidson et al. (1995) and Davidson & Piersma (1992) for one coastal waterfowl species world-wide.
In general there are several types of biological information that can be needed as the basis for setting flyway plan objectives. These include:

(1) distribution and population size (both total numbers of a biogeographical population, and numbers at each site used);
(2) the ecology and population dynamics of the population(s) (e.g. which habitats are used (see Tables 1 and 2);
(3) the role each site plays in the annual cycles of each population;
(4) how each site is used in relation to other sites on the flyway; and
(5) the features of each site that determine its use.

In addition there are needs for human-related information, e.g.:

(1) the current constraints on site use by waterfowl populations;
(2) the pressures that threaten continued usage of each site; and
(3) the level of conservation law provision in different flyway countries.

Although the types of information listed appear simple, in practice it can be very complex to provide clear answers to some of the topics. For example identification and selection of sites for conservation designation can depend on knowing just the maximum numbers using a site, and the extent of the site used. Such vital basic information is becoming increasingly widely available, often through the activities of widespread volunteer networks (see e.g. Anon. (1994), Cranswick et al. (1992) for the UK, Rose & Taylor (1993) for Europe, and Taylor & Rose (1994) for Africa. Increasingly, however, this type of information alone is insufficient for providing acceptance of the conservation needs of migratory species, especially in the face of increasingly sophisticated arguments for increasing damaging human uses of sites in flyway networks. It is often information about the links between sites and flyways that proves most difficult to collect, and itself requires major international collaboration to achieve (Piersma & Davidson 1992).

Davidson & Piersma (1992) have recently reviewed current levels of knowledge in relation to perceived information needs for one of the better-known coastal waterfowl species, the Knot. This has revealed large gaps in even the most basic types of knowledge for some subspecies, for example in population size and breeding locations (Table 4). For this species substantial new discoveries about the location and use of sites have been made over the last 10 years even for the intensively studied populations using the East Atlantic flyway. In other parts of the world careful scrutiny of available information reveals that for some populations knowledge is poor even for the most basic types of information such as population size and location of breeding and wintering sites.

Table 4. Levels of knowledge of key features of flyway use by different subspecies of the Knot *Calidris canutus* (from Davidson & Piersma 1992). Note that levels of knowledge are better for the two subspecies [*canutus* (*can*) and *islandica*(*isl*)] using the East Atlantic flyway than for other subspecies (*ruf* = *rufa*; *rog* = *rogersi*; *ros* = *roselaari*).

	subspecies				
Topic	*can*	*isl*	*ruf*	*rog*	*ros*
Population size & trend	☺☹	☺☺☺	☹	☹	☹
Breeding location	☺☹	☺☹	☺☹	☹	☹
Non-breeding location	☺☺☺	☺☺☺	☺☹	☺☹	☹
Site r™les & links	☺☺☺	☺☺☺	☹	☹	o
Key features of sites	☺☺☺	☺☺☺	☺☹	☹	o
Pressures on sites	☺☺☺	☺☺☺	☹	☹	o
Constraints on site use	☺☹	☺☹	☹	☹	o

Level of knowledge: ☺☺☺ good; ☺☹ fair; ☹ poor; o none.

Such analyses help to identify key gaps in the information base for coastal migrant waterfowl. Attempting to fill such gaps forms one of the key steps (along with assessing how and where human impacts occur, and determining the effectiveness of conservation action along the flyway) needed to promote future flyway conservation plans. Nevertheless much can be and is being achieved through the collation of existing levels of knowledge of migratory waterfowl, and the value of this use can be maximised by ensuring that the habitat conservation objectives for waterfowl are linked to the objectives of conserving the habitat in its own right.

Coastal habitat conservation initiatives

The EC ÔHabitats DirectiveÕ

The implementation of the 1992 *EC Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora* (commonly known as the ÔHabitats DirectiveÕ) has focused attention and activity on the objective of establishing a coherent European ecological network of sites under the title of *Natura 2000.* Under the Directive this is achieved by Member States first identifying a suite of sites of community importance at a national level. Subsequently these sites may, with Commission agreement, be designated as Special Areas of Conservation (SACs). For species, the Directive provides lists of plants and animals (except birds, which are covered by the earlier Birds Directive) whose conservation requires designation of SACs and others in need of strict protection or whose exploitation may need appropriate management measures. For habitats the Directive lists (in Annex 1) habitat types based on the CORINE classification of biotopes. Those habitat types that are considered in danger of disappearance and whose range is largely within the EC area are termed *priority habitats*. These are afforded a higher degree of protection. More than one habitat type and/or Directive-listed species can occur within a site of community importance; indeed the number of these features present in a site forms one of the criteria against which the site is assessed for potential SAC designation. Others include site area and the ecological value of the site for its relevant biogeographical region (five are defined: Alpine, Atlantic, Continental, Macaronesian and Mediterranean) and/or for the EC area.

The Directive establishes links with the Birds Directive, notably that the Natura 2000 site network is to be formed from both SACs and SPAs. Hence the two designations appear complementary. Since sites of community importance may be identified under the Habitats Directive that are already designated or proposed SPAs there will be some geographical overlap in the two designations contributing to the Natura 2000 list.

Article 10 of the Habitats Directive is particularly important in relation to migratory waterfowl. It indicates the importance of improving the ecological coherence of Natura 2000 by encouraging the management of linear features and those that function as essential stepping stones in the migration of species. Coastlines are amongst the most continuous of linear features, and the stepping stone approach emphasised in Article 10 offers a potentially strong link between coastal habitat networks and the objectives of the international flyway conservation plans described above.

Annex I of the Habitats Directive lists 39 habitat types for Coastal and Halophytic Habitats and Coastal Sand Dunes, of which 10 are identified as priority habitats. In addition, some other coastal habitats, e.g. dry coastal heath, are listed under terrestrial groupings. The habitat types provide, however, an uneven spread across the coastal habitat spectrum: for example estuaries are considered as one habitat type but there are 20 sand dune types and seven saltmarsh types. Some categories of habitat types cover the entire EC area (e.g. ÔOpen seas and tidal areasÕ); others refer to one or more of the biogeographic areas (e.g. ÔSea dunes of the Mediterranean coastsÕ).

It is not yet possible to assess the relationship between areas and sites for coastal habitats in the SPA network and any future SAC network, since site selection and delimitation procedures for SACs are not complete. Some general points can, however, be made, drawing chiefly on the situation in the UK.

First, habitat types listed in the Habitats Directive do not cover all the main habitat types on which coastal

migratory waterfowl depend (Table 1). Although habitats excluded are chiefly heavily human-influenced (e.g. salinas, arable farmland, rice fields) or occur only outside the EC area (e.g. mangroves), also in this category are lowland coastal wet grasslands (grazing marshes). These have intrinsic habitat conservation value as well as being of major importance to both breeding and wintering waterfowl, with some areas designated SPA for this reason (Stroud et al. 1990; Hštker 1991). So the SPA network will include some areas outside the terms of the Habitats Directive. Conversely some important coastal habitats e.g. cliffs and sand dunes fall within the Habitats Directive but are little used by migratory waterfowl (although note that some of these areas are in the SPA network for their breeding seabird populations).

Second, in addition to those sites chosen for their coastal habitat type(s) some areas of coastal habitats will be identified as sites of community importance for the presence of plant and animal species listed in Annex II of the Habitats Directive. In the UK this includes the small snail *Vertigo angustior* whose occurrence includes coastal grazing marshes, and plants including *Liparis loeselii* in sand dune slacks, and *Gentianella anglica* on calcareous grasslands including coastal sites. Several mammals listed in Annex II may also require substantial areas of coastal habitats in the UK under the Directive, notably the Otter (*Lutra lutra*), Grey Seal (*Halichoerus gryphus*) and Common Seal (*Phoca vitulina*), Harbour Porpoise (*Phocoena phocoena*) and Bottle-nosed Dolphin (*Tursiops truncatus*). In some places the sites selected for species will be those also selected for habitats, but elsewhere they will be only for species - a parallel with the designation of coastal habitat areas under the Birds Directive.

Third, the area of some coastal habitats covered by national proposed and designated SPA networks could be larger than those areas identified directly as coastal habitat of community importance through the Habitats Directive. For example 38780 ha of saltmarsh, some 87% of the total area of saltmarsh habitat in Great Britain, is on estuaries in the British SPA network. Over 90% of British saltmarsh will be included in the SPA network since saltmarshes provide important feeding, roosting and nesting habitat for waterfowl. Almost all the SACs selected for saltmarsh under criteria relating to size, diversity and natural functioning fall within these SPA areas, and the overall coverage of saltmarsh by SACs will be much less than that by SPAs (Davidson et al. in litt.). In contrast, however, it seems probable that many potential sites of community importance selected as examples of, for instance, sand dunes or reefs will be in other geographical locations than SPAs.

Clearly then the potential for SACs to complement the existing suite of SPAs as an international coastal habitat network is considerable. In some places, where SPAs exist, such sites will widen the range of conservation features identified as internationally important; in others, outside SPAs, they will widen the geographical recognition of the international wildlife and environmental importance of the coastal zone.

Resource and activity inventories

In selecting sites for habitat types listed by the Habitats Directive, member states are required to set these sites in the context of the size and distribution of the national habitat resource, and to make a global assessment of the value of the site for the conservation of the habitat type [Annex II, A (b) and A (d)]. Once SACs are designated surveillance of their conservation status is also required. There are also requirements to avoid deterioration of habitats and disturbance to species in SACs. Similarly, the Birds Directive indicates that particular attention shall be paid to research and work on subjects that include the listing and ecological description of areas particularly important to migratory species on their migratory routes and as wintering and nesting grounds.

Hence in implementing the Directives it is critical that the Natura 2000 network is established within a framework based on sound knowledge of national and international distributions of habitats, and of what human uses and pressures, and management (including conservation status), occur on each part of the resource. To do this requires the compilation of resource and human activity inventories at both national and international scales. In the coastal zone such inventories have been compiled for some habitats and regions: examples from Great Britain are summarised below and future developments in this work are then outlined.

Several coastal habitats have been the subject of national British surveys of vegetation communities. These include saltmarshes (Burd 1989), sand dunes (e.g. Dargie 1993) and shingle (e.g. Sneddon & Randall 1993). These detailed vegetation surveys are complemented by broader-based general habitat surveys, including a 10 km square coastal habitat survey for Great Britain (Anon. 1993c) based on 1: 50 000 scale maps. On a more localised scale detailed vegetation survey has been used to monitor change in coastal habitat, e.g. the erosional and land-claim changes to saltmarshes in Essex and Kent (Burd 1992).

A major review of British estuaries, covering their distribution and characteristics, wildlife interest, conservation status and human uses, was completed in 1991 (Davidson et al. 1991). This brought together information on both coastal habitats and marine communities, and the variety of species of conservation interest. Further estuarine resource assessment is continuing with

the production of a site-by-site inventory of UK estuaries (Buck 1993).

There have, as yet, been fewer attempts to bring together coastal habitat resource information on an international scale. Several basic reviews of European coastal features were compiled in the 1980s (Dijkema 1984; GŽhu 1985; Mitchell 1987), but only DijkemaÕs (1984) report contains information on sites in relation to the overall resource. More recently, work has begun on simple Europe-wide habitat inventories based on existing information, the first being for sand dunes (Doody 1991). This approach is being further developed (see below).

These national and international inventories of both the natural resource and how people are using it are needed for several types of coastal conservation and management initiative. As well as providing the context for the selection and designation of conservation sites both domestically and under international commitments such as the Ramsar Convention and the EC Habitats Directive, they can also provide a baseline for monitoring coastal habitat change. In addition, this wide-scale baseline information is used in the increasingly widespread development of integrated coastal zone management initiatives on parts of the European coastline. This will include the future need to integrate the management of SACs within a wider coastal framework.

Future opportunities

With the increasing interest and development of integrated shoreline and coastal zone management based upon sustainable use of coastal resources, the recent issue by the European Commission of a Communication on the integrated management of coastal zones (Anon. 1995b) and the implementation of the Habitats Directive, it is an appropriate time to improve delivery of coastal information at different geographical scales. To meet these requirements it is important to provide information on both coastal habitats themselves, and links to a variety of other wildlife features and what is happening to them. Several initiatives are underway.

In the UK the Joint Nature Conservation Committee (JNCC) has developing mechanisms for handling and reporting coastal conservation and management information. This is being achieved by managing coastal habitat and human activity inventories and developing links with datasets of other coastal wildlife features (Doody & Davidson 1993). This development of standardised review methodology builds on the experience of compiling the multi-topic Estuaries Review (Davidson et al. 1991).

Collation and production of standardised multi-topic information also forms the basis of the UK national series of coastal directories now being produced by the JNCC on behalf of a wide range of coastal zone users and decision-makers. Initially developed to provide information on the coastal margin of the North Sea (Doody et al. 1993) for the 1993 North Sea Quality Status Report (Anon. 1993b), the project has now extended to the production of 17 regional directories covering the coasts and coastal waters of the UK (e.g. Barne et al. 1995). Each directory covers a wide range of resource and human use topics, for each topic providing a summary of the location, size and importance of each feature in the region set in a national context and listing sources and contacts for further information. To meet the widest range of user needs each directory is being produced in book and electronic form, as part of a suite of electronic and paper publications being developed for the UK marine and maritime areas in support of sustainable resource management.

Other inventories of European coastal wetland resources are underway, notably the development by the International Waterfowl & Wetlands Research Bureau (IWRB) of an inventory of Mediterranean wetlands (Hecker & Tomˆs Vives 1995; Tomˆs Vives 1996). International inventories of shorebird habitats and human activities, making use of existing relevant information collected by simple techniques are also encouraged in the Odessa Protocol on international co-operation on migratory flyway research and conservation (Anon. 1992).

Developing standardised review and directory methodologies, and compiling further Europe-wide coastal habitat inventories also form two of the four parts of the EUCC *EcoCoast* project designed to provide a framework for describing, reviewing and monitoring the coastline of Europe (Doody et al. 1995). The *EcoCoast* project also incorporates the development of a basis for coastal survey, monitoring and surveillance, and establishing a support system for integrated coastal zone management.

A further recent development of coastal inventories is the linking of summary inventory work as a joint project between EUCC and Birdlife International. This forms a part of Birdlife InternationalÕs European conservation programme which is preparing an analysis of the extent of European habitats and the problems facing their future management. The coastal element of this project, which aims to produce a comprehensive guide to European habitats and the requirements for conservation action, has been initiated through a workshop in late 1993 that developed summaries of national coastal resources, the habitat types, and their extent and regional variations. Information on land uses and threats to habitats will help set conservation management objectives and broad action requirements.

This initiative provides a good example of the value of linking the requirements of habitat conservation with those of species, in this case birds, which depend upon them. Work of this kind, coupled with the linking in Natura 2000 of networks of sites of importance for habitats, plant species, birds, and other animal species, will help to ensure a better integrated approach to coastal conservation in Europe. Many coastal sites in Natura 2000 are likely to have multiple qualification as internationally important under both the Birds Directive and the Habitats Directive. This leads to added conservation value for such sites since there will be a wider range of natural values identified for functional coastal systems. Since the relationship between the two designations will not become clear until after lists of proposed sites of community importance have been prepared by Member States, there remains a need to ensure that SPAs and SACs combine to form a coastal habitat conservation network that fully meet the objectives of the Habitats Directive.

Many migratory waterfowl depend also on areas outside the European Community during their year. So it is important that effort is put also into the development of international flyway conservation plans, for example through the mechanism of the Bonn Convention migratory waterbird agreements. Such agreements can benefit from the experience of developing resource inventories, review methodologies and integrated coastal habitats networks described in this paper.

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