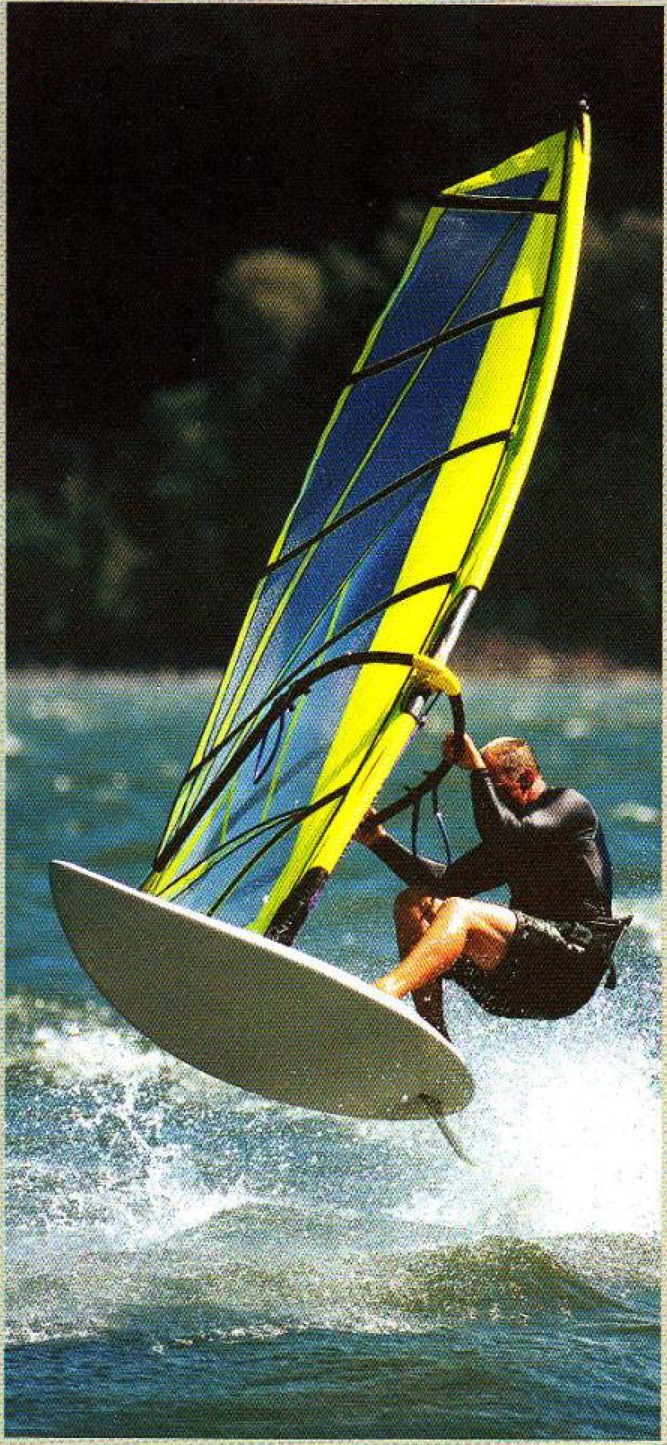

Waterbirds & Wetland Recreation Handbook

A review of issues and management practice

Jeff Kirby, Nick Davidson, Nick Giles, Myrfyn Owen and Chris Spray

WWT The Wildfowl & Wetlands Trust

NORTHUMBRIAN WATER

Published by The Wildfowl & Wetlands Trust Supported by Northumbrian Water

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With the support of

Thames Water RWE Group

Severn Trent Water

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Contents

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Foreword

Much has been written about the loss and degradation of wetlands; drainage schemes, pollution, over abstraction all take their toll and so the wetland wildlife that depends upon them is threatened. The Wildfowl & Wetlands Trust (WWT) and others strive to protect wetlands and their biodiversity from such perils as a matter of course. The Waterbirds and Wetland Recreation Handbook does not seek to address this fundamental conservation concern. Instead the book focuses on the balance that needs to be struck between the needs of waterbirds that depend on wetland habitats and the ever-growing interest in using bodies of water for recreation.

When Peter Scott first came to Slimbridge in 1945, he did so as a man on a mission. He knew that the Slimbridge foreshore on the Severn Estuary was the best place to see the thousands of White-fronted Geese that migrated from their Siberian breeding grounds to spend the winter here. He also hoped to see the uncommon Lesser White-fronted Goose and in this quest he was successful. He was so inspired at this goose spectacular that he took the decision to settle at Slimbridge and establish what was to become the world famous Wildfowl & Wetlands Trust.

There was, however, an immediate issue to be resolved. Scott had managed to get close to these wild birds by approaching stealthily from behind the sea wall and watching the birds from a pillbox, ironically now being used to observe welcome visitors from overseas! But how would he manage to share his enthusiasm for the birds and for their dramatic wetland habitat with others, without disturbing them and threatening the integrity of the very landscape that ensured their survival? Well, from that pillbox, the bird observation hide that we now take for granted evolved, and bird watching became a very popular pastime.

As more birds were viewed discretely, interest in their protection blossomed, so much so, that in 2003, WWT's nine UK centres welcomed over 750,000 people to its reserves. This public acclamation has encouraged an interest in waterbirds and their habitats throughout the world. At Slimbridge and beyond, there is now a successful mixture of disturbance free bird reserves and recreation, and from this enjoyment of wetlands comes a better understanding of the pressures on the natural environment.

This is perhaps not completely surprising as we all have a natural affinity with water. We like to be in it or near it. Feeding the ducks is often the classic childhood memory and WWT has reawakened this particular pleasure to visitors of all ages. These early experiences often lead to the recognition that water has many uses, from drinking to swimming, from industry to yachting; real worth to wildlife and people.

If wetlands are seen as a resource, they will be better valued by all, which has to be ultimately good for the environment. WWT hopes that the publication of this book will help lead to a better understanding of the needs of waterbirds and how they may be able to exist in harmony with recreational use on wetlands. WWT is grateful to all those who have made its production possible, with particular thanks due to Northumbrian Water.

Tony Richardson
WWT, Slimbridge 2003

Introduction

Many of our wetlands in the UK are man-made and even more, the vast majority, have been heavily modified one way or another for use by man. It has been estimated that there are some 84,000ha of inland water in England and Wales, of which 25% alone is accounted for by public water supply reservoirs of varying kinds. To this can be added 140,000km of rivers, 3,000km of canals and the estuaries and inshore waters that surround our coastline. Together, this represents a significant, but finite environmental resource, against which must be set a growing demand for recreational and non-recreational use of the same resource.

The importance of these artificial habitats in Britain has increased considerably in recent decades, especially for dabbling ducks and as goose roosts (Owen *et al.* 1986). Nine artificial sites have been designated as Internationally Important and designated as Ramsar sites and/or Special Protection Areas under the EC Birds Directive (Musgrove *et al.* 2001). The Government regards the state of our wetland birds as one of their Quality of Life Indicators.

Even heavily modified and manmade water bodies can develop an important conservation value. For example, for certain bird species such as Gadwall, Tufted Duck, Pochard and Shoveler, reservoirs and gravel pits are the most extensively used habitat in the UK during winter. Of the 370 reservoirs in England and Wales owned by the water companies, nearly half have areas designated as Sites of Special Scientific Interest, with numerous bird hides and other facilities for bird-watching.

Estimates for the number of people interested in water sports vary from 5 – 7 million in the UK, and figures from the 1994 UK Day Visit Survey emphasise the importance of water as part of the leisure experience – more than 120 million leisure day visits were made to canals and rivers alone; angling participants were estimated at some 3.3 million people; and reservoirs such as Rutland and Kielder have become major tourist destinations in their own rights.

Back in 1996, the British Ornithologists' Union and the Wildfowl & Wetlands Trust organised an international conference in Bristol on "Waterbirds and Recreation: - Considerations for the sustainable management of Wetlands". Just prior to this, Northumbrian Water, who became the lead sponsor for the conference, had commissioned the WWT's Wetlands Advisory Service to undertake a major three-year study of waterbirds on all their reservoirs, and to investigate the interaction between recreation and conservation interests. At the end of the conference it was felt that rather than produce a formal edited volume of conference papers, WWT and Northumbrian Water would work towards the production of a specific handbook on the management of potential areas of conflict between waterbirds and wetland recreation.

This, the resulting book, goes much further than the original aims of the conference, and through the work of the authors and Just Ecology has expanded greatly. We have been able to include the results of more recent research and to cover areas that were previously omitted. It is above all now a practical handbook for management, with the emphasis firmly on understanding the science, conservation values and practices associated with the integrated management of wetlands for both waterbirds and recreation.

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(ENVIRONMENTAL CONSULTANCY) LTD.

1. BACKGROUND

1.1 Purpose and scope of the handbook

This handbook is about wetlands as places for humans to enjoy recreational activity and as habitats supporting very significant waterbird populations. It focuses on what we know about the interactions between the two and on management approaches that may remove or alleviate any conflicts of interest. Geographically, it draws on information from most parts of the world. However, our emphasis is on Europe, where recreation on wetlands is intense, with Great Britain given the most comprehensive treatment in this handbook. However, many of the issues raised, and the solutions presented, will be more widely applicable, making the handbook of interest to an international readership.

We follow the 'Ramsar Convention' for our definition of wetlands (Box 1.1); this definition having been adopted by more than 60 governments throughout the world for wetland management and conservation purposes. Wetlands of course exhibit enormous diversity according to their origins, geographical location, water regime, chemistry, dominant plants and soil or sediment characteristics (Finlayson & Moser 1991). They may vary also within a single wetland area and over time, and many different types of wetland may be found in close proximity, forming not just different ecosystems, but wholly different landscapes. Whilst aspects of this handbook are relevant to the conservation and management of most of these wetlands, our focus is mainly on estuaries, lakes and man-made wetlands, such as reservoirs and gravel extraction pits. These are indeed the wetlands used most for human recreation.

Wetlands teem with animal and plant life but waterbirds are perhaps the most visible and well known of the many species present in wetland environments. With over 150 European bird species intimately linked with wetlands for their survival, waterbirds are the focus of this handbook.

Our definition of 'waterbirds' is broad and pragmatic. It includes all wetland bird families monitored by international conservation organisations involved in wetland surveillance (*e.g.* Rose & Scott 1994, 1997). 'Wildfowl', namely swans, geese and ducks, are included as well as 'waders' covering oystercatcher, avocet, plovers and sandpipers; and some other wetland bird families notably gulls and terns, and herons and egrets. We also include species from other families that are ecologically dependent on wetlands: divers, grebes, cormorant, coot and rails; river-based species such as king-

Box 1.1: What are wetlands?

Exactly what constitutes a "wetland" has always been the subject of debate, not surprisingly given the enormous variety of wet habitat types and the difficulties involved in defining their boundaries with any precision. The 1971 "Convention on Wetlands of International Importance Especially as Waterfowl Habitat" (usually called the "Ramsar Convention") uses a definition that conveys the essential character of wetlands, as well as implying the complexity involved (Davis 1994). It defines them as: '*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed 6 m [just over 19 ft]*'. Within this definition, five major wetland systems are recognised (see further Maltby 1991):

- **marine: coastal wetlands including rocky shores, lagoons and coral reefs**
- **estuarine: including deltas, estuaries, tidal marshes and mangrove swamps**
- **lacustrine: wetlands associated with lakes**
- **riverine: wetlands along rivers and streams, including floodplains**
- **palustrine: marshes, swamps and peatlands**

Artificial wetlands, such as rice paddies, fish and shrimp ponds, farm ponds, reservoirs, extraction pits, sewage farms, canals and salt pans, add to the diversity of wetland types.

fisher, grey wagtail and dipper; reedbed species such as bittern, marsh harrier, reed and sedge warbler and bearded reedling; and open water species such as osprey. Inevitably, not all of these species have had the same level of research devoted to them and hence the bulk of the material in this handbook refers to the waders and wildfowl *sensu stricto*, groups for which there is by far the most information. Scientific names for all species mentioned in the handbook are provided in Appendix 1.

As well as a place for wildlife, wetlands provide a diversity of recreational opportunities for people, and many millions of people enjoy being in wetlands for this purpose. Because of this the government regards the state of our wetlands and their birds as one of their *Quality of Life Indicators* DEFRA 1999. Growth in traditional activities, such as walking, horse riding, angling and wildfowling, has been complemented by the introduction of newer activities such as mountain biking, paragliding and the introduction of personal watercraft ('jet skis'). Throughout the developed world, recreation is important to everyone's quality of life and the amount of time devoted to it and the demand for facilities are growing. In Britain, for example, there might be as many as 62 million people around the year 2030 and thus the demands for new forms of recreation, and other leisure activities, will continue to grow, in some cases putting pressure on the environment (HMSO 1994b). In Britain, around 15% of holidays are activity-based with one third of these involving water-related recreation, especially boating and fishing.

In this handbook, we focus on recreational activities of particular significance for waterbirds, which we group into five main categories:

- angling: game, coarse and sea angling
- mechanically powered water-sports: water-skiing, power boating, jet skiing and motor cruising
- non-mechanically powered water sports: sailing, windsurfing, canoeing, rowing, and scuba diving
- shooting: wildfowling only
- informal recreation: birdwatching, natural history, photography, walking and swimming

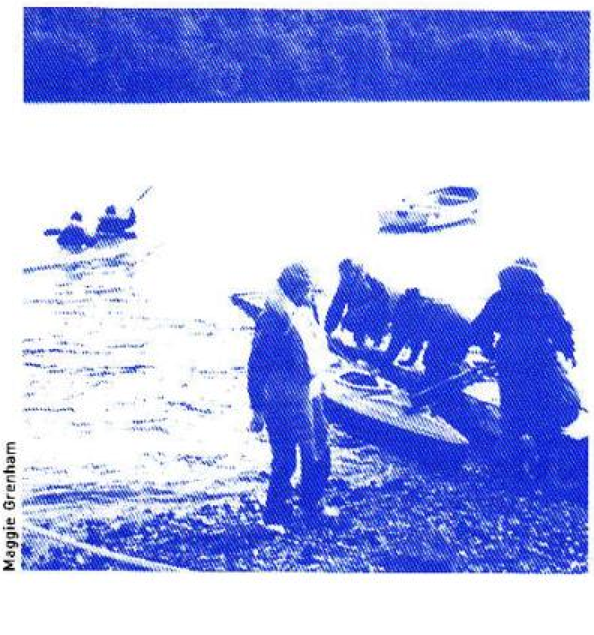
In producing this handbook, our overall aims are to provide a balanced view of waterbird and recreational interactions, and to offer practical advice for minimising the adverse effects and impacts of recreational activities on waterbirds. It must be recognised that there is an important difference between *effects* and *impacts* (see Box 1.2) but both are relevant to the content of this handbook. This understood, the handbook should allow the recreation manager to know when effects and impacts are likely to matter and whether it is possible to mitigate against them with appropriate action. Case studies are used to illustrate a range of interactions and the success of a range of management

Box 1.2: Effects and Impacts

Studies assessing the significance of man's activities on wildlife have often referred to "effects" and "impacts" loosely and without definition.

Here we define an *EFFECT* on a bird as any noticeable change in behaviour, physical or chemical state that is brought about by an external influence such as disturbance. Examples of effects would include stopping feeding and looking up to observe a boat, an induced increase in adrenaline production due to stress, swimming away from a wading angler or flying away at the sound of a gunshot. Effects can be compensated for.

An *IMPACT* is generally more serious. It represents a measurable change in survival or breeding success and hence population size, at least locally, which the population is unable to compensate for in the normal course of events (see, *e.g.*, Vos 1986). In this circumstance the effect is strong enough to partly determine species abundance. Examples include failure to nest, abandonment of a clutch or brood, consequential predation losses or a reduced over winter survival due to disturbance, all of which may knock-on to final population levels. Clearly, in many instances, it will be difficult to understand where recreation imposes a real impact on a bird population or where the effects stop at imposed variations on distribution and condition/behavioural performance that the population can compensate for. Whether effects are knocked-on or compensated for is, of course, a key consideration.



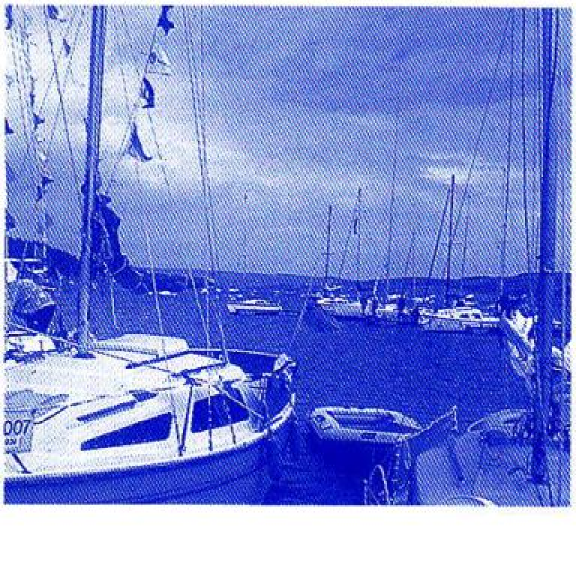
Maggie Grenham

solutions. However, the handbook does not offer detailed management solutions for every situation. There are no such magic formulae that will work in every instance, but there are general principles that can be applied and a wealth of practical experience on which to draw. Each real life problem needs to be considered individually, using teams of appropriately qualified people to carry out appraisals over adequate time periods and to devise solutions.

In summary, this handbook has been produced for interested scientists, ornithologists, sports enthusiasts and other users of the countryside, as well as waterbird/wetland contacts and site managers in governments, local government and non-governmental conservation, development, planning and sports agencies. It is offered as a balanced account of the interactions between waterbirds and recreation - a contribution towards raising awareness of waterbirds and wetlands. It focuses on a topic of interest to many people; a tool to be used which should help to discourage wetland degradation; and a contribution towards sustainable development in wetlands for both wildlife and people.

1.2 Conservation context

The habitats considered here - wetlands - have played a crucial role in human history, probably supporting major stages in the evolution of life itself and accommodating human settlements from early prehistoric times (Maltby 1991). Wetlands have a wide range of values that are essential for supporting plant and animal life and for maintaining the quality of the environment (Box 1.3). The interactions between the main wetland elements (water, soil, nutrients, plants and animals) allow wetlands to perform these functions and to generate healthy plant, wildlife, fisheries and forest resources. The combination of these functions and products, together with the natural and cultural values of wetlands means that these ecosystems are of critical importance to people. Many wetlands provide good opportunities for economic activities, including recreation, and sustain dense populations of fish, livestock or wildlife. Today, wetlands continue to be essential to the health, welfare and safety of millions of people globally (Ramsar Convention Bureau 2000).



NWL

Despite this, wetlands have been destroyed and degraded, particularly throughout the industrialised world; mainly due to drainage, land reclamation, pollution and over-exploitation of wetland resources (Finlayson & Moser 1991, EC Com 1995). Wetland losses have been severe. As an example, Figure 1.1 (from Dahl 1990) shows the difference between the distribution of wetlands some 200

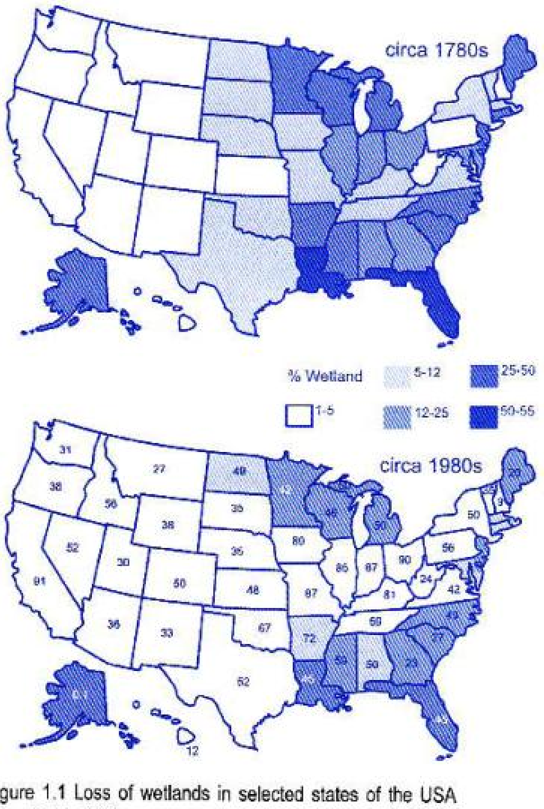


Figure 1.1 Loss of wetlands in selected states of the USA (from Dahl 1990)

years ago and at the end of the 1980s in the USA; the lower map shows percentage loss between the 1780s and the 1980s in each of the States. Clearly, losses, even in recent times, have been both widespread and dramatic.

Wetlands have been massively reduced in area in Britain and Europe also. Hollis & Jones (1991) suggest that more has been lost here than anywhere else in the world. The common and important

Box 1.3: Wetland Values, Functions and Attributes

	Estuaries	Mangrove	Open coasts	Floodplains	Freshwater marshes	Lakes	Peatlands	Swamp forest
FUNCTIONS								
1. Water storage	*	***	*	***	***	***	*	*
2. Carbon storage						***	***	***
3. Habitat stabilisation	*	***	*	*	***			
4. Chemical retention	*	***	*	***	***	***	***	***
5. Transport	*	*		*		*		
6. Amenity/recreation	***	*	***	*	*	*	*	*
PRODUCTS								
7. Water supply				*	*	***	*	*
8. Other resources	***	***	*	***	***	***	*	***
ATTRIBUTES								
9. Biodiversity	***	*	*	***	*	***	*	*
10. Culture/heritage	*	*	*	*	*	*	*	*

*** Common and important value of that wetland type; * less common/important. Modified from IUCN (1992)

DESCRIPTIONS

1.Wetlands may recharge groundwater tables and, as water stores, can diminish the potentially devastating effects of flooding by retaining water.
2.Wetlands have the capacity to store large quantities of carbon, a fact that can reduce carbon dioxide emissions into the atmosphere, responsible for global warming.
3.The binding effect of wetland vegetation helps stabilise banks and shores, assisting also with the consolidation of soils and accretion of sediments, thus counteracting the forces of erosion, subsidence and sea level rise.
4.Wetlands store nutrients in sediments and in their biota, which may later be discharged to the benefit of other systems; for example agriculture. They also filter out contaminants, reducing their penetration into the underground aquifer.
5.For centuries, coastal wetlands have been inhabited and developed for their strategic positions for trade and transport.
6.Many wetlands harbour a rich wildlife and provide important spaces for recreational activity.
7.Wetlands act like sponges, storing and slowly releasing rainfall and run-off, and helping to prevent drought during dry conditions and periods of high demand for domestic, agricultural or industrial purposes.
8.Wetlands can sustain natural communities of fish and the sustainable farming of fish, crayfish and grazing animals. Many commercially exploitable coastal species of fish, shellfish and crustaceans spend at least part of their life cycle in wetlands. Other traditional uses of renewable wetland resources include peat cutting, reed harvesting and the extraction of salt.
9.Wetlands provide habitat for a great diversity of plant and animal species, many of which cannot be found elsewhere and represent a unique contribution to the world's genetic resources. Wetlands serve as dispersal and migration corridors and "stepping stones" for many species. Wetland flora and fauna include species of high commercial value.
10.Wetlands are appreciated by millions of people for attributes such as biological diversity, landscape value and cultural heritage. Wetlands may have a considerable archaeological heritage value since their chemical make-up preserves much that is buried in them.

causes of global wetland degradation and loss are described in Box 1.4.

This destruction and degradation of wetlands is not only damaging to society but it leads to inherent loss of biodiversity - the variety of life forms around us, including the genetic and morphological variability within a species and the assemblages of plants, animals and micro-organisms which together form their ecosystems and natural habitats. This goes against the principles of sustainable development (Box 1.5) - "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). This handbook has been produced because wetland degradation can include non-sustainable recreational activities. It should be of great value to the many people responsible for the protection and management of wetland habitats, including their human usage.

1.3 Conflicts of interest

For over 30 years, conservationists have been concerned that recreation may lead to a decline in the amenity and wildlife values of sites (*e.g.* Atkinson-Willes 1969, Forman 1968, Morzer-Brujns 1967, Tuite *et al* 1983). Waterbirds and recreation are intensive users of wetland areas and their requirements often overlap, with resulting conflict between the defenders of wildlife and the devotees of wetland-based recreation. This has triggered a number of detailed reviews of the impacts of recreation, though these have often only focused on disturbance effects. For Britain, excellent reviews have been provided by NCC/RSPB (1988), summarised by Ward (1990) and Ward & Andrews (1993), and by Liddle & Scorgie (1980), Hockin *et al.* (1992), Davidson & Rothwell (1993), Land Use Consultants (1994), Sidaway (1994) and Hill *et al* (1997).

Whilst differing in scope and detail, these studies share at least one important conclusion. They show that human recreational activity often has important consequences for waterbirds. Recreational activity may directly impact on waterbirds through mortality and disturbance, whilst such activity may result in habitat loss, degradation and reductions in the food supplies of birds (Box 1.6).

Another common conclusion is that effects and impacts are not easy to assess. This is because there are many interacting factors that can influence the numbers, distribution or behaviour of animal species. For example, natural causes of redistribution for waterbirds include succession in aquatic ecosystems, changes in food supplies, movements to breeding grounds and adverse weather conditions. When assessing the effects of recreation, it is necessary to take such factors into account; easier said than done. Also, the effects and impacts of recreational activity seem to vary in relation to the species of waterbirds involved, their use of the waterbody, the presence of alternative sites nearby, and the type and intensity of recreational activities. It is thus a complex subject. Overall though it is clear that recreational activity can cause fluctuations in bird numbers, distribution and behaviour, and this may influence the nature conservation value of particular sites. What remains particularly unclear is whether there is a long-term impact of recreation on bird populations, in terms of mortality or breeding success.

It is important to remember that the relationships between recreation, waterbirds and their environments are neither simple nor one-sided. Indeed, by focusing almost exclusively on potentially harmful impacts, many reviews and studies have given the impression that recreational activities are especially harmful. The local impacts of recreation can be serious and require management action. However, there have been national and regional assessments that have shown non-recreational impacts on habitats (*e.g.* land use changes, associated destruction and pollution) to be far more serious for the survival of species than recreation (Tuite 1982, Watmough 1983a&b, NCC/RSPB 1984, Sidaway 1994, Sidaway & Thompson 1991). The task of the recreation manager is to balance any possible harmful effects that recreation may have on the environment against the considerable range of benefits that so many people derive from enjoying the countryside. The best examples of multi-use indicate that it is possible to take account of all users' needs and provide opportunities for recreation as well as securing good habitats for waterbirds.

There may even be beneficial effects of recreation on waterbirds, for example when birds are fed by the public in urban and suburban areas or by organisations such as the Wildfowl & Wetlands Trust. However, not often do these benefit overall populations, affecting a few tame and habituated individuals. Other sites may well be created for recreation, which are subsequently adopted by birds.

Box 1.4: Main Causes of Wetland Loss and Degradation

	Estuaries	Open coasts	Floodplains	Freshwater marshes	Lakes	Peatlands	Swamp forest
LAND CLAIM/ALTERATIONS							
Drainage for agriculture, forestry and mosquito control	***	***	***	***	*	***	***
Filling for solid waste disposal, roads, commercial and residential	***	***	***	***	*		
Conversion for aquaculture/mariculture	***	*	*	*	*		
Hydrological alterations by canals, roads and other structures	***	***	***	***	***		
Construction of dykes, dams, levees, and seawalls for flood control	***	***	***	***	*		
Sediment diversion by dams, deep channels and other structures	***	***	***	***			
Dredging and stream canalisation for navigation and flood protection	***			***			
EXCESSIVE USE							
Mining of wetlands for peat, coal, gravel, phosphate and other materials	*	*	*		***	***	***
Subsidence due to extraction of groundwater, oil, gas *etc.*	***	*	***	***			
Groundwater abstraction		*	***				
ENRICHMENT/POLLUTION							
Discharges of pesticides, herbicides, silts, nutrients from domestic sewage	***	***	***	***	***		
RECREATION/TOURISM							
Recreational pressure and environmental impacts	***	*		***	***	*	
Tourism pressure	***	***			***		
CLIMATE CHANGE							
Sea-level rise	***	***					***
Drought	***	***	***	***	*	*	*
NATURAL DISASTERS							
Erosion, subsidence, storm damage	***	***	*				
BIOTIC EFFECTS							
Feral/exotic species		***	***	***			

*** Common and important cause of wetland degradation and loss; * present, but not a major cause of loss.
Modified from IUCN (1992)

There are also the consequences for the recreational manager and user of having waterbirds present on sites used actively for recreation, and of the measures taken to protect waterbirds. Large numbers of waterbirds may be noisy throughout the daylight hours. They may deposit smelly guano on nesting islands and eat large quantities of fish in competition with anglers. They may defecate into lakes and reservoirs where they feed or roost (and so may add food poisoning organisms if they have fed on rubbish tips) and add nutrients to the water (which may lead to blooms of toxic algae or cyanobacteria). Furthermore these birds may be afforded protected status and may reside on wetland sites that are themselves protected for their wildlife importance. Clearly, waterbirds can impinge on recreational values; hence the waterbirds-recreation issue is a two-way concern.

Box 1.5: Sustainable Development & Biodiversity Conservation

Sustainable development is about finding a way to achieve economic development to secure higher standards of living, now and for future generations, while also seeking to protect and enhance the environment for now and for our children. Put another way, resources which future generations will need should not be destroyed or damaged by meeting the needs of the present generation. Economic prosperity is important but so is the quality of life.

Sustainable development was considered by around 170 Heads of State or Governments attending the United Nations Conference on Environment and Development (the 'Earth Summit') at Rio de Janeiro in June 1992. Major outputs from Rio included:

- *The Rio Declaration: a statement of principles addressing the need to balance the protection of our environment with the need for sustainable development.*

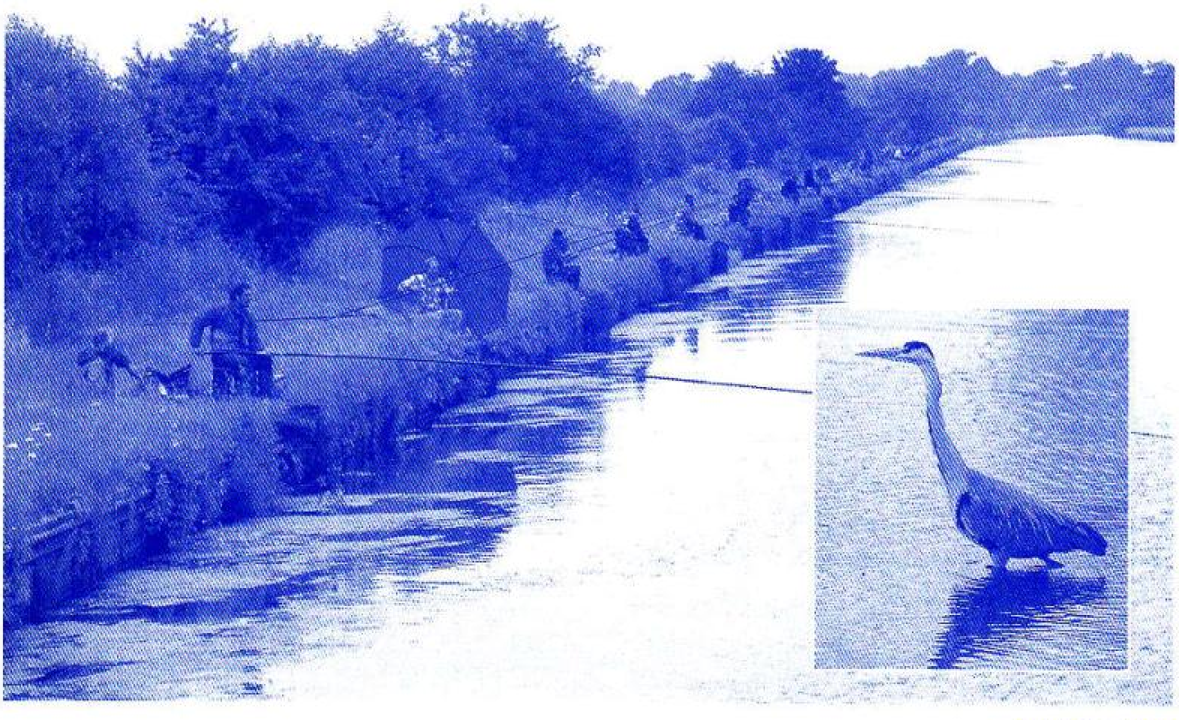
- *Agenda 21: an action plan for the next century aimed at the integration of environmental concerns across a broad range of activities including industry, agriculture, energy, transport, recreation and tourism, land use and fisheries.*

- *The Convention on Biological Diversity: Article 6A of which requires parties to "develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity, or adapt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned". The Convention allows the 'use' of resources provided this is sustainable.*

After Rio, the UK issued simultaneously its action plan for biodiversity (BAP - HMSO 1994a) and a national sustainable development strategy (HMSO 1994b).

The first five years of the BAP were reviewed in 2000 and it was reported that good progress had been made, with 391 species and 45 habitat action plans having been completed, together with 160 local BAPs covering all of Scotland and Wales and most of England (UK Biodiversity Group 2001).

Progress on sustainable development in the UK has also recently been assessed; one of the key quality of life indicators which had improved was chemical and biological river quality (DETR 1999). A set of biodiversity indicators were published at the end of 2003.



Mark Hulme/WWT

Box 1.6: Some Potential Consequences of Recreation for Waterbirds

Concerns	Description	Angling	Boats	Hunting	Informal
Direct kill	The intentional removal of birds.	Not applicable.	Not applicable.	Of concern only when non-sustainable.	Not applicable.
Death from litter, pollution or poisoning	Unintentional poisoning or pollution perhaps causing deaths.	Discarded tackle, litter and lead shot.	Oil pollution.	Lead poisoning.	Discarded litter.
Destruction of nests/young	Unintentional damage to nest/young, causing reduced productivity	Probably insignificant.	Where overcrowding occurs.	Very unlikely.	Where overcrowding occurs.
Disturbance through noise/activity	Can, at critical times, cause redistributions, reduce breeding success, effect community structure or influence habitat use.	Usually insignificant	Can be important.	Integral to the sport.	Can be important where overcrowding occurs.
Habitat loss or degradation	Damage to vegetation and soils through trampling can reduce/ degrade food supplies for birds and invertebrates and result in loss of vegetation and soils.	Trampling of banks, channels and vegetation. Removal of potential foods for bait.	Trampling effects, erosion from boat wash & increased turbidity by propeller action.	Habitat degradation through stocking of game birds.	Trampling effects, litter contamination and bird feeding, encouraging feral species.
Building sporting facilities, infrastructure developments	Loss of habitat and remaining less available through disturbance.	Disturbance from increased activity.	Increased density of boats in marinas.	May make some areas more accessible.	Probable increased accessibility, disturbance.
Habitat management	Sport-specific management may be detrimental or in some cases beneficial to conservation interests.	Habitat modifications can be adverse or beneficial.	Habitat modifications can be adverse or beneficial.	Habitat modifications can be adverse or beneficial.	Habitat modifications can be adverse or beneficial.
Increased competition	Species management for sport may be detrimental to conservation interests.	Competition with stocked fish.	Not applicable.	Competition with stocked birds, hybridisation.	Competition with feral birds, hybridisation.


Martin Senior/WWT

2.0 WETLANDS FOR WATERBIRDS

2.1 Introduction

Wetlands provide the food, shelter and resting places for a rich assemblage of waterbirds. They also provide the habitat networks that allow waterbirds to make some of the most spectacular migratory journeys of any animals in the world. In time to breed, millions of swans, ducks, geese, waders and other birds undertake annual journeys from more southerly wintering areas to arrive each spring on the vast Arctic wetlands of North America and Eurasia. Here they take advantage of the extreme productivity of wetlands, successfully breed during the brief summer, before migrating once more to over-winter on inland and coastal wetlands many thousands of kilometres to the south. Some of these arctic-breeders travel as far south as Australia, South Africa and South America to winter, making use of a whole network of wetlands as vital refuelling stops on the way. Clearly, such migrations depend on the integrity of wetland networks. Too few could spell disaster for the millions of birds that depend upon them.

Whilst many waterbirds make long migrations to breed, others remain to breed in areas closer to wintering sites, thus resulting in shorter migrations. Birds returning from over-wintering sites elsewhere, usually to the south, may augment these. The wetlands of individual countries may therefore support a whole range of waterbirds from different populations and at various times of the year, for breeding, moulting and wintering purposes. Their conservation and management is a multinational responsibility, with each country playing its part in supporting this shared resource.

In this chapter we provide insight into the ways in which waterbirds use and are dependent on wetland habitats. Data from Britain are used to illustrate the numbers and range of species and populations involved and the general patterns of wetland usage. Readers requiring further information on waterbirds in Britain should consult, for example, Prater (1981), Evans *et al.* (1984), Owen *et al.* (1986), Davidson *et al.* (1991) and annual reports from the Wetland Bird Survey (*e.g.* Cranswick *et al.* 1997, 1999). For international accounts see, for example, Batt *et al.* (1992), Baldassarre & Bolen (1994), and reports from the international waterfowl census (*e.g.* Dodman *et al.* 1997 *et seq.*, Lopez & Mundkur 1997, Scott & Rose 1996, Rose & Scott 1997).

Our aim is to emphasise the true importance of British waterbirds and their intimacy with wetlands. However there are consequences for the recreation manager in sharing sites used for sport with the birds. We therefore highlight the most important of the constraints: impacts of waterbirds on water quality and health, predation on fish stocks, habitat degradation and constraints associated with the protected status of species or sites. We conclude with some considerations for wetland managers in helping to safeguard our important waterbird resource.

2.2 Places to breed

For breeding, as in winter (see below), patterns of global distribution differ markedly between species. Some are distributed across several continents (*e.g.* mallard, pintail or dunlin) whilst others are found only in one or few localities (*e.g.* Svalbard barnacle goose, black-tailed godwit). This means that particular countries will support a mixture of relatively common waterbirds and also species or populations that are either internationally relatively scarce, on the edge of their range or are unique. It also means that particular regions or sites within countries will have strong international importance for certain species.

Just a fraction of the waterbird species wintering in Britain remains to breed there. The rest journey to the Arctic. For Britain, the most comprehensive information on breeding distributions, population sizes and trends comes from national breeding bird atlases (Sharrock 1976; Gibbons *et al.* 1993), whilst changes since the 19th century are the focus of a book by Holloway (1996). British information can be placed in a European context by reference to Hagemeijer & Blair (1997). Other breeding surveys in Britain have focussed on particular habitats or species (*e.g.* Smith 1983; Allport *et al.* 1986; Prater 1989; Delany *et al.* 1992).

There is a wealth of information from Britain on breeding waterbird populations; not all countries may be so fortunate. Regular breeding populations in Britain include 24 wildfowl species; 16 waders; 11 gull and tern species (excluding wholly marine species such as kittiwake) and at least 27 other wetland specialists (Box 2.1). Based on recent estimates, overall almost 2 million pairs of waterbirds breed in Britain, of which about half (almost 950,000 pairs) are waterfowl. With immature and non-breeding birds present during the breeding season, the summer total may reach 4-5 million waterbirds, perhaps about half of the numbers present in winter (see below).

Box 2.1: British breeding waterbirds

Source: Stone *et al.* (1997) in which details of estimation methods are provided. Updated in some cases from WWT/WeBS data.

Species/population (measure)	Population size
Red-throated Diver	935-1,500 pairs
Black-throated Diver	155-189 pairs
Little Grebe	5,000-10,000 pairs
Great-crested Grebe	8,000 individuals
Red-necked Grebe	2 pairs
Slavonian Grebe	70-78 pairs
Black-necked Grebe	23-48 pairs
Cormorant	7,000 pairs
Bittern	20 males
Grey Heron	10,000 pairs
Mute Swan	25,750 individuals
Whooper Swan	2 pairs
Greylag Goose* (Scottish)	11,000 individuals
Greylag Goose* (introduced)	20,000 individuals
Canada Goose (introduced)	46,700 individuals
Barnacle Goose (introduced)	730 individuals
Egyptian Goose (introduced)	700 individuals
Shelduck	10,600 pairs
Mandarin	7,000 individuals
Wigeon	300-500 pairs
Gadwall	770 pairs
Teal	1,500-2,600 pairs
Mallard	100-130,000 pairs
Pintail	8-42 pairs
Garganey	15-125 pairs
Shoveler	1,000-1,500 pairs
Red-crested Pochard	100 individuals
Pochard	251-406 pairs
Tufted Duck	7,000-8,000 pairs
Scaup	0-3 pairs
Eider	31,000-32,000 females
Common Scoter	76-89 pairs
Goldeneye	83-109 pairs
Red-breasted Merganser	2,200 pairs
Goosander	6,000 pairs
Ruddy Duck (introduced)	570 pairs
Marsh Harrier	157-160 individuals
Osprey	99 pairs
Water Rail	450-900 pairs
Spotted Crake	1-20 pairs
Moorhen	240,000 territories
Coot	46,000
Crane	3 pairs
Oystercatcher	33,000-43,000 pairs
Avocet	400-492 pairs
Little Ringed Plover	825-1,070 pairs
Ringed Plover	8,500 pairs
Golden Plover	22,600 pairs
Lapwing	190,000-240,000 pairs
Temminck's Stint	1-3 pairs
Purple Sandpiper	2 pairs
Dunlin	9,150-9,900 pairs
Ruff	two-24 females
Snipe	55,000 pairs
Black-tailed Godwit	29-53 pairs
Whimbrel	530 pairs
Curlew	33,000-38,000 pairs
Redshank	30,600-33,600 pairs
Greenshank	1,100-1,600 pairs
Wood Sandpiper	1-5 pairs
Common Sandpiper	15,800 pairs
Red-necked Phalarope	36 males
Mediterranean Gull	13-22 pairs
Black-headed Gull	167,000 pairs
Common Gull	68,000 pairs
Lesser Black-backed Gull	83,000 pairs
Herring Gull	160,000 pairs
Great Black-backed Gull	19,000 pairs
Sandwich Tern	14,000 pairs
Roseate Tern	64 pairs
Common Tern	12,300 pairs
Arctic Tern	44,000 pairs
Little Tern	2,400 pairs
Kingfisher	3,300-5500 pairs
Yellow Wagtail	50,000 territories
Grey Wagtail	34,000 pairs
Dipper	7,000-21,000 pairs
Cetti's Warbler	17-282 pairs
Savi's Warbler	1-15 pairs
Aquatic Warbler	40 individuals
Sedge Warbler	250,000 territories
Marsh Warbler	11-34 pairs
Reed Warbler	40,000-80,000 pairs
Bearded Reedling	339-408 pairs
Reed Bunting	220,000 territories

* native Hebridean population
\+ Introduced (mainly England and Wales)

British breeding waterbird assemblages are characterised in Figure 2.1. The commonest waterbirds are sedge warbler, moorhen, lapwing, herring gull and black-headed gull, which together make up over 50% of the total breeding population. Amongst waterfowl, moorhen and lapwing are by far the most abundant breeding species, together being over 47% of the total assemblage, with mallard and coot also abundant. Aside from lapwings, the most abundant waders are oystercatcher, curlew and redshank, each with populations of around 30-40,000 breeding pairs. However, none of these waterbird populations are particularly common by comparison with more widespread and cosmopolitan British breeding birds: there are an estimated 250,000 territories of sedge warbler, the commonest waterbird, but 7.1 million territories of wren, the commonest British breeding bird (Gibbons *et al.* 1993).

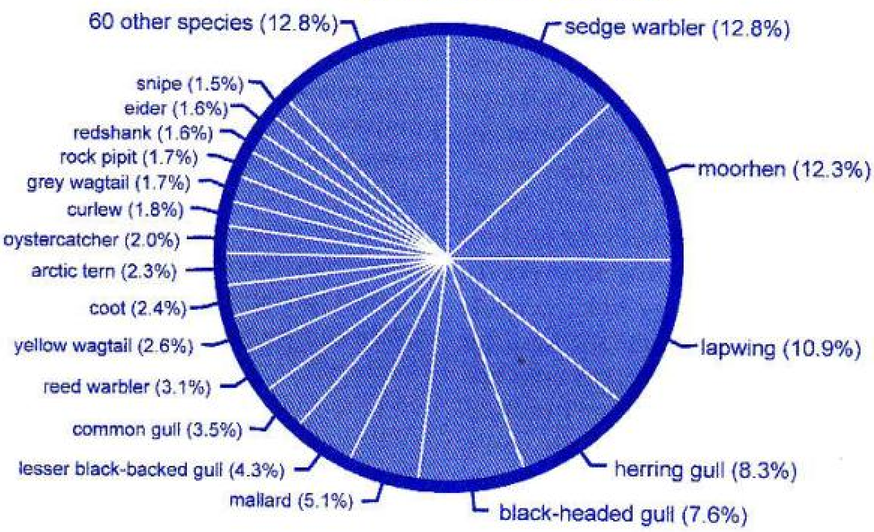


Figure 2.1. The proportion of the total of Britain's breeding birds which are made up of different species.

Many of the waterbirds that breed in Britain have a widespread distribution in Europe, and for these a relatively small proportion of their international population is present (Figure 2.2). Some populations, although numerically small however, are very important, not just in their contribution to overall biodiversity, but because Britain supports a significant part of their international breeding populations (Box 2.2). Other waterbirds have very small and vulnerable populations and are at the edge of their natural range in Britain (Box 2.3). The continued presence of these populations is important in maintaining the range and variability of these species. Recreation managers in Britain can use the information presented here (Box 2.1, 2.2 and 2.3) to determine the degree of importance attached to particular breeding species. It is also important to consult UK Biodiversity Action Plan listings (HMSO 1995) and general reference books and papers concerning the status of breeding species (*e.g.* Batten *et al.* 1990, Gibbons *et al.* 1993, Gregory *et al.* 2002).

In Britain, and elsewhere, wetland habitats vary in the range and abundance of waterbirds they

Box 2.2: Small British breeding populations - of international significance

- the small resident population of greylag geese breeding in north-west Scotland, regarded as a discrete population; estimated at 11,000 birds.
- the small, possibly discrete, British-breeding goosander population, frequenting rivers in northern Britain; estimated at 6,000 pairs.
- a substantial part (c. 30%) of the breeding population of the nominate redshank race *totanus*, nesting on wet grasslands and saltmarshes throughout the country.
- the large part of the small temperate breeding population of *schinzii* dunlins, breeding chiefly in the Outer Hebrides machairs.
- a breeding population of sandwich terns which is larger than any other European country, breeding on shingle ridges and islands on estuaries mostly in eastern and southern Britain, and representing about 30% of the European population.
- about 17% of the European population of little terns, vulnerable breeders on shingle and sand ridges, beaches and islands, with the largest populations being in eastern England from the Humber to the Solent.

Box 2.3: Rare breeding waterbirds in Britain - with 100 or fewer pairs

Slavonian Grebe	Purple Sandpiper
Black-necked Grebe	Temminck's Stint
Red-necked Grebe	Ruff
Whooper Swan	Red-necked Phalarope
Scaup	Bittern
Common Scoter	Mediterranean Gull
Goldeneye	Roseate Tern
Spotted Crake	Savi's Warbler
Black-tailed Godwit	Marsh Warbler

support, and all wetland habitats support some species. Even the inshore marine zone of Britain is used by breeding waterbirds (Box 2.4), for example by adult divers for feeding during their breeding season. However, of the 74 regularly occurring breeding waterbirds in Britain the greatest diversity occurs around open stillwaters - ponds, lakes, reservoirs and gravel pits - which provide concealment for nests and abundant food for adults and young. Stillwaters support over half the breeding waterbird species and are a particularly important breeding habitat for ducks, geese, swans and other wildfowl (26 out of 30 British-breeding species). Artificial waterbodies (reservoirs and gravel pits) support important parts of some breeding populations, *e.g.* about 40% of the national totals of great-crested grebe, tufted duck and coot. Reedbeds and other swamp and fen habitats also support a diverse breeding assemblage, notably of passerines such as warblers and some species such as bearded reedling and bittern, which are wholly dependent on large reedbeds.

Wet grasslands and peatlands are of particular importance for waders, each supporting over half the British breeding species. The machair grasslands of the Outer Hebrides, and the grazing marshes of the Ouse and Nene Washes, Somerset Levels, Norfolk Broads and the Greater Thames estuary are particularly significant for their large numbers and high densities of breeding waders. Saltmarshes also provide good breeding areas for waders, notably redshank, and breeding densities here are generally higher than on adjacent grasslands (Davidson *et al.* 1991). Estuaries overall are important breeding areas, both for their relatively undisturbed nesting opportunities on their saltmarshes and for the food available on tidal flats and in sheltered shallow waters. Estuaries, however, do support a much lower diversity of breeding than of wintering waterbirds. This emphasises that waterbirds are much more widely dispersed across the spectrum of wetland habitats when breeding than in winter (see below), the time when estuaries and coasts support particularly high numbers and diversity.

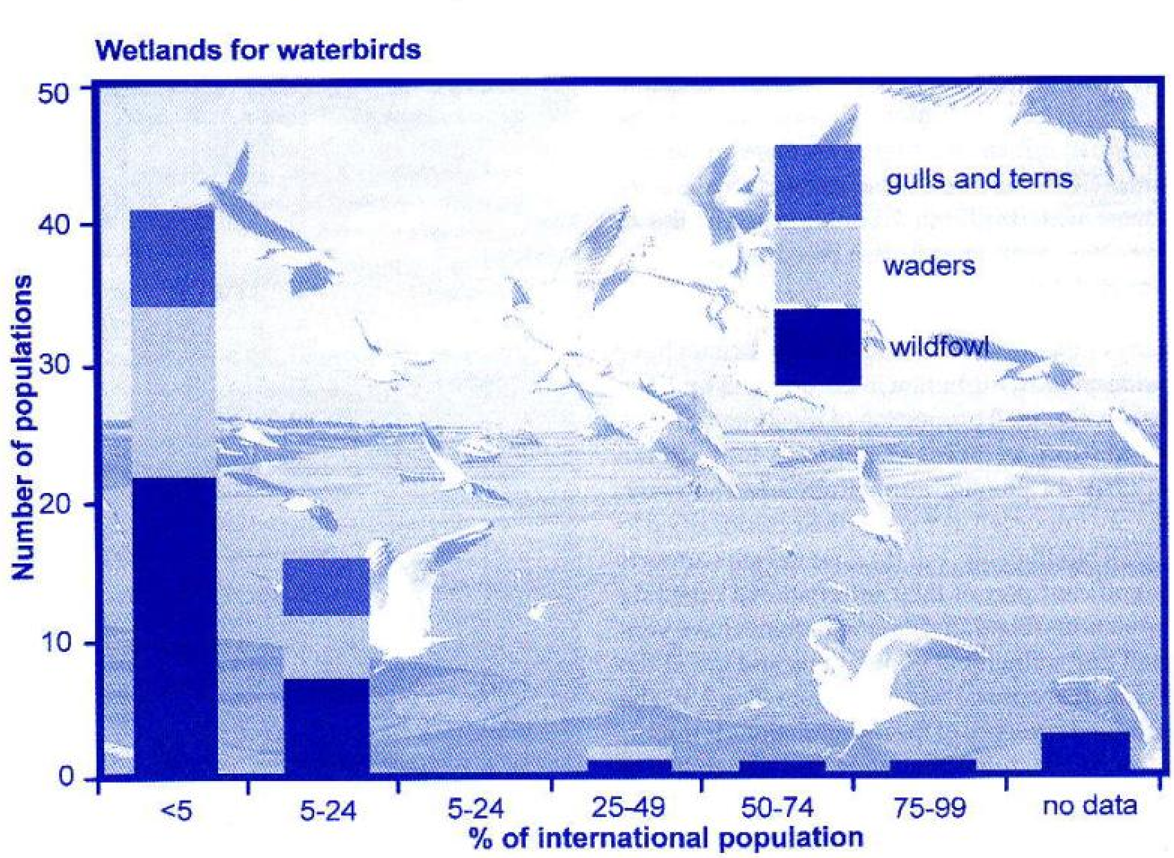


Figure 2.2. The number of populations of breeding waterbirds in Britain which represent different proportions of their international populations.

Box 2.4: Wetland bird assemblages breeding on different types of wetlands in Britain

Note that not all species will be breeding in the same wetland sites in a wetland habitat type; also some species occur in more than one nesting and/or adjacent feeding habitat.

BREEDING HABITAT	WATERBIRD					
	swans, geese & ducks	grebes, etc.**	waders	gulls & terns	other wetland species*	Total
Inshore marine	0	2	0	0	0	2
Estuaries (incl. saltmarsh)	3	1	6	6	1	17
Open soft coast (incl. shingle & dunes)	2	1	2	8	0	13
Rocky coast/cliffs/islands	2	1	1	7	1	12
Grasslands (grazing marshes/ wet grasslands/wet machair)	4	0	9	1	1	15
Peatlands	3	0	9	4	0	16
Fens/swamps/reedbeds	4	7	1	0	8	20
Open still waters (and their fringes)	18	8	5	3	4	38
Rivers/streams (and their fringes)	4	7	1	0	3	15
Total no. of species	*20*	*10*	*17*	*13*	*14*	*74*

** grebes, divers, cormorant and coot

* kingfisher, marsh harrier, osprey, rock pipit, grey wagtail, yellow wagtail, dipper, cetti's warbler, savi's warbler, sedge warbler, reed warbler, marsh warbler, bearded reedling, reed bunting

Breeding waterbirds usually use several habitat types whilst breeding. Many species nest in one habitat and feed whilst off-duty in another, or take their young after hatching to feed in markedly different areas. There are many examples: red-throated divers nesting on the edge of small, freshwaters but flying to feed in coastal waters or at larger lakes; goldeneye nesting in holes in trees and taking their ducklings to feed in rivers, and shelducks nesting in holes in field-banks and sand dunes but raising their young in tidal flats, lagoons and coastal bays. Recreation managers will find it useful to know when particular species are breeding (*e.g.* Box 2.5) as well as the particular habitats used to ensure minimal disturbance.

In summary, there are important breeding populations of waterbirds dependent on the whole spectrum of British wetlands, and perhaps even more than in winter waterbirds are dispersed across the wealth of large and small wetlands throughout the country. Although there is often a focus of attention on the rarer wetland breeding birds and their habitats, many of the commoner species depend on the network of these wetlands of different sizes for the maintenance of their breeding populations. Furthermore, even within their daily cycles, breeding waterbirds use a variety of wetland habitat types and locations, and an understanding of their breeding season requirements is an important part of their management.

2.3 Places to moult

After breeding, many waterbirds undergo a complete moult - the replacement of the feathers as they become worn and perform sub-optimally in terms of insulation and flight. The pattern and timing of

A male Mallard in moult, in a transition from its familiar breeding plumage to its summer moult plumage (eclipse).


WWT

moult varies amongst species and locations. The main moult of wildfowl and waders in Europe takes place in late summer and early autumn, when both body and wing feathers are replaced. Most wildfowl moult all their flight feathers simultaneously, becoming flightless in late summer, usually on or near their breeding grounds before migrating to wintering grounds. They may be flightless for a period of between 3-5 weeks (Salomonsen 1968). However, since individuals within a population may moult at different times, the period in which some birds may be flightless can be much longer, for example, May to October for Mute Swans in the UK (Coleman *et al.* 2002).

For some wildfowl, moulting areas for species that undertake moult migrations are quite well documented:

- Shelducks from Britain journey to the Heligoland Bight (German Wadden Sea) with small numbers also on the Firth of Forth, Dee, Humber, Wash and Severn estuaries (Jones 1989, Bryant 1978, 1981).
- male goosanders move to northern Norway (Little & Furness 1985).
- some feral Canada geese journey to northern Scotland to moult (references in Allan *et al.* 1995).
- British mute swan populations undergo distinct local moult migrations (Coleman *et al.* 2002, Spray *et al.* 2002).

For other wildfowl, information is severely lacking, though late summer surveys have been undertaken to attempt to locate key moulting sites (Salmon 1988; Cranswick 1995). Further work is necessary in Britain, and no doubt in many other places, to provide a greater understanding of moult

Box 2.5: Timing of breeding by waterbirds in Britain

Illustrated for all breeding species except the very rare (<100 pairs). See further: Gibbons *et al.* (1993).

Species/population	Month(s) of breeding	Species/population	Month(s) of breeding
Red-throated Diver	May-August	Avocet	May-June
Black-throated Diver	May-August	Little Ringed Plover	May-August
Little Grebe	February-September	Ringed Plover	March-July
Great-crested Grebe	April-September	Golden Plover	April-July
Cormorant	April-August	Lapwing	April-July
Grey Heron	February-August	Dunlin	May-July
Mute Swan	March-June	Snipe	April-July
Greylag Goose (native)*	April-August	Whimbrel	May-July
Greylag Goose (introduced)	March-July	Curlew	April-July
Canada Goose (introduced)	April-July	Redshank	April-July
Barnacle Goose (introduced)	April-July	Greenshank	May-July
Egyptian Goose (introduced)	February-May	Common Sandpiper	May-July
Shelduck	May-July	Black-headed Gull	April-July
Mandarin (introduced)	March-July	Common Gull	May-July
Wigeon	April-August	Lesser Black-backed Gull	April-August
Gadwall	May-August	Herring Gull	April-August
Teal	March-July	Great Black-backed Gull	April-July
Mallard	March-June	Sandwich Tern	May-June
Garganey	April-July	Common Tern	May-August
Shoveler	April-July	Arctic Tern	May-August
Pochard	April-August	Little Tern	May-July
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Eider	May-August	Yellow Wagtail	May-August
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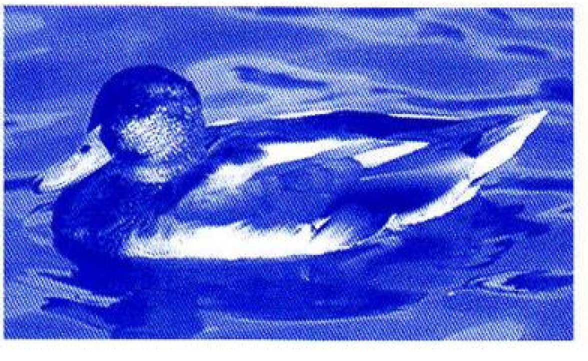
WWT

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Moorhen	March-September	Reed Bunting	April-August
Coot	March-August		
Oystercatcher	April-July		

* native Hebridean stock

ecology and to quantify the relative importance of individual wetlands as moulting sites.

As well as inter- and intra-specific variation in patterns of moult, further complexity arises because of geographical variations and differences in the timing of moult in relation to migratory movements. Many wildfowl moult on or close to their breeding grounds although some undergo a moult migration, travelling many hundreds of miles (Salomonsen 1968, Ogilvie 1975). More southerly wintering wader populations begin their moult at staging sites and then suspend it whilst they migrate further, completing moult on their wintering grounds. Moult is more rapid in northerly wintering populations than for those wintering in warmer, more southerly areas.

The moult period of ducks is particularly stressful, not just because moult is energetically costly (Masman *et al.* 1986), but also because there is an increased risk of predation and increased susceptibility to disturbance because the birds are flightless. Recreation managers need to be sensitive to the needs of moulting birds and may find the information presented on the timing of moult to be useful (Box 2.6).

It is well known that many waterbirds seek the safety of particular wetland sites during periods of moult. Often these are traditional, long established sites and some wetlands are very important in this respect. Unfortunately, however, there is generally little information for species other than wildfowl on which wetlands are used for moulting purposes and why these sites are selected. In Britain, for example, it is known that moulting waders concentrate on a few large estuaries, with major and diverse moulting wader concentrations in the Wash, Morecambe Bay, Dee and Ribble

Box 2.6: Moulting in adult waterbirds in Britain

Species included are relatively common breeders in Britain. The timing of the complete moult is given. Other codes are used to indicate a complete pre-nuptial moult (p), where the moult results in flightlessness (f), where the moult is commenced on the breeding area but suspended and finished in the winter quarters (s) and where the moult is not commenced in Britain (w). For further information see Ginn & Melville (1983).

Species/population	Post -nuptial/nesting	Species/population	Post -nuptial/nesting
Red-throated Diver	August-December (f)	Avocet	June-January
Black-throated Diver	January-April (p)	Little Ringed Plover	July-November
Little Grebe	July-October (f)	Ringed Plover	July-August
Great-crested Grebe	July-December (f)	Golden Plover	July-November
Slavonian Grebe	August-October (f)	Lapwing	June-October
Cormorant	July-December	Dunlin	June-September
Grey Heron	June-November	Snipe	June-October
Mute Swan	May-October (f)	Whimbrel	August-January (s)
Greylag Goose (all)	May-August (f)	Curlew	June-November
Canada Goose	June-July (f)	Redshank	June-November
Barnacle Goose	June-August (f)	Greenshank	June-February (s)
Shelduck	July-October (f)	Common Sandpiper	August-March (s)
Mandarin	May-August (f)	Black-headed Gull	June-October
Wigeon	June-September (f)	Common Gull	June-October
Gadwall	June-August (f)	Lesser Black-backed Gull	May-October
Teal	July-August (f)	Herring Gull	May-October
Mallard	June-September (f)	Great Black-backed Gull	May-October
Shoveler	June-August (f)	Sandwich Tern	July-December (s)
Pochard	June-September (f)	Common Tern	July-January (s)
Tufted Duck	June-September (f)	Arctic Tern	September-March
Eider	July-August (f)	Little Tern	June-December (s)
Red-breasted Merganser	July-August (f)	Kingfisher	July-December
Goosander	July-September (f)	Yellow Wagtail	July-December
Ruddy Duck	March-April, July-August (p,f)	Grey Wagtail	July-December
		Dipper	May-September
Marsh Harrier	May-October	Cetti's Warbler	July-September
Water Rail	July-September (f)	Sedge Warbler	- (w)
Moorhen	May-August (f)	Reed Warbler	- (w)
Coot	May-September (f)	Bearded Reedling	June-October
Oystercatcher	July-October	Reed Bunting	July-September

estuaries, and much smaller numbers in many places elsewhere (Davidson *et al.* 1986).

2.4 Places to winter

Wetlands support the greatest concentrations of waterbirds in winter, providing plentiful feeding opportunities as well as safe places to rest and sleep. Most wintering waterbirds feed and roost in flocks, sometimes numbering thousands, gaining advantages such as an improved awareness of predators and shelter that reduces thermoregulatory costs. Roosts are used when digestion takes precedence over feeding or when food is unavailable or not profitable to gather; when covered by the tide at coastal sites perhaps, when it is too dark (for visual feeders) or when the risk of predation is too high. The best roost sites are probably those where energy loss is minimised: those close to feeding areas, where there is shelter and where disturbances are few. Adequate feeding, roosting and loafing areas are essential components of wintering waterbird habitat. Providing sites relatively free from disturbance is an important element of the management of waterbird habitat networks.

As for breeding birds, the global distributions of wintering waterbirds vary greatly amongst species. They can be expansive or very restricted, whilst the numbers and species diversity at particular sites varies with wetland type, location and the quality of the habitat available. Britain is fortunate to host substantial waterbird populations (Owen *et al.* 1986, Davidson *et al.* 1991), drawn from breeding locations over a vast area of the northern hemisphere (Figure 2.3) as well as from within Britain itself. Regular counts show that over 85 populations of waterbirds use British wetlands in appreciable numbers in winter. These include 38 wildfowl populations (including the non-native Canada goose); 22 wader species; five gull species; and the grey heron (Box 2.7). In total, more than 10 million waterbirds are present in winter, with black-headed gull, lapwing, reed bunting and moorhen together contributing just over half of the total (Figure 2.4). Over 5.5 million wildfowl and waders are included (2.1 million wildfowl and 3.4 million waders - but note that the latter figure includes the 1.5-2 million lapwings and golden plovers that predominantly use non-wetland farmland). This assemblage is dominated by lapwing, mallard, dunlin, knot, wigeon and oystercatcher, with 14 species each having British wintering populations exceeding 100,000 birds, the largest being lapwing (>1.5 million) and mallard (500,000). Although these may seem large populations, the great majority of waterbirds are markedly scarce in comparison to other British birds, *e.g.* wren (7.1 million), chaffinch (5.4 million) and blackbird (4.4 million) (Gibbons *et al.* 1993). The relatively small population sizes for waterbirds make them vulnerable to the loss and degradation of the wetlands on which they depend.

Of course relatively few waterbird species winter only in one country. Britain, like other countries, contributes to the maintenance of global

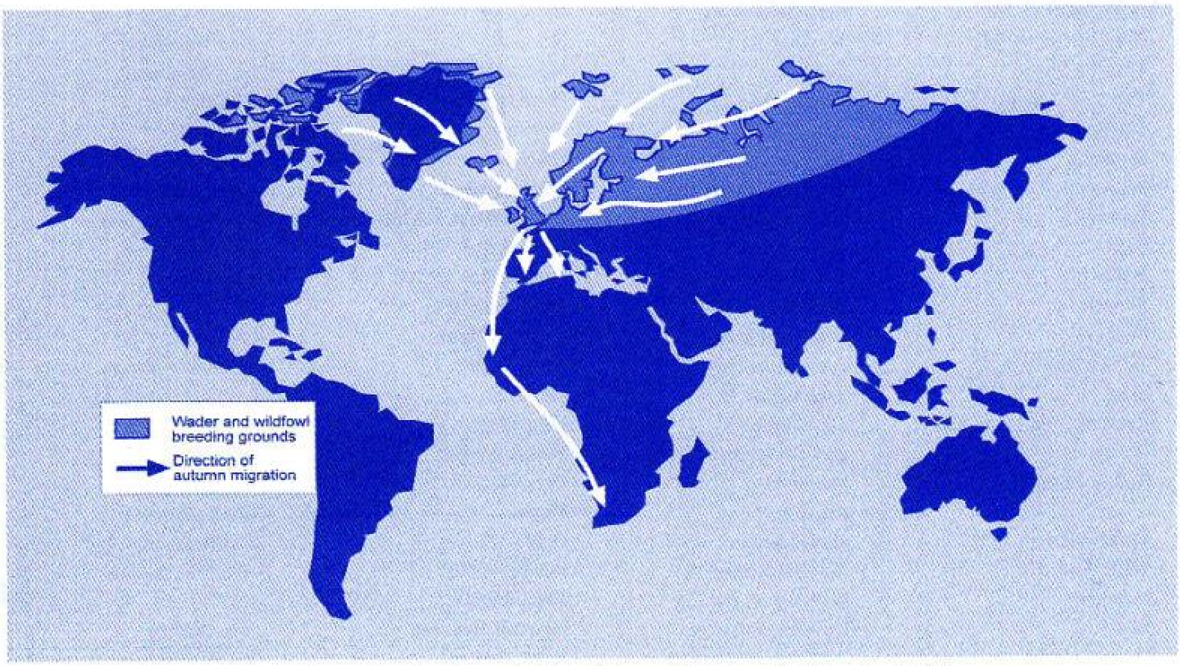


Figure 2.3 Breeding range and migration routes of waders and wildfowl that use Britain (from Davidson *et al.* 1991)

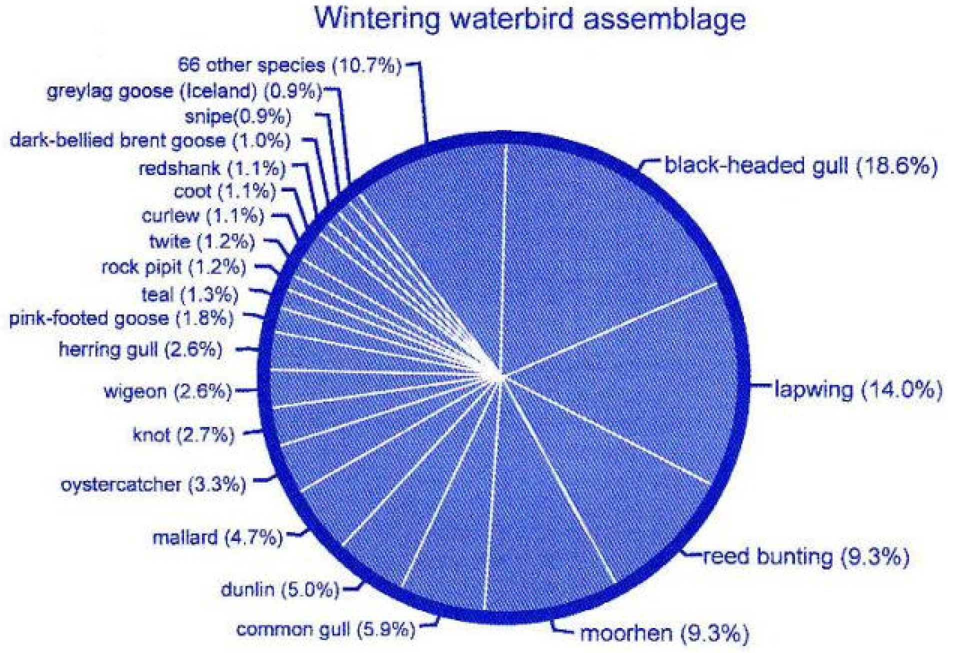


Figure 2.4. The proportion of the total of Britain's wintering waterbirds in Britain which are made up of different species.

populations, with substantial proportions of many species: over 25% of the total winter populations of 30 migratory waterbirds, and for nine of these over 75% (Figure 2.5). These nine are all wildfowl and wader populations: the pink-footed goose, Icelandic and North Scottish greylag geese, Greenland and Svalbard barnacle geese, goosander, redshank, turnstone and knot (Box 2.7). In severe winters, British wetlands attain even greater significance as more birds arrive to find refuge (see below).

Waterbirds often use a great variety of wetland habitats in winter; here illustrated for Britain (Box 2.8). Whilst at least one species uses all main wetland types, coastal wetlands, and particularly estuaries, are of great importance and are used by 75% of all wintering populations and 86% of wader populations. Of the 5.5 million waterfowl wintering in Britain, estuaries support over 30% of birds. Open stillwaters also support a diverse wintering assemblage, especially of wildfowl (68% of the total), as do grasslands such as coastal

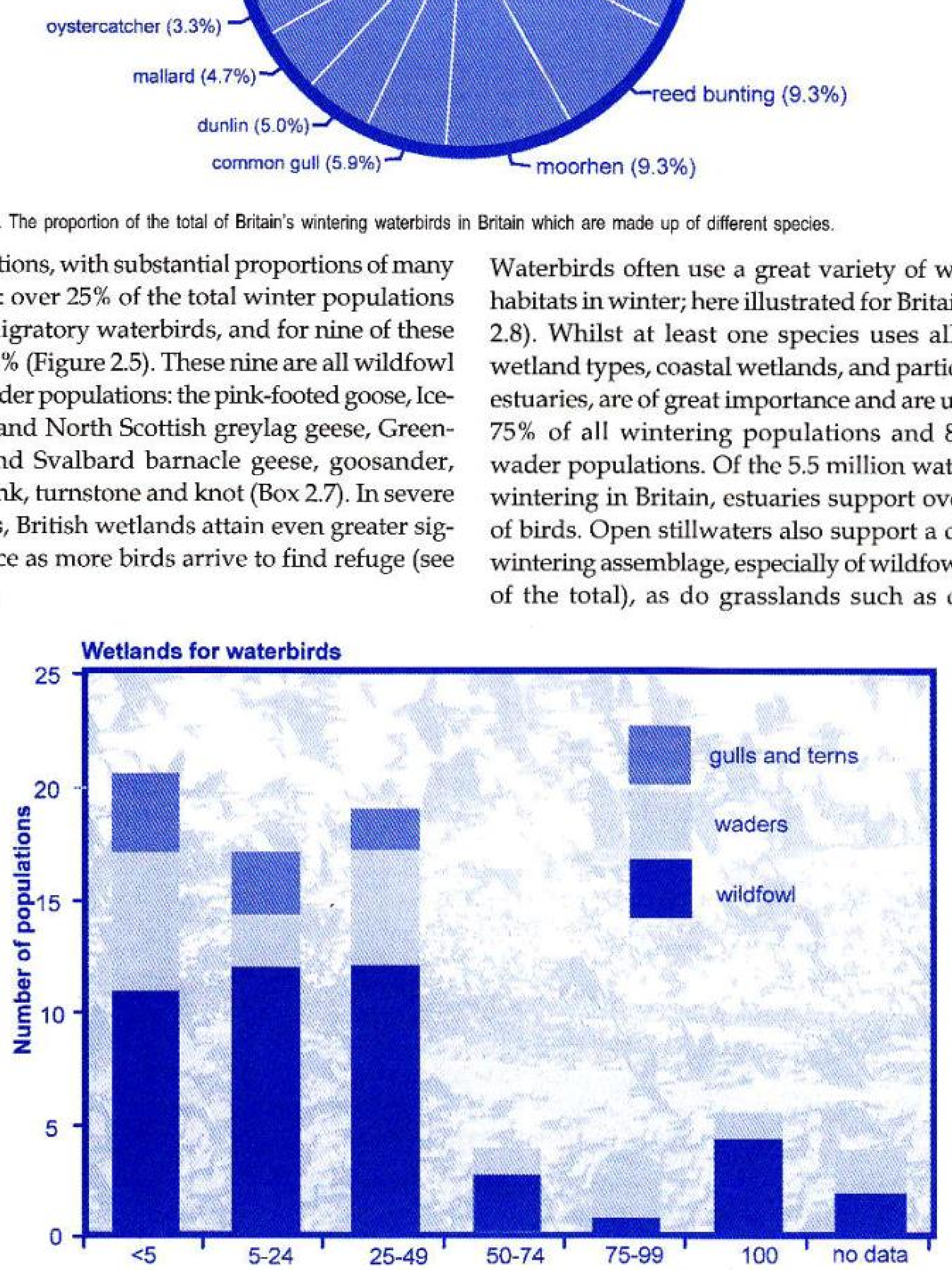


Figure 2.5. The number of populations of wintering waterbirds in Britain which represent different proportions of their international populations.

Box 2.7: British wintering population and flyway population sizes of waterbirds

Based on estimates provided by Stone *et al.* (1997), Rose & Scott (1994, 1997) and Scott & Rose (1996). See these publications for details of estimation methods. Precise percentages of international populations present in Britain are not included since not all estimation methods are directly comparable: % ranges are A (<5%); B (5-24%); C (25-49%); D (50-74%); E (75-99%); F (100%). International population estimates for waders are mainly for the early 1980s (Smit & Piersma 1989) and are under review.

Species/population	Flyway/population range	International population	British population	% in Britain
Red-throated Diver	Europe/Greenland	75,000	4,850	B
Black-throated Diver	Europe/W Siberia	120,000	700	A
Great Northern Diver	Europe	5,000	3,000	D
Little Grebe	W Palearctic	?	3,290	?
Great-crested Grebe	NW Europe	150,000	9,800	B
Red-necked Grebe	NW Europe	15,000	150	A
Slavonian Grebe	NW Europe	5,000	400	B
Black-necked Grebe	W Palearctic	100,000	120	A
Cormorant	NW Europe	120,000	13,200	B
Bittern	Europe	25,000-100,000	50-150	A
Grey Heron	Europe	400,000-500,000	20,000	B
Mute Swan	West/Central Europe	240,000	37,500	B
Bewick's Swan	Europe	17,000	7,200	C
Whooper Swan	Iceland	16,000	5,600	C
Bean Goose	W Siberia	80,000	450	A
Pink-footed Goose	Iceland/Greenland	225,000	225,000	F
European White-fronted Goose	NW Europe	600,000	6,100	A
Greenland White-fronted Goose	Greenland	30,000	13,700	D
Greylag Goose	Iceland	100,000	100,000	F
Greylag Goose	N Scotland	8,400	8,400	F
Greylag Goose	Introduced	-	18,900	-
Canada Goose	NW Europe	120,000	61,000	D
Barnacle Goose	Greenland	32,000	26,950	E
Barnacle Goose	Svalbard	12,000	12,000	F
Barnacle Goose	Introduced	-	820	-
Dark-bellied brent Goose	Siberia	300,000	103,300	C
Light-bellied Brent Goose	Svalbard	5,000	2,430	C
Egyptian Goose	Introduced	-	910	-
Shelduck	NW Europe	300,000	73,500	C
Mandarin	Introduced	-	7,000	-
Wigeon	NW Europe	1,250,000	277,800	B
Gadwall	NW Europe	30,000	8,200	C
Teal	NW Europe	400,000	135,800	C
Mallard	NW Europe	5,000,000	500,000	B
Pintail	NW Europe	60,000	27,800	C
Shoveler	NW Europe	40,000	10,000	C
Red-crested Pochard	Introduced	-	100	-
Pochard	NW Europe	350,000	43,700	B
Tufted Duck	NW Europe	1,000,000	60,600	B
Scaup	NW Europe	310,000	11,000	A
Eider	Europe	2,500,000	77,500	A
Long-tailed Duck	NW Europe/Siberia	4,750,000	23,500	B
Common Scoter	NW Europe/W Siberia	1,600,000	34,500	A
Velvet Scoter	N Europe/W Siberia	1,000,000	3,000	A
Goldeneye	NW Europe	300,000	17,000	B
Smew	NW Europe	25,000-30,000	250	A
Red-breasted Merganser	E Greenland/Iceland	15,000-25,000	10,000	C
Goosander	NW Europe	125,000	8,900	A
Ruddy Duck	Introduced	-	3,500	-
Marsh Harrier	Europe	?	?	-
Water Rail	Europe	100,000-1,000,000	?	-
Moorhen	Europe/ N Africa	>1,000,000	?	?

Box 2.7: British wintering population and flyway population sizes of waterbirds (continued)

Species/population	Flyway/population range	International population	British population	% in Britain
Coot	NW Europe	1,500,000	114,100	B
Oystercatcher	E Atlantic	874,000	359,000	C
Avocet	W Europe/W Med.	67,000	1,270	A
Ringed Plover	Europe/N Africa	47,500	28,600	D
Golden Plover	NW Europe	1,800,000	250,000	B
Grey Plover	E Atlantic	168,000	43,200	C
Lapwing	Europe	7,000,000	1,500,000+	B/C
Knot	NW Europe	345,000	291,000	E
Sanderling	E Atlantic	123,000	23,200	B
Purple Sandpiper	E Atlantic	50,500	21,300	C
Dunlin	Europe/W Africa	1,373,000	532,000	C
Ruff	Europe/W Africa	>1,000,000	700	A
Jack Snipe	Europe	?	10,000-100,000	?
Snipe	Europe	>20,000,000	>100,000	?
Black-tailed Godwit	W Europe/W Africa	350,000	7,410	A
Bar-tailed Godwit	W Palearctic	115,000	52,500	C
Curlew	Europe	348,000	115,000	C
Spotted Redshank	Europe/W Africa	75,000-150,000	120	A
Redshank	Iceland/Faeroes	109,000	114,000	F
Greenshank	Europe/W Africa	100,000-1,000,000	380	A
Green Sandpiper	Europe/W Africa	100,000-1,000,000	750	A
Common Sandpiper	Europe/W Africa	>1,000,000	100	A
Turnstone	W Palearctic	67,000	64,400	E
Black-headed Gull	NW Europe	>5,000,000	2,000,000	B/C
Common Gull	NW&C Europe/Med.	1,600,000	900,000	C
Lesser Black-backed Gull	NE Atlantic	500,000	500,000	F
Herring Gull	W Europe/Iceland	1,300,000	450,000	B
Greater Black-backed Gull	NE Atlantic	480,000	40,000	B
Kingfisher	-	-	?	-
Grey Wagtail	-	-	38,000	-
Dipper	-	-	?	-
Reed Bunting	-	-	?	-

Box 2.8: Wintering waterbird assemblages on different types of wetlands in Britain

Note that not all species will be wintering in the same wetland sites in a wetland habitat type; also some species winter in more than one habitat.

WINTERING HABITAT

	swans, geese & ducks	other wildfowl	waders	gulls & terns	other wetland species*	Total
Inshore marine	7	9	0	2	0	18
Estuaries (incl. saltmarshes)	19	10	18	5	8	60
Open soft coast (incl. shingle & dunes)	0	0	9	5	5	19
Rocky coast/cliffs	1	1	8	2	1	13
Grasslands (grazing marshes/ wet grasslands/wet machair)	11	2	6	4	4	27
Peatlands	1	0	0	0	0	1
Fens/swamps/reedbeds	2	3	3	0	4	12
Open still waters	22	8	4	5	4	43
Rivers/streams	8	6	1	2	4	21
Total no. of species	*30*	*14*	*21*	*5*	*11*	*81*

* kingfisher, dipper, snow bunting, shorelark, rock pipit/water pipit, lapland bunting, twite, grey wagtail, pied wagtail, cetti's warbler

Box 2.9: Assessing the significance of individual wetland sites

For waders and wildfowl (*i.e.* waterfowl), determining the relative importance of wetland sites in Britain is quite straightforward. Criteria for assessing the international importance of wetlands have been agreed by the Contracting Parties to the Ramsar Convention on Wetlands of International Importance (Ramsar Convention Bureau 1988). Under one criterion, a wetland is considered internationally important if it regularly holds at least 1% of the individuals in a population of one species or subspecies of waterfowl, while any site regularly holding a total of 20,000 or more waterfowl also qualifies. Britain's wildfowl belong to north-west European populations and waders to East Atlantic Flyway populations. A wetland in Britain is considered nationally important if it regularly holds 1% or more of the estimated British population of one species or subspecies of waterfowl. For both international and national importance, regularity is usually defined on the basis of a winter (five-year) peak mean count. Current 1% thresholds for national and international importance are listed in annual reports from the Wetland Bird Survey (*e.g.* Cranswick *et al.* 1997, *et seq.*), in which further detail is provided. Similar methods have been used to assess regional (within-country) and local importance, using 1% or 5% levels calculated from regional or local population estimates, but no formal criteria are available for this purpose. Likewise for non-waterfowl species, there are no accepted criteria for site assessment in Britain, whilst up-to-date national estimates are unavailable for most species (cf. Stone *et al.* 1997).

grazing marshes and other wet grasslands (33% of the total).

The presence of a very diverse bird assemblage in many wetlands is also important, with particularly the larger wetlands supporting many different species of national and international importance (for guidance on winter site assessment see Box 2.9). In total some 118 British wetlands support at least one internationally important wintering population: about half of these are estuarine and coastal, with many of the others being lakes and reservoirs that act as roosting areas for geese. In addition at least 51 wetlands, 40 of them estuarine or coastal, regularly support an assemblage in excess of 20,000 wintering waterfowl, making these places internationally important for this reason alone. But for the scarcer species the population size for international importance is small (*e.g.* whooper swan 160, Bewick's swan 170; Svalbard barnacle goose 120; Svalbard light-bellied brent goose 50) so that even some relatively small wetlands are of international importance. For information on the relative importance of particular sites in Britain see the annual reports from the Wetland Bird Survey (*e.g.* Cranswick *et al.* 1997, 1999, Pollitt *et al.* 2000, Musgrove *et al.* 2001, Pollitt *et al.* 2003). For international distributions of key sites see Scott & Rose (1996).

It is important to understand that there is considerable variability in the distribution patterns of particular species. Some species are concentrated into just a few wetland sites (*e.g.* Svalbard barnacle goose, bean goose, knot, bar-tailed and black-tailed godwit in Britain), whilst many, especially the commoner waders and ducks, are widely dispersed throughout the wetland resource. This means that parts of some populations are dispersed around many smaller wetlands that individually hold small numbers (Davidson *et al.* 1991). It is clear, therefore, that waterbirds use a network of small wetlands, and, together with the larger ones, these form a vital component of the wintering range of the many flyway populations (a flyway population is a rather discrete group of birds separated from others by their different migration routes). Thus sympathetic management of small as well as large wetlands is important for the safeguard of these populations.

Whilst waterbirds may be quite sedentary during the breeding and moult periods, at other times many waterfowl are highly mobile, using a whole suite of wetlands. The exact usage of wetland habitat by waterbirds often varies between sites, from day to day and from year to year. Factors affecting use include the location of the most profitable food supplies; the distribution of competitors and conspecifics; levels of disturbance, both natural (*e.g.* predators) and man-made; daily energy requirements; and weather conditions, especially temperature, wind speed and direction.

Within the daily cycle, waterbirds sometimes fly considerable distances from their feeding grounds to find suitable roosting sites and return. Waders and others may traverse large estuaries, journey

WWT

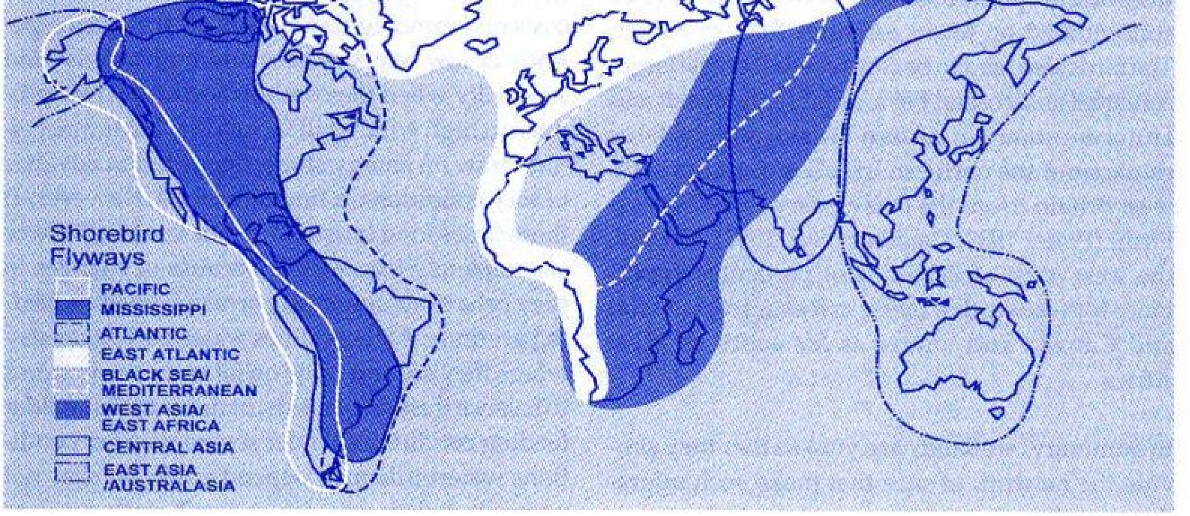
long distances along one shoreline, and even skip to different estuaries (see *e.g.* Furness 1973, Symonds *et al.* 1984, Davidson & Evans 1985, Mitchell *et al.* 1988, Kirby *et al.* 1993). Wildfowl, such as swans and geese, generally forage close to their roost sites, mostly within 5-10km (*e.g.* Owen *et al.* 1986, Giroux & Patterson 1995, Keller *et al.* 1998), but longer distance flights are sometimes necessary. Within this flexibility of use there are also interspecific differences in the consistency of birds' distribution (see Pienkowski & Pienkowski 1983, for dunlin in Western Europe).

Common to many of these movements is the need for birds to exploit a profitable food supply to meet their daily energy needs, and to find safe and undisturbed localities in which to rest and sleep. Sometimes it is important to store energy also, for use during migration or during emergency periods, *e.g.* in severe weather (see below). In these cases, freedom from disturbance may become paramount. A clear understanding of the requirements of each species and of the use of wetland habitat networks in winter should enable managers to minimise recreational effects and impacts at the key times of year and safeguard an area's waterbird populations.

2.5 Networks for migration

Many waterbirds are migratory and a key conservation feature of these is the use of a network of sites for journeys between breeding, moulting and wintering areas. Each waterbird species or population (and even different individuals within a population) has its own particular migration strategy and habitat preferences and so migrates in a different way and uses a different suite of sites during its migrations. This leads to many migration systems that overlap in time and space. These can be grouped, for convenience, into broad 'flyways' used by many populations during their annual migrations (Wader Study Group 1992). Britain, for example, sits at mid-latitudes and at the western side of the East Atlantic Flyway, the route used by many African-Eurasian waterbirds. British wetlands therefore play host to migrating waterbirds in spring and autumn, birds often staying only for relatively short periods (especially waders) but, nevertheless, taking on energy and resting in order to complete their migrations. Maintaining this flyway, and indeed the variety and quality of waterfowl site networks throughout the world, is a cornerstone of waterbird conservation and management.

Most migratory waterbirds are unable to fly non-stop between their breeding and wintering grounds because the distance is too far. Some species make a large number of small 'hops' - a strategy dependent on the availability of suitable feeding in many places and one in which birds need store only small reserves of fat as migratory fuel (Piersma 1987b). Others, such as the brent goose, fly long distances (perhaps >3000km) between very few staging areas and store very large amounts of fat and muscle protein. Others occur at more numerous staging locations but each individual uses only a few. This complex mixture of migratory strategies is poorly understood and underlines the need for a precautionary approach to site protection. When in doubt on the actual importance of a staging post for a given species - look after it.



A few waterbird species only regularly occur only on British wetlands during their spring and autumn migrations, for example curlew sandpiper and spotted redshank. For others, populations different to those present in summer or winter occur on passage. In dunlin, for example, spring and autumn populations on estuaries can include birds from the small British-breeding *schinzii* population; a larger *schinzii* population from Icelandic breeding grounds; a small Greenland-breeding *arctica* population; and the *alpina* wintering population from Scandinavia and Russia, which accounts for the greater proportion of our wintering birds. These are different breeding populations, distinguishable by plumage and size.

Relatively few wildfowl use British wetlands only as migratory stopovers, since most travel no further south or southwest than Britain and Ireland to over-winter. In autumn many stop for a time outside of Britain before moving here in early winter. In some instances, however, autumn staging sites in Britain are of major importance. For example almost the whole of the Greenland barnacle goose population uses Loch Gruinart, Islay, in October before dispersing throughout their Irish and western Scottish wintering range. In spring many British wintering waterfowl populations move to stopover sites north and east of Britain, notably the Wadden Sea. Wader populations wintering further south on the Atlantic coasts do, however, occur in large numbers in spring and autumn on British wetlands, particularly estuaries. Total peak spring estuarine populations are smaller than those in winter, but allowing for population turnover, between 750,000 and 1,500,000 waders probably use British estuaries in spring, representing in excess of 20% of the flyway population.

In spring, populations of most waders tend to be concentrated on fewer estuaries than in winter. The birds also tend to be concentrated on the larger estuaries and coastal bays, notably the Wash and Humber estuary in eastern Britain, and the large estuaries of the northern Irish Sea coast of northwest Britain (from the Dee estuary to the Solway Firth) (Prater 1981; Davidson *et al.* 1991). Overall, the west coast of Britain is of particular importance for waders that breed in Iceland, Greenland and Canada and winter as far south as West Africa.

In summary, wetlands are vital in that they provide the network of sites that make such migrations possible. Crucial for such places to serve successfully as stopovers on migration is a suitable, abundant and available food supply so that birds can refuel for onward migration, and security from disturbance so that they can feed and refuel as rapidly as they need. Wetlands used for staging may be important for reasons other than just the accumulation of fat and muscle protein. For example, spring stopover sites may be vital sources of resources scarce on the breeding grounds: female knots have recently been found to store calcium in their bones at late spring staging areas (Piersma *et al.* 1996). Sufficient calcium is essential for eggshell formation and lack of calcium is known to greatly reduce breeding success in birds.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2.6 Safe havens

Of all of the emergency situations faced by waterbirds (*e.g.* pollution events, disease outbreaks), severe winter weather most frequently poses problems, at least at northerly latitudes. Waterbirds generally live in exposed conditions and severe weather greatly increases the energetic costs of thermoregulation. Indeed, it is during periods of low temperatures and high winds (and especially when the combination of the two produces a high wind-chill factor) that birds must either draw on energy stores deposited in advance of such conditions or find more food. However, at these times food is usually either less available or is completely inaccessible because of changes in prey behaviour or freezing or snow-cover on feeding grounds. At these times waterfowl either stay where they are and draw on fat and protein stores to balance their daily needs, or move to find milder feeding conditions. Under severe weather conditions waterbirds may depend either on sites not normally in their network, redistribute themselves across network sites, or use the same sites in ways different from normal. Different species adopt different survival strategies under severe conditions; see the detailed reviews of Baillie *et al.* (1986), Ridgill & Fox (1990), Davidson *et al.* (1991) and Kirby (1995b) for Britain and Europe.

Severe winter weather is an important factor for the waterbirds of British wetlands. In general, waterbirds over-wintering in freshwater and inland wetlands are most rapidly or severely affected, since these places are the first to freeze. Estuaries and other coastal wetlands are less vulnerable to freezing because of the buffering effect of relatively warm sea temperatures combined with tidal water movements and the lower freezing point of salt water. Hence estuaries take on a major importance as refuges during severe winter weather. Furthermore in many severe weather events the conditions are less extreme in Britain than in continental Europe. This, combined with the larger tidal ranges of British estuaries compared with major continental estuaries such as the Wadden Sea, makes British estuaries less likely to freeze and so with added importance internationally as refuges.

Some oystercatchers, redshanks and dunlins are known to move to Britain from continental estuaries in severe weather. Some grey plovers recorded at Teesmouth in north-east England were only reported in years when there was severe weather in the Wadden Sea (Townshend 1982). Other species may move in too, Kirby (1995b) presenting evidence for influxes of bar-tailed godwits, ringed plovers, knots and sanderlings. Many inland and grassland-wintering waders, notably lapwing, golden plover, snipe and curlew, move to coasts and, when these are frozen, out of Britain into Ireland, France and Iberia (*e.g.* Kirby & Lack 1993, Kirby 1995b). Evidence exists for regional re-distribution within Britain also, involving at least five species (ringed plovers, black-tailed godwits, bar-tailed godwits, curlew and turnstone) (Kirby 1995b). However, many waders remain on their usual wintering grounds in severe weather, exploiting their fat and protein stores to survive. Even with this and other adaptations, such as minimising energy expenditure by seeking shelter, or in extreme cases remaining on roost sites rather than feeding during low tide, many waders have increased mortality at such times (Baillie *et al.* 1986, Kirby 1995b). Severe winter weather often affects oystercatchers and redshanks more rapidly than other waders, and mortality of these species is often higher on continental and eastern British estuaries. Others suffering severe weather mortality in Britain include ringed, golden and grey plovers, lapwing, sanderling, dunlin and curlew (Kirby 1995b).

Many wildfowl are also known to move in response to severe weather since inland wintering sites are more vulnerable to freezing. Ridgill & Fox (1990) showed that seven (shelduck, wigeon, teal, pintail, shoveler, tufted duck and pochard) out of nine common wildfowl species moved out of north Britain and the Wadden Sea into south and west Britain and north and west France, with some moving as far south as Iberia. The numbers of birds moving, and where they go, seems to depend on the distribution and severity of the weather. Some geese also move in response to severe weather. Most pink-footed geese move south from Scotland into the coastal regions of north-west Britain. Moreover, the proportion of the small Svalbard light-bellied brent goose population reaching Lindisfarne in north-east England is closely linked with the winter weather conditions on its other wintering grounds in Denmark (Owen *et al.* 1986, Ridgill & Fox 1990).

Overall, severe weather events can place waterbirds under severe stress. Minimising disturbance, from recreation for example, is especially important under these circumstances. In the UK, there has been a voluntary agreement in place for some years to ban shooting and some other disturbing activities during severe weather in order to ensure maximum survival through these periods.

Humans can also have a beneficial effect on waterbirds. For example, some conservation organisations provide food for birds or manage habitat in such a way that food is more abundant, in order to increase the conservation value of sites or attract birds close to public viewing sites. The fact that birds flock to such places indicates that they benefit from such action, especially when severe weather makes other sites unavailable. Prime examples of habitat creation and management to benefit both birds and people are fount at the reserves of the Wildfowl & Wetlands Trust, where the aim of habitat improvement is not only to benefit birds but also to bring them closer to public viewing areas, where hundreds of thousands of human visitors can see them near at hand. In some cases bait is provided to attract birds close to viewing facilities. Such reserves no doubt have a beneficial effect on over-winter survival. The public at parks or suburban sites also feeds many of the tamer species and no doubt supplementary feeding enhances winter survival.

2.7 Implications for wetland managers

It should be clear from previous sections that a great variety of waterbirds are dependent on wetlands when breeding, feeding and resting, in many localities across their summer, winter and migratory ranges. The implications for wetland managers are numerous and must be considered in developing effective and sustainable management for waterbirds and their wetland habitats. They include:

- wetlands can support rich assemblages of waterbirds, or just a few species that may nevertheless be important.
- many wetlands support a mixture of birds that breed or winter in different countries, emphasising the global nature of the resource and international responsibility for action.
- even the commonest waterbirds, whether breeding or wintering, are important contributors to biodiversity and may, in any case, not be especially numerous in a wider context.
- any waterbird community may include species that are internationally relatively scarce, on the edge of the range, vulnerable or unique.
- small or vulnerable waterbird populations may suffer the most from further changes, loss and degradation of wetlands throughout their ranges.
- all types of wetland habitats may be important for the waterbirds they support, and even artificial sites may be of considerable importance.
- moulting birds, and those enduring severe weather events, need extra energy and are particularly vulnerable to predation and disturbance.
- many waterbirds are highly migratory and use a network of sites for moving to and from breeding, moulting and wintering areas. Maintaining the variety and quality of waterfowl site networks throughout the world is a cornerstone of waterbird conservation and management.
- bird concentrations may attract increased human use, which can in itself cause deterioration in water quality (Whitmore *et al* 1995).
- some individuals, populations or species depend on just a few key places long distances apart during their annual migrations; others require a network of many places at relatively short distances apart. Key migration staging areas are often used for only short (days or weeks) periods of the year: so duration of use of a wetland is not the only good indicator of its importance.
- because of rapid population turnover during migration, larger proportions of flyway populations use staging areas than is apparent from the number present at any one time, so the significance of such sites is readily underestimated. Many waterbirds are mobile within seasons, regions and sites and utilise a whole suite of wetlands and habitat types.
- many different scales of network (from a few to several thousand kilometres) must be safeguarded.
- reliable information is needed on the relative importance of particular species so that these can be safeguarded. It is useful to know in which months particular species breed and moult, and of their requirements for nesting, raising young, whilst in moult or for wintering.
- an understanding of the year-round habitat requirements of each species is an important part of waterbird and wetland management. A clear understanding of the requirements of each species and of the use of wetland habitat networks should enable managers to minimise recreational effects and impacts and safeguard an area's waterbird populations.

2.8 Are waterbirds a constraint on recreation?

From the sections above, it is clear that waterbirds are closely associated with wetlands and that a diverse, wetland network is essential for supporting diverse and abundant waterbird populations. However successful waterbird conservation measures may result in large and concentrated groups of birds, sharing the wetland resource with recreational users. The latter may view the birds as a constraint on their enjoyment of sport in the wetland environment. There may be health and enjoyment difficulties and constraints on the development of sporting opportunities because of the presence of protected species or the protected status of wetland sites.

2.8.1 Water quality and public health

Recreational water users may have concerns about reductions in water quality attributable to waterbirds. The faeces from large numbers of roosting or feeding birds, especially when flocking in winter, can have appreciable impacts on aquatic nutrient budgets that could induce eutrophication processes on sensitive waters. High densities may potentially have a negative influence on environmental quality for a wide range of recreational

Box 2.10: Water quality implications of bird concentrations

- in an urban situation in North America, Harris *et al.* (1981) demonstrated that eutrophication can and does occur rapidly, under certain conditions, on the two small ponds studied, with waterfowl contributing an excessive nutrient loading.
- Manny *et al.* (1994) showed that over 6500 Canada geese and 4200 ducks added 4462kg of carbon, 280kg of nitrogen and 88kg of phosphorus per year to a lake in SW Michigan, mostly during their migration. These amounts were 69% of all C, 27% of all N, and 70% of all P that entered the lake from external sources.
- at the Loch of Strathbeg, Scotland, roosting waterfowl contributed up to 1 tonne total phosphorus per year, 16-18% at most of the total phosphorus load (Hancock 1982; Raffaelli *et al.* 1991; Milne 1998). The actual impact of bird faeces on water quality at this site remains uncertain due to its incorporation into the bottom sediments.
- at St Fergus Winter Loch, Scotland, pink-footed geese imported 94kg N, 54kg P, 90kg of potassium (K) and 4,840kg of organic material in the course of one winter (Patterson *et al.* 1996, Patterson 1997). Overall, the geese accounted for some 61% of N and 86% of P deposited by birds, with most of the deposition in early winter. In this study, it was not possible to relate the inputs from birds to the measured concentrations of nutrients in the loch.
- gulls feeding on rubbish tips and roosting on reservoirs have the potential to carry pathogens into drinking water.
- bird concentrations may attract increased human use, which can in itself cause deterioration in water quality (Whitmore *et al.* 1995).

water users, as well as for the birds themselves and other wildlife.

Scrutiny of relevant research studies reveals that the quality of surface waters may be affected by nutrients in bird faeces (Box 2.10). Since waterbirds may roost in very large concentrations, and since the use of roost sites is generally sustained over periods of months, waterbirds may play an important role in the determination of a site's water quality. Hypertrophic waters often have species-poor invertebrate faunas (conservation impact), can be subject to blooms of toxic blue-green algae (cyanobacteria - animal and human health threats), have low dissolved oxygen concentrations (potential fish mortalities) and poor water clarity (reduced aesthetic appeal). Most attention has so far focused on the impact of mass gull roosts on public water supply reservoirs and the associated public health concerns (*e.g.* Fennell *et al.* 1974; Butterfield *et al.* 1983). Gulls often forage on rubbish tips and landfill sites, picking up a wide variety of bacteria, and thus there is the distinct possibility of transfer to reservoirs when the birds return to communal roosts. Botulism and *Salmonella* poisoning could result.

A related concern centres on the transfer of pathogenic bacteria to grasslands used for amenity purposes, with waterbirds the focus of concern in public parks containing waterbodies. A recent assessment for Canada geese, which produce large quantities of faeces and are often in close contact with humans, concluded by finding no conclusive evidence for transmission of pathogens to humans in this way (Allan *et al.* 1995). However several types of potential human pathogens have been isolated from Canada goose and other waterbird faeces and thus there is an unknown, but possibly significant, disease risk to humans from contact with waterbird faeces.

Bird concentrations in themselves make such water attractive to the informal user as well as birdwatchers, so the presence of bird concentrations could result in increased human use. Recreational users may themselves cause a deterioration in the quality of water and, where treatment facilities are limited, it is recommended that access to water bodies supplying potable water should be restricted (Whitmore *et al.* 1995).

2.8.2 Predation of fish stocks

Another concern, specifically for anglers, is about the growing numbers of fish-eating birds and the levels of predation on both natural and stocked fisheries. The bird species involved in Britain are mainly cormorant, goosander, red-breasted merganser and grey heron (Box 2.11), and occasionally great crested grebes or kingfishers also. Such birds have generally prospered in recent times, resulting in expansion of both numbers and distribution. Furthermore, they are protected in Britain and Europe although licences can be issued to prevent 'serious damage' to fisheries where non-lethal methods of damage limitation have been tried but have failed (see 4.3.1.3).

Fishing interests have expressed anxiety, and sometimes anger, about the levels of fish-eating bird predation at various types of fishery and in many different situations (Box 2.12). Key concerns focus on the combined effects of consumption and

Box 2.11: Some facts about fish-eating birds in Britain

(based on Carss & Marquiss 1996; Holmes & Clement 1996; Russell *et al.* 1996, Marquiss *et al.* 1998, Hughes *et al.* 1999)

	Cormorant	Goosander	Red-breasted Merganser	Grey Heron
Distribution	"Atlantic" birds are primarily marine, breeding on rocky coasts. "Continental" birds inhabit mainly freshwaters and nest in trees. Both occur in the UK.	Occupies both freshwater and marine sites. Breeding confined to upland river systems, with a northerly and westerly distribution. Widespread in winter, occupying many inland freshwaters.	Predominantly marine and occurring in shallow coastal waters. Move into sea lochs, estuaries or the lower reaches of rivers to breed. Most breed in Scotland - some in north England and Wales.	Widely distributed, occurring almost everywhere except in mountainous regions. Generally more abundant at low altitudes, along major river systems and on the coast.
Population	Numbers have increased rapidly throughout Europe to more than 150,000 pairs. There are 7,200 pairs in the UK, and at least 19,000 in winter - 6,000 inland.	Current breeding population estimated at 6,000 pairs, with a recent extension of range southwards from Scotland. Winter population is around 8,900 birds.	Current breeding population estimated at 2,150 pairs. Winter population is around 10,000 birds.	There were an estimated 10,300 pairs in 1991.
Diet	Versatile hunters in terms of foraging methods, habitats exploited and fish species eaten. Mostly regarded as opportunists and non-specialists. Take at least 67 species of fish, from 5-69cm in length.	Takes a range of freshwater fish but breeding pairs and young often depend largely on salmonid fry, parr and smolts. Prey normally 5-13cm in length.	Fish are taken via surface feeding and diving, with many prey types recorded. Prey is normally 2-10cm in length.	Opportunistic feeders, taking a variety of different prey from many habitats. Prey mainly on fish but also take birds, mammals and invertebrates. Fish prey is mostly 10-30cm in length.
Daily food intake	Published estimates vary widely but suggest 300 -525g per day, or 13-23% of mean body mass, for "continental" birds and 465-775g (15-25% of body weight) of *carbo* in Scotland.	Estimated to be 522g (males) and 480g (females) in Scotland, or 32% and 40% of body mass. Other estimates suggest lower values: 15-25% of body mass per day.	The few estimates available suggest a daily food intake of 210-320g, or 23-29% of average body weight.	Estimates vary from 300-500g per day, perhaps some 13-34% of body weight.

attempted capture of fish (causing fright and damage to fish from beak marks), considered to be important issues for the performance of a given fishery. The subject therefore encompasses the conservation of fish-eating waterbirds and of native fish, and economic considerations pertaining to fisheries performance. Economic considerations tend to be most relevant to intensively stocked fisheries, where stock are expensive but are seemingly easy prey, and for some, high-density, coarse fisheries.

The conflict between fish-eating birds and fishery interests has stimulated a number of very detailed assessments of the perceived problems, both in Britain (*e.g.* Marquiss & Carss 1994; Carss & Marquiss 1996; Holmes & Clement 1996; Kirby *et al.* 1996; Russell *et al.* 1996, Hughes *et al.* 1999) and elsewhere (*e.g.* Nettleship & Duffy 1995; van Eerden *et al.* 1995; Baccetti & Cherubini 1997; Gromadzki & Gromadzka 1997; van Dam & Asbirk 1997).

Three years of new research, commissioned by MAFF, DETR and EA in Britain, has recently been completed to investigate the full range of problems, policy implications and possible management solutions, for herons, cormorants and goosanders (Hughes *et al.* 1999).

Box 2.12: Categories of fishery affected by fish-eating birds in Britain

Natural salmon and trout fisheries the loss of young salmon and trout from rivers may affect the numbers returning, though losses at sea are probably more important in affecting future stocks. Atlantic salmon are protected, many British stocks are currently low, and management is underway to improve habitat and to re-stock. Bird predation is regarded as being potentially damaging to the conservation of this endangered salmon stock - an example of one protected species eating another of high conservation value.

Wild trout and grayling in many lowland rivers, numbers of wild brown trout, sea trout and grayling are currently low, probably due to habitat damage, low-flows, poor survival, increased angling pressure, predation by various species, *etc.* Fishery interests, undertaking management to try to conserve self-sustaining fish populations, are naturally frustrated by regular bird predation. There seems a genuine argument for control of predators if these are shown to threaten the viability of the fishery.

Artificial trout fisheries many rivers are stocked with hatchery-reared trout for put-and-take angling purposes. Some also contain a wild trout stock, though usually small. Fishery managers question the degree to which it is reasonable for birds to depredate fish stocked specifically for angling purposes. Is there a case for compensation of fishery owners or should such predation be viewed simply as part of the inevitable costs of running a countryside business?

Natural coarse fisheries self-sustaining coarse fisheries on both rivers and lakes have an important conservation value but most tend not to support rare species. Bird predation is thought by many fishery managers to be appreciable but rigorous data are often not available to substantiate this view. If stocks of common native coarse fishes are substantially predated then many anglers and managers advocate predator control or compensation. If rare species are involved, there may be a conservation argument for control.

Artificial coarse fisheries many stillwater fisheries have been created for day ticket coarse angling, and are often stocked with high densities of coarse fish. As in other situations, fisheries managers become frustrated at the perceived damage to fish stocks from predatory birds. The argument for predation control on these fisheries is similar to that on stocked stillwater trout fisheries, *i.e.* one of fishery economics.

Ornamental fish stocks. where colourful varieties of carp, goldfish and golden orfe are accessible to fish-eating birds (especially herons) they may be very vulnerable owing to their lack of natural camouflage. Such fish have a high value on the ornamental market and economic losses have been reported from open-water sites. Nets often protect smaller farms.

Regarding the impact of fish-eating birds on UK fisheries, the conclusions of this research indicate that:

- both cormorants and grey herons may sometimes impact greatly on intensive fish farms or fish ponds, though these can generally be guarded from attack.
- impacts from both cormorants and goosanders are only poorly understood on stillwater coarse and game fisheries, though high wounding rates from cormorants may be a particular concern.
- both cormorant and goosander impacts on salmon are likely to affect parr and smolts, rather than adult fish, and such effects may be small in relation to those from fishing at sea or in estuaries.
- where rivers contain depleted salmon runs it may be necessary to protect large parr and smolts where predatory birds congregate at the time of the smolt run.

This work is summarised in Box 2.13. It seems also that more research is required for many aspects of this problem, and that it is certainly unwise to generalise on the impacts of fish-eating birds on freshwater fisheries. In the meantime, a management balance needs to be struck between the acknowledged high conservation value of the various bird species and the potential economic and conservation impacts of the birds at both riverine and stillwater fisheries.

2.8.3 *Habitat degradation*

There are a number of situations where waterbirds, through their very presence degrade the habitat required by recreational groups. Some such impacts, quite obvious to all users of a particular area, include the fouling of amenity grassland, for example, by swans, geese and domestic ducks, a well-known nuisance to picnickers, walkers and anglers and perhaps even a health risk. Grassed areas may become slippery, with the possibility of injuries from falls. Damage to habitat, for example, by overgrazing or trampling may also be an issue in parks, as well as bank erosion where birds frequently commute between land and water. Whilst these problems may well be serious at some sites, they have not been quantified and may equally apply to other forms of mess, for example from dogs and general litter (see Allan *et al.* 1995).

On several southern England rivers there have been consistent complaints from fishery managers about immature herds of mute swans, up to 100

Box 2.13: Predation impacts from fish-eating birds (based on Carss & Marquiss 1996, Russell *et al.* and 1996 Hughes *et al.* 1999)

Cormorant

- at some European fish farms, 50-75% of stocks have been removed, and several commercial operations have closed.
- intense attacks at enclosed systems also cause high wounding rates, stress and behavioural responses that may lead to lower growth and higher incidence of diseases.
- for wild stocks of freshwater fish, 5-15% of total biomass may be taken annually,though the effects have been poorly quantified.
- in the UK, signifcant losses of salmon smolts (24-66%) and brown trout have been reported from studies in Northern Ireland. Recent estimates indicate overwintering losses of 2-38% of cyprinids on the River Ribble.
- impacts at stillwater fisheries have rarely been estimated in Britain, but it is here where predation has been *perceived* as most evident.

Goosander

- adults may take 3-16% of migrating salmon smolts on some Scottish rivers, in addition to large numbers of parr.
- one researcher estimated that an average brood could consume 25,000 salmon parr during the 5 weeks before fledging.
- with relatively high juvenile salmon densities, predation of fish during their first year of life may, at some sites and in some years, represent a removal of surplus production of a stage that is regulated by density-dependent processes. In these cases, losses to predators will be compensated. This is likely to apply for larger parr.
- predation of smolts will reduce the numbers of adult salmon returning from the sea as the rate of return of adult salmon is proportional to the smolt output.

Grey Heron

- fish farms, offering a superabundance of fish are the only places where herons appear to aggregate regularly. In most places they occur in low densities and a signifcant impact on fish populations is unlikely.
- available information from few studies suggests that herons may damage 5% of dead fish at farms.
- stock losses of 7% have been recorded at a Scottish cage fish farm and, although not directly comparable, this seems high relative to aquaculture facilities elsewhere in Europe (0.3-1%).
- there are no published studies of heron predation on natural or semi-natural fisheries in Britain.
- elsewhere in Europe, breeding herons took an estimated 6% of fish standing crop in marshland and river study sites.
- it seems unlikely that herons can cause 'serious damage' to fisheries in the UK.
- one or two licences granted to protect brown trout stocks.

strong, moving into sections of river and stripping out virtually all of the water crowfoot growth. Under low-flow conditions, plant growth has been poor and the effect of the swans marked. Water crowfoot provides cover for fish, substrates for invertebrate communities, and maintains depths by retarding flows. On the River Wylye, study of the problem showed that the swans were removing vital cover and insect food habitat for (scarce) wild brown trout, causing the fish to vacate previously important fishing areas and to move into the few deep pools that may have afforded better protection from predators.

Local mute swan populations have increased rapidly in recent years; birds feed on reseeded pastures in winter/early spring and also on aquatic plants, such as water crowfoot, as they grow in the spring and summer (Trump *et al.* 1994). However the problem of over-grazing of the water crowfoot is rather intractable since mute swans are protected species, are long-lived, tend to return if moved and are not easily displaced by traditional scaring techniques. Flocks of mute swans impact the most on water crowfoot growth and if prevented from using grasslands may well vacate the area. The problem appears to be a genuine dilemma for anglers, requiring further research, including field trials, which are underway.

Far more subtle habitat degradation may be mediated through food chain effects. The recent case of mute swans overgrazing important in-stream trout habitat provides an important and fitting example (Box 2.14).

2.8.4 Protected species and protected wetlands

Most waterbirds benefit from extensive legal protection under national and international legislation and agreements (see Section 4.2.1). Similarly, many of the sites they frequent are protected. Conversely there are no such provisions for sportsmen or the sites that they use (Spray 1997). The activities of recreational groups are sometimes compromised because of the need to conserve waterbirds and their wetland habitats. For example:

- on many protected sites, there is a maintained coarse angling close season whilst the legal need for this restriction has been removed from most stillwaters (but is still available at the discretion of the owner).
- the zoning of wildfowling to certain sites, severe weather bans and restrictions on numbers of days of permitted shooting on many reserves may limit the degree of participation by wildfowlers in a given season.
- planning decisions often go against some sports developments, such as sailing, water- and jet-skiing, as a means of restricting disturbance to waterbirds and other wildlife.

Box 2.14: Mute swans on chalk streams

On several rivers in southern England there have been consistent complaints from fishery managers about immature herds of mute swans, up to 100 strong, moving into sections of river and stripping out virtually all of the water crowfoot growth. Under low-flow conditions, plant growth has been poor and the effect of the swans marked. Water crowfoot provides cover for fish, substrates for invertebrate communities, and maintains depths by retarding flows. On the River Wylye, a study of the problem showed that the swans were removing vital cover and insect food habitat for (scarce) wild brown trout, causing the fish to vacate previously important fishing areas and to move into the few deep pools that may have afforded better protection from predators.

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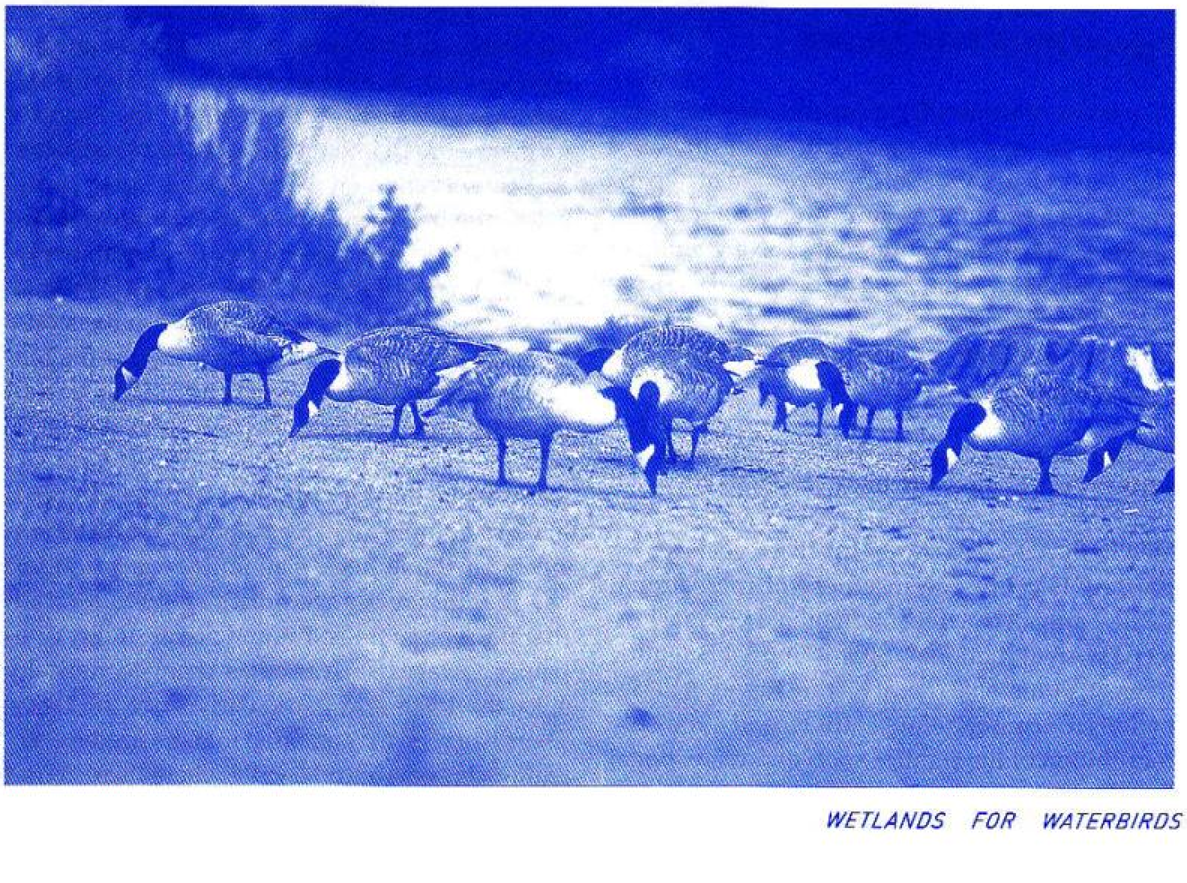
There is often a considerable overlap between areas favoured by waterbirds, the areas protected for them and areas where sportsmen wish to pursue their hobby. Waterbird and wildlife conservation is sometimes viewed as too restrictive by some sports participants and, in some cases, is believed to be limiting the enjoyment and development of recreational activity.

In some areas, there has been increasing conflict between recreational and other demands for water space as recreation became more popular, although solutions to many of these are being implemented by water managers. For example, in the 1990s, Northumbrian Water undertook a strategic review of the values of all its reservoirs for conservation and recreation. This involved studies of the effects of recreational disturbance on waterbirds as well as an assessment of each site for conservation value (habitats and birds) and for recreational use (site characteristics, accessibility, visitor facilities, *etc.*). This led to a strategic plan at regional and site level where recreation was given priority on some waters while conservation was assessed as being more important on others and recreation stopped (Spray 1997).



Martin Senior/WWT

3. WATER-BASED SPORT AND RECREATION

3.1 Introduction

Until the late 1950s, access to reservoirs supplying potable water was, in most cases, severely restricted because of the fear of pollution from recreational participants. The freedom from disturbance meant that they were very attractive to waterbirds and even in the 1950s held substantial numbers of birds. Disturbance from recreational activities was not a problem "....in *view of the present policy of the water authorities, who as a body are firmly set against any form of human interference with their reservoirs*" (Atkinson-Willes 1961a).

Since then, however, the demand for recreation and access to the countryside, especially on or near water, has escalated and the policy of landowners and authorities controlling water has been under pressure to change in the direction of relaxation of access restrictions. Initially this was signalled through a Code of Practice for water authorities and eventually through the Countryside and Rights of Way (CRoW) Act, 2000.

A number of studies have been carried out to investigate the needs for, and participation in, water based sport and recreation by government departments, recreational organisations such as the Sports Council, and individual sporting and recreation bodies over the years. However, these have not resulted in official changes of policy or legislation to protect or enhance recreational opportunity.

3.2 Current policy on the provision of water-based recreational facilities

Within the UK, there is no effective legal basis for the provision or enhancement of recreational value, equivalent to the international (Special Protection Area), national (Site of Special Scientific Interest) or regional (Local Nature Reserve) designations for conservation. Until recently, the only recognition of the right of sport and recreational activities to lay claim on natural resources, along with other land uses was the Department of Environment's Planning Policy Guidance on Sport and Recreation (DoE 1991). The Guidance requires that Local Authorities plan for recreational activities on regional, structural, unitary and local planning levels. However, although some sports such as water-skiing have defined their needs, standards and facilities at a local and regional level, this is not being coordinated into a comprehensive strategy (Sports Council 1992).

The Sports Council recognised in the early 1990s that there was a need to adopt policies that are based on the sustainable use of the natural resources of the countryside (Sports Council 1992). However, there has been continued friction between watersports and conservation which was of concern to both sides. This has, at least partly, been due to the lack of agreed methodology to weigh recreational values and to compare them with conservation values. In addition, many areas designated for conservation or landscape reasons are often also key areas for both informal and organised water-based recreation. The need for further research into the integration of recreation and conservation on water areas is being recognised, and the recent commissioned research and the steps taken as a consequence by Northumbrian Water (Westerberg *et al.* 1994, Spray 1997) illustrates the progress that can be made in the strategic management of wetland resources for the benefit of recreational users and conservation interests.

Recognising that recreational users of water areas have a legitimate right for their interests to be considered in the strategic planning of water resource use, the attitude of government agencies, local authorities, voluntary bodies and private utility companies towards such use has changed radically since the 1960s and particularly since the 1980s. There has been a recognition that the needs of recreational users should be met where these do not conflict significantly with other uses of the countryside. Most recently, The Department of Environment, Transport and the Regions (DETR) (later The Department for Environment, Food and Rural Affairs (DEFRA)) commissioned a report into the current participation in and probable future need for water- based sport and recreation, and Brighton University's School of the Environment carried out the work (Brighton University 2002). The following account draws substantially on that report, in describing the current position and possible future needs for recreational activities that might interact with wetland birds.

3.2.1 Government policy

The government department most concerned with issues of access is the Department for Environment, Food and Rural Affairs (DEFRA – was DETR). Its policy was outlined in a recent paper (DETR 2000), which contained the following statement:

"The government wants to encourage people to make use of inland waterways for leisure and recreation, tourism and sport. Many waterways are well used for pleasure boating; and rowing, canoeing and sailing are widespread. Angling is very popular. Much larger numbers of people use the waterways for informal recreation such as walking, cycling and exploring the waterway heritage. The waterways are an important tourism resource, supporting a large holiday hire-boat industry. We will encourage their greater use for recreation; increased access for the young, disabled and disadvantaged; and better communication with the widest possible range of users."

In England, planning regulations place a duty on local authorities to take the needs of sport and recreation into account in planning policy. However, it is generally considered that there is a lack of sufficient specific guidance on all kinds of sport and recreation provision in England and Wales. Recreational groups consider that the provision of water-based sport and recreation is vulnerable to competing land uses, particularly conservation (Brighton University 2002).

There is a general presumption that access to the countryside should be allowed unless there is an over-riding reason why it should not. The Countryside and Rights of Way Act (2000) aimed to extend the rights of access, whilst also safeguarding the rights of landowners. It created a new right of access to open country and registered common land, modernised the rights of way system and strengthened wildlife enforcement and protection, particularly to SSSIs.

The policy of government at present is that water-based sport and recreation should be accommodated wherever possible; though not to the extent that it damages the natural environment. This policy is being translated into access policy by government agencies such as the Environment Agency and English Nature.

The Environment Agency has duties relating to Conservation, Recreation and Fisheries, amongst others, and their policy on access is broadly based:

"The Environment Agency will promote sustainable increased access where it will not adversely impact on existing uses and users, the economic and conservation value of the site, and associated area, now and in the future. Subject to resources, we will encourage access where managed solutions can be found to remove adverse impacts."

English Nature has a duty to protect and enhance conservation interests; however, it's stance towards access and recreation is tolerant (English Nature 2000):

"English Nature recognises that recreational pursuits in the countryside play an important role in people's lives and in contributing to the social and economic well-being of communities. When dealing with the wide range of recreational activities which take place in the countryside we will be guided by the need to sustain our natural heritage for all to enjoy now and in the future.

Positive benefits from recreational activities can be achieved where there is a good awareness and understanding of wildlife and natural features by those participating in countryside recreation. Any income generated can be used by land managers to sustain and enhance the natural environment under their control. New recreational developments, such as golf courses or gravel pits used for watersports, if sensitively sited, can be designed to maintain and enhance existing wildlife habitats and can be used to restore or create new habitat which is valuable for wildlife.

Recreation may also have unwelcome impacts including physical damage to plants and sensitive geological features through trampling and erosion, collecting of biological or palaeontological specimens, changes in water quality, localised disturbance to wildlife, particu-

larly birds, and negative by-products such as noise, artificial lighting, dog excreta and litter.

English Nature's vision is for countryside recreation which contributes to sustainable development and environmentally sustainable practices. This means that it needs to avoid damage to important and irreplaceable wildlife assets, minimise and compensate fully for other unavoidable effects, and should contribute to the delivery of UK Biodiversity Action Plan targets and objectives."

3.2.2 Local and regional policies

Local authorities are responsible for ensuring that recreation is built into the planning process and that recreational users can participate in their activities without risk to their health.

3.2 3 Water company policies

Recreational provision has been opened up in many of the larger reservoirs, where spatial and temporal zoning of activities have become the norm, to ensure that recreation does not impact on the conservation and amenity uses of reservoirs. Indeed the needs of conservation and recreation were taken into account in the design of the reservoir, now Rutland Water, which was flooded in the second half of the 1970s. Representatives of recreational and conservation groups met well before the reservoir was flooded and agreed the design and purpose of each section of the reservoir, including the creation of waterbird habitats in the form of bunded lagoons. Now, the reservoir is the most important enclosed water for waterbirds in Britain and the site having the greatest participation in water sports and recreation (Appleton 1993). It is one of the premier fisheries in the country and probably the most important single site for many forms of boating. All the water supply companies now provide varying degrees of access for sport and recreation, the kind and number of activities being dependent on the size of the water and other attributes (for example its importance for conservation and sensitivity to disturbance).

Both the reservoirs that have been created since the 1970s have had visitor facilities incorporated and public access is encouraged. Kielder Water, Northumberland was flooded in the early 1980s; the Visitor Centre there attracts an estimated 300,000 visitors a year (Spray & Bacon 1997). Its rather high altitude, great depth, steep sides and enclosed surrounds makes it rather unsuitable for wildfowl and Northumbrian Water make it a high priority for recreation (Owen *et al.* 1986, Spray 1997). Similarly, at the Severn Trent reservoir at Carsington Water, opened in 1992, visitor facilities were planned from the outset, and the site is now a major tourist attraction in the region. At both, zoning of different activities ensures that recreation and waterbird conservation can co-exist and also that different recreational activities do not interfere with each other.

Box 3.1 gives a summary of the activities provided for at the reservoirs of the main regional water

Box 3.1. The sporting and recreational activities provided for at the reservoirs of the 10 main regional water companies (from Spray and Bacon 1997).

Company	Total Reservoirs	Fishing	Sailing	Wind-surfing	Canoeing	Water Skiing	Guided Trails	Cycling
Anglian	9	7	6	6	4	4	3	3
Northumbrian	24	21	4	4	4	2	6	1
North West	72	47	15	17	17	2	7	36
Severn Trent	24	21	11	8	4	2	11	5
Southern	4	4	2	2	2	0	1	1
South West	23	23	6	6	8	1	0	0
Thames	12	4	7	7	1	1	1	0
Welsh	83	65	8	7	9	1	15	9
Wessex	11	9	3	1	1	1	4	0
Yorkshire	18	25	18	*	1	*	*	*
Total	332	231	80	58	53	13	48	55
% Total Sites offering facilities		70	24	17	16	4	14	17

* reliable figures not available

companies. Clearly, fishing is the most commonly allowed activity, occurring on 70% of reservoirs. Water skiing is one of the most disturbing activities, not only to wildlife, but also to other recreational users, so this tends to be allowed on very few reservoirs.

Rights of access to informal recreational users are generally provided free of charge, though charges are generally made for water sports (which are generally licensed through clubs), and in some cases for parking. Often, visitor facilities such as toilets, picnic sites, visitor centres (6 of the 7 reservoirs built in the last 20 years have visitor centres), hides for birdwatching are provided for open access, and the costs of these are met from general water charges across the region. Although providing facilities is costly, most water companies continued to invest in them after privatisation, in most cases spending being increased. The private companies realised that providing good facilities for visitors (generally also their customers) was very good for their image and many of the companies use their visitor facilities to convey messages to the visitor about the water and sewerage business.

The Water Services Association published a report in 1997 assessing their performance and vision in relation to conservation, access and recreation. Their conclusions, as quoted by Spray & Bacon (1997), were that the water companies had:

- attained a balance between environmental, operational and recreational interests on many of their reservoirs and land holdings;
- provided millions of visitors with educational and recreational facilities and access to large areas of countryside and that they would:
- continue promoting sustainable development and management of their land holdings and properties;
- and expand opportunities for recreation and education facilities where appropriate.

3.3 Participation in water-based sports and recreation

Analysis of the UK Day Visit Survey figures (conducted by the Social and Community Planning Research in the mid-1990s) indicated that about 12% of the adult population of the UK (over 5 million people) undertook recreational visits to inland waters, though whether they used the water or the surrounding land is not recorded. The degree of participation is increasing, with more recent figures indicating that 25% of the population visited watersides and the associated spend of those visiting water was £2.6 billion.

Other surveys involving segments of the UK population indicate that the level of participation in active water sports is accurate, with about three quarters of the participants being adult males. Overall, the trend in participation rate is relatively static, though it varies for the different sports (see Box 3.2), and expert opinion suggests that demand is likely to remain static in the foreseeable future (Brighton University 2002). Box 3.2 gives an indication of participation in some of the active sports.

3.3.1 Angling

Angling or fishing is one of the most popular and widespread of recreational activities. In England and Wales alone there was an estimated 3.3 million anglers in the mid-1990s (NRA 1994b). The number is fairly static (Box 3.2). Coarse anglers are by far the most numerous type of angler in Britain, involving an estimated 2.3 million people. 'Coarse' angling normally refers to the pursuit of freshwater fish - species such as common carp, crucian carp, tench, common bream, roach, rudd, chub, dace and barbel (members of the carp family) - as well as other species such as perch, pike, eel, zander and catfish. Coarse angling is undertaken on streams, rivers, ponds, lakes and canals and is, therefore, a very widely practised sport with a great potential both for positive environmental

Box 3.2 Participation estimates for some active water sports in the UK. (from Mintel 1998), reproduced in Brighton University (2002).

	Club Members	Regulars	Occasional	Trend over time
Dinghy sailing	87,000	-	-	up
Windsurfing	-	640,000	-	down
Water-skiing	9,000	80-100,000	400,000	static
Canoeing	35,000	100,000	500-1,000,000	up
Fishing	1,500,000	3,000,000	-	static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improvement and adverse disturbing effects or habitat impacts.

Game fishing includes river and lake angling, primarily for fish of the salmon family: salmon and sea trout, brown trout, rainbow trout and char. Many people also include fishing for the grayling as game angling on account of the "sporty nature" of this fish. There are fewer game anglers than coarse anglers; about 1 million in the mid-1990s in Britain (NRA 1994b). There are a further 2 million or so sea anglers in Britain (National Trust 1995). Sea anglers fish either from beaches or from boats and take a very wide variety of fish species. The collection of bait for sea angling occurs year-round, with a peak in winter.

There are numerous angling organisations and angling clubs, and the sport enjoys huge popular appeal. Anglers have a large vested interest in the maintenance of aquatic environmental quality and are an important watchdog on the riverbank and lakeside, watching for pollution, low water levels and other potential problems. New lakes and ponds are often created specifically for angling and, with good design, these often incorporate useful wildlife habitat. Fishing interests may also be at the forefront of habitat restoration projects, often delivering substantial benefits for wildlife.

A statutory coarse fish close season (15 March - 15 June inclusive) applies to all rivers, streams, drains, some SSSIs and some canals. Site owners have the right to impose any fishing close season if they see fit on still waters. Salmon action plans have been prepared by the Environment Agency for about 50 rivers in the England and Wales, and more are in preparation. These include method, size and bag limit and season restrictions. Similarly for wild trout and grayling, site-specific restrictions are imposed by riparian owners.

3.3.2 Boating

Boating involves the use of both mechanically powered (*e.g.* speedboats, jet-skis, cruisers, canal boats) and non-powered (*e.g.* sail and rowing boats, sailboards and canoes) craft. Water-skiing occurs in conjunction with the use of speedboats.

Box 3.3 summarises key information from 2001 on the number of enclosed inland waters and the length of linear waters being used by various kinds of boat-based water sports (from Brighton University 2002). This indicates that, apart from angling, the activities take place on a rather small proportion of the total inland water resource.

Water skiing developed in the 20th century with the invention of the speedboat. Estimates of participation are around 150,000 regular skiers and 250,000 casual participants (National Trust 1995), with perhaps more indulging on an occasional basis (Box 3.2). There used to be intensive use of some sites, *e.g.* some 20,000 per year using Lake Windermere, Cumbria (Sports Council 1991). However, a full public Inquiry was held in 1994-95, which resulted in The National Park Authority imposing an effective ban on water skiing and jet-skiing on the lake through the introduction of a 10mph speed limit for boats in March 2000. However, in order to give the tourism industry time to adjust, the limit will not be enforced until March 2005. The issue was that the activity marred the quiet enjoyment of the area by many more people than were participating in the sport (information from the Lake District National Park Authority website). However, the issue is hotly contested by water sports participants.

When water skiing is allowed on a site, a club almost always controls access to that site, and the national governing body in Britain is the British Water Ski Federation.

There is continued growth in the sport and considerable demand for new facilities in almost all areas of Britain. However, conflicts with conservation and passive enjoyment of quiet areas for shared access to inland waters is thought to be

Box 3.3: Key facts on the number of enclosed inland waters and lengths of major linear waters used by various kinds of water-based sports, and the percentage of the total such waters in England and Wales (in the case of sailing, rowing and wind-surfing, the percentage is of the total with public navigation rights). Enclosed waters are more than 1ha in area.
Summarised data from Brighton University (2002).

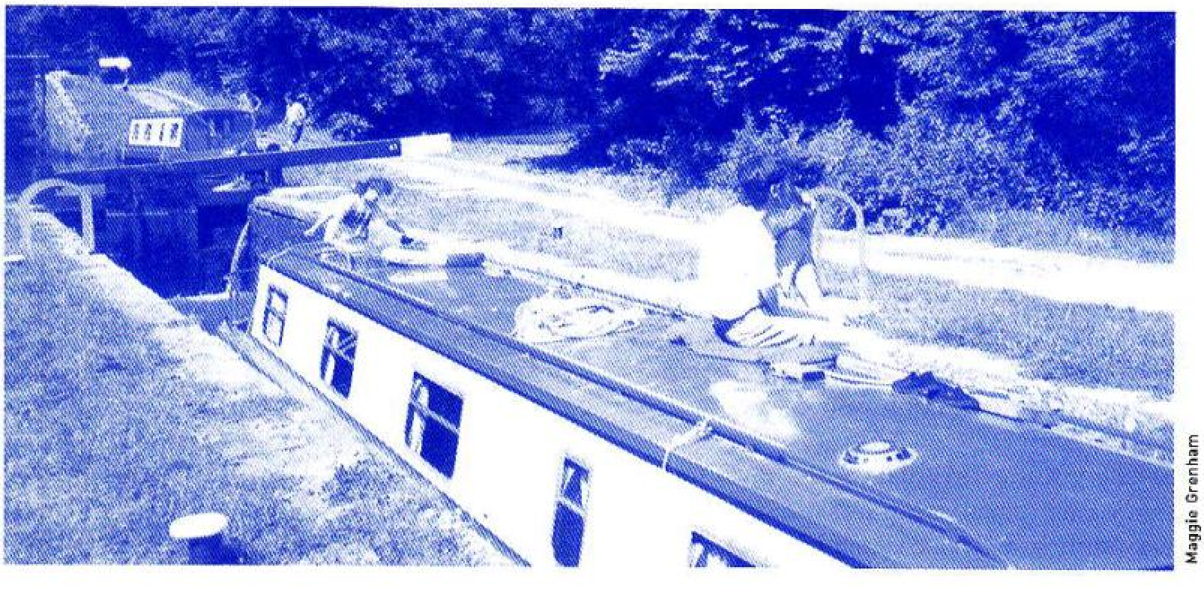
	Lakes, etc. used		Sole use		Rivers and canals	
	n	%	n	%	km	%
Angling	883	45	590	30	8,814	30
Sailing	279	14	25	1.3	194	3.7
Windsurfing	190	10	3	<1	194	3.7
Canoeing	136	7	9	<1	5,490	27
Rowing	52	2.6	2	<1	1,374	51
Water Skiing	94	5	12	<1	5 rivers	-
Scuba Diving	51	2.5	0	0	informal	-

curbing the development of the sport (Sports Council 1991). Water skiing is perceived to be noisy, polluting and disturbing to wildlife (see, *e.g.*, Pierce 1989) though others consider the actual impact of water skiing to be very low, owing to its restricted season and limited numbers of sites (Sidaway 1989; Harbinson & Selwyn 1993). Though water-skiing is most commonly carried out from April to September (CEED 1993) the advent of dry suits has lengthened the water-skiing season so as to increase the overlap and the potential for disturbance to wintering waterbirds (Varney & Crookes 1989).

Jet skiing is enjoyed by at least 90,000 people annually in Britain (NRA, undated). The jet-skiing season is mostly restricted to the summer months and the sites used are often the same or similar to the venues used for speedboats and water-skiing. The Personal Water Craft Association administers competitive racing, provides a code of conduct, promotes the sport and administers access.

Motor cruisers are used extensively around Britain's coasts, in estuaries, and on navigable river and canal systems and certain large inland lakes and reservoirs. Their use is mainly, though not exclusively, restricted to the summer season, with a large take up by tourists. Canal boats are less powerful than most motor cruisers and generally restricted to Britain's extensive canal network. Canal boats are mostly used for pleasure and sometimes for commercial purposes.

In 1988 there was an estimated 200,000 privately owned powered craft in Britain, ranging from small outboard dinghies to large motor cruisers (G. Levens and Company 1988). Participation has increased strongly in recent decades and there is considered to be a considerable shortage of accessible inland and coastal water (Sports Council 1991). Along the coast, there is a public right to navigate all waters, unless removed by statute.

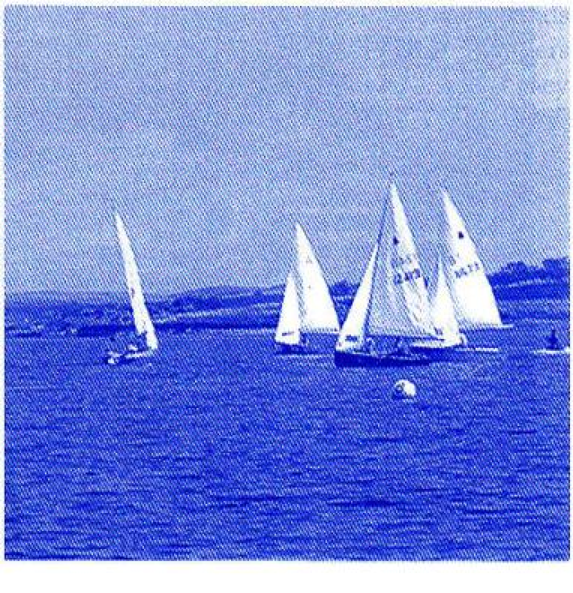

Maggie Grenham

Britain has over 8,300 kilometres of inland waterway that are or were navigable. Principal managers of inland navigable waters include British Waterways, Environment Agency, Broads Authority and many other local authorities or groups. A national survey of boating activity in 1988 estimated that around 45% of all boating activity takes place on inland recreational waterways, with an estimated 75,000 registered boats on the inland waterways system (cited in the IWAAC consultation document). The number was similar in 1996, when the Environment Agency and British Waterways together issued 60,000 licences to powered craft and 16,500 for non-motorised boats. Clearly, canals and inland rivers represent a very important amenity resource.

Murphy *et al.* (1995) consider that recreational boating on navigable waters is likely to increase, since in 1993 restoration schemes were in progress on 160km of rivers and 1,014km of canals. Restoration plans for another 136km of rivers and 143km of canals were being developed and a substantial further list of waterways was being evaluated. Such restoration schemes seek both to re-establish existing navigational networks and to establish new links. It is inevitable that conflicts will arise between canal restorers and devotees of derelict canal systems, which often harbour abundant wildlife resources. As with other forms of powered boating, motor cruisers and canal boats have the potential to create wash and physically damage bankside and in-channel vegetation, with possible implications for waterbirds. An example of the kind of conflict that can arise is in relation to the restoration of the Montgomery Canal for navigation. In its un-restored state, the canal was of great conservation importance, particularly for its aquatic plants. All the Welsh parts of the canal and some of the English sections were designated as SSSIs. There were considerable potential conflicts, which would be brought about by the restoration, and some conservation groups vigorously resisted the plans. When the plans went ahead, British Waterways, navigation groups, local authorities and conservation groups joined in a Montgomery Canal Management Strategy to oversee the development and devise ways of minimising its impact. Conflicts are still likely, but the group is acting positively to minimise the effect of navigation on the wildlife resource.

Sailing, governed in Britain by the Royal Yachting Association (membership 90,000 in 2001), includes windsurfing, and is a very popular pursuit within coastal and inland wetland environments. In 1988, there were an estimated two million active sailors and wind-surfers in the UK (Martin *et al.* 1989). Over 1200 sailing clubs were in operation in Britain in 1990. Additionally, there are some 150,000 to 300,000 wind-surfers, with a continued though slowing growth in popularity (NRA, undated), though this is either an underestimate or the number of participants grew after the NRA survey (Box 3.2). 1.5 million people in the UK sail (National Trust 1995) and there are also sub-aqua clubs operating in inland waters and on the coast. The degree of interest is growing, and proficiency is generally at a high level; sailing was the most successful sport, in terms of medals, in the Sydney Olympics in 2000 for the UK.

Previously carried out mainly between April and September, sailing and windsurfing are becoming much more of a year-round activity, especially on inland waters (CEED 1993). This has been facilitated by the development of wet- and dry-suits, which allow several hours of cold-weather water sports for people of average constitution. Winter sailing, coupled with the fact that sailing can, if allowed, cover most of the surface area of typical reservoirs and gravel pits, brings considerable potential conflict with waterbird conservation interests. Sailors also want weed beds to be cut to allow their activity, which may be against the interests of wildlife. There is a tendency now to use redeveloped docklands and back-excavated areas of disused low-grade land with water frontage to provide facilities for boating, so that this provision does not conflict with wildlife interests. There are also many examples of canal restorations which allow boating without detriment to conservation interests.



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In 2003, the British Canoe Union boasted an estimated 21,000 members, with participation increasing (BCU data). Including casual and holiday canoeists, Leisure Consultants (1989) considered there to be up to 800,000 participants. The report of the National Trust (1995) indicates that 1 million people canoe at least once per year and more recent data confirm this (Box 3.2). Several purpose built facilities have been created for whitewater canoeing in the UK. Otherwise, canoeists navigate Britain's river and canal systems, though only c.10% of navigable rivers may be legally available to canoeists (Sidaway 1994). There are also Canoe Access Agreements, which cover more areas and help coordination, through Canoe Access Officers, to many river systems. Canoeing is a year-round activity.

3.3.3 Wildfowling

'Wildfowling' is the name most commonly attached to the sport of hunting ducks, geese and some waders during morning flights from roosts to feeding areas or during return flights at dusk. Wildfowling is by lone wildfowlers or by organised groups, and involves the use of shotguns or boat-mounted, large-bore fixed cannons ("punt-guns"), which are capable of killing many birds with a single shot.

Callaghan *et al.* (1997) estimate that there are more than six million wildfowlers world-wide, taking in excess of 23 million waterfowl each year. Within the UK an estimated 160,000 wildfowlers kill around a million birds each year (Harradine 1983). Many wildfowlers are affiliated to the British Association for Shooting and Conservation in Britain (111,000 members - National Trust 1995), to international hunting federations and to local wildfowling clubs. Wildfowling takes place on the coast and inland, with many wildfowling clubs directly controlling access to important refuge areas and exercising sole or shared management responsibility, the best example being at Lindisfarne in north east England. Wildfowling can be an important source of income for wetland owners.

Wildfowling groups have become an important driving force for wetland conservation. The principle of using the bird resource in a sustainable way can substantially contribute to wetland conservation, providing the negative effects of wildfowling are avoided or minimised.

3.3.4 Informal recreation

Walking (for more than two miles for exercise and pleasure) is easily the most widespread recreational activity in Britain. Walking is essentially an un-governed activity, but membership organisations in Britain include the Rambler's Association and the Long Distance Walker's Association. The numbers of people walking in wetland environments is difficult to ascertain. However a general survey in February 2000 found that 77% of the adult population of Britain say they walk for

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pleasure at least once a month and 62% stated that they had recently been for a walk of more than two miles (information from the Ramblers Association). Hence, millions of people may be involved; RA membership was 139,000 in 2003 (RA pers. comm.), an increase of nearly 50% in the previous decade. Walking club memberships are increasing and walking next to water, either coastal or inland is very popular, leading to high potential levels of disturbance. Residents and tourists alike enjoy walking; in the summer of 1992, over 50 million day visits were made for this purpose. The intensity of visits is greatest in the summer months, with particular 'hot spot' for informal recreation including national parks, coastal beaches, rivers, canals and other scenic locations.

Walkers include birdwatchers, an increasingly popular leisure activity. The membership of the RSPB alone is in excess of 1 million and a combination of other organisations (WWT, Wildlife Trusts, BTO, *etc.*) must account for a similar number. The National Trust has over 3 million members and manages nearly a quarter of a million hectares of land and 600 miles of coastline. Much of this land and coastline is of very high conservation significance and is open to the public. Managing people without impacting the landscape and wildlife is a continual challenge.

Dog walkers are another significant group. There are an estimated 7 million dogs in Britain, with many people exercising at least three (National Trust 1995). Uncontrolled dogs pose a particular menace to waterbirds and other wildlife. Other types of informal recreation activity include swimming, nature study and photography.


Martin Senior/WWT

4. HOW RECREATION AFFECTS WATERBIRDS

4.1 Introduction

As considered earlier, there are sometimes conflicts between conservation and recreational interests. The conflicts are two directional, with recreational users sometimes concerned about the presence of waterbirds and conservationists worried about the effects and impacts of recreation on birds. These may include mortality incidents, but primarily relate to behavioural disruption through excessive disturbance, habitat loss and degradation, and reductions in available food supplies for the birds. Clearly such effects and impacts are of particular concern when they result in a population decline or where distribution is altered, perhaps forcing birds to use less suitable areas and non-refuge sites.

In this chapter, we assess the strength of effects and impacts of recreation, whilst also noting whether the appropriate studies have been done and offering guidance for future research.

4.2 Evidence for recreation-induced mortality

4.2.1 Mortality concepts

Bird numbers in a defined population vary because of changes in breeding success, mortality, immigration and emigration. The estimation of the population size of a given waterbird species is not, therefore, a straightforward exercise. Many species are secretive when breeding and widely dispersed in inaccessible wetland habitats. Nesting attempts are often unsuccessful and juvenile mortality can be rapid and difficult to monitor. After breeding many species undergo local, regional or international migrations during which time flocks intermingle and disperse over a wide range of habitats (section 4.4). This complexity can be understood with sufficient data, but the information available is generally lacking for most waterbird populations.

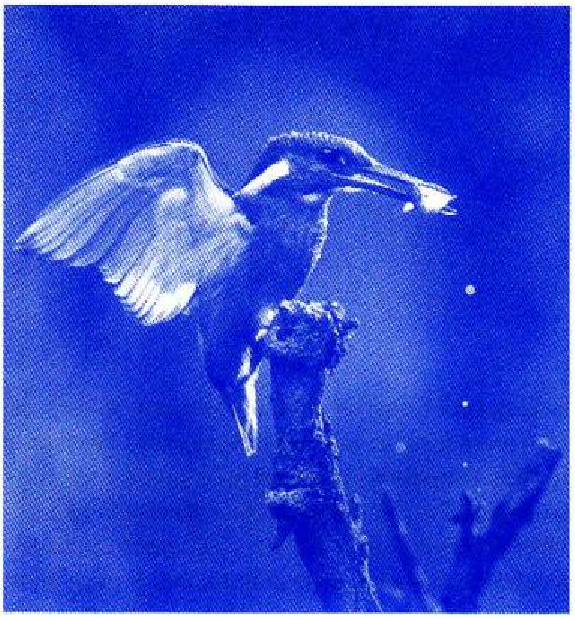
Bird populations are affected by many factors, often interacting in self-regulatory ways. Increases in bird numbers produced in a given area may well be offset by subsequent reductions in individual survival in a density dependent manner. *Density independent* mortality factors act in a blanket way, irrespective of population density of the species in question, and can lead to sudden, marked population declines that may take many years to recover. Relevant factors include the prevailing weather, including severe cold, floods, droughts, saline incursions after storms, hurricanes *etc.* There can also be pollution incidents and failures of food supply, such as unusual timings of marine planktonic blooms *etc.* The kingfisher is a waterbird often susceptible to density independent mortality (Box 4.1).

Box 4.1: The kingfisher's sensitivity to severe weather (density independent)

Having its stronghold on lowland rivers, the kingfisher may be the species most vulnerable to severe weather in Britain. Sharp population crashes have occurred immediately after the hard winters of 1916/17, 1939/40, 1946/47 and 1962/63. The species is, however, very resilient (given adequate habitat) and is able to rapidly recover numbers because of large clutch sizes (6-7 eggs) and an amazing ability to produce up to four broods per year. The run of mild British winters between 1965/66 and 1975/76 allowed kingfisher numbers to reach a relatively high level in 1976 but with a subsequent decline during the cold winters of 1978/79 and 1981/82.

Overall, the national index of kingfisher numbers (1974-1988) shows a decline, but this may be partly attributable to stream pollution and related habitat degradation (Marchant *et al.* 1990). Nonetheless, in many areas, the kingfisher remains a common sight on the UK's wetlands.

In contrast, when competition for food or space or predator evasion occurs, the actual density of birds can have an important bearing on individual survival. When this occurs, one or more *density-dependent* effects influence individuals. Density-dependence is a subtle concept whereby deaths of



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individual birds may be offset by improved survival chances of those remaining - a natural counter-balancing mechanism. Density-dependence has important consequences for waterbird population dynamics, particularly with regard to compensating for other sources of mortality within the population. The death of an individual bird may have little or no effect on final population levels because, under certain circumstances, it is recovered by better survival of others amongst the flock.

Clearly, there must be a limit to the population's ability to compensate for losses and it is likely that there are threshold values (maximum yield) above which any form of mortality necessarily becomes *additive* (Figure 4.1). Additive mortality translates through directly to population abundance: a good example is likely to be a duck sitting on a clutch of eggs which is killed by a fox. The loss of the duck and her breeding output is likely to impact on the local productivity of the population.

Consider a hunting club that shoots, on average, 300 wigeon each year on a saltmarsh in southern England. At first sight this would appear to represent a significant impact on the ducks frequenting that stretch of coast. Overall, however, it is quite possible that the birds killed by the wildfowlers may be compensated for over the course of the winter by improved survival of the rest of the wigeon population because more food is available. In this case the mortality is *compensatory*, i.e. subsequently recovered to some degree and the 'harvest' deemed to be at a sustainable level (Figure 4.1).

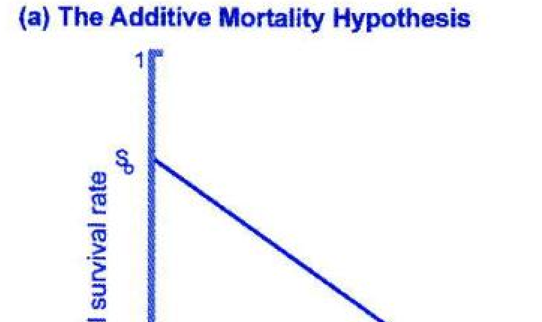

Figure 4.1. Annual survival vs harvest rate (from Anderson & Burnham 1976)

Take now a situation where a shooting ban is imposed on a given goose species. If the breeding population increases in response, to reduced shooting pressure, then subsequent crowding on the breeding grounds, with accompanying habitat damage, may well lead to reductions in gosling survival with a consequent decline in breeding output. Competition for resources (*e.g.* food or nesting sites) has increased with population density and mortality has increased in response. This is density-dependent mortality in operation.

What is critical to understand is where, and to what degree, within given life cycles, density-dependence operates. This knowledge allows an assessment of the likely ability of a bird population to compensate for increases in mortality at a given site and at a given time of year. There are few cases, however, where density-dependence has so far been demonstrated but establishing this conclusively is very difficult (Box 4.2). We return to the issue of density dependence in our consideration of shooting mortality, in the following section.

Box 4.2: Evidence for density dependence in waterbird populations

- for mallards, Hill (1984) showed that winter mortality was proportionately higher after relatively productive breeding seasons than after poor ones - evidence of density-dependent mortality during winter;
- for lesser snow geese nesting in Canada there is evidence of density-dependence during either spring or summer:

    clutch size decreased progressively as bird numbers increased and geese have started to impact on their food resources (Cooch *et al.* 1991) body size of young geese decreased with increased colony size, and the juvenile survival rate declined (Cooch *et al.* 1991).

    the number of geese fledged was negatively related to the proportion surviving to return the following summer (Bousfield & Syroechkovsky 1985).

- for barnacle geese breeding in Svalbard there are density-related declines in the proportion of birds breeding, nest success, and in juvenile and adult survival (Owen & Black 1990).

4.2.2 Shooting mortality

Wildfowling is the only recreational activity that may normally cause a substantial and direct mortality of waterbirds. This involves the hunting of birds such as geese or ducks, which are either killed or wounded and may or may not recover. Earlier reviews of wildfowling have clearly shown that shooting disturbance (Section 5.4.1) influences the distributions of birds (*e.g.* Bell & Owen 1990, Madsen & Fox 1995, Madsen *et al.* 1995, Rees & Rowcliffe 1995, Fox & Madsen 1997). However an impact at the population level, through mortality or reduced reproductive output, has been documented only rarely (Box 4.3). As with other studies of cause and effect, the investigation of wildfowling impacts is complex, requiring long-term experiments to research the multitude of potential factors influencing any particular waterfowl population. Research currently underway at Lindisfarne NNR may be useful in this respect (Box 4.4).

Madsen *et al.* (1995) have recently assessed the status of hunted waterfowl populations in north-west Europe (Box 4.5). Stable or increasing trends for most quarry species (c.71%) was indicative of a generally sustainable shooting regime. The only exception was pochard, described as 'probably declining' (also by Kirby *et al.* 1995). In a further, more extensive, analysis, utilising indices of sensitivity to hunting (after Madsen & Pihl 1993), a variety of population declines were apparent (Box 4.6), though centred on the Black Sea/eastern Mediterranean area, and with no obvious relationship with hunting in Britain or northwest Europe. Here, habitat loss and degradation may be the causal factor (Finlayson *et al.* 1992).

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As discussed elsewhere, a key question is whether hunting mortality is additive or compensatory, which determines the influence of harvest on population size. Rees & Rowcliffe (1995) have recently modelled the likely strength of density-dependent mortality on waterbird species with different life history strategies. Species with the most potential to compensate for hunting mortality were those that are short-lived, relatively fecund and close to their equilibrium density *i.e.* are currently abundant, *e.g.* ducks. Duck populations probably

Box 4.3: Population level impacts from wildfowling

- Trumpeter swans, once numerous, were hunted almost to extinction in North America, but the population recovered when hunting was controlled (Mitchell 1994).
- Canada geese of the Mississippi Valley population, held low because of hunting pressure, responded dramatically to the creation of a non-shooting refuge and to changes in the hunting kill (Reeves *et al.* 1968).
- several Pacific Flyway goose populations experienced serious declines in the 1970s but responded dramatically to restrictive hunting strategies (*e.g.* Raveling 1984, Pamplin 1986, Childress & Rothe 1990).
- Ebbinge (1991) showed the same was true for most populations of migratory geese and swans in Europe.

Box 4.4: Monitoring shooting mortality at Lindisfarne NNR

Studies are underway at Lindisfarne, north east England, to assess the effects of hunting on both quarry and protected species (Percival *et al.* 1996). Here, numbers of several waterfowl species have fluctuated greatly. Wigeon and whooper swans have declined, whilst brent geese and shelduck have increased, and mallard and teal have shown no significant trend. It may be significant that eelgrass stocks have declined. There has been a decline in hunting activity but a stable bag size indicates increasing hunter efficiency. A key finding is that numbers of wigeon (the main quarry) shot seems to bear no relationship to the subsequent population size (*i.e.* that shooting is not affecting this species significantly). Controlled experiments are needed to assess the importance of each potential factor. There may be changes in food supply and resource competition, hunting disturbance and bag sizes and changes at adjacent wintering sites that may cause local bird re-distributions.

normally run below their equilibrium densities and their population densities will tend to be regulated via variations in productivity (duckling survival). If this view were correct, hunting mortality would, therefore, tend usually to be compensatory to other factors causing ducks to die. Long-lived, low-productivity species, however, such as geese and swans, are probably more affected by increases in mortality rates but can be resilient in the face of a phase of years with adverse weather, as individuals may live long enough to breed successfully when natural conditions improve.

Overall, compensatory mortality may be relatively rare in waterbirds (see *e.g.* Anderson & Burnham 1976; Nicholls *et al.* 1984; Krementz *et al.* 1988; Sauer *et al.* 1990, Trost 1990, Nichols 1991). It seems likely that if harvests exceed a critical 'threshold level', then bird populations suffer marked additive mortality and are driven into sharp decline. This threshold level will vary markedly between species and even within species between years - making its assessment a demanding procedure (discussed by Callaghan *et al.* 1995, 1997). At best a suitable 'envelope' of sustainable harvest rates could be estimated for quarry species - an important research topic for waterfowl managers to address. Where population declines are detected, then voluntary measures or legislation should regulate hunting pressure by varying the allowable harvest of given species, restricting the open season, hunting areas, the timing of shooting or placing restrictions on the types of weapons and methods used.

4.2.3 Angling litter

Fishing involves the use of equipment and accessories that can be dangerous for waterbirds. Studies such as those summarised in Box 4.7 show that

Box 4.5: Recent population trends for hunted waterbirds in northwest Europe

Based Madsen *et al.* (1995, 1999) but modified. Population estimates and trends are largely from Box 2.7 (using data from Rose & Scott 1994, 1997; Scott & Rose 1996, Pihl & Laursen, in press). Included are species that can be legitimately hunted in at least one part of the geographical sea and land area where the EC Birds Directive applies.

Species/population	Flyway/ population range	International Population	Status
Mute Swan	NW/Central Europe	240,000	Increasing
Bean Goose	W tundra-breeding	300,000	Increasing
	W taiga-breeding	100,000	Unknown
Pink-footed Goose	Iceland/Greenland	225,000	Increasing
	Svalbard	30,000	Increasing
White-fronted Goose	NW Europe	600,000	Increasing
	Central Europe	100,000	Decreasing
	Greenland	30,000	Increasing
Greylag Goose	Iceland	100,000	Stable
	N Scotland	8,4000	Increasing
	NW Europe	250,000	Increasing
	Central Europe	25,000	Stable
Canada Goose	Britain	61,000	Increasing
	NW Europe	60,000	Increasing
Brent Goose	Siberia	300,000	Increasing
	Ireland	20,000	Stable
	Svalbard	5,000	Stable

Box 4.5: continued

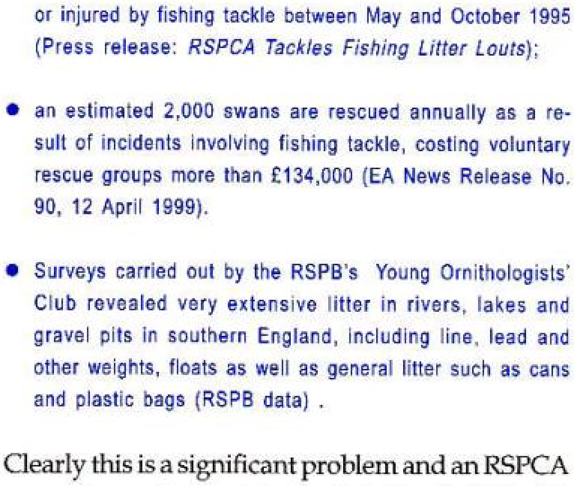
Species/population	Flyway/ population range	International Population	Status
Wigeon	NW Europe	1,250,000	Stable
	Black Sea/E Med.	600,000	Decreasing
Gadwall	NW Europe	30,000	Increasing
	Black Sea/E Med.	75,000	Stable
Teal	NW Europe	400,000	Stable
	Black Sea/E Med.	1,000,000	Stable
Mallard	NW Europe	5,000,000	Stable
	Black Sea/E Med.	4,000,000	Stable
Pintail	NW Europe	60,000	Stable
	Black Sea/E Med.	300,000	Decreasing
Garganey	Europe	2,000,000	Decreasing
Shoveler	NW Europe	40,000	Stable
	W Mediterranean	175,000	Increasing
	Black Sea/E Med.	220,000	Unknown
Red-crested Pochard	SW/Central Europe	20,000	Stable
	SE Europe	50,000	Decreasing
Pochard	NW Europe	350,000	Decreasing
	Black Sea/E Med.	1,250,000	Decreasing
Tufted Duck	NW Europe	1,000,000	Stable
	Black Sea/E Med.	600,000	Increasing
Scaup	NW Europe	310,000	Unknown
Eider	Europe	2,500,000	Increasing
Long-tailed Duck	NW Europe/Siberia	4,750,000	Unknown
Common Scoter	NW Europe/W Siberia	1,600,000	Unknown
Velvet Scoter	N Europe/W Siberia	1,000,000	Unknown
Goldeneye	NW Europe	300,000	Stable
	Black Sea/E Med.	20,000	Unknown
Red-breasted Merganser	NW Europe	125,000	Unknown
	Black Sea/E Med.	50,000	Unknown
Goosander	NW Europe	125,000	Unknown
	Black Sea/E Med.	50,000	Unknown
Water Rail	Europe/N Africa	100,000-1,000,000	Stable
Moorhen	Europe/ N Africa	>1,000,000	Stable
Coot	NW Europe	1,500,000	Stable
	Black Sea/E Med.	2,500,000	Decreasing
Oystercatcher	E Atlantic	874,000	Increasing
Golden Plover	NW Europe	1,800,000	Decreasing
Grey Plover	E Atlantic	168,000	Increasing
Lapwing	Europe	7,000,000	Stable
Knot	Siberia/W Africa	516,000	Stable
	Greenland/Canada	345,000	Stable
Ruff	Europe/W Africa	>1,000,000	Decreasing
Jack Snipe	Europe	100,000-1,000,000	Decreasing
Snipe	Europe	>20,000,000	Decreasing
Black-tailed Godwit	W Europe/W Africa	350,000	Decreasing
	E Europe/E Africa	100,000-1,000,000	Unknown
	E Med./SW Asia	10,000-100,000	Unknown
	Iceland/W Europe	65,000	Increasing
Bar-tailed Godwit	Siberia/W Palearctic	115,000	Increasing
	Siberia/S & W Africa	700,000	Increasing
Whimbrel	Europe /Africa	700,000	Unknown
Curlew	Europe	348,000	Decreasing
Spotted Redshank	Europe/W Africa	75,000-150,000	Unknown
Redshank	E Atlantic	177,000	Decreasing
	NW Europe	109,000	Decreasing
Greenshank	Europe/W Africa	100,000-1,000,000	Stable

anglers may discard a vast amount of angling litter during changes of fishing, after tangles and at the end of the angling session. Nylon line readily entangles the legs and wings of waterbirds, sometimes ligaturing parts of the body and causing serious wounds. Furthermore, general litter, tin cans, hooks, baits and ground baits are sometimes all left at the waterside in large quantities (Cryer & Edwards 1987a&b). The presence of large numbers of maggots and ground baits may often tempt waterbirds into areas where they are at risk of entanglement with discarded fishing tackle; the birds may, however, benefit from the food resource. Swans and ducks are the most frequently reported victims of angling litter but many other less conspicuous species may also suffer from angling litter and go undetected.

The full extent of waterbird mortality from angling litter is not really known but recent information indicates that:

- inspectors from the Royal Society for the Protection of Cruelty to Animals spent an equivalent of 209 days in man-hours dealing with 1,141 birds and other animals killed or injured by fishing tackle between May and October 1995 (Press release: *RSPCA Tackles Fishing Litter Louts*);
- an estimated 2,000 swans are rescued annually as a result of incidents involving fishing tackle, costing voluntary rescue groups more than £134,000 (EA News Release No. 90, 12 April 1999).
- Surveys carried out by the RSPB's Young Ornithologists' Club revealed very extensive litter in rivers, lakes and gravel pits in southern England, including line, lead and other weights, floats as well as general litter such as cans and plastic bags (RSPB data) .

Clearly this is a significant problem and an RSPCA campaign and associated leaflet, *Here's A Line To Remember*, was supported and used by the National Federation of Anglers and their 500 affiliated (coarse fishing) clubs across the UK.
A prolonged campaign would be useful in making anglers more aware of the problems associated with angling litter, whilst segregation of anglers and swan feeding areas has been shown to be effective in reducing tackle-related injuries (EA News Release No. 90, 12 April 1999). Many coarse angling clubs recognise the fact that they may lose their leases if litter accumulates on their waters and include warnings in their club permit books. It is usual to ban any tin cans at the waterside and many clubs will ban anglers found with litter at their pegs, even if they did not discard it themselves. This self-regulation of environmental problems by anglers is an encouraging development actively promoted by such bodies as the National Federation of Anglers. The Salmon and Trout Association has, together with other angling bodies, produced a Game Angling Code of Conduct that has been widely circulated and should raise angler awareness of these problems.


Steve Jones/Fairford Swan Aid

4.2.4 Lead shot poisoning and other shooting effects

Lead was once a common component of angling litter (Box 4.7), yet lead is highly toxic and has been responsible for the death of large numbers of waterbirds, especially swans (Goode 1981, Sears & Hunt 1991, Pain 1992, Spray & Milne 1988). Ingested lead affects the neuromuscular system, inhibits the normal functioning of the gizzard and may result in severe liver and kidney damage, marked anaemia and general emaciation. Birds may quickly weaken but die slowly. Lead poisoning from angling was once a widespread problem for swans in Britain and was implicated in local population declines (see Hardman & Cooper 1980; Birkhead & Perrins 1985; Sears 1988; Thomas *et al.* 1987). Subsequently, an ineffective voluntary ban on lead shot use was followed by legislation in 1987, banning the use of lead weights from 0.06-28.36g for fishing (see Kirby *et al.* 1994). Unfortunately, lead takes a very long time to degrade and lead poisoning continues where birds are exposed to shot present in wetland sediments. However the incidence of lead poisoning in swans nationally has been effectively reduced by the introduction of lead weight restrictions (EA News Release No. 90, 12 April 1999).

More recently, attention has focused on the lead cartridges used by wildfowlers; see, for example, the review by Callaghan *et al.* (1995, 1997). Wildfowling cartridges contain toxic lead shot that can build up to very high densities where shooting activity is intense. Before any ban on lead, each year waterfowl hunters spread a total

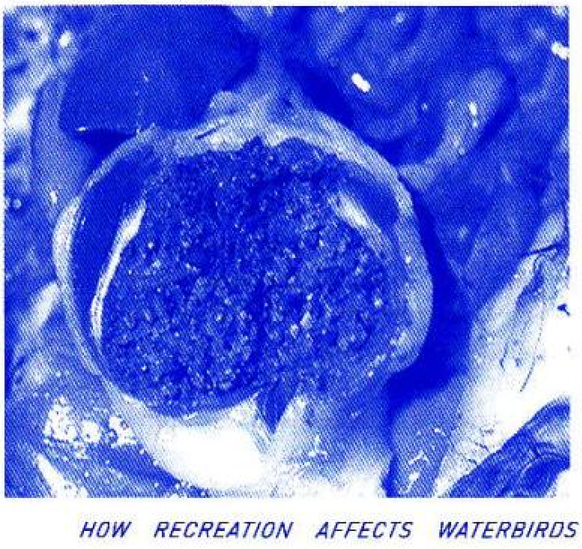
Box 4.6: Population trends and sensitivity to hunting for waterfowl in northwest Europe

Species	Degree of **sensitivity**	Population trends in key European areas **(declines are underlined)**
Mute Swan	low	increasing
Greylag Goose	High	declining
White-fronted Goose	high	increasing generally but decline in Central Europe
Bean Goose	high	increasing or unknown
Pink-footed Goose	high	increasing
Brent Goose	high	stable or increasing
Canada Goose	high	increasing
Mallard	medium	stable but decline in Black Sea/Eastern Mediterranean
Teal	high	Stable
Pintail	high	stable but decline in Black Sea/Eastern Mediterranean
Wigeon	high	stable but decline in Black Sea/Eastern Mediterranean
Shoveler	high	stable, increasing or unknown
Pochard	high	probably declining
Scaup	high	unknown
Goldeneye	medium	stable or unknown
Long-tailed Duck	low	increasing
Eider	medium	increasing
Common Scoter	medium	unknown
Velvet Scoter	low	unknown
Tufted Duck	high	stable or increasing
Goosander	medium	stable or unknown
Red-breasted Merganser	low	unknown
Coot	medium	stable but decline in Black Sea/Eastern Mediterranean

of 9,000 metric tonnes of lead shot over the wetlands of western Europe and North America and most of today's waterfowl lead poisoning originates from this source; lead shot densities in marshy areas can exceed 1 million shot per hectare. Lead poisoning can 'knock-on' to predatory species such as bald eagles, golden eagles and marsh harriers, and both common and protected species are at risk. One of the most extensive surveys of lead poisoning was carried out in the early 1980s by Mudge (1983). This found that levels of shot ingestion was significant in dabbling ducks, at least in some areas and that large numbers of ducks died unnecessarily each year. Of 50 Whooper Swans found dead in Scotland whose cause of death was established, 27 (54%) had died of lead poisoning from shotgun pellets, as had 19 (21%) of 90 Mute Swans (Spray & Milne 1988).

There is now widespread agreement that lead poisoning is an unacceptable form of waterbird mortality. Steps have been taken to replace lead with non-toxic alternatives in England and Wales (Thomas & Owen 1995; Anon 1997), and non-toxic shot is now required legally in Denmark, The Netherlands, Norway and the USA, and is required regionally in Australia and Canada (Thomas & Pokras 1993). Additionally many countries in Europe and Africa have agreed, on endorsing the African-Eurasian Migratory Waterbird Agreement (section 5.2.1.3) to a phase out of lead. Lead was banned over wetlands in England in September 1999, in Wales and Spain in 2001 and bans are under consideration in many other countries. The imposition of a ban does not necessarily mean the elimination of the problem. For example, of a sample of 29 of young mallard (birds hatched after the ban) examined in 2001/2002, 19 (66%) had been shot with lead (Cromie *et al* 2002). It is generally accepted that the continued use of lead was due largely to ignorance, and education programmes are being undertaken by shooting and other organisations.

The gizzard of a lead poisoned wildfowl cut open to show that bright green staining typical of poisoned birds.



WWT

Box 4.7: Studies investigating angling litter

- Bell *et al.* (1984) searched the substrate at three out of fifty fishing positions at Woodstock Pool, Wales, finding 1451 lead shot (highly toxic weights) and 1,025 pieces of nylon line, much with hooks attached. At two angling positions, a total of 399 lead shot and 17 hooks (76% attached to fishing line) were recovered over an eighty-day period from June to September 1984. The estimated shot accumulation rate was 3-4 per peg per day which grosses up to 12,487 shot at just those two fishing pegs over the six year life of the fishery, assuming equally intensive angling usage throughout the year.
- Bell *et al.* (1984) showed that trout fly fishermen angling on Llanishen Reservoir, Wales, discarded, on average, 2.5-5 m of nylon line per visit. Serial clearances revealed, at any one time, the equivalent of around 30 weeks' worth of discarded line present. Presumably, nylon line gradually washes or blows down into the water where it sinks to the bottom and then degrades very slowly.
- Cryer & Edwards (1987b) found that 95% of split lead shot recovered from the margins of Llandrindod Lake, Wales was found within 2.5 metres of a fishing position and estimated that, on average, anglers discarded 2-3 shot during each fishing visit. Densities of around 230 shot per square metre were found around the pond margins with an estimated total of 33.5kg of lead on the shore and fishing platforms.
- Forbes (1986), also working at Llandrindod Lake, estimated that the lake as a whole was littered with over 40,000 lead shot, 96,000 pieces of nylon fishing line and over 5000 pieces of general litter.

Illegal shooting may affect protected species in other ways. For example, the 34% incidence of lead gunshot revealed by X-ray analyses of 272 Bewick's swans at WWT's Slimbridge reserve, examined from 1970-73, has remained fairly constant amongst birds examined from 1989-1992 and during 1995, indicating a substantial shooting effort aimed at this protected species (Callaghan *et al.* 1995, 1997). It is possible that for every Bewick's swan wounded a further three may have been harvested, indicating active pursuit of this species, despite full legal protection.

4.2.5 Predation of waterbirds

Many waterbodies are stocked with predatory fish for angling purposes, or there is positive management for them, and this may have important consequences for waterbirds. Pike have been recorded taking a variety of waterbirds including young canvasback, redhead, teal, lesser scaup, gadwall, mute swans, mallard, coot and grebes. Young waterbirds tend to be taken by relatively small pike of 48-76cm (0.7-2.7kg) around the weeded margins of slow-flowing rivers and streams (Bajkov & Shortt 1939, Ross 1940, Solman 1945, Ahlen 1966). The removal of large pike from waterfowl sanctuaries, in order to conserve the birds, may in fact be unwise management. Large pike often cannibalise smaller individuals and the removal of mature specimens usually leads to increased numbers of smaller fish which are the principal predators of young waterfowl (Wright 1991). A few large pike are, therefore, probably of benefit to waterfowl, especially when their predation of invertebrate-feeding coarse fish is taken into consideration. If any pike are stocked into coarse fisheries, which is fairly unusual, then they will generally be large specimens so the net effect may be positive.

4.2.6 The significance of recreation-induced mortality

Our brief review of literature and experience has identified wildfowling as the key direct source of recreation-induced mortality in waterbirds, with indirect mortality arising from entanglement with angling litter and lead poisoning from angling and wildfowling activities. Additionally, there is probably a small amount of predation from native and exotic fish species, stocked or managed for angling purposes. There is also competition-induced mortality or depressed breeding success (see section 4.5.2).

Though varying amongst species and, of course, with shooting intensity, shooting mortality seems most likely to be *additive* to natural sources of mortality. The many examples where waterfowl populations have responded to reduced levels of hunting serve to indicate that quarry populations are probably maintained at lower than 'normal' levels by this activity. There is widespread evidence that several protected waterfowl species are regularly shot and that better hunter education programmes may improve this situation. Where protected species are difficult to distinguish from quarry species then local bans may be appropriate to increase the effectiveness of protection.

These problems are well recognised by responsible sporting organisations and intensive efforts are being made to reduce the problems, through legislation and through education programmes.

4.3 Disturbance

Concern about recreational disturbance (Box 4.8) is both genuine and widespread. Hill *et al.* (1997) noted that 49 of 117 of Britain's Red Data Birds were potentially affected or threatened by some form of disturbance: habitat loss, water-based recreation, walking in remote countryside, large scale developments and hunting. Pritchard *et al.* (1992) noted that high proportions of the UK's 'Important Bird Areas' were affected: 62 out of 127 sites in Scotland, 56 out of 74 sites in England and 10 out of 14 sites in Wales. At a European level, 35 out of 129 bird species of 'European Conservation Concern' were considered threatened or affected by disturbance according to Tucker & Heath (1994). Clearly, there is considered opinion that disturbance is a major factor affecting key bird conservation sites over much of Britain and Europe.

Assessing the significance of disturbance has been a popular research subject and several groups of researchers have produced extensive reviews of disturbance research (*e.g.* Dzubin 1984; Edington & Edington 1986; NCC/RSPB 1988; Dahlgren & Korschgen 1992; Hockin *et al.* 1992; Keller 1995, 1996; Hill *et al.* 1997) (see also Box 4.9). Studies of disturbance often need to take account of many factors, such as the relative effects of different types of activity (boating, angling, hunting *etc.*) and the behaviour of different waterbird species in different seasons and sites (see section 4.3.6). Hill *et al.* (1997) examined attempts to produce "disturbance gradients" - a ranking of the relatively severity of disturbance from different types of activity (Figure 4.2) (see also Korschgen & Dahlgren 1992, Platteeuw & Henkens 1998b). These range from a relatively passive low-level continuous source, to which birds may readily habituate (*e.g.* the noise from an adjacent motorway), through increasing levels to an active high-level source where a site remains species-poor as a result of the disturbance.

Box 4.8: What is disturbance?

According to White & Pickett (1985), disturbance is "*any relatively discrete event in time that disrupts ecosystem, community or population structure and changes resources, substrate availability, or the physical environment*". Disturbances can be natural (*e.g.* earthquakes, avalanches, floods or fires, predators) or man-induced (*e.g.* habitat removal or visual or audible disturbance).

Whilst we support this definition, in the handbook we use the term only for artificial visual or audible disturbances that influence the behaviour or condition of individual waterbirds. Natural disturbances are not considered whilst habitat loss and degradation are considered separately.

Clearly disturbance research is complex. The need to record and consider many variables means that interpretation, and comparison between studies, is often difficult. For now, we consider disturbances to waterbirds associated with different types of wetland recreational activity. Throughout we highlight difficulties of interpretation and conclude with some general considerations. In a later section we consider the quality of the science available and outline future directions for research.

4.3.1 Shooting disturbance

Wildfowling is most usually carried out during autumn and winter and is a noisy activity, involving sudden loud sounds, that are necessarily close to waterfowl. Hunting disturbance can reduce feed-

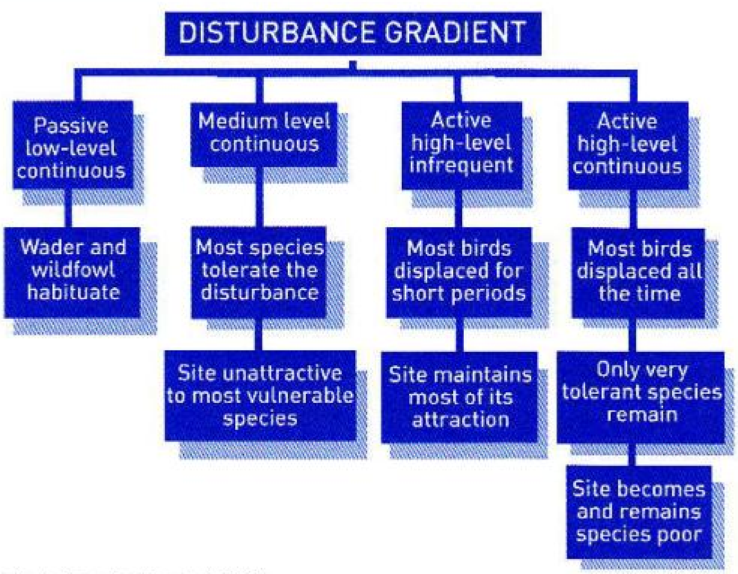


Figure 4.2 Disturbance gradients (from Hockin *et al.* 1992).

ing, loafing and roosting opportunities for birds and thus may effectively constitute temporary loss of access to habitat (Madsen *et al.* 1995). Bell & Owen (1990), reviewing shooting in relation to other forms of waterbird disturbance, conclude that hunting displaces waterfowl at greater distances than other forms of recreation, creating wider exclusion zones (see also Watmough 1983a).

Many studies are available that show a clear displacement effect of wildfowling disturbance, at various geographical scales: flyway (amongst countries), regionally (amongst sites) and locally (within sites) (Box 4.10). Conversely, there are studies that did not show any displacement effect, *e.g.* Tamisier (1976), Tuite *et al.* (1984), Schricke (1983) and Mudge (1989). Where displacement from wildfowling does occur, the creation of refuges should attract birds from hunted areas. In Britain, Owen & Thomas (1979) described a large increase in usage of areas of the Ouse Washes, especially by wigeon and swans, after conservation bodies purchased large areas as reserves. Although habitat management positively influenced this result it was concluded that reduced disturbance from hunting was also a key factor. In a larger scale analysis, Owen (1993) found a progressive trend for the number of wigeon using British refuges to increase as new sanctuaries became available and to stay in the refuges longer as birds moved away from hunting areas. Madsen *et al.* (1995) conclude that 'before and after' studies, making use of refuges to reduce hunting pressure, have repeatedly shown increased bird usage of undisturbed habitat (in 14 of 18 cases examined). It seems as though displacement may often be clearly associated with hunting disturbance.

Shooting disturbance may also produce a number of behavioural effects in addition to displacement and, importantly, may substantially reduce feeding time (Box 4.11). Taken together, these studies show that, when shot at, waterfowl are often forced to change their intended destination and to seek a safe haven habitat that is as suitable elsewhere. Such havens may not exist locally, meaning an appreciable extra expenditure of time and flight energy before the bird is able to rest for the night or

Box 4.9: Insights into disturbance research

Numbers of studies/citations in the literature reviewed by Dahlgren & Korschgen (1992), Hockin *et al.* (1992) and Hill *et al.* (1997) according to source of effect and type of effect. These authors considered 211, 148 and 153 publications, respectively. Note that comparisons between columns are invalid because of differences in the categories used. Note also that some papers qualify under more than one category.

Source of effect	Number of citations: Dahlgren & Korschgen (1992)	Number of studies: Hill *et al.* (1997)
aircraft	47	11
angling	57	12
developments (roads, buildings, noise *etc.*)	67	35
hunting, persecution	77	18
investigator, research	86	19
boating, sailing, shipping, windsurfing, water-based activities	102	31
shore-based activities, including off road vehicles	-	31
walking, dogs	64	22
agriculture and forestry activities	19	14
military	5	-

Type of effect	Number of citations: Dahlgren & Korschgen (1992)	Number of studies: Hockin *et al.* (1992)
breeding/breeding success	23	62
nest site choice	-	14
nesting, population density	96	14
community structure	-	5
outside the breeding season	-	53
energetic costs (flight)	23	-
feeding	52	-
predation increased	31	-

Box 4.10: Studies demonstrating displacements by wildfowling

- Reichholf (1973) found an inverse relationship between duck numbers and the proportion of the lake surface shot over.
- Andersson (1977) found that numbers of dabbling ducks halved when shooting was in operation and doubled in years with full protection.
- Thomas (1978) found that 86% of waterfowl habitat use on the Ouse Washes during the hunting season was on refuges but this declined to 46% after the hunting season.
- Campredon (1979) described a dramatic increase in numbers of roosting shorebirds (more than 10-fold) in one part of France following protection.
- Meltofte (1980) recorded 40-44% fewer shorebirds at high-tide roosts when hunters were present than when they were not.
- Tamisier & Saint-Gerand (1981), comparing waterbird numbers in coastal areas with and without night shooting, found 7-10 times greater numbers in those without night shooting.
- Gomes (1981, 1982) found sudden declines of mallard and teal at the beginning of the shooting season whilst, during cold weather hunting bans, numbers of wigeon and pintail increased markedly.
- Maher (1982) showed that four out of five waterbird species in New South Wales moved to refuge areas after the opening of the duck-shooting season.
- Madsen (1985) considered that pink-footed geese now by-pass Denmark, going straight to Dutch and Belgian wintering sites, on account of winter crop-protection and associated shooting (see also Madsen & Jepsen 1992).
- Jettka (1986) recorded a 60-70% reduction in mallard when hunted for one day per month and it took around three weeks for pre-shooting numbers to be regained.
- Jacobsen (1988) alternated shooting and non-shooting periods finding corresponding declines and increase in duck numbers. Meltofte (1994) obtained similar results.
- Norriss & Wilson (1988) found that Greenland white-fronted geese increased in flock size and were better able to exploit food resources following the creation of no-shooting areas.
- Bell & Fox (1991) recorded within-site re-distributions of wigeon, teal and mallard in response to shooting disturbance, with birds often seeking sanctuary on open water.
- Meire & Kuijken (1991) and Mooij (1991) showed European white-fronted geese to have built up to large wintering flocks in Belgium and Germany after the imposition of shooting bans.
- Schneider-Jacoby *et al.* (1991) showed that whooper swans wintering on Lake Constance increased substantially in numbers, probably due to improved access to previously restricted food resources after a shooting ban.
- Jakobsen (1993) describes how the majority of the Svalbard pink-footed goose population (*c.*25,000 birds) can leave west Jutland (Denmark) towards the Netherlands after just a single day with shooting on the major site.
- Frikke & Laursen (1994) found that dabbling duck densities were inversely related to both hunter density and shooting frequency.
- Salvig *et al.* (1994) showed that eiders were displaced to deeper areas, away from the coast, on days with more than two motorboats with hunters.
- Madsen *et al.* (1998a) found that one or two mobile shooting punts reduced wigeon numbers, whereas numbers were unaffected by the presence of up to 4-6 stationary punts.

reach a profitable feeding site. Of course, there is concern that both quarry and non-quarry species, including protected species, may sometimes be disturbed (*e.g.* Madsen 1988; Meile 1991; Schneider-Jacoby *et al.* 1991; Frikke & Laursen 1994) and that the alternative safe haven may not be as good as the original sites.

Further considerations for waterbirds include the potential impacts of hunter disturbance on flock structures and reproduction. Some waterbirds exhibit a complex social structure, where association with a mate or extended family group enhances social status and hence the best feeding opportunities. Radio tracking of individual Canada geese has shown hunting to reduce cohesion amongst family units and increase mortality (Bartelt 1987). Snow geese also show greater rates of family disintegration as a result of hunting disturbance (Prevett & MacInnes 1980). In a later study, Madsen (1995) showed that frequently disturbed pink-footed geese failed to accumulate nutrient reserves as well as and subsequently produced less young than birds not disturbed whilst using the same spring staging area. Madsen *et al.* (1995) considered it likely that midwinter depletion of reserves, or a failure to attain critical spring levels of nutrient stores prior to migration to breeding areas, may also affect the reproductive output in waterbird species depending on endogenous stores for successful breeding attempts. These subtle factors would seem to have the potential to be important in hunted populations of particular species.

Box 4.11: Behavioural effects of hunting disturbance

- Mikkola & Lind (1974) demonstrated an increase in the flight height of ducks after the opening of the shooting season.
- Goransson & Karlsson (1976) observed that bean geese flew more and in smaller groups after the opening of the shooting season compared to before.
- Owens (1977) found that brent geese (non-quarry) could not be approached within 500m at a wildfowling site but would tolerate approaches to within 150m at an adjacent undisturbed location.
- Gerdes & Reepmayer (1983) recorded decreased escape flight distances of wintering bean and white-fronted geese following the closure of the shooting season.
- Arctander *et al.* (1984) found that both snipe and dabbling ducks increased their escape flight distances from walkers after the start of the open season.
- Joensen & Madsen (1985) showed that shoveler and pintail stopped feeding diurnally, and wigeon and coot reduced feeding intensity, when shoreline wildfowling and motorised punt gunning took place.
- Madsen (1985) showed that escape flight distances of similarly sized pink-footed goose flocks decreased from autumn (hunting) to spring (close season).
- Mayhew (1985) found that wigeon fed on pastures closer to a safe open water roost in the open season compared with the close season.
- Frederick *et al.* (1987) found that shooting disturbance disrupted feeding by lesser snow geese, reduced food intakes and caused emigration. Early forced emigration was thought to have a greater impact on the population size of the geese than the direct hunting harvest.
- Madsen (1988) considered that Danish Wadden Sea dabbling ducks under-exploited foreshore food resources in areas where shooting took place compared with protected areas.
- Madsen (1988) found that escape flight distances of brent geese increased during the autumn as the shooting season commenced.
- Belanger & Bedard (1990) found that foraging snow geese were disturbed by hunters and by aircraft causing them to increase hourly energy expenditure by 4-5% because of extra flying activity and 3-20% because of lost foraging time which they may compensate for by nocturnal feeding.
- Bell & Fox (1991) showed that wigeon and brent geese lost 7-14% of feeding time, and birds were often forced to fly for 2-3 minutes because of disturbance but adding only 5-10 minutes extra flying per day. This may not be crucial but does represent energy expended plus feeding time lost.
- Madsen *et al.* (1992) found that feeding wigeon were disturbed for five to six times longer after experiencing moving punt-gunners than by stationary punts. If disturbed again the difference in time taken to resume feeding increased 21-fold, and on days with repeated disturbance, up to 25% of foraging time was lost.
- Gerhard (1994) found that mallard were more scared of walkers during the open season than after closure of hunting, concluding facilitation due to hunting disturbance.
- Madsen *et al.* (1998a) identified shooting from mobile punts as the most disturbing of a range of activities at two wetlands in Denmark, causing a decrease in bird numbers even at low densities. On the basis of a daily time budget, wigeon lost 10% of the day because of disturbance from mobile punts.

Despite the obvious potential for disturbance from shooting, not all studies record it as being of overriding importance in terms of the proportion of occasions when birds are disturbed (see Game Conservancy Trust 1995). For example, shoorting was responsible for;

- 35% of disturbance to tufted ducks (Pedroli 1982);
- 34% of disturbance to snow geese (Belanger & Bedard 1989);
- 6% of disturbance to brent geese (Owens 1977).

It is not known whether redistribution by disturbed birds has any longer term effects upon waterbird populations (Game Conservancy Trust 1995). However, well-designed experiments (see Box 4.12) are demonstrating a potentially very important effect of shooting disturbance in depressing the size of waterbird populations.

4.3.2 Angling

Fishing, in both salt and freshwaters, is a year-round and widespread activity that may result in disturbance to both breeding and wintering waterbirds. As waterbirds are spread throughout the wetland habitat resource there is potential for disturbance wherever recreational activities take place.

Fishing may cause displacement of waterbirds, either between or within sites, or a reduction in numbers. In an excellent early study, Tydeman (1977, 1978) took advantage of variations in the application of close seasons (from mid-March to mid-June) on gravel pit fisheries to assess the local effects of the presence and absence of coarse anglers during the summer. The studies were undertaken at two gravel pits where there was no close

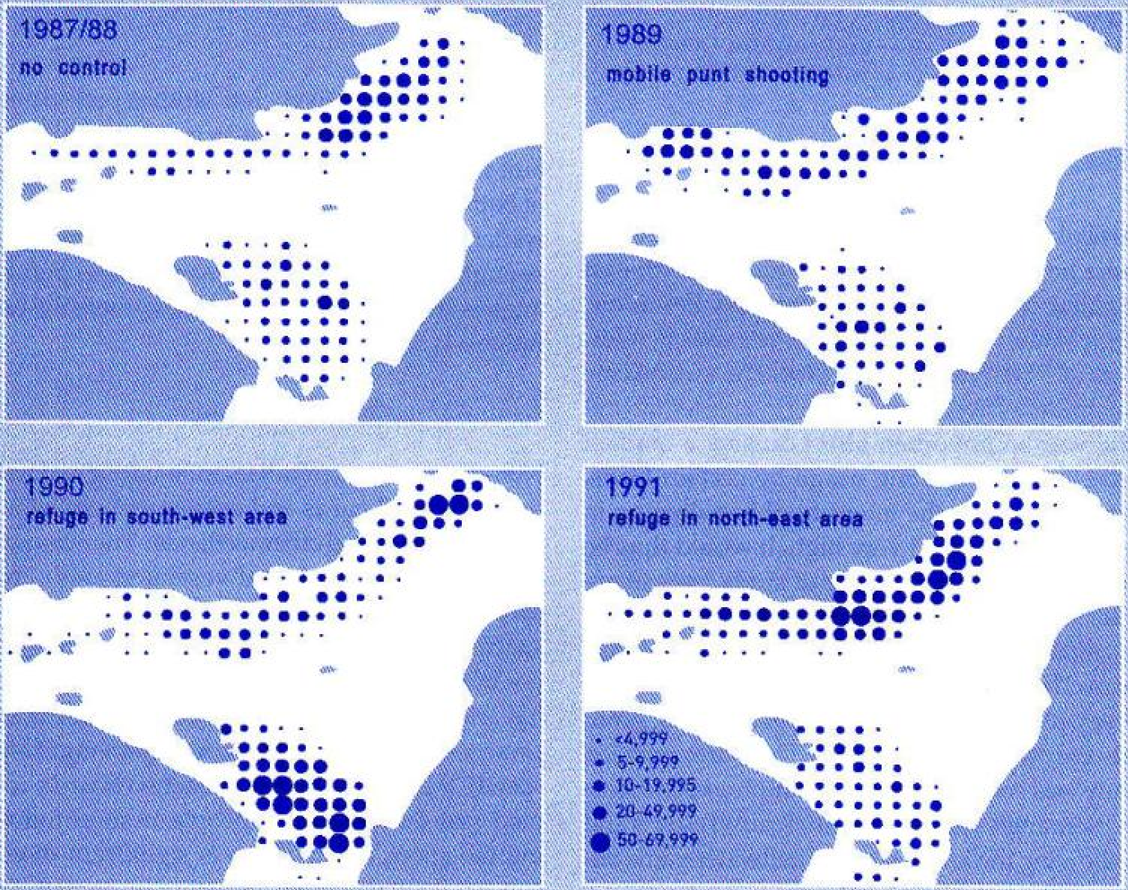
Box 4.12: Research into shooting disturbance (Madsen 1995; Madsen *et al.* 1995, 1998b)

Two coastal Danish wetlands were used to test the hypothesis that shooting disturbance was depressing waterbird abundance. Baseline data were collected before an experimental phase where hunting disturbance was manipulated by reversing areas where wildfowling was allowed. Finally, permanent refuge areas were established for long-term monitoring. Data were collected on bird abundance, food supplies, weather and water levels and hunting pressure.

At both sites, waterbird numbers increased following refuge creation and quarry species redistributed according to the position of the hunting-free areas. These refuges held the highest bird densities. Quarry species increased 3 to 50-fold compared with base-line years, but protected species did not, suggesting that abundance of the latter were not critically affected by hunting. The background data showed that variations in human use (other than shooting), food resources (of herbivores), weather or water levels could not explain local increases in bird numbers. Importantly, increases in refuge bird numbers were not associated with declines in the hunted zones. There were, in fact, real local population increases.

This was a large field-based experimental study with controls and well-established baseline data. Peripheral site counts allowed an understanding of where birds were going and when. Though not available, it would have been most valuable to have measures of any density-dependent effects operating so as to allow an assessment of the potential national and flyway impacts of this local study. It is not known whether the increased habitat usage on non-hunted sites actually led to increased survival or productivity of the birds concerned.

The regimes imposed were as follows:



Disturbance of wigeon

season in 1973 but there was one in 1974, whilst a third pit served as a control with no close season in either year. At the pits with a close season introduced, there was a marked increase in the numbers of nesting birds (waterbirds and songbirds), and many new species were recorded breeding and migrating through the site. Overall, the number of breeding pairs increased by 33% and 58% at the two pits, compared with a 9% increase at the control site. A marked increase in numbers and species diversity of breeding birds was recorded when coarse fishing did not take place in the spring at these pits. There are several other examples of waterbird displacement by angling activity (Box 4.13).

Box 4.13: Studies demonstrating displacement by angling

- Bell *et al.* (1984) conducted a detailed study of disturbance to wintering waterfowl at Roath Park Lake, Cardiff, both by coarse anglers and the general public. They found no effect of angler presence on overall waterfowl abundance but re-distributions away from the sections most popular with anglers.
- Cooke (1987), examining the effects of trout angling disturbance to waterbirds at Grafham Water, Cambridgeshire, found a 30% increase in waterbird numbers within a week of the end of the fishing season and movement out from the designated reserve area as birds made use of a wider area of the reservoir.
- Yalden (1992) found that disturbance from game anglers reduced overall numbers of common sandpipers nesting at Ladybower Reservoir, Derbyshire, with fewer than expected settling to nest in 'busy areas' also.
- Pierce *et al* (1993) found that fishing boats caused a significant source of disturbance on a lake in Thailand, but less so in habitats with more cover.

Particularly rigorous studies of angling disturbance have taken place at Lindisfarne, north-east England (Box 4.14), at Llandegfedd Reservoir, south Wales (Box 4.15), and for the inland reservoirs of Northumbria (Box 4.16). The Lindisfarne example effectively showed that intensive bait digging was an important effect causing a marked reduction in shoreline usage by certain birds, though note that the intensity of bait digging in this area was indeed very high. It would thus be valuable to repeat this type of study over many other sites to gain an insight into how widespread this effect is under more usual bait-digging pressures. The study at Llandegfedd Reservoir, south Wales, produced clear displacement effects, probably linked to feeding success. The Northumbrian study was successful in using simple experiments to disentangle various potential causal effects and in showing the importance of stillwater game angling disturbance to waterbirds.

Without rigorous experimental protocols, it is often difficult to be sure that disturbance, for example from anglers, is the factor of most importance. For example, Campbell & Mudge (1989) reviewed possible reasons for poor breeding success of black-throated divers in the remote Scottish Highlands, concluding tentatively that whilst disturbance may be important it is probably not as significant an effect as was once feared. Time-lapse camera studies at around 60 nest sites each year showed that anglers quite often disturbed nesting divers but that there was no significant difference in breeding success between divers nesting on actively fished and relatively undisturbed lochs. Some pairs were regularly kept off the nest for long periods by fishermen but, nevertheless, managed to hatch their clutches. Here, other factors such as poor food supply and habitat degradation were perhaps of greater significance. In a further example, angling first took place at the newly-created Carsington Reservoir, Derbyshire, in 1994, one year after the reservoir reached top water level and analysis of waterbird count data indicate that there were sharp drops in the numbers of pochard and wigeon using the site. However, other changes, such as standing stocks of aquatic invertebrates, have also taken place making unambiguous interpretation of the results difficult (Menendez & Bell 1996).

Overall, these relatively few studies provide evidence that angler activity may indeed exert important influences over the numbers and behaviour of both breeding and wintering birds at individual wetland sites. The effects have proved significant enough to persuade water managers to prevent anglers from using particular sites where the bird interest is significant.

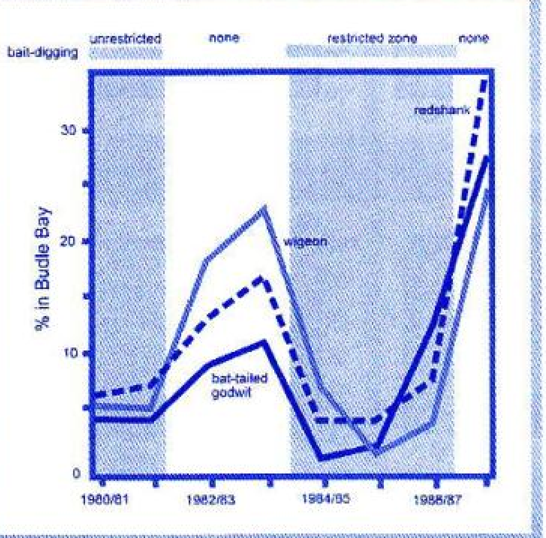
4.3.3 Non-motorised watercraft

Non-powered watercraft include sailing and rowing boats, sailboards and canoes and are widely used on British and other wetlands. They can penetrate shallow waters and vegetated areas, thus accessing a high proportion of the available water space. Also, unlike wildfowling and angling, the use of watercraft is a generally high profile activity, with large numbers of people involved. The presence of brightly coloured sails (moving at high speed), the flapping sails of beached boards, coupled with the numbers of people on shore following the sport, means there is significant disturbance potential. Indeed, the use of these craft, and especially sailboats and sailboards, constitutes sport that is considered to be very disturbing to waterbirds (*e.g.* Taapken 1982).

As for other disturbance agents, there is widespread evidence of disturbance resulting in lowered numbers of waterbirds, displacement or reduced breeding success from association with non-powered craft (Box 4.17). In many of these studies, however, it is not clear whether the birds can com-

Box 4.14: Winter disturbance from bait-digging (Townshend & O'Connor 1993)

This study was triggered by concern about the possible disturbing effects of lugworm digging to migrant and wintering waterbirds at Lindisfarne, Northumberland. Bait digging for lugworms became a regular activity in the 1970s and early to mid-1980s in one, otherwise, relatively disturbance-free refuge zone, Budle Bay. With around ten bait-diggers within the 300ha bay during the 1970s, numbers had increased 10-fold by the early 1980s. During the 1982/83 and 1983/84 winters, local bylaws were invoked to ban bait digging due to fears over depletion of the lugworm stocks, disturbance to the sediments and disturbance to other invertebrates. After re-opening part of the bay during the period 1984/85 to 1986/87, intense bait digging resulted in a denuded lugworm stock, with an estimated 4 million worms removed and a release of heavy metals from the disturbed anoxic sediments. The principal concern, however, was the clear disturbance effects on wintering wigeon, bar-tailed godwit and redshank. Count data for these three species showed that reduced digging activity was closely associated with higher bird numbers and vice-versa. From 1987/88, bait digging was permanently prohibited from the bay.



Disturbance to waterfowl at Lindisfarne.

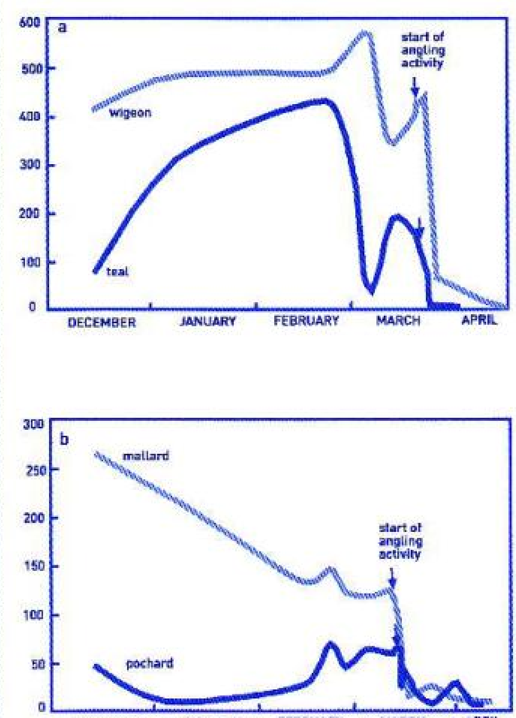
Box 4.15: Angler disturbance at Llandegfedd Reservoir

(Bell *et al.* 1984, Bell & Austin 1985, Cryer *et al.* 1987)

The effects of an earlier start to the trout fishing season (4 April to 20 March) on wintering waterbirds was studied at Llandegfedd Reservoir, south Wales. Here, changes in the abundance of four duck species (wigeon, teal, mallard and pochard) through the winter were similar, each showing steep declines soon after the start of the trout-fishing season, and contrasting with the patterns at Slimbridge, the chosen control site some 45km away.

Disturbance from anglers was believed to displace the birds from preferred areas and out to the deep central part of the reservoir. However this zone tended to be disturbed by dinghy sailors and, at this point, probably because of the combined effects of fishing and sailing, wintering flocks of waterbirds left the site.

The presence of anglers appeared not to affect overall bird numbers in a second winter but probably influenced their feeding success. The distribution of wigeon, pochard and mallard changed markedly following the cessation of angling with all three species tending to move out into the shallower northern end of the reservoir, an area previously popular with anglers. At this time the proportion of daytime feeding increased markedly, indicative of improved feeding conditions.



Disturbance at Llandegfedd Reservoir.

pensate for disturbance during the breeding season (by re-nesting) or whether forced moves to other localities, in summer or winter, actually make any discernible difference to overall population numbers. There are often clear-cut cases of disturbance but also ones that may have little impact on the condition of the birds, owing to the presence of suitable alternative habitat nearby. Also, few of the studies reviewed were long-term or investigated other explanatory factors in any detail. Researchers should at least try to take account of differences in food availability across the areas being investigated as these may sometimes explain or contribute to the effect being described (Box

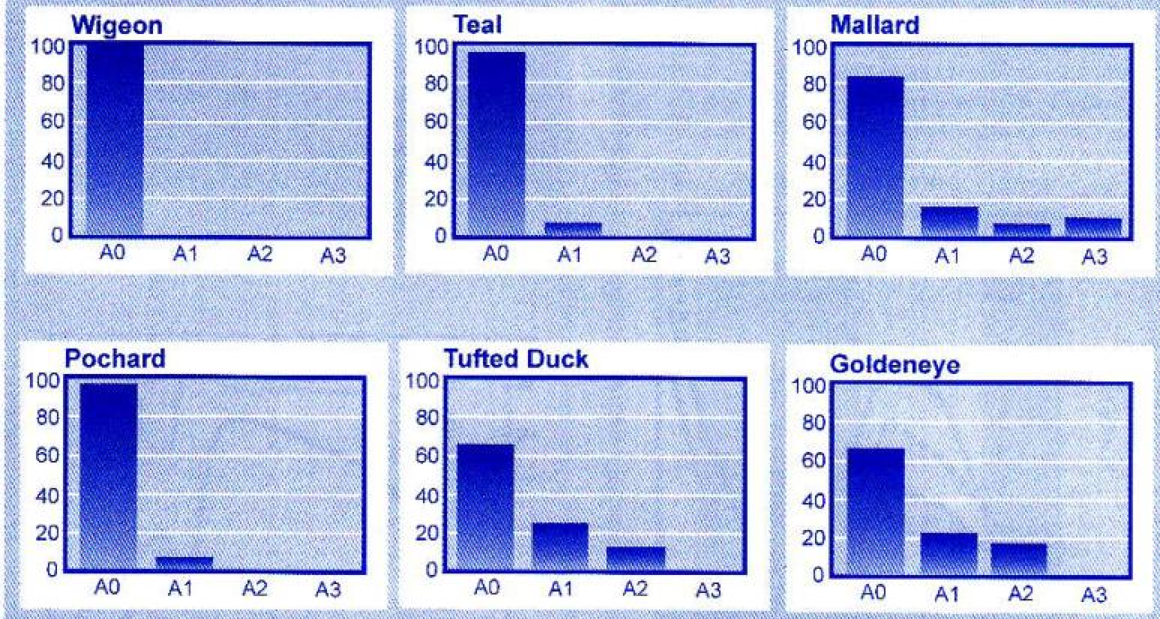
Box 4.16: Experimental manipulation of angler disturbance (Westerberg *et al.* 1994)

At 30 reservoirs and two lakes in north-east England, observations on recreational activities and experimental manipulations were made together with simultaneous recording of waterbird numbers and behaviour. The ornithological interest centres on wintering waterbirds and breeding wigeon, teal and grebes. Angling and sailing were the main sports activities, with water-skiing on two sites.

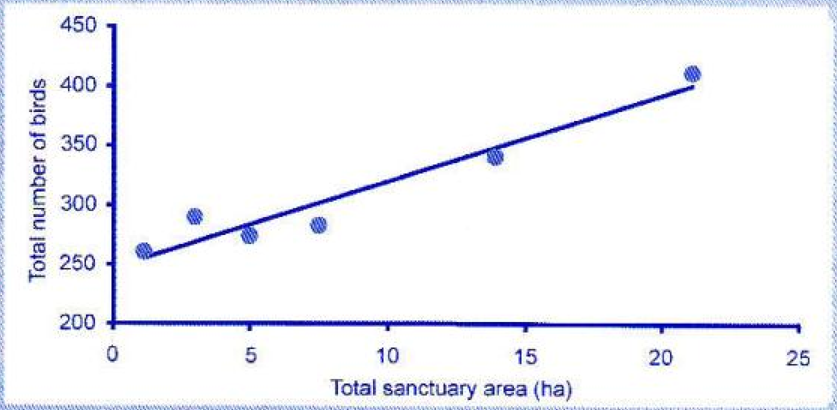
At six reservoirs used for trout fishing there were substantial differences in the abundance and distribution of waterbirds in the presence of small and large numbers of shore and boat anglers. The disturbing effects of anglers were mitigated somewhat if they grouped together and if a safe refuge was present far enough away from the anglers. At Bakethin Reservoir, experimental manipulation of numbers of bank anglers produced a negative effect on waterbird abundance and distribution even when there were very few anglers. At all six reservoirs, the highest bird counts occurred when anglers were few or absent. At Scaling Dam Reservoir, the nature reserve size was manipulated six times from 16% to 279% of normal, with ten anglers themselves creating experimental reserve boundaries. The number and density of birds in the effective sanctuary increased with decreasing sanctuary size until a threshold area (about 2ha) was reached when most birds left the sanctuary.

This study is one of the few which uses simple experiments to disentangle causes and effects and is successful in showing the importance of recreational disturbance to waterbirds. It would be very interesting to extend this approach to other reservoir complexes where both bird numbers and recreational pressures are higher.

Effects of the number of anglers on the six most abundant duck species, at six Northumbrian Water reservoirs.



Key : A0 = 0 anglers, A1 = 1-7 anglers, A2 = 8-20 anglers, A3 = >20 anglers.
Note: no single reservoir zone was observed with more than 40 anglers



The relation between sanctuary size and the number of birds in the site at Scaling Dam reservoir

4.18). The inadequacies of the science lead to uncertainty about the significance of disturbance from watercraft.

There are, however, times when waterbirds cannot move, for example when moulting. This was the focus of a study by Grice (1993) who recorded sailboard disturbance at a site with moulting tufted ducks. Here, all birds capable of flight left the site but the remainder underwent obvious stress. Such disturbance had the effect of depressing the numbers of moulting tufted ducks at this site for several years.

4.3.4 Motorised water sports craft

Despite being a noisy and obvious form of recreation, the use of powered watercraft - motor and speedboats and jet-skis - appears not to have been the focus of much disturbance research so far. The few studies available (Box 4.19, Box 4.20) demonstrate clear displacement effects and whilst probably insignificant at a national level, any local disturbance effects may be substantial (see also Tuite *et al.* 1984; CEED 1993). The available research, however, is limited in scope, short-term and lacks the scientific rigour needed to investigate the relative importance of this factor amongst others likely also to be important. In most cases, zoning in large sites or restriction of these activities to one or two waters (for example in gravel pit complexes) generally minimises the effects.

Box 4.17: Studies demonstrating displacement by non-powered watercraft

- Parr (1974) noted that winter sailing at Island Barn Reservoir, Surrey, appeared to have excluded black-necked grebes and goldeneye and reduced numbers of teal, tufted duck and goosander.
- White (1986) noted that counts of six waterfowl species appeared to be depressed by sail boarding activity on a reservoir in southern England. Birds were displaced altogether when a refuge zone was opened to windsurfing.
- Batten (1977) found that great crested grebes ceased regular nesting on the northern arm of Brent Reservoir, London, after sailing was developed on this site. In winter, many birds left altogether when sailing occurred.
- Tydeman (1978) found no nests or young coot at water-skiing gravel pits compared with successful breeding attempts amongst 53-71% of pairs on sailing waters and up to 100% on undisturbed waters.
- Vos *et al.* (1987), investigating wind-surfer disturbance at a lake in The Netherlands, showed clear displacement of birds to non-wind-surfing areas when windsurfing commenced.
- Keller (1989) recorded that reedbed nesting great crested grebes suffered high egg loss after disturbance by boaters on Lake Neuchatel, Switzerland.
- White (1993), studying waterbirds across 100 waters in the Lea Valley Park, London, showed that birds often moved between waters in response to sailing and windsurfing.
- Fox *et al.* (1994), working in the Cotswold Water Park, southern England, showed that even the launching of a single dinghy could cause flocks of wintering pochard to move from a large lake and land on a smaller adjacent lake with restricted bank access.

4.3.5 Informal recreation

Informal recreation includes casual use of the countryside for birdwatching, walking, swimming, dog-walking *etc.*. The effects on waterbirds can include displacement, reduced numbers or densities and lowered reproductive output through nest destruction or chick loss (*e.g.* Pienkowski 1983, 1993). Problems with informal recreation normally arise where large numbers of people congregate, for example on tourist beaches, in National Parks and at countryside beauty spots. It follows that most impacts occur in the summer season, when waterbirds are breeding, though impacts at staging and wintering sites are sometimes also apparent. Problems often arise because there is conflict for preferred habitats between diving birds and people. For example, many divers and people like clear-water lakes with convoluted shorelines, abundant fish stocks and islands. This can result in conflict between them (McIntyre 1994).

There have been many casual observations of reproductive failure and disturbance leading to displacements, both in summer and winter, reported in the literature (*e.g.* Cooke 1977; Jungius & Hirsch 1979; Hand 1980; Anderson & Keith 1980; Robertson & Flood 1980; Burger & Gochfield 1983; Levenson & Koplin 1984; Inversen 1986; Fluger & Ingold 1988; Buick & Paton 1989; Yalden & Yalden 1989a&b, 1990). However, rigorous, in depth, studies are rather few and far between.

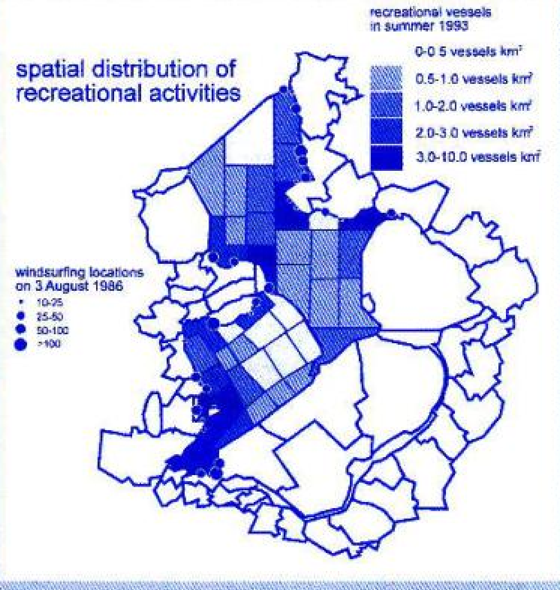
On the Schleswig-Holstein coast, Germany, large numbers of beach-users displaced breeding kentish plovers, leaving large areas of potential nesting habitat unoccupied (Schulz & Stock 1993). Furthermore there was a strong association between the intensity of beach disturbance and the rate of clutch-loss. More than half of the nests failed,

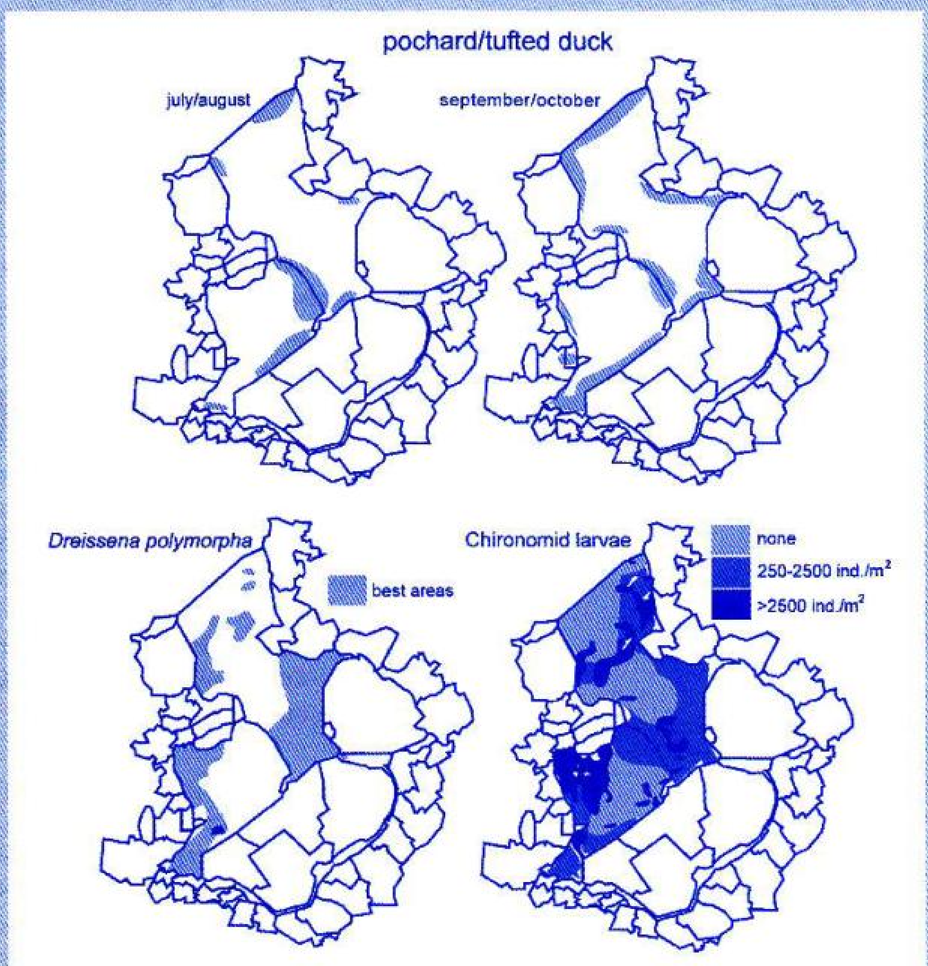
Box 4.18: Recreation, birds and food in IJsselmeer (from Platteeuw & Henkens 1998).

These researchers have worked extensively on the very large Lake Ijsselmeer, building up a spatial and temporal quantitative inventory of bird usage, bird movements, recreational uses, food availability for birds and roost site availability. The Ijsselmeer is a very important waterbird site and also caters for large numbers of sailors, boaters, canoeists and windsurfers.

Unusual patterns of habitat use by moulting diving duck and mute swan flocks, and by foraging cormorants, suggested avoidance of crowded recreational areas. Alternatively, however, the birds may have been reacting to other specific ecological needs. Activity by windsurfers in November was increasing, leading to potential disturbance of wintering Bewick's swan flocks. Diving ducks may deliberately avoid disturbance by choosing to feed mainly at night but use richer food patches (zebra mussels and chironomid larvae) when recreational use declines. Whether the diving ducks were formerly excluded from these good feeding sites by disturbance remains unknown.

The authors deliberately attempt to analyse bird usage and movement data with respect to both recreational pressures and underlying food availability factors, which is a great strength of the work. For example: moulting great crested grebes on the Ijsselmeer forage mainly at dawn and dusk seemingly avoiding peak recreational times. However, an analysis of the availability of their prey fish (smelt) in the upper layers of the lake shows peak abundance at exactly these times (Piersma *et al.* 1988, van Eerden *et al.* 1993).





Box 4.19: Studies demonstrating displacement of waterbirds by powered watercraft

- Hume (1976) found that goldeneye at Chasewater Lake, Staffordshire, are put instantly to flight at the sight of a powerboat, whilst regular water-skiing there has probably caused a reduction in population/diversity;
- Cooke (1985), observing a one-day water-skiing trial on Grafham Water, found a 41% decrease in waterbirds numbers from two, notable waterbird areas;
- Varney & Crookes (1989) found that when total powerboat numbers increased bird numbers decreased, with displacement from the centre of the lake;
- Caron & Robinson (1994), working at lake sites in Michigan, found that great northern divers left their nests more often, and for longer, at disturbed sites. However there were no significant differences in either the proportions of nests hatching young, or the number of chicks per pair, between disturbed and less disturbed sites;
- Westerberg & Spray (1996) found that breeding wigeon generally avoided the waterskiing areas of a reservoir, whether the sport was taking place or not.
- Pierce *et al* (1993) found that powered fishing boats caused significant disturbance to waterbirds on a Thai lake, especially in areas of little cover.

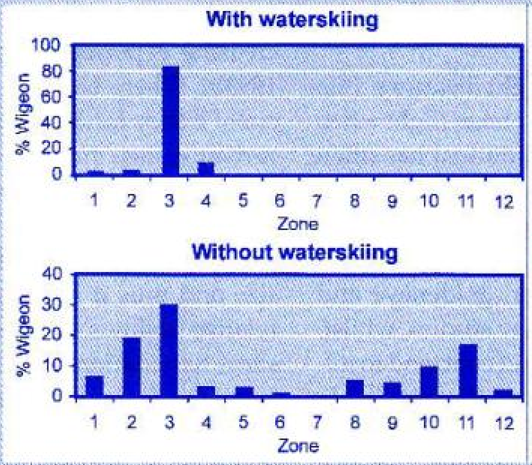
with various causes including crushing, egg collecting, probable increased predation of untended nests by gulls and crows and perhaps by foxes and dogs. Studies such as these make it clear that recreation can displace breeding waterbirds from where they would ideally like to be, and possibly into sub-optimal habitats. This study is one of the few to provide a clear link between the extent of disturbance and the survival/reproductive success of individuals.

On the Dee estuary, northwest England, excessive beach disturbance from day-trippers and local residents was considered a likely reason for declines in the size of winter wader roosts (Mitchell *et al.* 1988). Subsequent work demonstrated that both knots and bar-tailed godwits, waders that had declined at the site, were particularly prone to disturbance and the numbers of knot were significantly lower at weekends when recreational activity tended to be greatest (Kirby *et al.* 1993).

Human disturbance (mainly walkers) caused considerable disturbance to wigeon at Strangford Lough, Northern Ireland but had a lesser effect on brent geese. This activity interfered with the birds' feeding activity, which was already restricted because of tidal patterns. Human disturbance may

Box 4.20: The distribution of Wigeon at Balderhead Reservoir in summer 1993 in the presence and absence of waterskiing activity (Westerberg *et al*.1994).

This study looked at the numbers of breeding Wigeon at the site when water-skiing was present and absent. In the absence of skiing, adults dispersed across the site, occurring in nearly all parts of the reservoir. When skiing took place, however, the birds concentrated in the shallow, less disturbed parts of the reservoir (beyond the limits for boats) or left the site altogether. When skiing was not taking place, more than one third of the birds were found in the zones where skiing was allowed, indicating that their distribution during skiing was related to disturbance rather than a preference for the shallow-water zones.



The distribution of adult Wigeon at Balderhed Reservoir in the presence and absence of water-skiing at the site.

There was also a change in the behaviour of the birds. When skiing was taking place, only 8% of Wigeon at the site were feeding, compared to 22%, nearly three times as many, in the absence of skiing. As a result of the study, the Water Ski Club voluntarily offered to reduce the number of days on which they skied early in the season and to alter the location of their skiing activity – a plan agreed by Northumbrian Water and English Nature.

have been a factor causing a decline in wigeon numbers at the site, though other factors may also have been involved (Mathers *et al.* 2000).

On the Exe estuary, south-west England, Goss-Custard & Verboven (1993) showed that disturbance to oystercatchers feeding on mussel beds was, at times, intense, reducing feeding time by up to 50%. However, this was a localised problem, with most feeding occurring away from the majority of beach-users (*e.g.* on neap tides, at night, and whilst the tide is advancing or retreating).

In an elegant study, Stock (1993) examined the effects of disturbances on spring staging dark-bellied brent geese in the Schleswig-Holstein part of the Wadden Sea, finding regular and varied sources of stimuli which changed bird usage of the area. As tourist numbers increased, the geese tended to concentrate in the best-protected areas of the north and south-east regions of the study site. The overall results indicate that parts of the saltmarsh could not be utilised by the geese because of frequent disturbance to feeding and that, as a consequence, a considerable proportion of the available food resource remains unused. This would appear to be an important disturbance effect that could constitute an impact at population level.

Not all studies of human disturbance have found such marked displacement. For wintering black-tailed godwits in south-east England, Gill *et al.* (1998) found no evidence that human presence had any effect on the use that was made of estuaries or sites within estuaries.

4.3.6 Inter- and intra-specific variation

The measurement of 'escape flight distances' (the distance at which a flock of birds takes flight when approached by a disturbing stimulus) has often been employed to try to characterise the relative sensitivity of particular species to disturbance. Example data are presented in Box 4.21 from which it appears that shelduck, goldeneye and curlew are relatively shy in many studies, whilst, in general, mute swan, grebes and coot tend to tolerate a closer approach. However, there is clearly great variability in the distances recorded, both between species and between studies. Furthermore, if the responses of the species were ranked, the ordering would differ between studies. The reaction of the same species may indeed be different in different habitats; Pierce *et al.* (1993) found that the effect of fishing boats on waterbirds was less in habitats that afforded more cover than in more open areas.

There are clearly dangers in generalising the results of any single study to cover other sites. It seems that it might be impossible to generate 'escape flight distances' that are generically useful. This is because the study of disturbance is complex. Indeed, there are at least eight main factors (see also Tanner 1979, NCC/RSPB 1988, CEED 1993) that seem to determine the responses of waterbirds to recreational activity, and hence the effects and impacts of that activity on them (Box 4.22). Of course many of these factors might covary or interact, further complicating the interpretation of disturbance responses.

4.3.7 Habituation and facilitation

Several researchers have demonstrated that some waterbirds may 'habituate' to disturbance. This is a behavioural adaptation by learning to ignore or reduce the response to a given disturbance stimulus. Cooke (1980), Titus & Vandruff (1981), Keller (1989) and McIntyre (1994) have all described habituation. This ability to 'get used to' disturbance by people is manifest amongst familiar waterbird species and in this ability may lie the key to the groups' continuing success even in the crowded developed countries of northern Europe. However, White (1993) cautioned that whilst feeding birds may habituate, moulting birds appear especially sensitive to disturbance, perhaps because they are 'aware' of their relative immobility.

Conversely, waterbirds may 'facilitate' to disturbance, showing a heightened response with increasing experience (*e.g.* Platteeuw & Henkens 1998b). Where birds do not habituate, and especially if they facilitate their response to local disturbance, then the site will have a lowered 'carrying capacity', or there will be a decrease in the body condition of many individuals. Both factors potentially lead to decreases in overall population size and thus it is important to understand the relative abilities of various waterbird species to show habituation. The challenge for the manager is to consider how real and important the disturbing influences are for each species, remembering that some may be more sensitive than others.

4.3.8 Indirect effects

A very important indirect effect of disturbance is enhanced rates of predation. For example, Mikola

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Goldeneye - a disturbance shy species

et al. (1994), studying the survival of velvet scoter ducklings in relation to boat disturbance, found that disturbance lengthened the swimming distances of ducklings and reduced the feeding time. Frightened ducklings dived and dispersed away from boats. Most importantly, however, while the duck was drawn away from her brood, both herring and great black-backed gulls opportunistically attacked the ducklings. The frequency of attacks by gulls was 3.5 times higher in disturbed compared with undisturbed situations.

This study is important because it shows that disturbance to breeding birds, from any source, can result in increased predation rates, which may produce an impact at the site or even population level for rare and endangered species. This may be a widespread phenomenon in coastal duckling-rearing sites where gulls are common (Ahlund & Gotmark 1989; Keller 1991a).

4.3.9 The significance of recreational disturbance

It is important to bear in mind that we have presented a series of restricted views of disturbance in the previous sections. Natural sources of disturbance have been ignored and we have concentrated solely on human sources related to recreation. However, in contrast to many natural disturbances, human disturbances can be managed and management can alleviate disturbance pressures on the birds.

Box 4.21: Escape flight distances for waterbirds

	(data from multi-species studies only)						
	Tydeman 1978	Cooke 1980	Tensen & van Zoest	Watmough 1983a&b	Smit & Visser 1993	Smit & Visser 1993	Smit & Visser 1993
Activity	**boats**	**researcher**	**people**	**researcher**	**people**	**kayaks**	**surfers**
Distance measure	**min**	**mean**	**mean**	**mean**	**mean[1]**	**mean**	**mean**
Little Grebe	60	-	-	-	-	-	-
Great Crested Grebe	20	142	-	-	-	-	-
Grey Heron	-	178	-	-	-	-	-
Mute Swan	3	14	-	-	-	-	-
Brent Goose	-	-	-	-	105	-	-
Shelduck	-	126	-	-	148/250	220	400
Wigeon	-	115	-	230	-	-	-
Gadwall	-	181	-	-	-	-	-
Teal	400	86	-	-	-	-	-
Mallard	10	127	-	207	-	-	-
Shoveler	200	126	-	-	-	-	-
Pochard	60	-	-	-	-	-	-
Tufted duck	60	131	-	107	-	-	-
Goldeneye	100	168	-	280	-	-	-
Coot	5	169	-	143	-	-	-
Oystercatcher	-	-	60	-	85/136	50	150
Ringed Plover	-	-	-	-	121	-	-
Golden Plover	-	-	40	-	-	-	-
Grey Plover	-	-	-	-	124	-	-
Dunlin	-	30	-	-	71/163	-	-
Knot	-	-	-	-	-	260	200
Bar-tailed Godwit	-	-	75	-	107/219	200	230
Curlew	-	-	95	-	211/339	220	400
Redshank	-	92	95	-	-	175	260
Turnstone	-	-	-	-	47	-	-

1.Two sets of distances are provided, based on observations in the Dutch Delta (van der Meer 1985) and Wadden Sea (Wolff *et al.* 1983; Smit unpublished) (cited in Smit & Visser 1993).

Box 4.22: Factors important in disturbance responses of waterbirds

Bird species: waterbirds vary with respect to their patterns of distribution, food choice and behaviour, factors that seem to influence the sensitivity of a given species towards disturbance (*e.g.* Korschgen & Dahlgren 1992).

Bird activity: whether feeding or resting, and the availability of other suitable areas for these activities. Note that breeding and moulting birds may be reluctant or actually prevented from escaping in the way they would like.

Bird satisfaction: a foraging bird at a site with abundant food resources or lack of alternatives might be more inclined to remain (discussed by Platteeuw & Henkens 1998b).

Bird position: the position of the birds relative to the activity: waterbirds seem able to distinguish between differing *degrees of risk*, tending to react sooner when on land than when either on water or on relatively safe islands (Watmough 1983).

Bird group size: large flocks are perhaps more sensitive (more vigilant) than smaller flocks. The flock tends to be as wary as the shyest individual since when a bird takes flight others tend to follow (*e.g.* Batten 1977, Hill *et al.* 1987, Platteeuw & Henkens 1998b).

Bird familiarity with recreation: birds may habituate or show a heightened response to disturbance (see section 4.4.7).

Nature of recreational activity: different types and intensity of activity (boating, angling, hunting *etc.*), cause differing degrees of disturbance (see Hill *et al.* 1997).

Character of the site: wetland size, shape and habitat composition may confer different degrees of exposure to disturbance. Several studies have shown that small sites may lose birds at weekends due to increased recreational disturbance whilst larger sites tended to buffer disturbance effects by allowing birds to avoid stress by moving around the larger area (Anderson *et al.* 1987, Underhill *et al.* 1993).

We have shown that a great variety of factors affect the degree of effect of a given source of disturbance. Given the acknowledged complications, is it possible to discern clear disturbance effects and to use these examples to guide us to sound management decisions? The answer to this question is yes because several recent case studies provide excellent examples of research aimed at providing good management information.

It is clear that human presence can force incubating birds off nests so risking hatching failure if eggs cool too much. It can also separate adults from free-ranging young - especially a problem in the first few days after hatching when the young need regular brooding by adults to maintain their body temperature (*e.g.* Yalden & Yalden 1990). Disturbance may also prevent access to preferred feeding areas for adults and/or young, and increase energy costs if birds are forced to move when resting. Again because of their excellent camouflage, nest and eggs also can be destroyed by direct trampling, and also by the increasing use of off-road vehicles - a particular problem for sand and shingle beach-nesting species (*e.g.* Buick & Paton 1988). The presence of dogs increases the risks of disturbance and depredation of eggs and young (*e.g.* Keller 1991a, Yalden & Yalden 1990). Again, it has been demonstrated that most sports have the potential to produce effects such as these and managers generally prevent or restrict access to particular sites where the bird interest is significant.

A related problem is that the presence of people (including research scientists and birdwatchers) may unwittingly draw the attention of predators to breeding birds - predators attracted by the alarm

Box 3.23: Attitudes to shooting disturbance

Bell & Owen (1990) outline a questionnaire-based study of the attitudes of wildfowlers, refuge managers and waterbird counters to shooting disturbance on British wetlands. There was good agreement between groups as to what constituted disturbance and on which activities were most disturbing locally: in rank order, walking, wildfowling, low-flying aircraft, power-boating, bait-digging, low-flying helicopters, birdwatching, sailboarding, water skiing, fishing from the shore, horse riding, sailing/rowing, cockling, fishing from boats. However, different groups had different perceptions of the probable impact of disturbance to waterfowl. Each group of respondents tended to regard its own key activity as rather less disturbing than the other two groups.

Some 23% of waterbird counters, 36% of wardens and 19% of wildfowlers regarded on-site disturbance of waterfowl as a major problem and wildfowling, birdwatching and walking were thought to be the most commonly controlled activities on refuge areas. Around one quarter of wildfowlers and a half of counters and wardens believed that there was a need for refuges on sites without one and similar proportions of respondents thought that existing refuge management could be improved to reduce disturbance. Interestingly, more than two thirds of all respondents believed that refuges could accommodate controlled recreation. Questionnaire surveys of this type have the potential to provide important insights into user group perceptions of waterfowl disturbance and other environmental issues

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behaviour of parent birds, by litter or food waste. Such indirect effects of recreation - facilitating increased predation rates - may in fact be an important problem (*e.g.* Titus & van Druff 1981, Keller 1989, Yalden & Yalden 1990) but is one that has not been extensively researched. Clearly managers must guard against such indirect impacts, especially where predators, people and rare species mix.

As in summer, some assessments of winter disturbance have resulted in the banning, restriction or non-establishment of particular recreational activities in important wetland areas. Available studies show that winter disturbance may frequently cause displacement, either between or within sites, or may influence feeding and resting behaviour. It should be noted that such movements perhaps do no harm to waterbirds, which are intrinsically mobile animals. Indeed there is no evidence that displacement is harmful at the population level but certainly may move birds away from where they wish to settle.

Research has demonstrated negative effects on winter bird numbers and densities from sports such as wildfowling, angling (including bait collection), wind-surfing, boating *etc.*. Some have concluded such displacement to have had limited impact because birds simply move to use 'adjacent' areas. However, high quality, unpolluted, relatively safe and undisturbed staging, wintering or breeding sites may often be in short supply in a given region. Also, if a given population is relatively abundant it is reasonable to assume that all high quality sites will be occupied and the arrival of further birds to these areas may increase interference between them (*e.g.* Zwarts 1972; Zegers 1973; Goss-Custard 1985, 1993; Goss-Custard *et al.* 1995a&b). The assessment of potential impacts of disturbance to waterbird populations at a given site must clearly take account of the likely availability of alternative sites within reasonable travelling distance for the birds. Alternatives are becoming fewer, because many wetlands continue to be lost to development or drainage.

Relatively few studies have included consideration of disturbance on energy budgets, though the resultant increase in energy expenditure may be appreciable:

- 21% increase in daily mallard energy requirements because of disturbance effects (Watmough 1983).
- 31% increase for disturbed brent geese (White-Robinson 1982).
- 11% increase for disturbed brent geese, and exceptionally 37% (Riddington *et al.* 1996).
- a potential increase of 20-50% in waterbirds on busy days for recreation (Platteeuw & Henkens 1998b).

It is important to place the increased energy demands within the context of daily energy budgets. For example, Watmough's ducks spent most of the day loafing and so the increase in energy expenditure was unlikely to have an overall effect. Indeed the author argued that the birds would be unlikely to stay within the area if they failed to attain the necessary energy balance at the site.

A bird's ability to compensate for disturbance, by extended periods of feeding, increased feeding rates or through finding very profitable food-rich patches is also important. Depending on the levels of energetic costs of particular disturbances, the duration of disturbance and the feeding strategy of the species, it is known that some compensation can indeed occur (Madsen & Fox 1995). In one study, wigeon spent most of their time foraging and were unable to compensate for lost feeding time (Madsen *et al.* 1992). By comparison, mute swans spent less time foraging and compensated for the lost feeding time within the same day. Birds may also compensate by intensifying the feeding effort (*e.g.* Swennen *et al.* 1989), moving elsewhere (White-Robinson 1982, Goss-Custard & Verboven 1993, Stock 1993) or feeding more at other times, for example at night (Tamisier 1974, 1976; Owen & Williams 1976; Goss-Custard & Verboven 1993). Visual-feeders or intertidal feeders with restricted feeding opportunity, however, may be unable to feed nocturnally and thus compensate for daytime disturbance. Further, increasing the need to feed under the cover of darkness may increase predation risk (*e.g.* for grazing wildfowl), though not where predation is mainly by diurnal predators.

An important point is that recreational disturbance is often indiscriminate in terms of the waterbird species affected, as well as affecting different species to differing degrees. In wildfowling, for example, legitimate quarry species often share their habitats with rare protected species and these may be affected through disturbance. Reaction distance studies have shown some species to be more sensitive to recreational disturbance while others may habituate. Site management therefore needs to be tailored to the needs of the most sensitive species. If birds do not habituate, and especially if they show a heightened response to disturbance, then the site will have a lowered 'carrying capacity' and support fewer birds. Alternatively, the birds present will be in relatively poor condition and either factor may potentially reduce overall population size. Whereas a 'desirable' population size is a subjective measure, it is likely that, owing to habitat loss, many waterbird populations are at lower than their historical levels.

The effects of disturbance do not always seem to relate closely to the intensity of recreational activity at particular sites. It would be a mistake, therefore, to think that low numbers of sportsmen (*e.g.* wildfowlers, water skiers *etc.*) are somehow unlikely to disturb birds nor necessarily that high numbers will cause unacceptable disturbance. As an example, Korschgen & Dahlgren (1992) noted that over 2,500 tundra swans were caused to leave their most important feeding area on the upper Mississippi River by the presence of two small boats. Other aspects of the activity are also important, such as the pattern of sports movements in relation to the position of waterfowl flocks.

It is important to recognise that waterbirds are not equally vulnerable to recreational disturbance at all times of the year. Most waterbirds experience energetic bottlenecks at some stage of their life cycle. There are periods when they might be expected to be especially sensitive to disturbance, such as when breeding, moulting, on migration, in midwinter, or in times of poor weather and/or low food availability. It follows that excessive disturbance under these circumstances may have particularly severe consequences for waterbirds and management agencies should strive to enhance the protection afforded to the birds at these times. Despite the likely importance of studies in these stressful periods, there have been relatively few disturbance studies undertaken during the flightless moult, on migration or during severe weather periods.

Overall, disturbance effects may be widespread and whilst we generally do not know whether there are population-level impacts, local effects may clearly often be substantial. But which types of disturbance are the worse for waterbirds? This seems to depend on whom you ask and how you phrase the questions, illustrated nicely by the study of Bell & Owen (1990) (Box 4.23). Furthermore, whilst there are some studies with comparative data for several forms of recreational activity (*e.g.* Tuite *et al.* 1984, Burger 1986, Belanger & Bedard 1989, Kirby *et al.* 1993, Koolhaas *et al.* 1993, Smit & Visser 1993, Stock 1993), these studies are not geographically extensive enough to allow overall generalizations regarding the disturbance ranking of particular sports. In any case it would be unproductive to pursue an answer to this question since all recreational activities have demonstrated potential to adversely affect the waterbird populations of individual wetland sites.

4.4 Habitat influences and competition

Habitats throughout a species' range are able to support an upper limit on numbers: the so-called 'carrying capacity'. This level of occupancy will vary from year to year with prevailing environmental conditions but continues to constrain numbers to a broad upper threshold. Habitat damage and loss lowers this threshold, often permanently, resulting in a reduced carrying capacity for the species. Recreational activity, or habitat management for recreation, may indirectly affect waterbirds if the quantity or qualities of waterbird habitats are reduced or enhanced.

4.4.1 The collection and use of bait for angling

Anglers either buy bait from fishing suppliers or collect it themselves, with bait collection being especially prevalent in coastal areas. Conservationists have sometimes been concerned that bait-collecting activity may be damaging to wildlife and this has provided the stimulation for a number of overviews (*e.g.* Fowler 1992; Huggett 1992) and detailed research studies.

Studies in coastal areas have focused on the collection of crabs, lugworm and ragworm for sea angling, the associated disturbance effects (see section 5.4.2) and possible reductions of food supplies or habitat quality (Box 4.24). The research shows that local patches of crabs or worms may be suppressed through harvesting, but longer-term effects seem unlikely.

For angling in freshwaters, bait is generally purchased from shops and as well as being used on the hook it is often added in large quantities to the water to attract numbers of fish to the area being worked. There has been concern that such 'ground baiting' may be damaging, altering the composition of invertebrate communities or triggering algal blooms

Such effects have been the focus of only a few studies in Britain (Box 4.25) and the conclusions have been contradictory. Overall, where coarse anglers ground bait naturally unproductive stillwaters, there is probably the potential for a modest degree of nutrient enrichment to take place. However, most intensive ground-baiting programmes are undertaken on productive lowland lakes where there are high densities of bottom-feeding fish such as carp, bream and tench. In these situations it is likely that most of the ground-bait will be eaten by the fish in a short enough period of time to reduce deoxygenating effects and impacts on benthic fauna. It is quite conceivable, given the good evidence of the ability of bottom-feeding fish to deplete benthic invertebrate standing stocks (section 4.4.2), that ground-bait may act as a buffer, protecting some invertebrates from intensive summer predation by fish. A final point is that that waterfowl including swans, coot, tufted duck and mallard are seen eating angler's ground bait. This may represent an important food source for such birds as well as for fish living in the same habitats.

Box 4.24: Potential concerns regarding bait collection in coastal areas

- Bell *et al.* (1984) showed that 60% of observed crab collectors failed to roll back the rocks they moved, with probable impacts on inter-tidal rock fauna and flora and possible disturbance and reduced food supplies for rocky shore wading birds.
- Bell *et al.* (1984), studying the implications of lugworm digging, recorded no recovery in lugworm numbers over ten weeks after harvesting of 60-70% of worms and no re-distribution. However this level of harvesting was much greater than that occurring under traditional bait-digging conditions, the conclusion being that the historical bait-digging regime had little effect on the overall lugworm population.
- Townshend & O'Connor (1993) describe how intensive cropping of lugworms at Budle Bay, Lindisfarne, resulted in a denuded lugworm stock. An estimated 4 million worms were removed, with an accompanying release of heavy metals from the disturbed anoxic sediments. However, re-colonisation occurred rapidly from adjacent stocks.

Box 4.25: Potential concerns about the use of angling bait in freshwaters

- Investigating the implications of ground baiting on freshwater invertebrates, Lloyd-Griffith (1975) found an increase in oligochaete worms and chironomid larvae in ground baited areas, thus enhancing potential waterbird food supplies;
- Bell *et al.* (1984) found that ground baiting had a remarkable lack of impact on benthic invertebrate communities, probably because the fish quickly removed the bait. However, 'knock-on' nutrient enrichment effects via increased fish faecal production were possible.
- Cryer & Edwards (1987) found marked reductions both in dissolved oxygen and in benthic fauna where ground bait was distributed; tubificid worms (characteristic of organic pollution) increased in number by 100-fold.

4.4.2 Fish stocking and fish-waterbird competition

Fish are often stocked for angling purposes because high fish densities increase the chances of a catch. There is concern, however, that a high fish density may impact adversely on wetland habitats, with possible consequences for waterbirds. In Britain, for example, the current trend on many commercial coarse fisheries is to increase stock densities especially of common carp, which offer high levels of angling performance. Many such fisheries are especially constructed for the purpose, pose no threat to important waterbird habitat, and are legitimate enterprises. However, the practice of heavy stocking on other waters, as currently contemplated, includes some large public water supply reservoirs that may have substantial wintering waterfowl populations, which could be adversely affected by lowered aquatic plant and invertebrate availability.

There is a good body of research to show that adequate supplies of aquatic invertebrates are an important component of waterbird habitat quality. This is nicely illustrated by studies undertaken for ducks (Box 4.26) where invertebrate abundance is key to obtaining good reproductive success and determining both breeding and wintering site locations. This may equally apply to other waterbird species.

Similarly there is much research to show that fish are strongly associated with rich invertebrate communities, which themselves are fundamentally affected by the presence of fish (Box 4.27). It is worth noting that these examples cover several fish and wetland types and although the fish have sometimes been stocked at higher than natural levels, some commercial coarse fisheries operate around this density, with considerable implications for invertebrates. Such marked food chain impacts must have significant knock-on effects for sympatric waterfowl, and there are many studies to show this indeed to be the case (Box 4.28).

Fish can affect the growth of aquatic plants also, through consumption of plants or seeds, by uprooting or by promoting the growth of dense shading phytoplankton populations due to nutrient cycling in the aquatic system. For example, carp and bream dig up and turn over lakebed sediments vigorously in their search for burrowing invertebrate prey. In the process they have a direct impact on submerged aquatic macrophyte growth. They uproot germinating seedlings and young plants and increase the suspended sediment load in the water column, so re-cycling algal nutrients, and cutting out light penetration to plants on the lakebed. This increased turbidity can lead to algal-bloom dominated primary production systems, rather than clear-watered macrophyte communities where light penetrates to the lakebed. Fish

Box 4.26: The importance of invertebrates to ducks

- almost all species of dabbling and diving ducklings studied at 1-14 days of age eat aquatic invertebrates, even if subsequently almost wholly vegetarian (Giles 1993). The relatively high protein content of insects is considered vitally important for rapid early growth.
- many duck species time their reproductive cycle to coincide with the maximum insect food availability and select their breeding sites accordingly (Danell & Sjoberg 1982; Talent *et al.* 1982; Haland 1983).
- a high protein diet in the spring results in good female duck condition, high egg quality and good subsequent duckling growth and survival (*e.g.* Krapu 1979; Pehrsson 1982). Conversely, declines in invertebrate abundance can result in nutritional stress and reduced reproductive output (Bengtson 1971).
- ducklings may improve their foraging success almost linearly in response to increases in the density of chironomid larvae (Giles 1990) or other benthic invertebrate prey (Carbone 1995).
- at Lake Myvatn, Iceland, production of young in most duck species was correlated with insect (chironomid and blackfly) abundance (Gardarsson & Einarsson 1994).
- wintering pochard foraged over chironomid-rich food patches at gravel pit lakes, concentrating 77% of observed dives over one small area on a single lake at a site where more than twelve lakes are available for feeding waterbirds (Phillips 1991). Differences in the density of chironomid populations between preferred and other sites were only slight, indicating a response to subtle variations in feeding habitat quality.

Box 4.27: Studies where fish suppress or alter invertebrate populations

- Hruska (1961), excluding carp from sections of a pond, found a peak biomass of chironomid larvae 10 times greater than in areas where carp were feeding.
- Nilsson (1972) found that arctic char introduced into Lake Pieskejavre, Sweden, eliminated the previously abundant limnetic fairy shrimp. Fish growth declined and there was a dietary switch to benthic snails, chironomids and sculpins (cottid fish).
- Crucian carp depressed the abundance of chironomid larvae and oligochaete worms in Lake Bysjon by around 50% in mid-summer, though the fish were stocked at an unrealistically high density (Andersson *et al.* 1978).
- Evans (1989) introduced brook trout into limed, acidified lakes in New York, and recorded a sharp reduction in the abundance of open water invertebrates including corixids, notonectids, dytiscids and chaoborus midges. Calculated trout predation levels on these invertebrate populations were sufficient to explain a major proportion of the observed decline.
- Common bream forage very efficiently by winnowing chironomid larvae, oligochaete worms and mussels from the sediments or by switching to open water plankton feeding. They are able to reduce prey population densities substantially (Giles *et al.* 1990).
- On Lake Christina, Minnesota, a fish-kill resulted in a changed dominant plankton community, from small cladocera to larger *Daphnia* species and benthic macroinvertebrate abundance also increased, particularly that of amphipod crustaceans (Hanson & Butler 1994).

Box 4.28: Competition for invertebrate prey - fish/waterbird interactions

- both goldeneye and long-tailed ducklings use habitats where a pelagic invertebrate community (fairy shrimps, beetles, damsel and dragonfly nymphs, corixids) thrives in the absence of fish (Pehrsson 1973, 1974, 1988; Eriksson 1978, 1979). However, where fish are deliberately introduced into formerly fish-free lakes, large zooplankton and pelagic invertebrate communities decline, making conditions for duckling survival much worse.
- Eriksson (1979, 1983, 1984) noted that goldeneye in Sweden preferred to feed on lakes without fish, perhaps because goldeneye dive for invertebrate food in open water and may thus compete more directly for food with the fish. Declines in Swedish fish populations due to acidification were considered to result in increased habitat use by goldeneye through reduced food competition for invertebrate prey.
- Eadie & Keast (1982) showed that goldeneye and perch showed a high degree of trophic overlap, both for prey family and size, with goldeneye tending to feed on lakes where perch were scarce.
- Desgranges & Rodrigues (1986) suggest that acid lakes with abundant populations of brook trout are poor rearing habitat for black duck and goldeneye ducklings both because of food competition from the fish and an overall reduction in invertebrate diversity and abundance due to acidification.
- in the south of France, mosquito fish appear to influence the choice of feeding ponds by wintering shoveler by selectively predating large crustaceans such as *Daphnia magna*. Shoveler filter-feed nocturnally at high densities on fish-free ponds where *D. magna* swarms are thought to be most available to the birds (Pirot & Pont 1987).
- in a survey of 20 high altitude Andean lakes, Hurlbert *et al.* (1986) found that Chilean flamingos foraged extensively on fish-free lakes with an abundance of calanoid copepods, *Daphnia* species and brine shrimp. Lakes with the small cyprinodont fish, *Orestias* sp., had only a sparse plankton community dominated by small cyclopoid copepods and chydorid cladocerans.
- coarse fish removal from gravel pit lakes led to large increases in biomass of chironomids, aquatic snails and plants, and triggered rapid increases in breeding and wintering waterfowl populations (Giles 1992).
- in Lake Victoria, the introduction of predatory nile perch resulted in decimation of the lake's endemic insect-feeding cichlid fish fauna, leading in turn to huge increases in the abundance of aquatic insects and an increase in wintering sand martins from small numbers to hundreds of thousands (Moller 1992).
- Winfield & Winfield (1994) found that chironomid larvae and molluscs dominated in the guts of both tufted duck and roach. A decline in numbers of tufted duck numbers at Lough Neagh, Northern Ireland, coincided with the introduction and proliferation of roach, and when roach declined tufted duck numbers recovered.

can also re-cycle plant nutrients from the sediments whilst rooting and through excretion of digestive products which can have a substantial (*e.g.* ca 50%) input to the phosphorus loading of a lake and thus a direct influence on plant growth (Lamarra 1975).

Examples of studies demonstrating such effects are provided in Box 4.29. It is also possible that predation by fish on snails and other invertebrates which graze the periphyton (the microbial community coating the leaves and stems of submerged macrophytes) could lead to a decrease in weed beds due to 'smothering' by the epiphytic community. This, however, has yet to be adequately researched.

Many of the effects discussed here are natural to many lakes but can be induced or exaggerated through the deliberate stocking of fish by man. Clearly, both from a waterbird conservation perspective and an environmentally sound fisheries management standpoint, the best fisheries are balanced self-sustaining fish communities which do not impose excessive impacts on aquatic plant or invertebrate communities.

4.4.3 Waterbird releases and competition with native species

Just as angler's stock waters to maximise their catch, wildfowlers have introduced species such as mallard and Canada geese to new areas and have added farm-reared birds to supplement native wildfowl populations. Such practices may have adverse implications both for native waterbirds and their habitats, with concerns about interbreeding (*i.e.* loss of genetic integrity), increased competition for resources, habitat deterioration and the spread of disease (see Callaghan *et al.* 1995, 1997).

Existing research reinforces the concern about hybridisation, with examples of genetic erosion in a number of populations through interbreeding with mallard (Box 4.30). However, whilst the other problems are genuine areas of concern, there is little research to determine the scale and significance of the problems.

Perhaps the most well publicised case concerning birds is the escape of the North American ruddy duck from captivity at Slimbridge and the build-up of a wild population in Britain in the following

Box 4.29: Studies where fish impact on aquatic plants

- Anderson (1950) applied rotenone to a high-density carp lagoon adjacent to Lake Erie. Here stonewort beds recovered by 95% and curled pondweed increased by around 25% after the fish kill.
- by excluding feeding carp in areas of Lake Pymatuning, Pennsylvania, Tryon (1954) showed that the fish had depressed weed growth by around 60%, mainly via uprooting.
- King & Hart (1967) reversed carp damage to stonewort beds by treatment with rotenone. The stonewort beds recovered within two months of treatment.
- at Great Linford, a fish-removal experiment stimulated abundant growth of water plants, which in turn, boosted autumn populations of mute swan, coot and gadwall (Giles 1992, Wright & Phillips 1992). Tufted duckling survival also increased by around 30%, probably in response to the greatly increased gastropod mollusc densities present on the newly established weed beds. At this site, the major factors involved in macrophyte suppression were considered to be the uprooting of seedlings by foraging bream and seedling eating by roach.
- Hanson & Butler (1994) conducted a large-scale fish-kill on Lake Christina, Minnesota. Following the fish-kill water clarity increased, there was extensive macrophyte growth and wintering waterfowl numbers increased markedly.

Box 4.30: Problems associated with the release or escape of exotic or farm-reared waterbirds

Loss of genetic integrity:

- in North America, the southward spread of the mallard has already caused the extinction of the pure Mexican duck genotype in the USA (originally numbering about 5,000 individuals) (Greig 1980; Callaghan & Green 1993).
- In a similar way, the pure American black duck genotype may well become extinct, with hybridisation with mallards one of the principal factors (Brodsky & Weatherhead 1984).
- Mallard are now widespread in New Zealand and introgressive hybridisation with the Pacific black duck is common (Williams & Roderick 1973; Haddon 1984; Gillespie 1985; Williams 1994).
- hybridisation of mallard with Pacific black ducks is becoming frequent in Australia (Paton *et al.* 1992).
- Ruddy duck hybridisation with white-headed duck in Spain is threatening an endangered species (Hughes & Grassu 1995).

Increased competition:

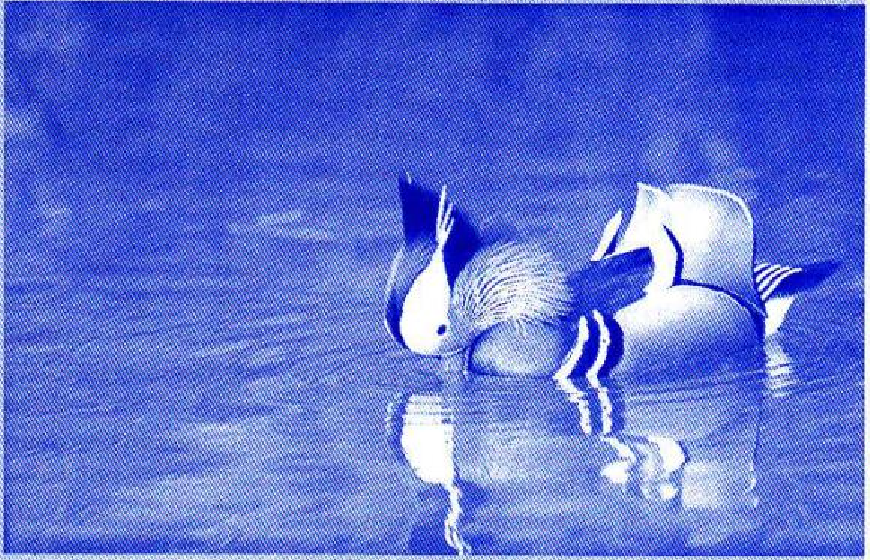
- Fabricius *et al.* (1974) found only limited evidence for aggression between breeding Canada geese and other native waterfowl and Giroux (1981) proposed that the nesting success of sympatric waterbirds may increase due to the protection from predators afforded by neighbouring Canada geese.
- by contrast, Master & Oplinger (1984) showed that mallard productivity may be negatively affected by increasing nesting densities of Canada geese.

Habitat deterioration:

- large numbers of Canada geese may degrade wetland sites at which they are largely resident, perhaps to the detriment of other wetland species (Allan *et al.* 1995).
- as with Canada geese, many resident populations of mallard have been established, which may be damaging to wetland habitats in areas where the species was formerly only a seasonal visitor (Callaghan *et al.* 1995, 1997).

Spread of disease:

- outbreaks of duck virus enteritis in wild birds have almost exclusively followed contact with captive-reared or feral waterfowl in North America and Eurasia (Brand 1987; Brand & Docherty 1988).
- in Britain, sporadic outbreaks in wild waterfowl have always followed contact with captive or released waterfowl (Gough 1984; Gough & Alexander 1990; Mitchell *et al.* 1993).



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decades. The species spread to many countries of Europe from the 1980s onwards and hybrids between the ruddy and the endangered white-headed duck on its Spanish breeding grounds were reported in the 1990s. The hybridisation was considered so serious that it threatened the white-headed duck's existence as a separate species and measures have since been taken in Spain and Britain to try and eliminate the problem by controlling the ruddy duck and shooting hybrids (Hughes & Grussu 1995). Meetings were held at national and International level and research initiated into the feasibility of control in 1992. This concluded that control was possible and a regional control trial in 1999-2002 managed to reduce the ruddy duck populations by 66% in one area and 93% in another. The study concluded that the population nationally in the UK could be reduced to less than 5% of current levels (less than 175 birds) within 4 to 6 years (B. Hughes pers. comm.). The decision was taken in 2003 to undertake national control.

4.4.4 Boat use, wash and associated pollution

Liddle & Scorgie (1980) explain how the force generated to push a boat forward is dissipated within the surrounding water body creating bow-waves and attendant wash that can cause physical damage to marginal vegetation and banks. When a boat passes, the water level at the bank first rises, then falls sharply and finally is washed by a series of waves. Clearly, the floating nest of a waterbird would be subjected to a 'roller-coaster ride' with potentially disastrous results.

Boats don't have to be powered in order to effect wetland habitats. Canoeing activity, for example, can result in localised damage to bankside vegetation at launching points, damage to littoral reed beds on regular paddling routes, localised modification of the stream bed and occasional disturbance to spawning fish and nesting waterfowl (Sidaway 1994).

These, plus effects such as pollution from combusted fuel and oil, turbidity due to silt suspension, chopping up water plants with propellers and bank erosion/water plant damage by boat wash are also associated with powered boat activity, including water skiing (Liddle & Scorgie 1980; CEED 1993; Land Use Consultants 1994). On canals, the quantity of aquatic vegetation has been shown to be negatively associated with boat traffic and major vegetation losses occur at high boat traffic levels (Murphy *et al.* 1995). Clearly, heavily used waterways offer poor waterbird habitats due to aquatic vegetation damage and a consequential lack of nesting and brood-rearing habitats. Lighter boat traffic can, however, suppress some common invasive aquatic plant species (see Murphy *et al.* 1995).

Liddle & Scorgie (1980) discuss the potential for eutrophication from sewage discharged directly from boats, though this practice is now illegal. They also consider pollution from outboard motors and provide a surprising estimate that the total hydrocarbon discharge from a single outboard engine running for one day would be equivalent to the sewage produced by 400 people, assuming that the products contain 85% degradable carbon. Murphy *et al.* (1995) conclude that, generally, pollution from boat motors is likely only to have local effects. Loch Lomond, however, receives an estimated 30 tonnes of hydrocarbons annually from powerboats, and summer water samples taken after heavy powerboat activity revealed hydrocarbon concentrations above theoretical safety limits at two out of three sites (Bannan *et al.* 1996). Clearly, there is potential for aquatic pollution from internal combustion engines and other sources but few studies to suggest whether the potential is often realised.

4.4.5 Wetland management for sport

Wetlands are sometimes actively managed so that they are enhanced for sport. Though all water-based sports will involve at least some wetland management, attention so far has focused on habitat management by angling and wildfowling groups.

In freshwaters, wetland vegetation is sometimes cut back or removed to facilitate access for fishing and sailing and to avoid tackle entanglement. However, wetland conservation managers may often wish to maximise feeding, nesting and cover habitats for waterbirds or, conversely to create open water for wintering waterbird flocks. Recreational and conservation endpoints may sometimes differ in terms of preferred botanical communities.

Tracks and pathways are sometimes worn by anglers through riparian grasslands, often with a considerable loss of rough grass and reed habitats. *Phragmites* and *Phalaris* beds tend to suffer more than lower-growing tougher species such as *Carex* sedges, *Agrostis* and *Poa* grass species

(Murphy & Pearce 1987). The Dartington Amenity Research Trust (1973) found that coarse fishermen used a gravel pit shoreline at a rate of 33.3 anglers per 100m of bank per week, causing 26% of the bank to be worn bare. It is worth noting that, at most sites; anglers are not totally to blame for these effects. For instance, Sukopp (1971), studying an intensively used German river shoreline, discovered that whilst the rich hydroseral botanical community was often eroded back to bare ground, much of the damage was done by the high density of bathers, boaters and swimmers.

Much of the active control of aquatic plants involves hand or mechanical cutting of bank-side and underwater stands of aquatic vegetation. For riparian nesting and true waterbird species grass, reed and rush cutting in summer is most damaging to nesting birds. Chemical control is also widely practised and it is imperative that the appropriate products are used in the correct way if damage to the aquatic environment is to be avoided. The Ministry of Agriculture, Fisheries and Food guidelines must always be followed (MAFF 1999). Many aquatic invertebrates are very sensitive to herbicides and considerable harm can be done through misapplications of these products. Conversely, where appropriately applied, chemicals on the MAAF (DEFRA) safe list can be very safe and useful for clearing invasive plant growth. Lewis & Williams (1984), Seagrave (1988) and RSPB/NRA/RSNC (1994) provide sound advice on aquatic plant management.

Maggie Grenham

Poor signing created a 'short-cut' along this riverside footpath.

Fisheries managers often create new wetlands and are constantly managing existing ones to optimise fishery performance. When such management, including habitat restoration techniques, is aimed at the promotion of self-sustaining native fish stocks, then the overall impact on conservation is generally positive (Giles & Summers 1996). Furthermore, angling does a great deal to finance and implement positive wetland provision and protection, benefiting waterbirds as part of the aquatic system. For example, anglers have been at the forefront of addressing important issues such as physical habitat change (deep-dredging, flood defence projects), predation by mink, and wetland acidification, thus helping to protect habitat for all wildlife living in wetland environments.

Since wildfowling is a primary activity in wetlands throughout the world, wetland management for hunting is primarily geared to provide an abundance of appropriate food, open water for resting and optimal nesting conditions. Smith *et al.* (1989) provide many examples of the type of habitat modification (or enhancement) practices employed. Management commonly includes the manipulation of hydrology, with resultant changes to vegetation and invertebrate communities (references in Callaghan *et al.* 1995, 1997) and often the virtual extirpation of fish (Weller 1978). Because of competition with waterfowl (section 4.4.2), fish are often considered undesirable in wetlands managed for waterfowl, and where draw-downs are not possible, other measures are often taken to reduce fish biomass, for example through the application of pesticides (*e.g.* rotenone) or by trawling (Kadlec & Smith 1992; N. Giles, unpubl.). The effect of such activities is site dependent but tends to result in marked changes to plant and animal communities (discussed by Callaghan *et al.* 1995, 1997). Further, large beds of tall emergent vegetation may be removed to increase the area of open water, often involving the use of herbicides (*e.g.* dalapon and glyphosate), sometimes repeatedly (Newbold 1975; Thomas 1982; Kadlec & Smith 1992). Burning is also commonly used to reduce the area of tall emergent vegetation, as is grazing. Whilst there is no doubt that wetland management for hunting impacts on non-target species and on wetland biodiversity in general, there appears to have been no studies that have critically evaluated these topics (Callaghan *et al.* 1995, 1997).

The value-added incentive placed upon wetlands via recreational waterfowl hunting drives many habitat management, restoration and protection programmes. For example, it has been estimated that 40 million hectares of wetland habitat in North America have been protected as a direct result of waterfowl hunting (Heitmeyer *et al.* 1993). In Europe also, habitat restoration is a core programme of some hunting organizations (Nicolle 1995; Laws & Lecocq 1996; Laws 1997). Although there seems to have been no critical analyses of these activities, the introduction of the concept of 'wise use' into waterfowl hunting and its acceptance by organised hunting groups has been a major step forward and the management of habitats by hunting groups offer substantial benefits to wetland biodiversity.

As with angling concerns, the managers of sites used for wildfowling have long practised predator control in an attempt to increase nesting success. Studies have shown that where predator densities are reduced substantially, waterfowl production can be increased in certain areas (Balser *et al.* 1968; Duebbert & Kantrud 1974; Duebbert & Lokemoen 1980; Greenwood 1986). This, plus the provision of nest boxes and platforms for waterfowl, would certainly bring benefits for non-quarry waterbirds as well.

4.4.6 The significance of habitat influences and competition

It is clear from the studies summarised that recreation, in its various forms, can have important consequences for waterbird food supplies and habitats. The indirect effects and impacts of angling have been the focus of much attention and it has been shown that the collection of bait in intertidal areas may result in reduced local populations of invertebrates (waterbird foods), which are replenished over time. Despite the short-term nature of this problem, the impact has been judged to be severe in areas with internationally important bird populations, and banning of bait collection has occurred. On rocky shores, the collection of crabs for bait must affect intertidal animals and plants to some degree, but impacts on waterbird populations seems unlikely. The evidence of damage to waterbirds from the use of ground baits in freshwaters is inconclusive. Again this seems unlikely to be a major problem for waterbirds, though a consideration is needed at sites of high importance for waterbirds or other wetland wildlife.

By contrast, it is certain that invertebrates and aquatic plants are fundamentally important to waterbirds, that fish populations can severely depress or alter invertebrate or plant communities, and that this can have adverse impacts on waterbirds through lowered reproductive success and reduced carrying capacities. Thus, there can be real impacts from fish stocking on local waterbird populations where high fish densities coincide with important breeding or wintering waterbird populations. In these circumstances self-sustaining fish communities are desirable, which do not impose excessive impacts on aquatic plant or invertebrate communities.

From a waterbird food and habitat point of view, the use of boats on wetlands is not free from problems. On wetlands with high levels of boat traffic, previous research has shown an impact in terms of major vegetation loss. Indeed some intensively used waterways are devoid of bankside and aquatic vegetation and suffer chronic bank erosion, leading to turbid waters. Though not established with certainty, there may also be local polluting effects from engines and sewage, with consequences for waterbird foods. Clearly, heavily used waterways offer poor waterbird habitats due to aquatic vegetation damage and a consequential lack of nesting and brood-rearing habitats.

Release and stocking of waterfowl for hunting have established populations of introduced species over large parts of the world, and continue to do so in parts of Europe. Introductions have inevitably caused alterations to the structure of native waterbird communities, and have caused substantial erosion of the genetic integrity of five waterfowl taxa, and the survival of at least three of these seems unlikely if present trends continue. There seems little doubt that the stocking of game-farm mallards for hunting has had a profound effect on the autecology of this species. There may also be disease implications arising from these releases and stocking but the significance of this for native waterbirds, and the possible broader effects on ecosystem structure remain un-researched.

The management of wetlands to facilitate recreation, for example fishing and wildfowling opportunity, may include undesirable activities for waterbirds and conflict with the aspirations of conservationists. Insensitive activities may include the introduction of an altered hydrology, removal or loss of wetland vegetation, removal or introduction of fish, excessive erosion and inappropriate use of chemicals. However the involvement of anglers and wildfowlers in wetland management can bring enormous benefits in terms of site protection, management and restoration, and the control of predators and alien introductions.

4.5 Overall strength of effects and impacts of recreation on waterbirds

We would like to emphasise in this summary the important sections in the forgoing account, especially sections 4.2.6, 4.3.9 and 4.4.6.

Most studies of the effects and impacts of recreation have concluded with an assessment of the relative severity of the observed influences. Madsen *et al.* (1998a), for example, provide an interesting summary of the degree of effect of different forms of recreation on mute swan, wigeon and coot in two Danish wetlands (Box 4.31). Here the combination of temporal, spatial and diurnal overlaps pinpoints fishing, shooting from mobile punts and shooting from stationary punts as the potential disturbance sources. Judging from behavioural effects, shooting from mobile punts ranks as the most disturbing activity because it caused the longest disruption to feeding. These, and the conclusions drawn from other studies, are site-specific and it is extremely difficult to generalise about recreational effects on waterbirds given the specific nature of many studies, the often-conflicting conclusions they draw and the fragmented nature of the information available.

Despite this, we attempt to summarise the strength of the evidence for effects and impacts on waterbirds from different forms of recreation in Box 4.32. Overall, it is clear that many activities have demonstrated potential to cause reductions in waterbird numbers, densities or reduced breeding performance at individual sites or clusters of sites. This is a fundamentally important *effect* of recreation because it means that the value of a site, from a waterbird and biodiversity point of view, is lowered on account of recreational activity. This may be unacceptable where nature conservation should take precedence, and may also be unwelcome at other sites because people generally are interested in observing wildlife on their 'own patch', suggesting that managers should strive to maintain or establish wildlife interests even on wetlands used for sport. Of the recreational activities producing site-based or regional effects, excessive fish-waterbird interactions and mortality from ingested lead (from angling and wildfowling) appear serious enough to *impact* on local populations, reducing breeding output and/or survival. Of all recreational activities, wildfowling is perhaps the only sport that may *impact* on waterbirds at the population level, and above a

Box 4.31: Summary evaluation of relative potential disturbance and actual behavioural and distributional effects of recreational activities on autumn-staging waterfowl in Nibe Bredning, Denmark (Madsen 1998a).

	Fishing	Sailing	Wind surfing	Shooting from marshes	Shooting mobile punts	Shooting stationary punts
Potential disturbance sources						
Seasonal overlap	Med	Low	Low	High	High	High
Spatial overlap	Med	Low	Med	Low	High	High
Diurnal overlap	Med[a]	Med	Med	Low	Med	Med
Behavioural effects						
Escape distance	Med	?	High	?	Low	Med
Disturbance period	Med	?	Med	?	High	Low
Distributional effects						
Daily distribution[b]	Low	Low	Low	Low	High	Med

Low, low impact; Med, intermediate impact; high, high impact; ? not studied.
[a]Increasing to high in late autumn.
[b]Applies to wigeon; for mute swan the effects of mobile punts is medium and the effect of stationary punts is low.

Box 4.32: An assessment of the overall strength of effects and impacts from recreation on waterbirds

Based on the material compiled for this handbook, the effect/impact of each type of recreational activity is scored as follows: unknown (?); rare/not applicable (-); site-based or regional effect (+); site-based or regional impact (++); population level impact (+++). See text for further detail.

Recreation type	Mortality		Disturbance		Habitat damage		
	direct	indirect	breeding	non-breeding	Loss of food	degraded habitat	competition
Angling							
- game/coarse fishing	-	+	+	+	+	+	++
- sea fishing	-	-	-	-	+	+	-
Non-powered craft							
- sailing, windsurfing	-	-	+	+	-	?	-
- canoeing, rowing			+	?	-	?	-
- scuba diving	?	?	?	?	-	?	?
Powered craft							
- boats, water skiing	?		+	+	-	+	-
- jet skiing	?		+	+	-	+	-
- motor cruising	-	-	+	?	-	+	-
Hunting							
- wildfowling	+++	++	?	+	-	+	+++
Informal recreation							
- birding, research	-	-	+	+	-	-	-
- dog walking	-	-	+	+	-	-	-
- beach use, swimming	-	-	+	-	-	-	-

threshold level, shooting harvests may place waterbird populations in jeopardy. There is also the associated stocking and introduction of birds for hunting purposes which may be responsible for the loss of genetic integrity amongst a restricted number of waterbird populations.

Although we have outlined the potential for impacts of water-based sport and recreation and given examples where there have been conflicts, in general the sensitive management of water areas and recreational activities has resulted in the numbers of most waterbird species increasing at the same time as recreational activity was becoming more intensive. Many sporting organisations have been very active in promoting sustainability in their sport so that it can co-exist with healthy waterbird stocks.

4.6 Limitations of the science and guidance for the future

Many studies have taken a restricted view of recreational activity and focused on one particular form of recreation. Indeed, angling, wildfowling and, to a lesser extent, sailing have been the focus of much of the research conducted to date. In most studies of disturbance the controlled stimulus eliciting escape flight is human approach. The presence of human activity denies access to resources (be it for loafing, sleeping, feeding, moulting or breeding) and reduces the level of resource use to below what would be attainable in the absence of such activity. In this context, it is important to realise that there is a multitude of recreational activities in many wetland areas, and the effects of multiple disturbance from different sources is likely to have a synergistic or cumulative effect on birds. However, there are really very few studies that have adequately quantified the intensities, distribution, phenology, diurnal patterns, and hence the potential effects on waterbirds, of the various human activities operating together in areas used by waterbirds. Very few studies have experimentally demonstrated the strength of response to disturbance by, for example, controlled removal of one or more activities from a site.

A further limitation is that it is necessary, but difficult, to define what constitutes the site, local, regional, national and flyway population of a given species (Hill *et al.* 1997a). This has rarely been done. Research needs to address the spatial scale of impact, relatively easy at the site level but very difficult for whole flyways. Site effects can give a local impression of severe disturbance impacts from a given activity (*e.g.* NCC/RSPB 1988). However it is often possible that the overall flyway population can absorb many local effects on condition and survival of individual birds whilst experiencing little or no overall impact on the larger scale. There is also the need to address more of the 'big picture'. Local and regional sub-populations of waterbirds interact and combine to constitute a global 'metapopulation'. This is the natural resource provided by a given species. Understanding how changes in habitat availability and recreational pressures affect or impact waterbird populations is a very important subject area for research development. At present this is being tackled on a coarse-scale through the provision of key site protection on the major flyways. Much more applied research is needed before we can understand how important each site is and where 'pressure points' for different species occur on their flyways.

Observations that suggest that waterbirds are displaced by recreational activity from a particular site are now common in the research literature. However it is apparent that much of the information available on the effects/impacts of disturbance on waterbirds is not based on causal scientific analysis. Therefore, it is often impossible to know the extent of an effect, or whether it constitutes a real population impact in any given situation. There is clearly a need for more controlled experimental studies that help to establish unambiguous cause and effect relationships. Experimental evidence is also needed to show that the displacement is not due to other, confounding factors, for example changes in habitat quality of sites or in overall population sizes (see Madsen *et al.* 1998b). It is also the case that displacement as a result of disturbance may only be temporary (*e.g.* Owens 1977) and thus may not have a long-term negative effect. Furthermore, it is important to know how many birds would use a site in the absence of disturbance to assess the full extent of any disturbance event. Gill *et al.* (1996) argue very cogently that it is important to understand the pattern of resource use in a given area before overlaying the influence of disturbance (see Box 4.33). This has rarely been achieved in studies of recreational impacts (for exceptions see Madsen *et al.* 1998a,b; Platteeuw & Henkens 1998a). Many of these aspects have often not been addressed adequately in the research studies so far.

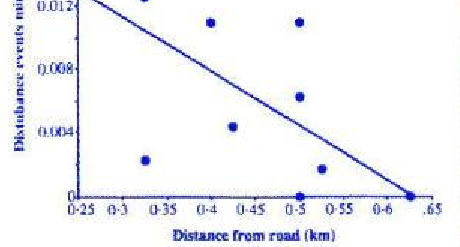
Overall, the scientific quality in studies of the interactions between waterbirds and recreational activities is questionable. This is nicely illustrated by Hill *et al.* (1997), who developed the following,

Box 4.33: Disturbance to wintering pink-footed geese (Gill *et al.* 1996)

In some areas, pink-footed geese rely on sugar beet root fragments as an important winter food. The authors developed a modelling approach that measures the trade-off that geese make between food intake rates and risk of disturbance. Geese use of harvested beet fields is not uniform but decreases linearly with proximity to roads: disturbed fields show greatly reduced food resource depletion. This is good evidence to suggest that bird disturbance has the potential to significantly affect feeding success rates. The key finding is that slight increases in disturbance can lead to large changes in goose feeding habitat usage.

On the other hand, movement into previously disturbed areas later in the season may be possible because of:

- habituation
- the need to take greater risks to gather depleted food supplies
- the disturbance has ceased (*e.g.* after end of shooting season)



The relationship between the distance from the goose flock to the nearest road at first landing and the disturbance rate (y=0.03x + 0.02, r^2 = 0.4, n=10, P< 0.05).

Gill *et al.* point out that if bird densities vary in an important habitat but resource levels do not, then the birds are losing out on a percentage of a key resource that could be critical in terms of survival. This study clarifies whether or not disturbance is influencing bird distribution at a given site and also allows the quantification of the effect of disturbance in terms of numbers of geese present. It would be good to build on this study to know whether this is a more general phenomenon; if so, then disturbance to feeding waterbirds could well be a very significant factor influencing over-winter survival.

declining scale of scientific rigour for disturbance studies:

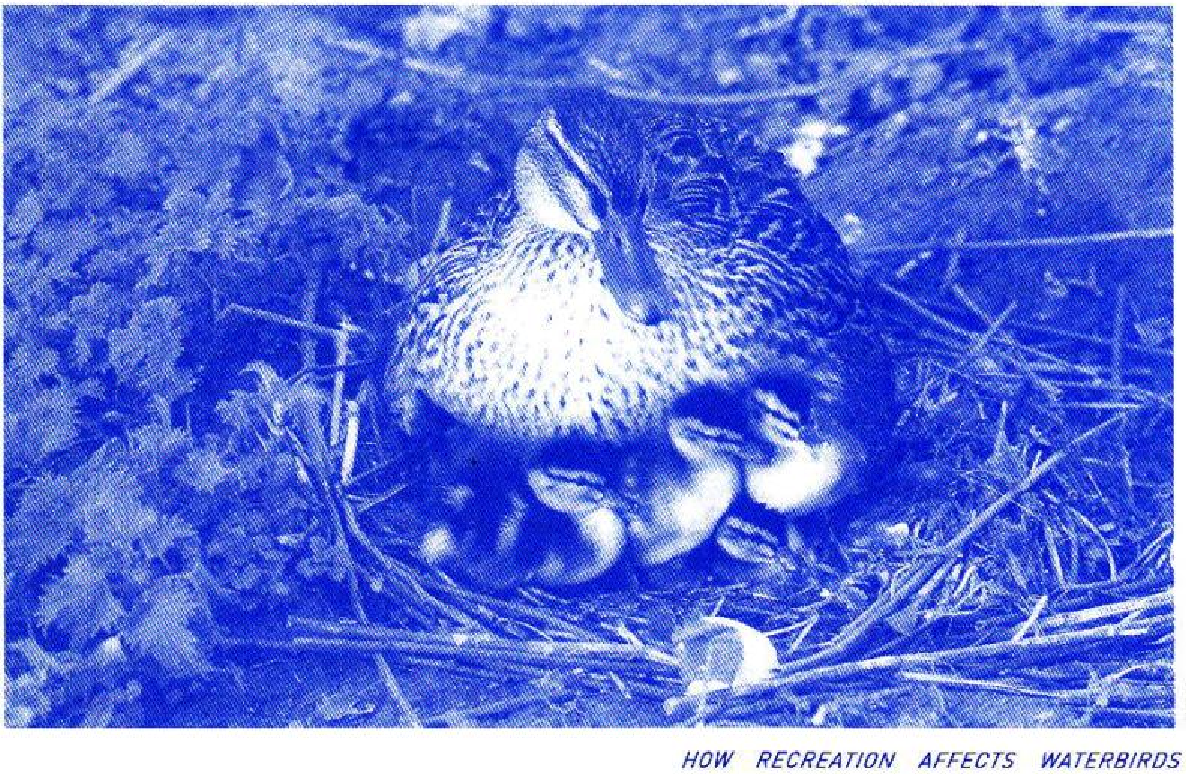
- use of experimental control, a before and after study, study with and without disturbance.
- more than two areas studied at the same time with known levels or a gradient of disturbance being investigated.
- a correlative study, multi-site or multi-years.
- a study based on simple observation, often involving no hypothesis testing.

They showed that of 153 studies reviewed only 20 used an experiment with a control, or were conducted under a protocol using a before-and-after or with-and-without disturbance manipulation. Of the studies considered, 54% relied on simple observations, often without testing any specific hypothesis. Further, the majority of Environmental Statements and Environmental Impact Assessments failed to address bird conservation satisfactorily and often misapplied survey techniques so as to produce unsound data (Box 4.34). This is indicative of a relatively poor standard of scientific rigour in disturbance studies, a situation that seems applicable to studies of waterbirds and recreation as a whole. Clearly an overall goal should be to improve the science available to support management decisions.

Box 4.34: Ornithological considerations in environmental assessments (Morris 1995)

This review showed how compliance with both minimum requirements and best practice has been increasing since 1988 but that 61% of environmental statements still failed (in 1994) to reach even the minimum requirements for a sound ecological assessment. It was the case, however, that more effort was made to comply with standard requirements where the perceived impact of disturbance was greatest.

Whilst interviewing a sample of environmental consultants who claimed to predict impacts and categorise their severity, all interviewees cited land-take as the most important factor of development on birds, followed by visual and noise disturbance (80%), habitat fragmentation (60%), hydrological impacts (20%) and lighting (10%). In the same study consultants were asked whether they advised on mitigation measures for disturbance on birds: all suggested minimising the initial loss, 90% advised timing the development outside the breeding season and minimising disturbance with a good construction protocol, 80% promoted habitat creation and 60% advocated screening. All consultants suggested a monitoring programme with 70% recommending that it be based on existing baseline data and only 30% recommending further detailed studies to establish a sound baseline. Hill *et al.* (1997) conclude that there is a major discrepancy between what consultants recommend and what is actually translated into the environmental statements. For example, only 5% of statements proposed long-term monitoring of bird population responses. Better monitoring is essential for sound environmental protection.



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5. MANAGEMENT FOR RECREATION AND WATERBIRD CONSERVATION

5.1 Introduction

The aim of this handbook is to help optimise the recreational and wildlife value of wetlands without compromising the ability of future generations to further develop and enjoy these benefits. Such long-term integration is what we consider to be "sustainable development". But as described in the previous chapter, recreation and waterbird interests often conflict and ultimately compromise the value of a site for both or either. Hence, management is necessary to alleviate conflict and maximise the value of a site for both interests as much as possible. This task is discussed under two main topics:

- management framework and process (which describes waterbird conservation politics and policies, integrated planning and management, cost-benefit analysis and environmental impact assessments).
- management techniques (which describes a wide range of practical methods that can be used to integrate recreation and waterbird conservation).

Although the emphasis is on Britain and Europe, the text is of relevance to wetland conservation and recreation world-wide. Case studies are used to highlight particularly successful or innovative approaches to management issues. For further reading see Box 5.1.

5. 2 Management framework and process

5.2.1 Waterbird conservation responsibilities

There is now an extensive framework of statutes for both species-based and habitat-based conservation relevant to waterbirds and wetlands in most developed countries and to an increasing extent in developing countries. In Britain and Europe, for example, statutory and non-statutory measures operate at a wide variety of scales and address a diversity of issues (Box 5.2). Domestic designations and legislation that include safeguards for migratory waterfowl and wetlands often provide the mechanism through which international conservation measures are delivered. Salathé (1991) describes the terms and implementation of many of these policies.

Site protection, through statutory designation, often lies at the heart of any particular waterbird conservation framework. With nine such designations, Britain has more types than any other European country, and overall there are at least 18 site-related conservation measures that are relevant to the conservation of waterbirds in Britain. These are summarised in Box 5.3 and described in more detail in Davidson *et al.* (1991).

The net result is often a complex framework of policies and politics under which management operates, and this needs to be understood fully before management actions are taken. The following sub-sections describe in more detail the principal statutory and non-statutory measures relevant to wetland and waterbird conservation in Britain and Europe.

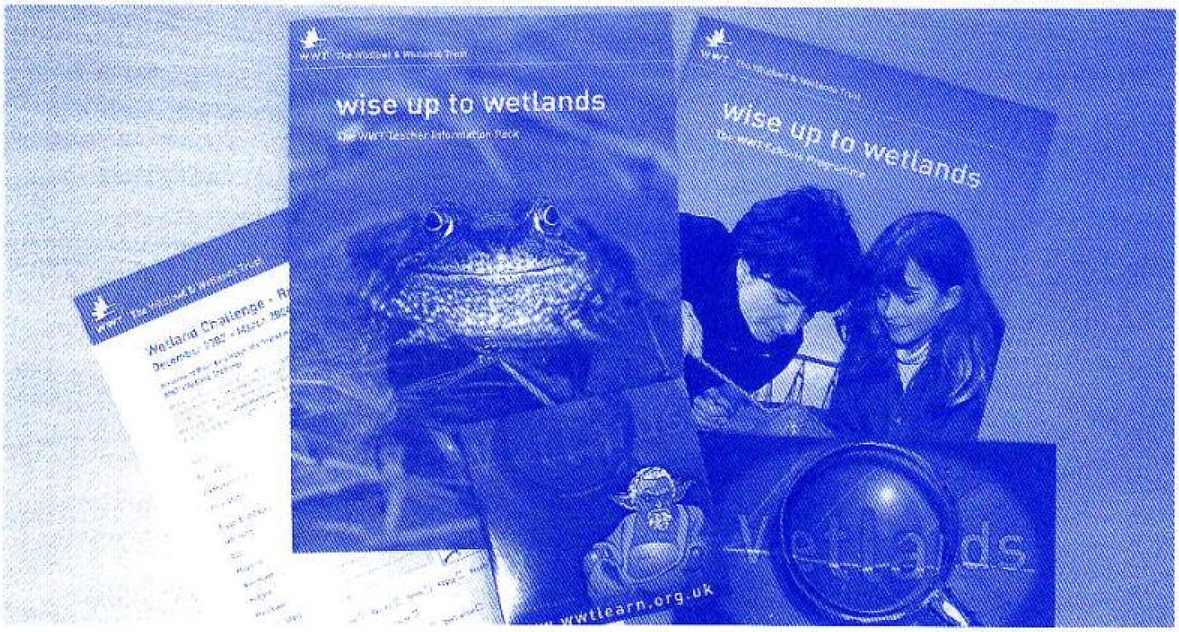
5.2.1.1 Ramsar Convention and Birds Directive

Two international agreements provide the core framework for the conservation of migratory waterbirds in the East Atlantic Flyway, the flyway of which Britain forms a part. The first is the "Convention on Wetlands of International Importance Especially as Waterfowl Habitat", for convenience usually called the "Ramsar Convention" 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 "EC Directive on the Conservation of Wild Birds" (Directive EEC/79/409), adopted in 1979, and often known as the "Birds Directive".

The Ramsar Convention requires contracting parties to take steps to stem the progressive encroach-

Box 5.1: Key publications in waterbird conservation policy, and waterbird and wetland management

Aspect	Citation	Details
Conservation policy networks	Stroud *et al.* (1990)	EEC Special Protection Area
	Pritchard *et al.* (1992)	Important Bird Areas in the UK
	Davis (1994)	Ramsar Convention Manual.
	EC COM (1995)	Wise use and conservation of wetlands
General waterbird and wetland management	Game Conservancy (1981)	Wildfowl management and management for wildfowl
	Batt *et al.* (1992)	American text on the ecology and management of breeding waterfowl
	Baldassarre & Bolen (1994)	American text on waterfowl ecology and management
	Coles (1995)	Wetlands review and management techniques
	Welch (1996)	Techniques for managing water in lowland wetlands
	Gilbert *et al.* (1998)	A manual of monitoring methods for key UK species
Coastal and Estuarine	Davidson *et al.* (1991)	Nature conservation and estuaries in Great Britain
Grasslands and Farmland	RSPB/EN/ITE (1997)	Managing floodplain and coastal wet grasslands for wildlife
Peatlands and Reedbeds	Hawke & Jose (1996)	Reedbed management
Lakes, Rivers and Steams	RSPB/NRA/RSNC (1994)	Rivers and wildlife
	Moss *et al.* (1996)	Restoration of shallow lakes
	Giles (1998)	Freshwater fisheries and wildlife
Man-made	Merritt (1994)	Industrial wetlands
	Andrews & Kinsman (1990)	Gravel pit restoration for wildlife
	Giles (1992)	Wildlife use of gravel pits



David Chamberlain/WWT

ment on and loss of wetlands, to promote the wise use of wetlands and to identify and list wetlands of international importance. The 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.

Regarding recreation, the Birds Directive requires member states to take account of economic and recreational needs (including hunting) whilst maintaining species populations. It also requires that pollution, habitat deterioration and disturbance to birds should be avoided where they would significantly affect survival and reproduction of birds in their area of distribution.

In a link to the Ramsar Convention, the Birds Directive stresses that particular attention shall be paid to the protection of wetlands and, in

Box 5.2: Statutory and non-statutory measures relevant to the sustainable use of wetlands and waterbirds in Britain and Europe (adapted from Stroud, in press)

Spatial scale	Habitat-based	Species-based
International legislation		
EC Birds Directive	Special Protection Areas (SPAs)	Regulation of time and mode of hunting
EC Habitats Directive	Special Areas of Conservation (SACs)	-
Bonn Convention	-	African-Eurasian Migratory Waterbird Agreement
Ramsar Convention	Wetlands of international importance, and wise-use requirements	Wise-use requirements, and international co-operation in species management
Biosphere Reserves	Zoning of land-use activity	-
National legislation	Nationally protected sites and nature reserves, *e.g.* in Britain: National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Areas of Special Protection (AoSPs)	National hunting/taking laws may further restrict time/mode of hunting or quarry species (*e.g.* cold weather shooting bans) Fishery law
Regulations	Byelaws - restrictions on certain activities *e.g.* sand-yachting, cockling, bait-digging, low-flying by aircraft *etc.* Refuge areas Local planning to avoid key habitats/areas	Local/site fishery regulations
Non-statutory measures	CEC communications on wise use of wetlands, and coastal zone management Local/Non-Governmental Organisations nature reserves Landscape and recreational designations *e.g.* Heritage Coasts Shoreline Management Plans Catchment Management Plans/Local Environment Area Plans Estuary Management Plans Other Integrated Coastal Zone Management Initiatives	Codes of conduct, *e.g.* for jet-ski users, hunters, birdwatchers, Royal Yachting Association, Water Ski Federation, *etc* Angling Codes of Practice

Box 5.3: Different types of statutory and non-statutory site-based conservation measures in Britain, including (in italics) the type of designation (landscape, conservation, heritage)

Type, usual abbreviation and legal status	Description
Area of Outstanding Natural Beauty (AONB): statutory *landscape*	Designated primarily to conserve their natural landscape beauty, and to meet the demands of recreation as far as is consistent with maintaining the natural beauty and other land uses. AONBs are designated under the National Parks and Access to the Countryside Act 1949, by the Countryside Agency in England and since 1991 by the Countryside Council for Wales in Wales. They do not apply in Scotland. Responsibility for local administration of an AONB lies with local authorities at county, district or unitary level.
Area of Special Protection (AoSP): statutory *conservation*	Designated by the British government under the Wildlife and Countryside Act 1981, with the agreement of the landowner or occupier, affording strong protection for particular bird species throughout the year.
Country Park (CP): statutory *landscape*	A local authority designation under the Countryside Act 1968, Country Parks are designed primarily for recreation and leisure, but often in areas of semi-natural habitat.
County Wildlife Trust reserves (CWT): non-statutory *conservation*	Nature reserves owned, leased or managed by the 48 non-statutory wildlife trusts, which in England and Wales generally each cover a county or small group of counties and in Scotland are 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 nature reserves are also partly or wholly NNRs managed on behalf of conservation agencies; others are LNRs managed on behalf of local authorities.
County Wildlife Sites (CWS) statutory *conservation*	Sites designated by local authorities under their structure plans – have legal authority through planning regulations.
Environmentally Sensitive Area (ESA): statutory *conservation*	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, for wetlands notably in river valleys and wet grasslands. ESAs provide incentives including payments to encourage favourable low-intensity farming practices.
Geological Conservation Review Site (GCR): non-statutory; identified by statutory agencies *conservation*	The Geological Conservation Review was started in 1977 as an earth science equivalent of the NCR, to identify and publish descriptions of all British sites of national and international earth-science importance. Coverage includes both geological and geomorphologic features arranged as a series of GCR blocks each covering a period of geological time, subject or geographical area. GCR-block sites are potential SSSIs.
Heritage Coast (HC): non-statutory *landscape*	Areas/lengths of largely undeveloped coastline of high scenic quality selected by the Countryside Agency (England) and CCW (Wales) as an aid to local authorities in planning and managing their coastlines. Local authorities develop management of HC plans that include sensitive management covering land use and protection, public enjoyment and nature conservation. Most HCs are on predominantly open sandy and cliff coasts.
Local Nature Reserve (LNR): statutory *conservation*	LNRs are designated by local authorities (District or Unitary 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.
Marine Consultation Area (MCA): non-statutory *conservation*	Scotland only. An identification by Scottish Natural Heritage of areas of marine nature conservation significance, to encourage consultation with the agency on other activities in these areas. Former proposals for an MCA series in England and Wales are now largely superseded by English Nature's *Important Areas for Marine Wildlife*.
Marine Nature Reserve (MNR): statutory *conservation*	Designated under the Wildlife and Countryside Act 1981 by the Secretary of State on request of the statutory conservation agencies. The designation procedure is complex and only two sites have been designated so far.

Box 5.3: continued

Type, usual abbreviation and legal status	Description
Maritime Natural Area (MNA): non-statutory *conservation*	England only. Areas identified by English Nature, representing coherent maritime wildlife systems based on major sediment cells and other coastal features. Seaward boundary is the 12-mile limit; landward boundary is the limit of coastal habitats.
Ministry of Defence land (MOD land): non-statutory *conservation*	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 and the long-term restrictions on public access has led to some areas becoming amongst the most pristine remaining.
National Nature Reserve (NNR): statutory *conservation*	Nationally important wildlife sites managed by conservation agencies or on their behalf. NNRs are declared by the statutory conservation agencies and are managed specifically for wildlife conservation purposes. All are also SSSI's (see below).
National Park (NP): statutory *landscape, conservation*	The 10 National Parks in England and Wales 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, taking into account the needs of park residents. The Countryside Commission (England) and CCW (Wales) advise government on NPs; each is administered by a Park Authority. Norfolk Broads and New Forest have similar status.
National Scenic Area (NSA): statutory *landscape*	Scotland only. NSAs are chosen 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.
National Trust properties (NT): non-statutory *conservation*	The National Trust, an independent charity founded in 1895, and covering the UK except Scotland, is the largest private landowner in Britain. The National Trust for Scotland has similar objectives. Under National Trust ownership land is as fully protected against development as is currently possible. The National Trust has major wetland and coastal land-holdings in Britain, coastal sites funded particularly through the Enterprise Neptune appeals Though these are non-statutory, the National Trust has legal powers to exclude the public from land.
Nature Conservation Review Site (NCR): non-statutory; identified by statutory agencies *conservation*	Sites identified as the key areas in Britain for statutory nature conservation initially by the Nature Conservancy Council in 1977 (see Ratcliffe 1977) and periodically updated. The NCR series helps to identify suitable candidates for biological NNR designation.
Royal Society for the Protection of Birds reserves (RSPB): non-statutory *conservation*	The RSPB is the largest voluntary wildlife conservation body in Europe and has over 125 reserves in the UK. Reserves 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, so wildlife safeguard levels are high. This also works with partners overseas via BirdLife International.
Sensitive Marine Area (SMA): non-statutory *conservation*	An English Nature identification of areas important for marine wildlife. Within each an initiative involving managers and users of the marine environment, based on voluntary measures in conjunction with existing regulatory controls.
Site of Special Scientific Interest (SSSI): statutory *conservation*	The key statutory site designation by which site-based wildlife and earth science conservation is delivered in Britain. Sites are identified by the conservation agencies and notified after a consultation period to owners, occupiers, local planning authorities, the Secretaries of State, water authorities and drainage boards. SSSIs were first notified to local authorities under the National Parks and Access to the Countryside Act 1949. Subsequently the Wildlife and Countryside Act 1981 and the Countryside & Rights of Way Act (2000) have strengthened the statutory notification process and management controls. Notification of land as an SSSI imposes requirements for prior consultation on proposed activities that might damage the conservation interest of the site. Biological sites are selected using a suite of guidelines (JNCC 1996); earth science sites are selected through the GCR process.

Box 5.3: continued

Type, usual abbreviation and legal status	Description
Special Area of Conservation statutory *conservation*	To be designated under the 1992 EC Directive on the Conservation of Habitats and Species, in the UK through the Conservation (Natural Habitats *etc.*) Regulations 1994. SACs are areas identified as outstanding examples of selected habitat types or areas important for the well being of, or survival of, selected non-bird species. 211 UK candidate sites (all are SSSIs) have so far been proposed for designation, including many coastal and freshwater wetlands. Together with SPAs, SACs will form the Natura 2000 European site network.
Special Protection Area (SPA): statutory *conservation*	The 1979 EC Directive on the Conservation of Wild Birds requires member states to take conservation measures particularly for certain rare or vulnerable species and for regularly occurring migratory species of birds. In part this is achieved through the designation of SPAs by the UK government on the advice of the statutory conservation agencies. Implementation of the Birds Directive in the UK is achieved through the Wildlife and Countryside Act and its procedures for SSSI notification - all SPAs must first have been notified as SSSIs. Many SPAs are designated for migratory waterfowl and so are closely linked with 'Ramsar sites'. Together with SACs, SPAs will form the Natura 2000 European site network.
Voluntary Marine Consultation Area (vMCA): non-statutory *conservation*	Local consultative or management groups establish Voluntary Marine Consultation Areas.
Wetland of international importance (Ramsar site): statutory *conservation*	Sites of international importance designated by the UK government on the advice of the conservation agencies under the 'Ramsar Convention' (the Convention on wetlands of international importance especially as waterfowl habitat). 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.
Wildfowl & Wetlands Trust reserves (WWT): non-statutory *conservation*	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 areas of high wildlife value and through ownership or long leases afford high levels of protection.
Wildlife reserves (various): non-statutory *conservation*	A variety of locally owned or managed reserves, including Woodland Trust reserves and Bird Observatories.

particular, to wetlands of international importance. In practice this means that many wetlands are designated under both the Ramsar Convention and Birds Directive in Britain (Davidson *et al.* 1991), as elsewhere in Europe.

Wetlands selected as of international importance under the Ramsar Convention fall into three categories:

- particularly good examples of a specific wetland type characteristic of its region.
- wetlands important for certain plant and animal species: *e.g.* rare, vulnerable or endangered populations and assemblages; endemic species or communities; quality and peculiarity of their species in maintaining genetic and ecological diversity; and as habitat for species at critical stages in their biological cycle.
- Wetlands important for waterfowl: regularly supporting 20,000 waterfowl or 1% of the population of a species or subspecies; or regularly supporting important populations of waterfowl indicative of wetland values, productivity or diversity.

In practice the numerical criteria (*e.g.* the 1% population criterion) for site selection for migratory waterfowl populations have proved so far the most widely and readily applicable. By December 1995, there were 771 Ramsar sites in 91 countries worldwide, of which over half (408) were in Western Europe (Frazier 1996). By July 2001 there were 124 contracting parties with 1073 wetlands of inter-


WWT

national importance designated, covering 81,766,195 hectares (information from Ramsar Convention Bureau). There are 118 Ramsar sites covering 487,658 ha in the UK.

Both 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, for example, the 1992 Odessa Protocol on International Co-operation on Migratory Flyway Research and Conservation (Wader Study Group 1992). It has also been stressed by more recent meetings of the Contracting Parties to the Ramsar Convention (Ramsar Convention Bureau 1990, 1993), and is explicit in the Bonn Convention (see further, section 5.2.1.3).

The Birds Directive governs waterfowl hunting in the European Union (EU). Member States are obliged to maintain populations of naturally occurring bird species at levels corresponding to ecological requirements, to regulate trade in birds, to limit hunting to species able to sustain exploitation and to prohibit certain methods of capture and killing (Temple Lang 1982). Each Member State legislates for hunting and is required to take special measures to conserve the habitat of species listed in Annex I of the Directive and any threatened and regularly migratory species present. Annex II species (Box 5.4) may be hunted under national legislation provided that hunting pressures do not jeopardise conservation efforts in their distribution area. Member states are required to ensure that waterfowl (and other bird) hunting complies with national and international legislation and the principles of 'wise use', ecologically balanced control of the species concerned and is compatible with protection of eggs, nests, habitats and established rules of exploitation (see Madsen *et al.* 1995 for further details).

5.2.1.2 Habitats Directive

A further international measure of major European importance in delivering wetland and waterbird conservation is the development of the 1992 "Habitats Directive" (EC Directive on the Conservation of Natural Habitats and Wild Fauna and Flora - Directive 92/43/EEC).

The implementation of the Habitats Directive has focused attention and activity on the objective of establishing a coherent European ecological network of sites, to be known as "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 desig-

Box 5.4: Huntable waterbirds under the EC "Birds Directive"

mute swan
bean goose
pink-footed goose
white-fronted goose
greylag goose
brent goose
canada goose
wigeon
gadwall
teal
mallard
pintail
garganey
shoveler
red-crested pochard
pochard
tufted duck
scaup
goldeneye
long-tailed duck
velvet scoter
common scoter
eider
goosander
red-breasted merganser
water rail
moorhen
oystercatcher
golden plover
grey plover
lapwing
snipe
jack snipe
knot
ruff
black-tailed godwit
bar-tailed godwit
whimbrel
curlew
spotted redshank
redshank
greenshank

nated 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 require appropriate management measures.

There are a large number of wetland habitat types listed in the Habitats Directive (based on the CORINE classification of biotopes), although there are some gaps such as grazing marshes and other lowland wet grasslands. Those habitats 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. SACs are currently being selected throughout the EC, and in the UK over 200 have been selected for consideration for designation, many being or including wetland habitats.

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. This overlap is likely to be particularly large in habitats used by significant waterbird populations. For example 38,780 ha of saltmarsh, some 87% of the total area of saltmarsh habitat in Britain, is within the present British SPA network (which will eventually cover well over 90% of British saltmarsh). This is because saltmarshes provide important feeding, roosting and nesting habitat for waterbirds. Almost all (99%) of the SACs selected fall within these SPA areas (N.C. Davidson, unpublished).

A particular significance of the Habitats Directive is that it covers habitats in the marine environment as well as those on land and its implementation requires the designation of marine SACs that extend below the low water mark (the lower limit in practice for other, terrestrial designations). SACs will therefore include parts of estuaries and other inshore marine areas important for waterbirds that are not currently covered in the SPA network.

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. Hence the Habitats Directive focuses further attention on the wetland networks of migratory waterfowl.

5.2.1.3 Agreement on the Conservation of African-Eurasian Migratory Waterbirds

The Bonn Convention on the "Conservation of Migratory Species of Wild Animals" 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 species' conservation including habitat conservation. Recently, and of particular importance to the protection of waterbird populations in Africa-Eurasia, is the "Agreement on the Conservation of African-Eurasian Migratory Waterbirds" (AEWA). The lead was taken in 1988 by the Dutch government in drawing up the Agreement and Action Plan, and the consultative meeting of range states in 1994 recommended that the Agreement be concluded. The Agreement was adopted by consensus by all the range states in 1995 and an Interim Secretariat established in 1996. In 1999 the required 14 range states signing up to the Agreement was achieved and it came into effect on 1 November 1999.

This Agreement provides an important new mechanism for co-ordinating and linking conservation action at the flyway scale, and provides a framework for developing consistent site safeguards and co-ordinated species/population conservation strategies. Such 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 individual waterbird species varies considerably between countries, flyways and seasons (*e.g.* see Davidson & Piersma 1992).

The AEWA is to be implemented through a series of Action Plans, whose requirements are wide-ranging, covering species conservation, habitat conservation, human activity management, re-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search and monitoring, education and information, and implementation. These are to be undertaken in a manner consistent with the general conservation measures required by the agreement, summarised in Box 5.5. The first Action Plan implementing these general principles covers swans, geese and ducks (Anatidae), storks (Ciconiidae), and spoonbills (Threskiornithidae). It contains several actions relating specifically to the effects and management of human activities such as recreation, and specifically hunting.

The Action Plan identifies that hunting may continue on a sustainable use basis where hunting of such populations is a long-established cultural practice, but that this sustainable use shall be

Box 5.5: General conservation measures required of Parties to the Agreement on the Conservation of African-Eurasian Migratory Waterbirds

- accord strict protection for endangered migratory waterbird species.
- ensure migratory waterbird use is: (i) based on assessment of best available knowledge of their ecology; and (ii) is sustainable for the species as well as their supporting ecological systems.
- identify sites and habitats for migratory waterbirds and encourage their protection, management, rehabilitation and restoration.
- co-ordinate efforts to ensure that a network of suitable habitats is maintained or rehabilitated throughout the entire range of each migratory waterbird species.
- investigate problems posed (or likely to be posed) by human activities, and endeavour to implement remedial measures.
- co-operate in emergency situations requiring international action and in identifying the most vulnerable species of migratory waterbirds to these situations.
- prohibit deliberate introduction of non-native waterbirds, and take all appropriate measures to prevent unintentional release, and where release has already occurred seek to prevent these species becoming a threat to indigenous species.
- initiate or support research into the biology and ecology of migratory waterbirds, including harmonisation of research and monitoring methods, and establishing joint programmes.
- analyse training requirements, including for waterbird surveys, monitoring, ringing and wetland management.
- develop and maintain programmes to raise awareness and understanding of migratory waterbird populations.
- exchange research, monitoring, conservation and education information and research results.
- co-operate so as to assist each other in implementing the Agreement, particularly in research and monitoring.

conducted within the framework of the special provisions described in an international species action plan. Importantly, Parties are required to co-operate to ensure that their hunting legislation implements the principles of sustainable use, taking into account the geographical range of the relevant species and their life history characteristics. More specifically it requires co-operation to:

- develop harmonised recording of hunting harvests, and to provide estimates for annual take of each population
- endeavour to phase out lead shot in wetlands by the year 2000
- reduce and eliminate poisoned baits
- reduce or eliminate illegal taking
- encourage hunters to group together to co-ordinate activities and help ensure sustainability
- promote a proficiency test for hunters, including bird identification.

More generally on human activities, there is a requirement to assess and publicise the impact of proposed projects that may cause conflict with waterbird populations, and to promote high environmental standards for the planning and construction of structures so as to minimise their impact on waterbird populations. Of particular importance in providing a guiding framework for managing recreational use of wetlands is paragraph 5.3.6 of the Action Plan.

One key requirement refers to disturbance-free zones:

"In cases where human disturbance threatens the conservation status of waterbird populations (listed in Table 1), Parties should endeavour to take measures to limit the level of threat. Appropriate measures might include inter alia, *the establishment of disturbance free zones in protected areas where public access is not permitted.*

In addition, the Agreement encourages cross-sector programmes to develop sensitive and appropriate ecotourism at wetlands holding waterbird concentrations, but avoiding core zones of protected areas. Hence the AEWA, as it develops, provides a valuable framework and impetus for countries to operate at both flyway and national levels in implementing sustainable management of waterbirds in relation to the effects of human activities.

5.2.1.4 Action plans

Aside from the AEWA Action Plans described in the previous section, a variety of other "action plans" is increasingly used as an approach in international waterbird conservation. These are variously called "action", "recovery", "conservation" or "management" plans, but fall into two broad types.

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

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 *e.g.* Stroud (1992b) for Greenland white-fronted goose and Black (1998) for barnacle goose. Examples include the North American Waterfowl Plan.

Single-species action plans have focused on globally threatened species. Under the Berne Convention, these have now been developed for 23 European globally threatened (or near-threatened) birds, including nine waterbirds (Heredia *et al.* 1996). Of these only the aquatic warbler occurs regularly in Britain but for another, the white-headed duck, actions are identified in Britain for the introduced North American ruddy duck. Broader global action plans for taxa are also being prepared through IUCN's Species Survival Commission. These review the conservation status of all species and populations, and then focus on actions for globally threatened (or near-threatened) species and populations. Under this initiative an Anseriformes Action Plan is in preparation (Callaghan 1996) and a Shorebird Action Plan is proposed (Stroud 1997).

The AEWA Action Plan requires the development and implementation of both international (flyway-level) and national species action plans. For waterbirds this links closely with the preparation of national Biodiversity Action Plans (BAPs) for both habitats and species as part of national governments' implementation of the Rio Biodiversity Convention (Box 1.5). In Britain, BAPs have now been prepared for all priority species and habitats, with directional statements for additional plans covering broad habitat types and plans for work on further species and habitats. These BAPs review factors affecting the species or habitat, set targets and identify conservation measures. Many concern wetland habitats and their species (HMSO 1994a; UK Biodiversity Group 2001).

5.2.2 Integrated planning and management

Given the often diverse politics, policies and interested groups surrounding recreation and waterbird conservation, effective and equitable planning and management will usually be dependent on the careful integration of these factors. In particular, integration must seek to fully involve all key stakeholders in planning and management issues and ensure all associated policies and politics are harmonised to the extent possible.

Probably the most popular integrated planning and management process relevant to recreation and waterbirds is "Coastal Zone Management" (CZM). The goal of CZM is to use an integrated approach to achieve sustainable use of natural, physical and biological resources of the coastal zone. Approaches differ between and within countries, and have complex overlaps in some places and patchy coverage in others (see Box 5.6 and 5.7). Huggett (1995) has provided a detailed review of CZM in the UK.

The Environment Agency has developed Local Environment Action Plans (LEAPs), which provide management planning for whole river systems. These plans could be extremely important in promoting biodiversity in wetland habitats, especially those associated with rivers. However, although LEAPs could in theory make a significant contribution, an RSPB report found that they were deficient in many areas in not setting targets for the achievement of biodiversity enhancement. The report recommended that there should be such targets set in each LEAP, and that these should be linked to UK Biodiversity Action Plan targets (Wood & Oates 1999).

Further ahead, the EU Water Framework Directive (2000/60/EC), which was agreed in the year 2000, could provide a major step towards the achievement of real integrated planning and management within the context of new river catchment plans. The Directive has the following key aims:

- expanding the scope of water protection to all waters, surface waters and ground water
- achieving 'good status' for all waters by a set deadline setting an ecological basis for the definition of 'good status'
- water management based on river basins
- 'combined approach' of emission limit values and quality standards
- getting the prices right
- getting the citizen involved more closely
- streamlining legislation

Although not to be fully implemented in all its aspects until 2015, the Water Framework Directive nevertheless requires member states to introduce national regulations on most aspects well before then. Crucially, it will require the completion of much of the planning, analysis and assessment stages for integrated river basin management in the immediate future.

In relation to the conservation of wetlands and waterbirds and their relationship to recreation, the Directive offers a number of distinct advantages over the current piecemeal approach to catchment planning. Amongst these are the identification of a single lead body (the 'competent authority') to be responsible for the delivery and implementation of river basin management plans. This will be the Environment Agency in England and Wales and is the Scottish Environment Protection Agency in Scotland. The Directive works towards achieving favourable status for waterbirds, and whilst there is still discussion on the treatment of heavily modified waterbodies, and what exactly constitutes a waterbody or wetland, their status will be assessed on ecological grounds as well as on chemical and quality parameters. Ground waters and surface waters will both be included, and alongside economic analysis of costs and benefits, there must also be an analysis of the impact of human activities on the ecological status of all such waters. Finally, there is a requirement for public consultation and stakeholder dialogue at all stages.

Participatory management has been advanced in recent years as a means of securing co-operation and understanding between diverse stakeholders, and has proven to be a useful tool in natural resource management (see Reitergen-McCracken 1998 for pointers on principles and practice). At Rutland Water (England), this approach has been particularly effective (Box 5.8). Integrated plan-

Box 5.6: Coastal Zone Management (CZM) in the UK (after Barne *et al.* 1995, 1996, 1997)

International measures; the European Commission (EC) prepared a Communication on integrated management of coastal zones in 1995, based on the principles of sustainability and sound ecological and environmental practice. It was implemented through a demonstration programme during 1996-1998, which consisted of two main phases:

Phase 1 - a series of separate projects throughout Europe in which CZM good practice and experience was demonstrated. Projects were funded through several EC funding instruments, notably LIFE (environmental management), TERRA (spatial planning) and INTERREG (trans-national spatial planning). Demonstration projects in the UK included the Forth Estuary, and the coasts of Dorset, Northern Ireland, and the Isle of Wight.

Phase 2 – synthesis of best practice experience in common themes through thematic analyses of legislation, information, participation, planning and management processes, and policies of the European Union, supported by scientific contributions. This is designed to then permit the Commission to prepare proposals for a coherent programme of actions and measures forming a European strategy in respect of integrated management of the coastal zones.

National measures; within the UK, the government has encouraged an integrated approach to coastal management through a number of guidance documents and through establishing three Coastal Forums (for England, Scotland and Wales). These lead on from a 1992 House of Commons Environment Committee report on coastal zone protection and planning. Guidance documents include:

- *planning policy guidance 20: coastal planning* (1992). Reissued as PPG 25 in July 2001.
- *development below the low water mark: a review of regulation in England and Wales* (1993).
- *managing the coast: a review of coastal management plans in England and Wales and the powers supporting them* (1993).
- *policy guidelines for the coast* (1995).
- *best practice guide to coastal management* (1996).
- *launch of a Coastal Habitat Management Plan initiative, with 7 pilot plans due for completion in September 2002. The intention is to identify coastal defence and flood works needed to safeguard Natura 2000 sites.*

In addition, an important policy statement, "Strategy for flood and coastal defence in England and Wales" (1993) was produced by MAFF and the Welsh Office. This recognised the need to reduce risks from flooding and coastal erosion to people and the developed and natural environment by encouraging environmentally sustainable defence measures. Finally, a "Review of bylaw-making powers for the coast" is currently assessing whether byelaw powers available to regulatory bodies on the coast meet modern needs.

Integrated management plans; much of the emphasis of CZM has been in the development and implementation of a variety of integrated management plans. Three main categories of plans are in place:

Shoreline Management Plans (SMPs); these set out a strategy for coastal defence for a particular length of coast, taking into account natural processes and human and other environmental influences and needs. They are based on coastal sediment sub-cells and compiled in line with guidelines from DEFRA on assessing the environmental impacts of proposals, including soft defence and 'do nothing' options. Each is managed by a Shoreline Management Group formed by a lead local authority, other local authority partners, statutory agencies and other important maritime local organisations.

Local Environment Action Plans (LEAPs); these are built on the success of the Catchment Management Plans (CMPs), which sought to reconcile the many conflicting demands on riverine resources. They cover a wide range of environmental issues, environmental protection and the enhancement of water, land and air quality. A plan is prepared for each river catchment or group of catchments. They are developed through a consultation draft procedure and provide an agreed strategy aiming to realise the environmental potential of the catchment within current political and economic constraints.

Estuary Management Plans (EMPs); a wide variety of estuaries-based initiatives are underway in the UK, and many initially sought to produce management plans for particular estuaries. Such cross-sector EMPs continue to be developed, although the approach differs according to local circumstances. Increasingly there is less emphasis on prescriptive and agreed plans (not least because it has proved difficult and complicated to achieve full consensus across all interest groups) and more on networks aiming to bring groups of interests together. Recreational uses and pressures generally feature strongly amongst the issues covered by estuaries initiatives.

Box 5.7: Coastal Zone Management (CZM) – the Berwickshire and North Northumberland Coast (Northumbrian County Council 1999)

Goal

The mail goal of the project was to develop a scheme of management for the Berwickshire and North Northumberland Coast Special Area of Conservation, which was designated in 1996 as one of 39 marine SACs throughout the UK. The project involved consultation with all stakeholders so that all aspects of the use of the site as well as its conservation and management could be incorporated.

Considerations

The SAC has four main features of conservation interest:

Intertidal and subtidal reefs occur throughout the area; these are some of the most diverse known in the north east of the UK and contain many species characteristic of cold water as well as warmer water species. Sea caves are also found throughout the site, varying in size from a few metres to extensive systems which may extend hundreds of metres into the rock. They typically are colonized by encrusting animal species but can also support shade tolerant algae. Intertidal sand flats and mudflats are extensive, especially in the area around Holy Island and Budle Bay. These support the most extensive *Zostera angustifolia* and *Z. noltii* beds on the UK east coast. These areas support communities of small crustaceans and marine worms and there are large mussel *Mytilus edulis* beds. The intertidal areas support internationally important concentrations of wintering wildfowl and waders. Grey seals *Halichoerus grypus*, of which the UK holds 50-74% of the world population and 95% of the European Union population, are abundant in the area. The colony on the Farne Islands is the largest in England, with 4,000 individuals and represents one of the most southerly breeding sites in the UK east coast. The undisturbed nature of the islands is thought to be critical to the success of breeding seals.

A wide variety of human activities take place in the area, some of the most important of which are:

Bait digging has been a traditional activity on intertidal areas but has been prohibited over most of the areas around Lindisfarne because of the disturbance it caused to habitats and wintering birds. Pleasure boating – the wildlife of the area is a significant tourist resource and sightseeing trips are made from several locations. The vessels are regulated and the landings on the Farne Islands (National Trust owned) are restricted. Diving is a popular activity over parts of the site. It is not regulated but a voluntary code of conduct operates and the size and number of shellfish landed by divers are monitored. Net fisheries include a drift net fishery for salmon south of Lindisfarne which is regulated and monitored by the Environment Agency. There are also fixed nets for salmon in Northumberland and Berwickshire which are privately owned but subject to management by the River Tweed Commissioners and the Crown Estate Commissioners. Land-based recreation is an important activity in the area, concentrated around hot-spots such as Lindisfarne and St Abbs Head. Water-based recreation is also important and includes sailing, surfing, water skiing, canoeing and windsurfing as well as motorized personal craft. The activity in Budle Bay is regulated by National Nature Reserve byelaws. Wildfowling is a popular winter activity especially at Lindisfarne, though the number of participants is declining. English Nature, in cooperation with the British Association for Shooting and Conservation, operate and police a permit system at Lindisfarne.

Management Framework

Following consultations between all stakeholders, an Action Plan has been developed which lists the management actions required, the lead agency responsible and those agencies in a supporting role. The plan includes action on all the areas of human activity likely to have an impact on the site and sets out a timescale over which each action is to be achieved.

Implementation

The project and Action Plan is overseen by a Management Group consisting of representatives from authorities in the area with powers over land and water management. It meets annually to review progress on the management scheme and produces an Annual Report, which is circulated among consultees and an Advisory Committee.

ning has also been applied to larger areas such as the Norfolk Broads (Broads Authority in draft) – see Box 5.9.

Geographic Information Systems (GIS) can be a powerful tool for integrating planning and management, in particular because they allow any amount of layers of information to be mapped on top of each other using real world coordinates. However, they can be expensive to purchase and manpower skills need to be developed and maintained in order to make full use of them.

5.2.3 Environmental Impact Assessment and cost-benefit analysis

The continued growth of recreation needs to be managed carefully so that effects and impacts on

Box 5.8: Zonation and integrated planning and management at Rutland Water (from Appleton 1993, 1996)

Description

Rutland Water is one of the largest reservoirs in the UK (1260ha) and is an internationally important site for wintering and passage waterbirds. In 20 years it developed from green fields to become a designated RAMSAR/SPA site. Rutland is the main site in the UK for autumn gadwall and supports internationally important numbers of wintering shoveler. Nationally important numbers of wintering mute swan, goldeneye, goosander, coot, great crested grebe, wigeon, teal and tufted duck also occur.

Zonation

Rutland Water also supports very large numbers of visitors who have controlled access to walk, cycle, sail, sailboard and fish for stocked brown and rainbow trout both from the bank and boats. The zoning of these activities both in time and space allows this water to be efficiently managed for both conservation and recreation. Disturbance to waterbirds and other wildlife is zoned to varying degrees, with nine miles of the western shoreline set aside as a relatively quiet nature reserve that incorporates constructed lagoons that act as year-round undisturbed refuges. The lagoons have good marginal vegetation including large areas of willow coppice, many peninsulas and islands and their water level can be varied so as to expose wet mud to wading birds on passage.

Participatory planning

A major aspect of the success of this site was the early establishment of a consultative panel, meeting twice per year and comprised of all the key recreational and conservation interest groups so that agreed zoning plans could be established in advance of the potential facilities becoming available. The panel vets all potential new users of the reservoir. This is a very unusual situation in the UK as most large recreational wetlands were constructed some time ago leading to an *ad-hoc* development of recreational facilities and an extreme reluctance for recreational users to relinquish areas which are thought to be important potential conservation refuges and *vice versa*. At Rutland, prior agreement avoided such conflicts, leading to a successful and diverse recreational facility and substantial nature reserve.

A map of Rutland Water showing the reserve and recreation areas.

waterbirds and their habitat are minimised. Environmental Impact Assessment (EIA) is used to determine the optimum solution for a proposed activity that may affect the environment. In its simplest form, it is a planning tool that is now regarded as an integral component of sound decision-making. As a planning tool it has both an information gathering and a decision making component which provides the decision maker with an objective basis for granting, modifying or denying a proposed development (see Gilpin 1995). Hence, all major new recreational activities on or around a wetland, or significant expansion of existing activities already established, should be subject to an EIA. Box 5.10 provides an outline of contents that should be included in such an assessment. Information on EIAs can be obtained from the websites of a number of organizations, including the Institute of Ecology and Environmental Management, The Institute for Environmental Assessment and the Department for Environment, Food and Rural Affairs.

Cost-benefit analysis (CBA) is another tool that may be used to evaluate the pros and cons of a proposed activity, and economic CBAs are increasingly being used in environmental projects. The goal is to categorise and value the current and future costs and benefits of a proposed activity. The financial benefits and costs are discounted and compared, and those projects where the net value is positive can be taken forward for further analysis. Many social and environmental values are difficult and imprecise to estimate. Even so, techniques used to value ecological non-market goods (*e.g.* clean water) are becoming more sophisticated and it is probable that these goods will increasingly be valued by society (see *e.g.* Per-Olov 1993).

5.3 Management techniques

The variety of problems associated with recreation and waterbirds can be tackled by a diversity of management techniques. These can be based on the management of sites and their species or the management of recreational participants and their equipment (Box 5.11 and Box 5.12). In this section, we discuss each of the techniques highlighted in Box 5.11 separately and provide case studies of their implementation. Together, these techniques provide a synthesis of methods that are currently being used to manage recreation on and around wetlands in a more ecologically sustainable manner.

5.3.1 Sites and species management

5.3.1.1 Habitat management

Both angling and shooting activities commonly involve the management of habitat in an attempt to improve sporting conditions. Indeed, the value-added incentive placed upon wetlands via these two activities has resulted in large areas of habitat being created or restored which, with good management, can offer substantial benefits to waterbird populations (see *e.g.* Box 5.13).

In the UK and elsewhere, angling interests have been key players in stream restoration projects. A common goal has been to recreate pool-and-riffle sequences, and promote the growth of emergent and submergent vegetation, providing important habitat for a variety of wildlife. The experimental restoration of Dorset chalk streams, involving livestock fencing and building in-stream structures that scour pools and deposit riffles, has resulted in substantial increases in wild brown trout, salmon, native crayfish, water crowfoot beds and varied new habitats for a wide variety of other wetland species (Giles & Summers 1996). Coarse fish river habitat restoration also has great potential to produce similar benefits and current research on lowland rivers is assessing the potential of methods such as corner pool excavation;

Box 5.9: Strategic Management planning on the Norfolk Broads. **Information made available by the Broads Authority from the Broads Plan 2004 (in draft).**

The Broads Authority, which is charged with the strategic management of this area, which is important for wildlife and also a honey-pot for recreational users, revises a strategic plan every few years and the following account is the 2004 version. The Plan sets out four closely related objectives:

- social progress that recognises the needs of everyone
- effective protection of the environment
- wise use of natural and cultural resources
- maintenance of economically and socially thriving communities.

Guiding principles

The following guiding principles are set out in the plan; those that are relevant to recreation and waterbird conservation are repeated here.

- the Broads will be protected as a national park, accessible to people of all abilities and social backgrounds to enjoy in quiet and sustainable ways that are in keeping with its distinctive natural and cultural beauty and that are appropriate to a nationally and internationally protected area.
- the tranquillity and wilderness of the Broads will be protected and enhanced for people to enjoy
- information about the Broads and its special features will be readily accessible to all those who need it.
- tourism will be of high quality, based on the special features of the Broads, and will contribute significantly to sustaining thriving local communities.
- water resources within the catchment will be managed sustainably to ensure the proper functioning of the Broads as a wetland system. Habitats, with their associated plants and animals, will be maintained and enhanced to protect them from damaging development, and degraded habitats will be restored to good ecological status. Opportunities will be sought to create new habitats to counter historic trends in fragmentation and degradation of habitats, and to increase the capacity of the floodplain to function more naturally.
- the Broads landscape is unique and reflects the interaction of people with nature over time. Its physical, natural and cultural distinctiveness will be restored, maintained and protected from intensive or inappropriate development, while allowing its continued evolution within levels that can be sustained by the environment.
- the waterways will be maintained and enhanced for purposes of navigation and their enjoyment and understanding by the public.
- access will be protected and enhanced, and new rights of way will be provided to maximise the benefits of nature to people, whilst ensuring that the resource itself is not degraded
- Where there are threats of serious or irreversible damage to the environment, lack of full scientific certainty will not be used to delay cost-effective measures to prevent environmental degradation (the *precautionary principle*).
- the floodplain will be managed sustainably to alleviate flooding in the Broads, taking into account the impacts of climate change and rising sea level. Cost-effective benefits to enhance the landscape, biodiversity, recreation and navigation will be sought in conjunction with flood alleviation works.

This plan provides a good model for strategic planning to maintain and enhance conservation and environmental protection, at the same time as increasing the opportunities for access and recreation.

Box 5.10: Contents of an impact assessment of recreation on or around wetlands, with special reference to waterbirds

- description of the proposed recreational activity (plus an analysis of need).
- analysis of site selection procedure and alternative sites.
- description of baseline conditions, including:
  - site ownership, leases, agreements, boundaries and designations (SSSI, NNR, SAC, *etc.*).
  - an accurate site map and inventory showing the prevalent wind directions, water areas and depth profiles, bank characteristics and landforms, types of terrestrial and aquatic vegetation.
  - the context of the site within the landscape, including surrounding areas of habitat which may act as alternative feeding or refuge sites.
  - waterbird use, including key breeding, roosting, feeding, and moulting areas. Data from waterbird counts, Common Bird Census data and Wildlife Trust records may be useful.
  - comprehensive species inventory, highlighting those of particular conservation importance.
  - description of recreational activities already taking place, including an assessment of their impact.
- description of the exact nature, siting, timing, duration and intensity of the proposed activity, including associated aspects such as car park siting and access routes.
- description of potential positive and negative impacts (environmental, social, economic and cultural), including cumulative, regional, temporal and spatial considerations.
- analysis of significance of impacts under the proposed activity. Use data from other studies conservatively and with caution. A good starting point for analysis is by mapping spatial and temporal overlaps in key areas of habitat usage. Time budgets of waterbirds will identify key activities and reference to the scientific literature will help to establish likely conflict points.
- mitigation plans, including predictive modelling of their effectiveness if possible.
- identification of issues related to human health.
- consideration of alternatives, including not proceeding.
- monitoring plans (impacts and mitigation measures). Parallel monitoring of one or more control sites (*i.e.* otherwise similar areas unaffected by the factor in question) will help considerably. Experimental studies designed to test specific hypotheses will further refine your ability to establish and quantify any effects.
- contingency plans for unpredicted impacts.
- public consultation programme.
- terms of reference.
- any other information deemed necessary.

riffle-and-pool reinstatement and increased cover provision (Swales & O'Hara 1983; Pearce & O'Hara 1984; Cowx & Welcomme 1998). Interested readers should also consult the 'Manual of River Restoration Techniques', documenting comprehensive restoration projects on two English rivers, the Cole and Skerne (RRC 1999).

Other habitat management for angling commonly includes the following measures (from Giles 1992; NRA 1994b):

- **control of bank-side and submergent vegetation** by cutting/dredging and herbicide application to open up fishing areas (or "swims").
- **addition of fertiliser** (usually manure) to increase productivity.
- **addition of lime** to increase water pH.
- **addition of barley straw** to reduce algal growth.

The effects of vegetation control (practised to clear banksides and to prevent snagging of anglers' lines) will depend on the nature of the site and the intensity and timing of the operation; it is more likely to result in adverse effects on waterbirds and other wildlife at sensitive sites or within areas of high angler density. Cutting and clearance of vegetation should be avoided during spring and early summer, when disruption to breeding species, particularly waterbirds, is likely. Ideally, cutting should be carried out in late summer or autumn and the vegetation removed; the clearance of bankside trees, tree roots and dead wood should be avoided (NRA 1994b). Herbicides should also be avoided and only used when physical control is ineffective. Consent from the Environment Agency is needed and only DEFRA approved pesticides should be used near water, and application of these chemicals should be limited to early spring, when plant biomass is low and hence deoxygenation resulting from the breakdown of dead vegetation is least likely to be a problem (NRA 1994b).

Regarding fertiliser and lime application, these can be particularly damaging to wetlands, especially those of naturally low pH. The only way to avoid the potential negative effects is to avoid application altogether. It should be noted that the

Box 5.11: Principal areas of conflict between recreation and waterbird conservation and possible management techniques (see Box 5.12 for description of techniques)

Management techniques (■ primary; • secondary)

Areas of conflict	Sites & species						Participants & equipment					
	Habitat management	Landscape design	Species management	Monitoring & research	Spatial zonation	Temporal zonation	Codes of conduct	Compensation	Education & interpretation	Participant limitation	Patrolling	Restriction/modification of equipment
Angling												
Bait digging				■	■	■	■	■	■	■	■	■
Bank-side trampling/erosion		■		■	■	•	■	■	■	■	■	
Control of vegetation	■			■	■	•	■	■	■	•	■	
Disturbance		■		■	■	■	■	■	■	■	■	
Fertiliser & lime application	■			■	■	•	■	■	■	•	■	
Ground baiting				■	■	•	■	■	■	■	■	
Introduction of exotic fish			■	■			■	■	■		■	
Lead poisoning				■	■		■	■	■	•	■	■
Litter				■	■	•	■	■	■	•	■	
Management of predators			■	■			■	■	■		■	
Over-fishing				■	■	■	■	■	■	■	■	■
Stocking of native fish			■	■			■	■	■		■	
Shooting												
Disturbance		■		■	■	■	■	■	■	■	■	
Control of fish	■	■		■			■	■	■		■	
Control of vegetation	■			■	■	•	■	■	■		■	
Fertiliser & lime application	■			■	■	•	■	■	■	•	■	
Introduction of exotic birds			■	■			■	■	■		■	
Lead poisoning				■	•		■	■	■	•	■	■
Litter		•		■	■	•	■	■	■	•	■	
Management of predators			■	■			■	■	■		■	
Over-hunting				■	■	■	■	■	■	■	■	■
Stocking of native species			■	■			■	■	■		■	
Shooting of protected species				■			■	■	■		■	
Water level manipulation	■	■		■			■	■	■		■	
Water sports												
Bank-side trampling/erosion		■		■	■	•	■	■	■	■	■	■
Damage to submerged plants				■	■	•	■	■	■	■	■	■
Disturbance		■		■	■	■	■	■	■	■	■	■
Increased water turbidity				■	■	•	■	■	■	■	■	■
Litter		•		■	■	•	■	■	■	•	■	
Pollution from engines/sewage				■	■	•	■	■	■	■	■	■
Informal recreation												
Bank-side trampling/erosion		■		■	■	•	■	■	■	•	■	
Disturbance		■		■	■	■	■	■	■	•	■	
Litter		•		■	■	•	■	■	■	•	■	
Waterbirds												
Predation & injury of fish			■	■				■				
Restriction of recreation	•	■	■	■	■	■			■			

Box 5.12: Possible management techniques for integrating recreation and waterbird conservation

Technique	Description
Sites & species	
Habitat management	Manipulation of physical and/or biological parameters that govern habitat types and structure.
Landscape design	Design and construction of landforms and visitor facilities.
Species management	Targeted management of single species, for example through the stocking or introduction of individuals, or through the manipulation of parameters that govern a species' abundance.
Monitoring & research	Careful study and investigation of, for example, the effects of recreation on waterbirds or the success of management techniques.
Spatial zonation	Restrictions on the areas within a site where activities can be pursued.
Temporal zonation	Restrictions on the times during which activities can be pursued.
Participants & equipment	
Codes of conduct	A set of laws or rules that govern the behaviour of people.
Compensation	A suitable payment in return for the loss or damage of wetland habitat or their component species.
Education & interpretation	Dissemination of knowledge and understanding to alter the behaviour of people.
Lease terms	Managers can incorporate elements in terms of leases. Ultimately, continued breach of terms (*e.g.* littering) could lead to loss of site to the club concerned
Participant limitation	Placement of limitations on the number of people that can engage in an activity or the duration which they can participate.
Patrolling	To walk or travel regularly through an area to ensure people are behaving within the regulations governing their activity.
Restriction/modification of equipment	Limitation or modification of the use and type of equipment that can be used in an activity.

application of fertiliser is likely to result in greater growth of aquatic plants (if a switch to an algae-dominated system is avoided), which may require further management to open suitable fishing areas (NRA 1994b).

A measure of control over excessive algal growth can be gained through the careful addition of barley straw to a wetland. The straw is enclosed within wire mesh and positioned within water inflows. It releases otherwise harmless chemicals that inhibit algal growth (Giles 1992). This is an inexpensive management tool that can have a positive environmental impact with careful application (contact the Centre for Aquatic Plant Management for further details; Appendix II). However, over-abundance of algae in wetlands is sometimes due to over-stocking of fish, and hence fish stocks should be managed in a more ecologically sustainable manner wherever possible (see section 5.3.1.3).

Habitat management for shooting usually focuses on creating conditions optimal for a few target species, usually dabbling ducks. Such management in particular focuses on providing an abundance of appropriate food, open water for resting and suitable nesting cover. At some sites this is practiced intensively, where common practices involve (after Callaghan *et al.* 1995, 1997):

- **water level manipulation** (often draining most of the wetland for the summer period every 1-5 years).
- **reduction of beds of emergent plants** (through burning, herbicides, grazing or cutting).

Box 5.13: Habitat creation for angling incorporating conservation objectives: Morgan's and Woodstock Pools (from Bell *et al.* 1984)

The Newport Angling Association, South Wales, created Morgan's and Woodstock Pools from low-grade pastureland. Conservation objectives were incorporated in the construction process, for example an undisturbed island was constructed on Woodstock Pool specifically for nesting and feeding birds.

So far, bird surveys have recorded 98 species at the site, of which 27 (83 pairs) have held breeding territories. Breeding species include mute swan, mallard, moorhen, lapwing and grey wagtail, while wintering waterbirds include water rail, shoveler, goldeneye, teal, heron, kingfisher, lapwing and common gull.

The site, developed primarily for coarse fishing, has certainly increased the diversity of bird habitats available in the area from the original low-grade pastureland. It is planned that management will include willow and alder coppicing to promote habitat heterogeneity, the avoidance of damaging pesticide use, and low-intensity grazing for rough grassland and scrub habitat maintenance.

- **reduction of fish stocks** (through poisoning or trapping).
- **application of lime** to increase water pH.

These management measures often result in an increase in target waterbird numbers, thus improving shooting success. But it can often be accompanied by a decline in the diversity of waterbirds and other wetland wildlife, since habitat diversity at a site and over a landscape can be reduced significantly. This is a particular problem in North America (Callaghan *et al.* 1995, 1997).

Buffer zones or refuges have become popular elements of habitat management for shooting in recent years. At wetland sites, they are usually strips of natural vegetation allowed to develop along the wetland edge. With regard to recreation, they can be used to reduce access to sensitive areas of the waterside, and in so doing alleviate associated disturbance and bank-side erosion. Also, the tall vegetation that usually develops can act as a visual screen and hence further reduce disturbance. Aside from reducing recreational impact, buffer zones can offer a variety of other benefits to waterbirds and other wildlife:

- creation of habitat corridors for wildlife.
- improvement of habitat for wildlife (*e.g.* nesting areas for waterbirds and bank-side cover for fish).
- stabilisation of banks through rooted vegetation (especially fringing rank grasses).
- reduction of pollution from adjacent farmland by providing zones free from spraying and muck-spreading.
- reduction of pollution from adjacent land by biological breakdown of pollutants by soil micro-fauna (nitrogen and phosphorus removal can be nearly 100%).
- reduction of silt inputs from adjacent land (*e.g.* autumn-ploughed fields).

Buffer zones should be at least 5m wide, with a gentle slope to the water edge. Sub-soil field drains need to be diverted across buffer strips to facilitate their benefits. Some form of vegetation management may be needed, such as low-density grazing or harvesting, which can be a source of revenue (*e.g.* through the sale of harvested willow, reed or hay). For further advice on the benefits and creation of buffer zones in the UK contact DEFRA, EN, or EA (see Appendix II for contact details).

A common problem with powered water sports is bank-side erosion from wave-wash. This is managed commonly by positioning wood or metal panels along the shoreline and back filling with debris (known as "bank-revetment"). This effectively removes the littoral fringe, which forms important habitat not only for waterbirds, but many other wildlife species. Where reductions in wave-wash are not possible (e.g. through zoning or speed limits), consideration should be given to planting species tolerant of wave-wash before bank-revetment. Haslam (1978) provides useful practical guidance on the relative sensitivity of different vegetation to wave-wash.

In summary, the manipulation of habitats to suit the needs of a few target species should be avoided, and habitat management should aim to produce a diversity of habitats typical of a particular region (see e.g. Box 5.14). This provides greater benefits to biodiversity and helps to ensure a diverse and healthy assemblage of wetland species, which incidentally helps meet future recreational needs (especially for shooting and angling). Potential negative effects should be identified before management commences and these should be balanced against the need for management. Consideration should be given to alternative management approaches wherever negative consequences are likely. With careful planning, the integration of habitat needs for recreation and conservation should be possible without too many compromises on either side (see e.g. Box 5.14 and 5.15). A wide diversity of techniques are available, many of which are described in detail in the habitat management handbooks highlighted in Box 5.1.

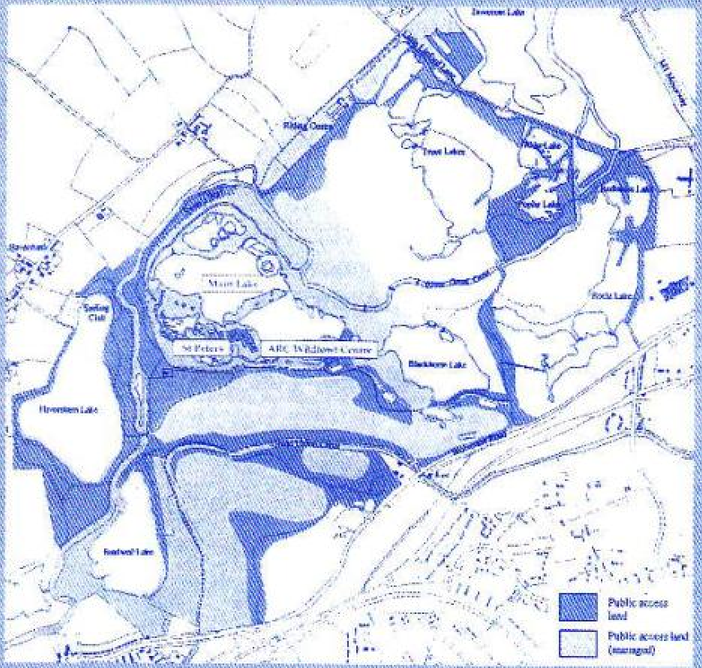
5.3.1.2 Landscape design

With careful screening, the continuance and even increase of recreational activities can be accommodated with negligible disturbance (see *e.g.* Box 5.16).

Many of the problems associated with recreation and waterbirds can be avoided or limited through careful landscape design, which is especially relevant to sites that are being created or restored. Former industrial sites, especially mineral workings, offer fertile ground for wetland creation and much attention has been given to this area recently (see *e.g.* Gawn 1983; Bickmore & Larard 1989; Andrews & Kinsman 1990; Giles 1992; James 1992; Merritt 1994; Box 5.14). The landscape design process should include:

- accurate identification of the site boundaries.
- investigation of site hydrology.
- survey of existing ecology, including surrounding areas which may act as sources for colonisation of new habitat.
- definition of legal and management requirements.
- definition of wildlife and recreation objectives.
- description of the requirements, characteristics and potential interactions of wildlife and recreation.
- detailed design of the required landscape, including biological features, physical features and land- and water-use activities.
- careful definition of the 'full visual envelope' from key receptor points.

Box 5.14: Landscape design and habitat management at Great Linford Gravel Pits, England. (from Giles 1992)



At the ARC Limited, Great Linford gravel working site, Buckinghamshire, the main restoration emphasis since flooding took place has been on the creation of habitats for waterbirds. The reserve is situated on the outskirts of the new city of Milton Keynes and is, therefore, subject to considerable disturbance. The choice of the waterbird breeding refuge (St Peters Lake complex) was made on the basis of the existing topography of a series of shallow lagoons interspersed with spits and peninsulas left over from the bulldozer excavation of shallow gravel seams. This easily allowed the creation of a convoluted shoreline with numerous small islands and shallow bays which were planted with a diversity of marginal plants so as to avoid over-dominance of a few highly competitive species (*Typha, Glyceria, etc.*).

Islands were designed so as to provide maximum shelter; good designs include cruciforms, atolls and horseshoes, set well offshore to minimise disturbance. Rough vegetation on the islands was allowed to develop, and goats were left on islands (with a temporary shelter) on a rotation basis so as to clear invading tree saplings. Where unwanted large willows or alders were present, they were felled into the littoral shallows, providing good isolated nesting platforms for species such as great crested grebe. Numerous small islands were considered better than single large ones. Shorelines were landscaped so that they were shallowly sloping into productive bays, providing good cover, shelter, feeding, preening, and moulting sites. Clean spoil was imported, tipped as long spits and then sliced across to form a series of small islands.

The 30ha Main Lake was left deliberately open so as to be attractive to wintering flocks of ducks, geese and swans. The northern boundary is protected from human intrusion by a wide, deep canal. The eastern boundary is the River Great Ouse and fences and hedges excluding unwanted visitors protect the southern and western sides. Wigeon and greylag geese graze a broad sward of grassland along the northern edge of the lake, maintained by low-density sheep grazing which also promotes good tussocky grassland for nesting redshank.

Shingle banks were formed, in particular to provide nesting habitat for ringed and little ringed plovers. These were polythene-lined to suppress plant growth. Meanwhile, a long, low bund across the Main Lake has proved attractive to nesting lapwings, where a water channel at either end has reduced the risk of predation.

A water regime was introduced in 1985 at a 2ha lake (Stanton Low) with the aim of improving the site for feeding waders and teal and also of improving duck breeding success. The water level at this lake is controlled using sluices. Levels can be progressively reduced by a few centimetres at a time. The lake is completely flooded in early spring, surrounding five islands (used by nesting ducks) with water and making them secure against predators and disturbance. The water level is held at the level of the bank top throughout the nesting period, and then a very gradual drawdown is initiated in mid-July. Lapwings, ringed and little ringed plovers, green sandpiper and redshank are quickly attracted to the exposed mud in early autumn.

Birdwatching is accommodated by two hides, which are reached via two short, screened pathways that minimise disturbance. Great Linford Gravel Pits now provide a variety of habitats typical of the region and have attracted a diverse assemblage of native flora and fauna, especially waterbirds.

Habitat corridors can be useful for reducing the effects of recreation on wetland wildlife, since they allow species to move between areas, including habitats outside the site boundaries. Also, islands, channels, earth mounds (bunds), bays, hedges and peninsulas can be very helpful to zone activities and reduce disturbance. Merritt (1994) explains that landforms such as bunds, islands and peninsulas are best for screening disturbing noises, for instance from water-skiing, whilst various types of vegetation are adequate for the screening of visually disturbing stimuli such as access paths to visitor centres or bird-watching hides.

5.3.1.3 Species management

Both fish and waterbirds are often managed intensively for angling and shooting. Ideally, management should be based at the population-level, as this is where impacts can be measured. This is easier where populations are sedentary, small and isolated, but more difficult for migratory species that are spread across a large geographic range.

The current trend in fisheries biology is to try to define distinct populations (or stocks) so as to be able to understand their individual dynamic processes and so manage them effectively. Birds often concentrate along migratory 'flyways' and management of a given population must also incorporate the key geographical aspects of this dimension. Furthermore, it is useful to remember the possible evolutionary migratory strategies of each species. For example, waterbirds whose numbers may be limited by a shortage of breeding areas (*e.g.* eider ducks) will have been selected to maximise use of this habitat. On the other hand, species whose numbers depend on overwinter survival and hence wintering habitats (*e.g.* teal) may be selected for efficient use of these areas. Such ideas provide a useful framework for consideration and potential understanding of potential energetic bottlenecks for survival in a given species (*e.g.* Alerstam 1990). Clearly, any disturbance effects would be critical in the areas which limit survival, whereas in non-limiting areas the effects may be small.

Box 5.15: Management of angling and nature conservation interests at Pevensey Levels, England.

The Pevensey Levels in East Sussex cover an area of around 3500ha with over 150km of the main River Cuckmere and associated drainage channels. The site is an SSSI and is currently lodged to become a Ramsar site. The main land use type is lowland wet grassland (marshes), a habitat type which has declined substantially in recent decades due to land drainage works and intensified agriculture.

The Levels were originally inter-tidal mudflats that were gradually reclaimed from the sea in the Middle Ages. Freshwater draining into the marshes can run out to sea on the ebb tide via a series of gravity-fed and pumped channels. There has been a gradual drying out of the system in recent decades due to increased drainage and water abstraction and the area of wet grassland is threatened by continued conversion to arable cultivation. The Environment Agency and Internal Drainage Boards are responsible for the operational management of water control structures; these are described in the Water Level Management Plan.

The Pevensey marshes support a diverse wetland fauna and flora including nationally important wintering lapwing numbers, large numbers of wintering snipe, breeding mute swan, mallard, lapwing, snipe, redshank, yellow wagtail, reed warbler, sedge warbler and reed bunting. A total of 15 species of dragonfly have been recorded including the nationally scarce hairy dragonfly and variable damselfly, the rare fen raft spider and great silver diving beetle and a wide assemblage of aquatic plants including the rare sharp-leaved pondweed. The wet grasslands also have a very diverse molluscan fauna and are probably the best habitat for its type for these animals in the UK. Clearly, water level management is the key to conserving much of this diverse (man-made) wetland resource.

In addition to being an important bird watching and walking area, the levels are a popular coarse fishery with good populations of roach, bream, tench, carp, pike, perch, gudgeon and eels. Fish surveys have revealed poor recruitment (breeding success) of many fish species coupled with poor adult growth rates. It is thought likely that many juvenile fish are washed out of the bottom-opening sluices during floodwater releases.

The Environment Agency aim to develop better self-sustaining coarse fish stocks in order to improve the value of the site as an angling venue. It recognises that simply stocking the fishery is unlikely to have lasting beneficial effects since habitat quality does not appear to be adequate to support increased fish biomass. Habitat quality in the main channels is thought to be poor with low levels of aquatic invertebrate productivity and more conservation-sensitive dredging and water level management practices are proposed.

Box 5.16: Screening to reduce disturbance at Dungeness Reserve, England. (after Gawn 1983; Scott 1982)

The huge Dungeness shingle spit at the eastern end of the English Channel is a site of both extensive commercial gravel extraction and opportunities for restoration to nature conservation and recreation end-uses. The RSPB reserve enables large numbers of visitors to view breeding and wintering waterbirds from purpose-built hides which are approached and built within a 2m high shingle ridge which shields the reserve area from the visual impact of visiting bird-watchers. Such design considerations must be addressed at the initial stages of gravel working restoration planning so that other physical features are built into the final site plan taking full account of the likely disturbing influences on wildlife conservation interests.

Careful land-forming has produced a mixture of shallow lagoons, deeper pools and islands that have proven to be very attractive to waterbirds. The site is a winter roost for ruff and Bewick's swan that feed on the nearby Romney Marsh, breeding common, sandwich and roseate terns, tufted duck, moorhen and sand martins. Wintering waterbirds include mallard, wigeon, teal, pochard, shoveler, tufted duck, pintail, gadwall, goldeneye and garganey. The screening of the viewing facilities has been of central importance in the successful development of this reserve.

The management of fish and waterbirds for angling and shooting often involves stocking, whereby individuals, usually of captive origin, are released in to the wetland to improve sporting success. Over-stocking could result in habitat degradation that not only results in negative impacts on waterbirds and other wildlife, but also on the fish themselves (Box 5.17). Ways of avoiding this problem are given in Box 5.18.

All too often, however, fish are stocked to such a density that a wetland switches to an algal-dominated system, with frequent algal blooms, turbid water, little aquatic plant growth and reductions in the diversity of both invertebrate and vertebrate species diversity. An effective method of restoring such wetlands has proven to be large-scale fish-removal, particularly of adult bottom feeding species such as bream and carp (*e.g.* through temporary drainage, trapping or electro-fishing). The method is thought to work as follows (after Moss 1983; McQueen 1990):

- when fish are removed, grazing cladocerans (water fleas) can increase in abundance and reduce phytoplankton communities, allowing better light penetration and thus stimulating aquatic plant growth from the existing seed bank.
- the removal of fish means that the lake bed sediments are less disturbed and that inorganic plant nutrient re-cycling is slowed down. The clearer, less eutrophic water conditions then favour submerged aquatic plant growth that in turn will support a more diverse invertebrate community and aquatic avifauna.

Following fish removal and the re-establishment of a healthy aquatic system, a balanced fish population can be re-established, which should be composed of a range of native species. Guidelines for ecologically sustainable fish stock densities are provided in Box 5.18.

Owing to strong angling interests or practical constraints, large-scale fish-removal to restore wetlands from algae-dominated systems may not be possible. In such circumstances, brushwood bundles staked in the lake margins can act as refuges from fish predation for large cladocerans (*e.g. Daphnia* species) which move out into open water at night and crop the planktonic algal populations (Moss 1983). Combined with the careful application of barley straw (see section 5.3.1.1), this may restore water clarity and aquatic plant communities to some extent.

Apart from potential adverse effects on wetland and waterbirds, it is important to acknowledge substantial risks to the fishery itself from an intensive stocking policy. Many of these risks arise from the health status of the stocked fish. In this regard, the Environment Agency has produced a useful leaflet for fishery managers: *Buyer Beware - Your Guide to Stocking Fish: Consents under the Salmon and Freshwater Fisheries Act 1975* (EA 1996). Imported fish are covered by EU legislation under their fish health regime aimed at the prevention, introduction and spread of serious fish diseases. It is all too easy to unwittingly introduce diseases and parasites into previously healthy fish stocks. Diseases such as spring viremia of carp (SVC) can wipe out native stocks if introduced into natural waters. Many other diseases and parasites are liable to be introduced via this route. Although most non-native parasites would be unlikely to complete their life cycles and therefore gain a hold in British waters, some have managed to do so with disastrous results for native fish stocks.

If a final decision to stock a waterbody is made, relevant legal constraints (Box 5.19) and good-practice guidelines (Box 5.18) should be followed. If a site is an SSSI then consultation with the appro-

Box 5.17: Ecological indicators of well-balanced and over-stocked stillwater fisheries in the UK (modified from Giles 1992)

Indicator	Well-balanced	Over-stocked
Water quality	Usually reasonably clear	Often turbid (from algal blooms or suspended sediment)
Aquatic plants	Usually rich communities, including soft-leaved species such as milfoil and fine-leaved pondweeds	If any, usually species-poor and dominated by hard-leaved species such as water lilies and broad-leaved pondweeds
Aquatic invertebrates	Usually diverse and abundant	Usually species-poor and low abundance
Fish	Usually a diversity of species, such as pike, tench, roach, rudd, and perch. Diseases and parasites are infrequent, and individuals show a good size-range, including a few specimen fish.	Often dominated by one or two species, of which individuals are often in poor condition. Disease and parasites are common, and stocked specimen fish often gain weight slowly (if at all).
Amphibians	Presence of frogs, toads and newts in good numbers	Few individuals
Waterbirds	Usually a diversity of species, including breeding pairs	Usually species-poor, with few breeding pairs

Box 5.18: Guidelines to reduce environmental damage from fish stocking (modified from Giles 1992; NRA 1994b)

- an assessment should first be made of what fish species and numbers currently occur in the water body;
- where possible, future stocking should be restricted to species already present;
- no more fish should be introduced than the site can support without adverse effects on flora and fauna;
- bottom feeding fish such as bream and carp should be avoided (or otherwise they should be stocked in low densities especially in soft-bedded lakes);
- where possible, predatory fish should form part of the fish community;
- adult fish should be removed regularly (particularly bottom feeding species);
- stocking that requires additional management, such as fertilizer application, should be avoided;
- total fish biomass should not exceed:
  100 kg/ha (mature acid/neutral upland lake/reservoir)
  150 kg/ha (recently created lake/gravel pit)
  250 kg/ha (mature gravel pit)
  350 kg/ha (mature lowland lake)
  500 kg/ha (rich farm pond)

Introduction of exotic species should be avoided (apart from rainbow trout in some circumstances).

priate country conservation agencies will also be required. Health checks on consignments of fish to be stocked will be required where there is a substantial risk to receiving waters, especially on river systems where diseases and parasites can easily spread.

An alternative approach to fish stocking is the management of habitat to improve the breeding success of fish already present. This potentially carries lower financial as well as environmental costs (NRA 1994b).

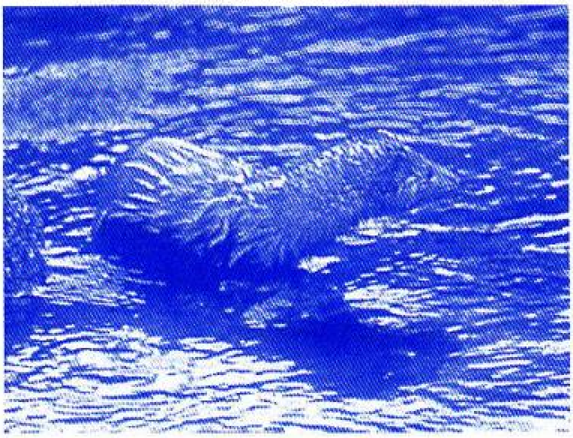
The stocking of waterbirds for shooting is commonly practised in many countries, but it imposes a number of potential risks to conservation interests, including (after Callaghan *et al.* 1995, 1997):

- altering the ecology and genotype of wild stocks.
- promoting and introducing disease amongst wild stocks.
- disrupting energy flow and nutrient dynamics within wetlands, with associated alterations to community structure.

Considering this, waterbird stocking should be discouraged wherever possible, and where it continues it should be practised sensitively and inspection of birds for disease prior to release should be encouraged.

Management for both angling and shooting commonly involves the control of predators. Where these are introduced predators, such as mink in the UK, this has obvious benefits for waterbirds and other wildlife. But native predators are also commonly controlled, such as pike, foxes and piscivorous birds.

A great deal of attention has recently been given to the management of piscivorous birds in Europe in response to concerns from fishery and angling interests. In particular, the European cormorant population continues to grow and spread in many countries. In response, a European Action Plan under the Bonn Convention has been prepared, which includes methods to limit bird numbers (from Bregnballe *et al.* 1997):


Robin Williams/WWT

- preventing new tree-nesting colonies becoming established by disturbing birds at the earliest phases of breeding and/or shooting individuals.
- cutting nesting trees and disturbing breeding birds.
- reducing reproductive output by treating eggs and/or killing chicks.
- introducing a hunting season.

Box 5.19: Relevant legislation and its consequences governing the transfer of fish between water bodies in the UK
(after NRA 1994b; CEFAS/EA undated)

- it is illegal to import any live salmon or freshwater fish, or the live eggs of those fish, without a licence under the Disease of Fish Act 1937;
- it is unlawful to introduce fish into an inland water without the written consent of the Environment Agency;
- under The Wildlife & Countryside Act 1981, it is an offence to introduce any species of fish that is not already established, or any of the following:
  - bitterling, wels catfish, large mouth bass, pumpkinseed, rock bass and zander;
- it is an offence under the Prohibition of Keeping or Release of Live Fish Order 1998 ((and the Import of Life Fish (England and Wales) Act 1980)) to release and/or keep specified non-native fish species without a licence. These include:
  - American brook trout, landlocked salmon, Pacific salmon, Pacific trout, steelhead, wels catfish, ameirurid catfish, sturgeon and sterlet, paddlefish, grass carp, silver carp, Chinese black carp, big-head carp, schneider, topmouth gudgeon, asp, blageon, blue cream, danubian bleak, nase, toxostome, vimba, Mediterranean barbel, bitterling, black bass, rock bass, pumpkinseed, pike-perch, burbot

Through these measures there is now a general presumption against the release of non-native fish species into the wild.

All of these have already been used in most countries at some time, but success has been mixed and much depends on local conditions (for further information see van Eerden *et al.* 1995; Baccetti & Cherubini 1997; van Dam & Asbirk 1997; Gromadzki & Gromadzka 1997).

At the site scale, a series of steps should be taken to manage conflict between piscivorous birds and fisheries/angling (Box 5.20). Attempts to scare birds are usually of limited success, since the birds soon become habituated. Also, special government licenses are required to kill the birds or take their eggs (but not to scare in the UK) in most countries, and these are usually issued to complement scaring. Rope bangers, gas guns, scarecrows and dummies can be used at small ponds and fish farms or where predatory birds are concentrated on large waters, for instance, close to fish-rearing cages.

Alternatively, management can focus on the fish stocks, which offers scope for development. For example, at Rutland Water (England) an increase in the size of stocked rainbow trout reduced cormorant predation and injury to fish and improved angler satisfaction due to increased catches of larger fish (T. Appleton, pers. comm.). However, stocking more or larger fish has obvious cost implications for fishery owners. Increasing habitat complexity, thus providing more shelter and increased invertebrate food resources for fish, is possibly a promising technique. Overall there is great scope for testing the efficacy of such techniques in Britain.

Although the primary aim of the management of both fish and waterbirds for recreational activities is not to promote a natural assemblage of species typical of the region (which arises from appropriate habitat management see *e.g.* Box 5.14), responsible recreation managers should consider this to be at least a secondary objective. This is the surest way of ensuring a healthy wetland system, and hence the guarantee of future recreation and wildlife resource.

5.3.1.4 Monitoring & research

Preventing and reducing conflict between waterbirds and recreation is heavily dependent on adequate monitoring and research, so that informed decisions can be made. However, procedures for monitoring, for example, visitor use and characteristics and the state of the environment at the site level are weak generally (Elson *et al.* 1995). Even very basic monitoring and research of the interactions between waterbirds and recreation can provide valuable insights to management issues and help guide appropriate decisions.

5.3.1.5 Spatial zonation

Spatial zonation of human activities is an important management technique that is particularly applicable to recreation and waterbirds. Largely depending on the size of the site and activity in question and the availability of other sites nearby, zones may need to include entire sites or parts thereof.

It is advantageous to take a strategic view of zonation on a regional as well as at site level. Such an approach, taken by Northumbrian Water, was described by Spray (1997). All the reservoirs in the region were assessed for their conservation value (habitats and birds) and for their suitability and potential for recreation. Research was also carried out on the disturbance caused by recreation to aid the zonation process. As a result the most disturbing activities were concentrated on a large reservoir of limited wildlife value, whereas recreation was stopped at a site which was sensitive to disturbance and of high conservation value. On other waters, recreation was zoned at the individual site level.

The highly migratory nature of most waterbird populations means that safeguarding waterbird populations requires networks of protected sites, often involving different habitats and alternative or emergency sites. Breaking links in such networks has potentially far-reaching consequences for the survival of migratory populations. Conservation measures were initially focused on the protection of bird species but it is self-evident that such measures must be rooted in habitat conservation, since without the maintenance of suitable habitat mosaics and networks, species conservation measures will not be effective (Davidson & Stroud 1996).

Box 5.20: Steps in the management of conflict between piscivorous birds and fishery/angling interests at the site-level

Ask the Farming and Rural Conservation Agency or other organizations for advice

Gather proof that a problem exists
For example, anglers' returns to show reduced catches over years, numbers of fish-eating birds

Quantify the scale of the problem
For example, the magnitude of reduced catches or the increased frequency of injured fish caught

Measure or estimate variables that may affect the problem from a baseline before it arose
For example, cormorant numbers and other predators, water quality, angling pressure and techniques, and fish stocking densities, species and sizes.

Where possible, manipulate other variables that may be the cause of the problem
For example, control of introduced predators or altering fish stocking practices

When it is beyond reasonable doubt that piscivorous birds are the cause of the problem, consider the following:

Management of fish stocks
Stocking of larger fish
Stocking during times of lowest densities of piscivorous birds
Spreading stocking over a greater time period
Stocking small coarse fish to reduce predation on more valuable stock

Management of birds
Scaring using gunshots, flares, boats, etc.
Shooting individuals (a government licence is needed in most countries, including Britain)

Management of habitat
Use brushwood, logs, buoyant rope tangles or plant growth to provide shelter for fish
Increase habitat complexity - pools, riffles, undercuts, channels, back channels, convoluted shorelines - to reduce contact and capture rates of fish-eating birds

In zones set aside for waterbirds (either sites or parts thereof), it is critical to ensure that the quality of the habitat provides adequately for the target species, especially with regard to feeding, nesting, roosting and moulting. Setting-aside the nearest water body irrespective of its ecological characteristics is clearly not sufficient to provide an adequate refuge.

Large wetlands with convoluted edges and hidden bays provide most scope for spatial zoning of activities within a site. Bickmore & Larard (1989) discuss the reconstruction of wetland habitats in development schemes and provide an example of a proposed water park following gravel extraction designed in an attempt to reduce potential conflicts. Their plan incorporates zones for nature conservation, dinghy sailing, sail boarding, a towed water ski run, a rowing and sprint canoeing course, a marina and central facilities.

It is difficult to provide general advice on zoning since many key aspects are related to individual site constraints. However, some attention has been given to guidance on the design of disturbance-free areas for waterbirds, particularly their size and shape. Hill *et al.* (1997) quote a notional size of 200ha for a stillwater capable of supporting fixed spatial or rotational zoning of activities through the year, although they emphasise the fact that little research has been done on this topic. They also note that restriction of multiple-use amenity activities, plus adequate conservation provision to sites of 200 ha or larger would mean that there would probably be fewer than 10 such waters in the UK (see Box 5.8 for an example of successful zonation at one of these sites). The area required for individiual recreational activity varies with the amount of disturbance it causes. This varies between 2 ha for angling to 15-20 ha for more disturbing activities such as water skiing and sailing (Spray 1997).

Nonetheless, there are many successful instances of spatial zoning on smaller wetlands. For example, Grice (1990) produced a valuable study of the Lea Valley Broadwater Lake (Mid-Colne Valley SSSI; England) where an approximately square sanctuary area of around 450 metres each side provides a refuge for 500+ moulting tufted ducks from sailing activity. The reserve has a number of islands with tall alder trees that provide additional visual screening from sailing. When sailing is taking place the birds move away from the boats down to the southern end of the refuge behind islands, meaning that much of the refuge is acting as a buffer zone. This visual screen may make an otherwise rather small refuge acceptable to the ducks and one recommendation arising from the study is to enlarge the sanctuary and to increase screening by building more wooded islands. Grice (1990) notes that, within Greater London, all other sites of national importance for moulting tufted duck are fairly large reservoirs with no sailing.

Fox & Madsen (1997) use the distance at which a bird takes flight when approached by a human (known as the "escape flight distance") to establish optimal refuge sizes and shapes. They describe three types of refuge area:

- core refuge (where virtually all distributional effects on birds due to disturbance are excluded).
- buffer zone (where activities are proscribed but where disturbance effects from outside the area are still manifest).
- the rest of the reserve (where various recreational activities take place under management).

From their studies, Fox & Madsen (1997) conclude the following

- refugia should be as large as possible and sited on high quality habitat - taking into account target species concerned and particularly their feeding and roosting requirements.
- refuge size and shape must effectively protect birds from both prevailing and potential forms of disturbance; it should have a minimum diameter of three times the escape flight distance of the most sensitive species present.
- the most effective refugia will be of regular (round/square) shape, because the core area is buffered consistently by a relatively long escape distance, minimising the potential for disturbing influences along the edges. Long thin refugia, therefore, will tend to be disproportionately affected by such edge effects, as will strings of smaller refugia. A few large refugia each with good habitat quality are, therefore, better than more numerous smaller ones.
- any inner core area of a refuge should be at least as wide in diameter as the escape flight distance of the most sensitive species.

Similar guidelines developed with particular reference to wildfowling (Box 5.21) set out best practice that is probably more generally applicable to refuge design.

Using studies of escape flight distance, Box 5.21 provides a rough indication of ideal refuge diam-

Box 5.21: Guidelines for the provision of refuges for waterfowl (from EN/BASC 1995)

- identify all current refuges and roosts - the first choice for recognised refuge areas;
- at least 50% of the area used by the main waterfowl concentrations should be free from the influence of shooting and therefore provisionally selected as refuges. Principal considerations should be given to species which occur in Nationally or Internationally important numbers on the site;
- the composition of habitats within a site's refuge network should reflect the varying roosting and feeding needs of all principal species;
- on large or composite sites, provide several smaller refuges if possible within a site to form a network rather than selecting one large one - this increases the likelihood that areas used by birds for different purposes are included and allows for use through a range of environmental conditions;
- refuges must be sufficiently large to allow the birds accommodated within them to be unaffected by sources of disturbance from outside - with reference to escape flight distances;
- the core area of any refuge should ideally be situated at least 500m away from built developments, hedges and other landscape features which can impede the view of roosting birds;
- inter-refuge distances for waders should reflect the roosting requirements of the most sedentary wader species that regularly occur in Nationally important numbers (c.f. Rehfisch *et al.* 1996);
- consider modifying wildfowling practices on the site, *e.g.* alteration to temporal patterns, rotational refuges, voluntary restraint etc.;
- monitor the success of the refuge(s) and experiment to achieve the best refuge arrangement
  - continued until the most effective refuge network is arrived at - measured against agreed "criteria for success";
- involve all interested parties, through close consultation at all times, in refuge designation.

eters for various waterbird species. Despite the obvious problems with interpretation of flight distances from these various studies, it is possible to gain an impression of useful refuge sizes for various waterbirds both in terrestrial and aquatic situations. For areas where walkers disturb ducks, refuge diameters of around a kilometre appear appropriate. Where diving ducks are disturbed on water by boats or wintering feeding goose flocks are disturbed by nearby roads or by shooting, refuge sizes of 1-2km may be more appropriate. Clearly, these figures are based upon open sites; the provision of screening or floating islands can enable smaller refuges to be developed, although it should be remembered that aggregations of wintering waterbirds prefer large open waterbodies (Tuite *et al.* 1984).

With regard to bait collection for angling on the coast, spatial zonation may also prove effective. The collection of bait has been shown to disturb waterbirds to an unacceptable degree, and to cause changes in coastal ecology. To alleviate the problem, Fowler (1992) recommended the introduction of zoning to ensure the sustainable cropping of the bait species, whilst also limiting habitat degradation and disturbance. Also, the collection of 'peeler' and 'soft' crabs is facilitated in muddy estuaries by artificial cover (boards, car tyres, *etc.*) which crabs hide under and from which they can easily be caught. Perhaps this concept could be extended to other sites and an inexpensive, environmentally acceptable form of 'shelter' devised for people harvesting crabs. Zoning of bait collection on the coast should be encouraged amongst angling clubs and integrated into the process of Coastal Zone Management (see Box 5.6 and 5.7).

Spatial zoning of water sports is feasible on large inland water complexes such as the Norfolk Broads (England), River Shannon (Ireland) and Loch Ness (Scotland). Indeed, there have been many successful attempts at zonation of watercraft. For example, at Chew Valley Lake (Avon, England), the development of a sailing club had little impact on waterbirds since it was carefully confined to a limited deep-water zone (Vinicombe 1975). This also appears to be the case at Rutland Water (England) (Appleton 1996). On linear waterways, however, such as canals, spatial zoning is often impractical (Murphy *et al.* 1995). Cross-channel zoning can, however, be used on wide rivers to protect sensitive areas, such as reed beds, macrophyte communities or fish fry habitats.

The siting of visitor facilities can also be used to spatially zone activities effectively. For example, The Peak District Park Joint Planning Board (England) have developed plans to gain agreements between landowners, farmers, conservation and access organisations on a strategy for pathway planning, including the siting of car parks, toilets, stiles and information boards. One of the aims is to guide walkers away from sensitive wildlife areas, particularly breeding golden plovers (see *e.g.* Yalden & Yalden 1989). On the Chatsworth Estate (England) the concept of 'access corridors' has been promoted, which also aims to channel walkers away from sensitive wildlife areas.

Box 5.22: Typical escape flight distances and estimated ideal refuge diameters for selected waterbird groups (after RSPB/NCC 1988; Ward 1990; Hockin *et al.* 1992; Fox & Madsen 1997)

Bird group	Escape Flight Distance (m)	Refuge diameter (km)	Species
Swans	30 (max, boat)	0.9	mute swan
Geese	500 (cars)	1.5	pink-footed geese
	500 (hunted marshes)	1.5	brent goose
	367 (hunted marshes)	1.1	brent goose
	500 (hunted areas)	1.5	bean goose
	500 (hunted areas)	1.5	white-fronted goose
	500 (hunting season)	1.5	pink-footed goose
Grebes	100 (max, boat)	0.3	little grebe
	400 (max, boat)	1.2	great-crested grebe
Diving Ducks	700 (boats)	2.1	goldeneye
	280 (human)	0.8	goldeneye
	200 (human)	0.6	tufted duck
	390 (boat)	1.6	tufted duck
	400 (max, boat)	1.2	pochard
	400 (max, boat)	1.2	smew
Dabbling ducks	200 (human)	0.6	shelduck
	400 (max, boat)	1.2	shoveler
	400 (max, boat)	1.2	teal
	425 (boat)	1.2	mallard
	230 (human)	0.6	wigeon
	200 (mobile boats)	0.6	wigeon
	700 (wind-surfers)	2.1	wigeon
	207 (human)	0.6	mallard

5.3.1.6 Temporal zonation

Temporal zonation involves restrictions on the time during which an activity can be practised. Although in general it is less effective than spatial zonation, it is nonetheless useful if used wisely. Restrictions can be placed on, for example, the hours or seasons during which an activity can be practiced. With regard to recreation on wetlands, temporal zonation is most evident in shooting and fishing. However, agreements to curtail certain activities at sensitive times can be arranged and are becoming more common. For example, following the work of Northumbrian Water and Westerberg *et al.* (1994), sailing was not allowed on one reservoir important for wintering birds during the winter months. On another site an agreement was reached to curtail water-skiing at the time when breeding Wigeon were mostvulnerable.

In Britain, there was traditionally a close season for stillwater coarse fishing running from 15 March to 15 June each year, and research has shown that this was effective at maintaining higher numbers of breeding birds than would be the case without the close season (*e.g.* Tydeman 1977). However, this statutory ban has recently been abolished, except on certain SSSIs. Fortunately, many environmentally responsible fishing clubs have decided to retain the traditional closed season, so as to 'rest' the fishery and to give waterside nesting birds a chance to breed. Also, fishing seasons at other sites have been tailored to reduce impact on important waterbird concentrations. For example, at Flanders Moss (Scotland) temporal zoning of game fishing minimises angler disturbance to an internationally important roost of pink-footed geese (Pritchard *et al.* 1992) (see also Box 5.23).

Shooting seasons have been long established in many countries as a means of reducing impact on quarry species. Generally speaking, shooting should not begin until all juvenile waterbirds have fledged (which in Europe corresponds to September in the north-east and October in the south-west) and should close before disturbance significantly affects breeding success (which roughly corresponds to the end of January for most species in Europe). Many countries, however, employ seasons that occur well outside these dates, for example there is no close season in Poland and in Germany shooting occurs in every month except May (Callaghan *et al.* 1995, 1997). Clearly, there is a need for European countries to revise shooting seasons so that they are based on clear ecological principles and are internationally compatible.

In addition to traditional closed seasons in the UK (and similarly in some other parts of Europe), legislation enables a temporary suspension of shooting during 'emergency periods'. This has allowed a mechanism to be developed in the UK for suspending waterbird shooting during periods of prolonged severe winter weather. Under current procedures, voluntary restraint is called for after seven days and a statutory ban imposed after 14 days of continuous freezing weather. Depending on where the weather is most severe, the ban may cover England and Wales, Scotland or the whole of Britain. It lasts for seven days after the amelioration of the weather. The ban is imposed in particular to avoid unnecessary disturbance to both quarry and non-quarry species of waterfowl, as well as to avoid excessive shooting bags of quarry species where these suffer from lack of food. The imposition of bans is reviewed by Stroud (1992a). As yet, there is no international coordination of such bans in Europe, although it would be wise so as to prevent potential increases in harvest of birds displaced from iced-up neighboring regions.

Box 5.23: Temporal zonation of trout fishing at Loch Leven, Scotland.

Loch Leven (1612 ha) is a good example of a temporally zoned trout fishery and an important wintering waterbird habitat, regularly supporting over 20,000 birds. Internationally important numbers of wintering whooper swan, pink-footed and greylag geese, gadwall and shoveler are joined by nationally important numbers of wintering teal, pochard, tufted duck, goldeneye and coot, and nationally important numbers of breeding wigeon, gadwall, mallard shoveler, tufted duck and black-headed gull (Pritchard *et al.* 1992).

The lake is a Ramsar site, partly an NNR and a candidate SPA. In recent years nutrient enrichment has caused serious periodic algal blooms. Declining water quality has prompted the stocking of rainbow trout to supplement the brown trout, for which the loch is famous within angling. The trout-fishing season runs from the spring through to the early autumn, largely avoiding the annual influx of wintering birds. The trout fly-fishing is boat-based with a low density of anglers on the lake as a whole such that disturbance is low-level and numbers of breeding waterfowl are high.

Shooting at night can seriously disturb roosting waterbirds (Mudge 1989) and is therefore banned in most developed countries, although not Britain. Many angling clubs have banned night fishing on their waters although it is allowed in some circumstances since it is a key time to catch some species.

5.3.2 Participant & equipment management

5.3.2.1 Codes of conduct

In May 1991, the Central Council for Physical Recreation, a forum for recreational governing bodies in England, published a policy statement on sport and the environment, in which it urged its constituent bodies to develop codes of practice which promoted sustainable use of the environment. Many governing bodies of recreation have now developed such codes in an attempt to reduce the impact of their activity on the environment (Box 5.24). These vary in quality, and in general deal with operational, legal and safety issues, while environmental issues are less fully covered. Also, the vigour with which governing bodies promote their codes varies greatly (Elson *et al.* 1995). These codes are easy and cheap to produce, and there is widespread evidence that such voluntary methods can be an effective way of managing recreation, particularly because lack of coercion elicits a positive response from affiliated participants (Elson *et al.* 1995). Fishing owners can draw up or adopt codes and demand that lessees follow them. This can be complemented through education and interpretation (section 5.3.2.3) and patrolling (section 5.3.2.5). The main problem arises with non-affiliated participants, who are not bound in any way by the codes and may not even be aware they exist. Also, codes can soon become out-dated with changes in law, policy and technology.

Supplementary codes for particular regions, types of sites or environments can be useful, as can detailed site-level codes. For example, on the Crouch Estuary (England) codes of practice have promoted "self-policing" amongst water ski enthusiasts, which has been particularly successful (Elson *et al.* 1995).

5.3.2.2 Compensation

Individuals, or the organisations to which they belong, can be made to compensate for their dam-

Box 5.24: Codes of practice produced by wetland-related recreational governing bodies in the UK

Association of Stillwater Game Fishery Managers
- The Game Angling Code: a guide to good practice

British Association of Shooting and Conservation
- wildfowlers code
- conservation code
- a code of practice for sporting agents and hotels offering goose shooting opportunities

British Canoe Union
- canoeing and the environment
- the canoeists and wildlife
- canoeist's code of conduct

British Federation of Sand & Land Yachting Clubs
- code of practice for protection of the environment and the safety of others

British Sub-Aqua Club
- divers, code of conduct

British Water Skiing Federation
- code of practice for water skiing and the environment
- code of practice for water skiing in noise sensitive areas

Central Council for Physical Recreation
- national water sports code

The Trout and Salmon Association
- game angling code of practice

National Federation of Anglers
- a variety of information sheets that cover litter, fisheries creation, mink control, conservation issues and environmental protection.
- codes of practice have been issued on the use of keep nets, nylon line and litter and a fact sheet (jointly with the RSPB) on lead-free weights.

National Federation of Sea Anglers
- a code of conduct for sports anglers

Personal Watercraft Association
- riding right: your guide to safe and responsible operation of your jet ski personal watercraft

Royal Yachting Association
- don't foul things up: guidelines for the anti-fouling user (the RYA clean code to restrict use of sea toilets)
- boats and birds

aging activities (the "polluter pays" principle). This can be in the form of:

- financial penalties;
- restoration activities;
- provision of alternative habitat.

The first is the most commonly used, since it is the easiest to establish and manage. But it can often be ineffective if not adequately advertised and enforced, or if the magnitude of the penalty is insufficient. The other two compensation schemes may offer scope for development, but as yet are not widely used in recreation management on and around wetlands. Their use could include, for example, angling clubs being charged to dredge fishing swims on a periodic basis to remove discarded tackle and other litter, or through the provision and maintenance of fishing platforms (or "pegs") in areas suffering from bank-side erosion. In one major example, the flooding of Cardiff Bay, the scheme was allowed to go ahead after a commitment had been made to create other wetlands areas in the region as compensation. Similarly, in sensitive areas suffering from disturbance, recreational bodies can be made to fund, for example, landforming to create screens. And in areas where there has been an irretrievable loss of habitat quality, they can be charged to fund the provision of alternative habitat, either within the site or as an extension to it. The possibilities are varied, but


Martin Senior/WWT

Box 5.25: Visitor education at Sanibel Island (USA) (from Klein 1993)

Sanibel Island supports a coastal National Wildlife Refuge and is located on the southern gulf coast of Florida. Annual visitor numbers exceed half a million and access is largely restricted to an 8km road built on an earth bund. Visitors scan mangrove and wigeon grass habitats where large concentrations of birds feed as they move through the reserve.

Research showed that the most disturbing activity from visitors was through birds being approached on foot, usually by photographers. Visitors who talked with refuge staff at the start of their visit were less likely to disturb birds than those who did not.

Recommendations from the study included educational programmes to explain to visitors how easy it is to disturb feeding and roosting birds, the development of observation blinds (hides) and the possibility of guided tours to reduce potential problems. It was felt that visitors were much more likely to support restrictions if they were made aware of their impact on the wildlife. Clear, easy to understand and brief educational material was considered most appropriate (e.g. the following slogan on an entry ticket: 'causing a bird to flee may reduce its feeding opportunities and chances of survival'). Also, by emphasising regional habitat loss, it was considered visitors could learn to associate their own effects with national conservation issues.

should be managed in a sensitive way that avoids conflict.

5.3.2.3 Education and interpretation

Education and interpretation are probably the most under-used methods for reducing conflict between recreation and waterbirds, but ones that can be effective in substantially reducing or removing most of the associated problems. For example, hunting mortality of the globally threatened and strictly protected freckled duck of Australia was reduced significantly in part through the establishment of waterfowl identification tests for hunters (using videos) along with other education material (see Callaghan *et al.* 1995, 1997 for further discussion).

To be effective, careful thought and planning needs to be given to the type of education and interpretation media to be used and the messages to be delivered. Simply producing a free leaflet, for example, is not a guarantee that anybody will read it and research shows that the contrary is usually the rule (Ham 1992).

Thankfully, environmental interpretation has developed rapidly in recent years, most notably in the USA. A significant result has been the production of a number of excellent guidebooks that provide a wide range of ideas for the management of recreation on and around wetlands (*e.g.* Hawkins 1991; Ham 1992).

Encouragingly, experience has shown that in many cases even very modest budgets can fund the production of highly effective interpretation, given careful planning (Ham 1992). For example, a series of signs led to an estimated 90% reduction in the accidental disturbance of nesting slavonian grebes at a Scottish site (NCC/RSPB 1988). See also Box 5.25.

5.3.2.4 Participant limitation

Wetland sites may have a threshold or carrying capacity beyond which the intensity of recreation causes environmental damage. Once all other management techniques have been exhausted, techniques should be used to reduce the number of participants pursuing an activity to below the threshold level. Leisure activities tend to lend themselves well to this approach, particularly at smaller sites or in areas with restricted access points. Limitation of participants is commonly used in angling, shooting and water sports, and is often imposed voluntarily by the participants themselves. For example, organized hunting groups commonly restrict participant numbers to improve hunting success.

In addition, time tickets are being used increasingly, whereby participants are limited to a period of time during which they pursue a particular activity. This has the added advantage of allowing a greater number of participants in total, and hence sharing the value of wetlands more equitably.

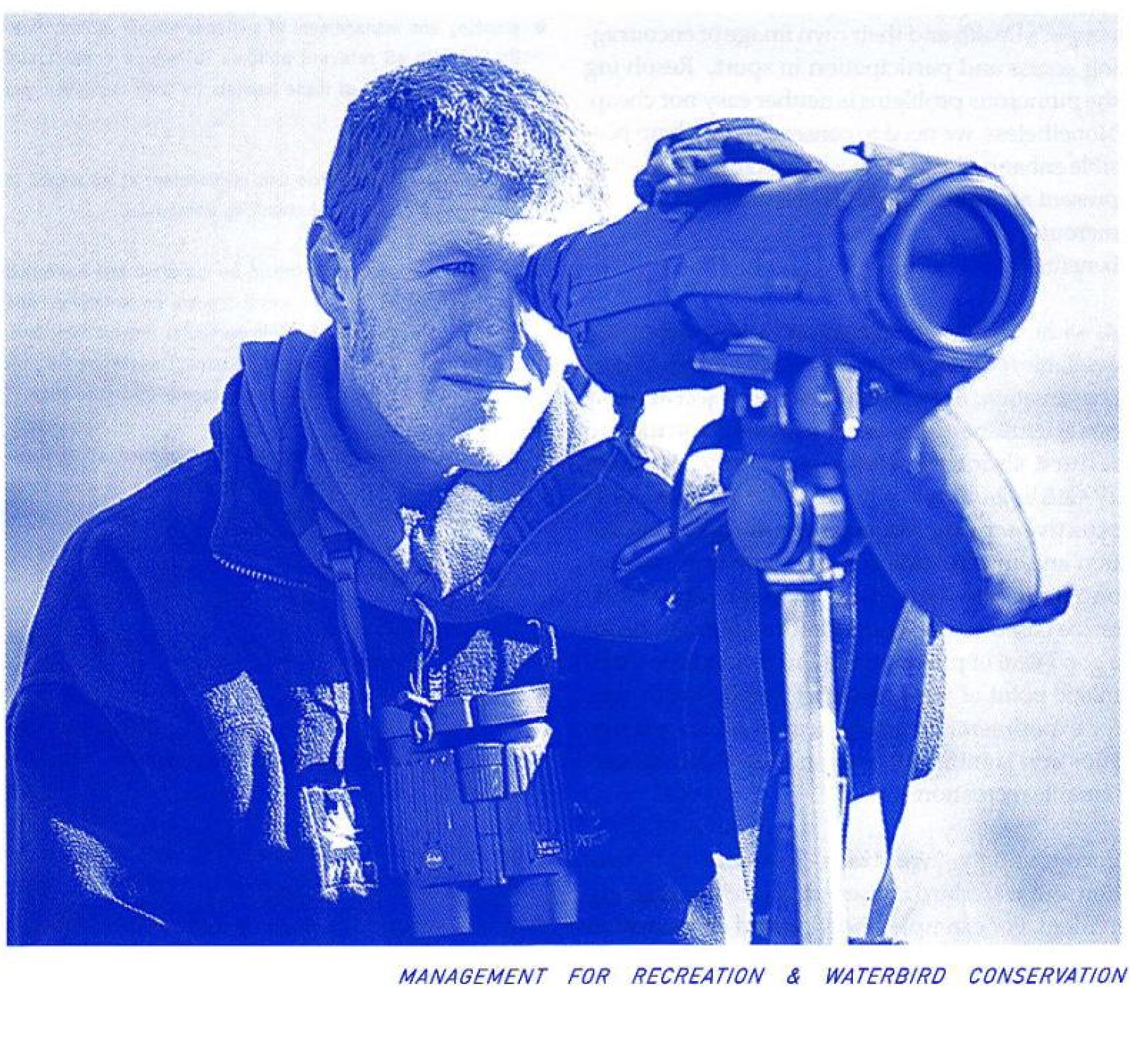
5.3.2.5 Patrolling

Many of the management techniques described in this chapter can only be effective if supported by adequate patrolling. In particular, this is relevant to spatial and temporal zonation, codes of conduct, participant limitation and regulation of recreational equipment. However, patrolling can be expensive and often needs to be carried out intensively at sites that attract large numbers of visitors. Hence, budget constraints often limit the effectiveness of patrols. A possible answer to this problem is voluntary wardening. For example, on the Dee Estuary (England) volunteers were enlisted to intercept and talk to informal recreation participants, especially on very high tides when the beach was narrow and the people most likely to walk close to roosting shorebirds. They distributed explanatory leaflets on bird disturbance and asked people to use pathways behind the beach out of sight of the birds (Kirby *et al.* 1993). The numbers of shorebirds increased, as did the numbers of visitors and types of beach recreation. It remains possible that other factors, perhaps operating at the whole-estuary scale, caused the increase in shorebirds. However, the voluntary wardening and public educational programme improved public perception of the birds and their roosting needs.

5.3.2.6 Restriction/modification of equipment

Restriction and/or modification of the use and type of recreational equipment are often necessary to reduce problems for waterbirds and other wildlife, in particular amidst rapid technological advances. For example, electrically powered engines on boats are being introduced on some waterways where adequate battery charging facilities are available. These cause no direct pollution and are popular with boat users because of their quiet operation. Batteries need to be recharged every 2-3 days, but this frequency should be lengthened with progress in battery technology (IWAAC 1983; NRA 1994b). Also, short, full bows produce high waves, and so the use of long, fine bows can reduce wave wash without further restrictions on boat speed. However, irrespective of hull design, speeds beyond 5 mph on rivers and canals cause waves likely to damage banks (and moored craft) (NRA 1994b).

In many countries, the poisoning of waterbirds from spent gunshot pellets and discarded fishing weights have been a high profile issue over recent years. Despite considerable effort to manage this problem, the only proven solution is a statutory ban on the sale of lead shot with a corresponding replacement by non-toxic alternatives. Fortunately, the latter are widely available at reasonable cost, so there is little excuse for the continued use of lead shot in angling and shooting. But even following transition to non-toxic alternatives, lead shot remains in wetland sediments for many years. Hence, lead poisoning will only disappear slowly, given the practical impossibility of removing it from the sediment.



WWT

6. CONCLUSIONS AND RECOMMENDATIONS

In response to growing public and political concern for the environment, there are now extensive frameworks of statutory and non-statutory measures for the conservation of waterbirds and wetlands in most developed countries, and to an increasing extent, in developing countries. Recreation on and around wetlands has affected and impacted on waterbirds (and other wildlife) in a variety of negative ways and to various degrees. At the same time, at many sites, the careful design, creation and management of habitat have resulted in benefits for both wildlife and recreational users (*e.g.* Appleton 1993). The demand for recreation will continue to increase as human populations and their affluence grows, and government and private companies see the value to people's health and their own image of encouraging access and participation in sport. Resolving the numerous problems is neither easy nor cheap. Nonetheless, we need to conserve and where possible enhance the present wetland resource so that present and future generations may reap the numerous
benefits.

A wide variety of management techniques are available for integrating recreation and waterbird conservation. A few have been the subject of rigorous scientific studies, such as spatial zonation to reduce shooting disturbance (*e.g.* Madsen 1998a&b), but most others have been given little objective scrutiny, for example the use of education and interpretation to promote best practice on a voluntary basis. Thus, management will often be based on inadequate information and hence a good deal of pragmatism. But from a more optimistic point of view, there is considerable scope for experimental management to fill knowledge gaps and significantly advance ecologically sustainable recreation.

Encouragingly, "win : win" scenarios in recreation and waterbird conservation are increasingly evident. For example, shooting and conservation bodies in Denmark have agreed the establishment of a network of 55 waterfowl refuges that should improve both hunting and waterfowl conservation opportunities (see Callaghan *et al.* 1995, 1997 for discussion). Also, there are many examples of recreation bodies instigating wetland creation, restoration and protection programmes, and where these are managed sensitively there are often substantial benefits to waterbirds and other wildlife.

Recognising growing commitment to ecologically sustainable recreation on and around wetlands, we make the following recommendations:

Management framework

- planning and management of wetlands should be fully integrated with all relevant policies to reduce conflict and optimise the value of these habitats for both recreation and waterbirds;
- stakeholder consultations and involvement at all stages is an essential element of obtaining consensus;
- the growth of recreation should be managed and evaluated carefully so that its effects and impacts on waterbirds and other wildlife are minimised, in particular through cost-benefit analyses and environmental impact assessments that incorporate the best possible environmental information;
- the Precautionary Principle should be applied where there is uncertainty and potentially serious risks to waterbirds and other wildlife from recreation.

Habitat management

- management should focus on creating conditions typical of the region and hence habitat that can support a natural assemblage of flora and fauna;
- management should avoid creating large areas of habitat tailored to suit a few target species;
- the application of fertilizers and lime in an attempt to increase productivity and pH should be avoided.

- control of vegetation should be limited as much as possible and confined to late summer and autumn;

- water levels should be manipulated sensitively, ideally by mimicking natural conditions;

- the application of poisons, such as piscicides and herbicides, should be avoided as far as possible;

- bank revetment should use natural materials such as willow or alder where possible;

- buffer zones should be created wherever possible, especially bordering sensitive areas (including whole sites).

Landscape design

- wetlands should be designed to reduce the likelihood of conflict between recreation and waterbirds, for example including:

  - habitat corridors (to facilitate wildlife movement across recreational areas);
  - islands, channels, earth mounds (bunds), bays, hedges and peninsulas (to help zone activities and reduce disturbance).

Species management

- wherever possible, management of species should be based at the population level, in particular with a focus on periods of stress in the annual cycle;

- introduction of exotic species should be stopped except in special circumstances, such as rainbow trout in enclosed waters, and populations that have arisen from this activity should be controlled in problem areas;

- stocking of species should be discouraged, and populations that have arisen from this activity should be controlled in problem areas;

- rather than stocking fish, management of habitat to improve the breeding success of fish already present should be considered;

- where fish stocking is planned, actions should include:

  - attainment of written consent from the appropriate authority e.g. the Environment Agency in England and Wales;
  - an assessment of what species and numbers currently occur;
  - restriction to stocking those species present;
  - prevention of stocking at a scale that causes adverse effects on native flora and fauna;
  - only stocking bottom-feeding fish, such as bream and carp, at low densities (or not at all);
  - insurance that predatory fish are part of the fish community where possible;
  - regular removal of adult fish, particularly bottom-feeding species, where high stock densities damage habitats;
  - avoidance of stocking that requires additional management, such as fertilizer application or feeding fish;
  - no release of non-native species (with the exception of rainbow trout in some circumstances).

- in algae-dominated wetlands, temporary fish-removal should be considered, or otherwise the addition of submerged brushwood bundles combined with the careful application of barley straw;

- where conflict between piscivorous birds and fishery/angling interests exists, actions should include:

  - seeking advice from e.g. DEFRA or the Environment Agency;
  - confirmation that a real problem exists;
  - quantification of the scale of the problem;
  - measurement or estimation of variables that may affect the problem from a baseline before it arose;
  - where possible, manipulation of variables other than bird numbers that may be the cause of the problem;
  - when it is beyond reasonable doubt that piscivorous birds are the cause of the problem, management should focus on fish stocks (*e.g.* stock ing of larger fish or stocking during times of lowest densities of piscivorous birds) and/or birds (*e.g.* scar ing using gun-shots, flares, boats, *etc.*, or shooting individuals [a government licence is needed in most countries, including Britain]).

Monitoring and research

- scientists should embrace guidance on improving research methods and standards for research on recreational effects and impacts (see Box 6.1, 6.,2).

- the research agenda is extensive but research that will result in better information for planners and wetland managers in the future should be a high priority for research (see suggested topics in Box 6.2).

Spatial zonation

- zoning for both conservation and recreation should be at a strategic regional level as well as at site level

- zoning of protected sites critical for the maintenance of waterbird populations should be expanded and maintained;

- zones set aside for waterbirds should contain habitat that provides adequately for their needs, especially with regard to feeding, nesting, roosting and moulting;

Box 6.1: Improving research quality for waterbirds-recreation studies (Sidaway 1994; Hill *et al.* 1997)

- the research problem should be clearly and simply stated. This should include species at risk, aspect of their ecology affected and origin of the recreational effect;
- hypotheses should be developed and then tested experimentally in a logical sequence
- the use of the 'cause and effect' concept underlines the importance of obtaining good data on both recreational activities and wildlife responses. Too often studies concentrate on the latter whilst paying scant regard to the former;
- it is always important to assess the intensity of activity, its duration and frequency (continuous, infrequent, regular, variable), the proximity of source and the presence of people associated with the source
- for birds it is vital to consider any seasonal variation in sensitivity of affected species, whether birds move away, but return after disturbance ceases, whether regional numbers are affected, whether there are alternative habitats nearby, and whether rare, scarce or especially shy species are affected;
- case studies designed to address specific effects should be used to fill in knowledge gaps regarding under-researched sports, activities, and types of habitat or site.
- management initiatives are seldom critically appraised to test their value. Far too many 'solutions' are accepted without any scientific validation. This is often quite simple to do but, nevertheless, most budgets fail to allow for post-project appraisals. The unfortunate consequence is that little is learnt from most new management ideas;
- research should be published both in the scientific literature and at popular level in sporting magazines where key messages can be spread and findings communicated in a readily digestible form;
- the objective should be an understanding of the long-term functioning of key ecosystems and the importance of disturbance effects (and, perhaps, impacts) within this context.

Box 6.2: Research to address the effects/impacts of recreation on waterbirds

Further studies are required that:

- establish key population parameters (survival, reproduction, and rates of movement) and identify bottlenecks (summer/winter) for a 'representative' suite of waterbird species at the population level;
- establish 'unusual' population trends and identify sites/regions with 'abnormal' patterns
- establish 'unusual' trends in distribution and identify sites/regions with 'abnormal' patterns
- provide new population models incorporating individual food exploitation rates, to account for losses of or disturbance to habitat patches of variable quality and to carry out sensitivity analyses of the models and testing with field data;
- allow understanding of the comparative importance of effects/impacts of different recreational activities, with reference to 'natural' levels (baseline reference) and any compensatory ability operating through density-dependence;
- energetic studies that address the relative ability of different species to compensate for disturbance;
- examine movement and displacement studies, using marked birds, and of sufficient precision to detect distribution changes with respect to specific recreational factors;
- investigate feeding ecology and interference, food depletion, intake rates and survival rates to determine whether sites and regions are at a critical carrying capacity;
- disturbance studies during moult, migration and severe weather periods;
- constitute before-and-after experimental studies at a range of sites for differing activities using a control site counted at the same time. Those activities perceived to be most significant in terms of effects and potential impacts should be given research priority. Activity patterns and temporal and spatial variation in distributions should be systematically recorded;
- consider habitat quality in and around key bird feeding sites and investigate the indirect effects/impacts of recreational use on habitat quality;
- test mitigation measures and site size effects, to provide sound data on the value of zoning, screening, habitat creation measures and the provision of dedicated refuges;
- addresses gaps in knowledge of the effects of specific sports activities and the impact on birds, for example:
    - what fish stocking levels are acceptable to avoid excessive depletion of the aquatic plant and invertebrate resources important to waterbirds?
    - what are the implications of large numbers of people on site following, but not participating, in sport?
    - what is the full extent of waterbird mortality from angling and other sources of litter?
- address predation levels as a side effect of recreation and measures that may counteract it.

- disturbance-free zones should be as large as possible, or at least three times the escape flight distance of the most sensitive species present (see Box 5.21);

- disturbance-free zones should be circular (as opposed to linear) and the inner core area should be at least as wide in diameter as the escape flight distance of the most sensitive species present (see Box 5.21);

- where the creation of adequately large disturbance-free zones is impractical, the construction of landforms such as peninsulas, islands and earth bunds should be used to screen noise and visual stimuli;

- visitor facilities such as car parks, toilets, paths and information boards should be sited carefully in order to retain or create disturbance-free zones.

Temporal zonation

- recreational activities should be zoned through time to reduce their effects and impacts on waterbirds and other wildlife, which should be coordinated internationally when needed;

- Recreational activity during the waterbird-breeding season should be discouraged;

- shooting should not begin until all juvenile waterbirds have fledged, for example September (north-east Europe) or October (south-west Europe), and should close before their breeding success is impacted significantly, for example the end of January for most European species;

- limitations on the number of days each week an activity can be practised should be considered;

- temporary suspension of recreational activities during unpredictable critical periods for waterbirds, such as prolonged severe winter weather, should be encouraged;

- night-time recreational activities should be discouraged, *e.g.* shooting, bait digging *etc.*

Codes of conduct

- codes of conduct should be further developed, with particular attention to measures that reduce the effects and impacts of recreation on waterbirds and other wildlife;

- codes of conduct should be reviewed at least every 5 years and updated as required;

- adequate implementation of codes of conduct should be encouraged (*e.g.* through education and interpretation, and patrolling), especially by relevant governing bodies.

Compensation

- parties responsible for any environmental damage should be made to pay the full costs of their activities (the "polluter pays" principle). Charging parties with the following should be considered:

  - financial penalties of adequate measure, advertisement and enforcement;
  - full restoration of damaged areas;
  - provision of alternative, adequate habitat.

Education and interpretation

- education and interpretation should be encouraged and the media and messages used should be planned carefully. Topics for such development include:

  - the value of waterbirds and wetlands;
  - the environmental impacts and effects of recreation and possible solutions;
  - proficiency tests for shooting, including bird identification;
  - implementation and development of codes of conduct;
  - ecologically sustainable management of fish stocks;
  - management of conflict between fisheries/ anglers and piscivorous birds;
  - habitat management.

Participant limitation

- once all other management techniques have been exhausted, techniques should be used to reduce the number of participants pursuing an activity to a level not exceeding the ecological carrying capacity of the area;

- time tickets should be encouraged as a means of limiting the number of participants at any particular time.

Patrolling

- regular patrols of problem areas should be encouraged, especially to implement management techniques such as spatial and temporal zonation, codes of conduct, participant limitation and regulation of recreational equipment;

- where resources are limiting, voluntary patrolling should be encouraged.

Regulation/modification of equipment

- restriction and modification of the use and type of equipment used in recreation should be reviewed frequently, in light of rapid advances in technology. In particular:

  - lead shot in gun cartridges and angling should be banned and replaced by non-toxic alterna tives;
  - mechanical bait digging equipment should be discouraged;
  - motor boat speeds on rivers and canals should not exceed 5 mph;
  - use of boats with thin, fine bows and electrically powered engines should be encouraged.

Appendix 1: Scientific names of species mentioned in the text

BIRD	Scientific name
Arctic tern	*Sterna paradisaea*
Aquatic warbler	*Acrocephalus paludicola*
Avocet	*Recurvirostra avosetta*
Bald eagle	*Haliaeetus leucocephalus*
Bar-tailed godwit	*Limosa lapponica*
Barnacle goose	*Branta leucopsis*
Bean goose	*Anser fabalis*
Bearded reedling	*Panurus biarmicus*
Bewick's swan	*Cygnus bewickii*
Bittern	*Botaurus stellaris*
Black-headed gull	*Larus ridibundus*
Black-necked grebe	*Podiceps nigricollis*
Black-tailed godwit	*Limosa limosa*
Black-throated diver	*Gavia arctica*
Blackbird	*Turdus merula*
Brent goose	*Branta bernicla*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Cetti's warbler	*Cettia cetti*
Chaffinch	*Fringilla coelebs*
Common gull	*Larus canus*
Common sandpiper	*Tringa hypoleucos*
Common scoter	*Melanitta nigra*
Common tern	*Sterna hirundo*
Coot	*Fulica atra*
Cormorant	*Phalacrocorax carbo*
Crane	*Grus grus*
Curlew	*Numenius arquata*
Curlew sandpiper	*Calidris ferruginea*
Dipper	*Cinclus c. gularis*
Dunlin	*Calidris alpina*
Eider	*Somateria mollissima*
Eygptian goose	*Alopochen aegyptiacus*
Gadwall	*Anas strepera*
Garganey	*Anas querquedula*
Golden eagle	*Aquila chrysaetos*
Golden plover	*Pluvialis a. apricaria*
Goldeneye	*Bucephala clangula*
Goosander	*Mergus merganser*
Great black-backed gull	*Larus marinus*
Great crested grebe	*Podiceps cristatus*
Green sandpiper	*Tringa ochropus*
Greenshank	*Tringa nebularia*
Grey heron	*Ardea cinerea*
Grey plover	*Pluvialis squatarola*
Grey wagtail	*Motacilla cinerea*
Greylag goose	*Anser anser*
Herring gull	*Larus a. argentatus*
House sparrow	*Passer domesticus*
Jack snipe	*Lymnocryptes minimus*
Kentish plover	*Charadrius alexandrinus*

BIRD	Scientific name
Kingfisher	*Alcedo atthis*
Kittiwake	*Rissa tridactyla*
Knot	*Calidris canutus*
Lapland bunting	*Calcarius lapponicus*
Lapwing	*Vanellus vanellus*
Lesser black-backed gull	*Larus fuscus*
Lesser scaup	*Aythya affinis*
Little grebe	*Tachybaptus ruficollis*
Little ringed plover	*Charadrius dubius*
Little tern	*Sterna albifrons*
Long-tailed duck	*Clangula hyemalis*
Mallard	*Anas platyrhynchos*
Mandarin	*Aix galericulata*
Marsh harrier	*Circus aeruginosa*
Marsh warbler	*Acrocephalus palustris*
Mediterranean gull	*Larus melanocephalus*
Moorhen	*Gallinula chloropus*
Mute swan	*Cygnus olor*
Osprey	*Pandion haliaetus*
Oystercatcher	*Haematopus ostralegus*
Pied/white wagtail	*Motacilla alba*
Pink-footed goose	*Anser brachyrhynchus*
Pintail	*Anas acuta*
Pochard	*Aythya ferina*
Purple sandpiper	*Calidris maritima*
Red-breasted merganser	*Mergus serrator*
Red-crested pochard	*Netta rufina*
Red-necked grebe	*Podiceps grisegena*
Red-necked phalarope	*Phalaropus lobatus*
Red-throated diver	*Gavia stellata*
Redhead	*Aythya americana*
Redshank	*Tringa totanus*
Reed bunting	*Emberiza schoeniclus*
Reed warbler	*Acrocephalus scirpaceus*
Ringed plover	*Charadrius hiaticula*
Rock pipit	*Anthus petrosus*
Roseate tern	*Sterna dougallii*
Ruddy duck	*Oxyura jamaicensis*
Ruff	*Philomachus pugnax*
Sand martin	*Riparia riparia*
Sanderling	*Calidris alba*
Sandwich tern	*Sterna sandvicensis*
Savi's warbler	*Locustella luscinioides*
Scaup	*Aythya marila*
Sedge warbler	*Acrocephalus schoenobaenus*
Shelduck	*Tadorna tadorna*
Shorelark	*Eremophila alpestris*
Shoveler	*Anas clypeata*
Slavonian grebe	*Podiceps auritus*
Smew	*Mergus albellus*
Snipe	*Gallinago gallinago*

BIRD	Scientific name
Snow bunting	*Plectrophenax nivalis*
Snow goose	*Anser caerulescens*
Spotted crake	*Porzana porzana*
Spotted redshank	*Tringa erythropus*
Teal	*Anas crecca*
Temminck's stint	*Calidris temmincki*
Tufted duck	*Aythya fuligula*
Turnstone	*Arenaria interpres*
Twite	*Acanthis flavirostris*
Velvet scoter	*Melanitta fusca*
Water rail	*Rallus aquaticus*
Whimbrel	*Numenius phaeopus*
White-billed diver	*Gavia adamsii*
White-fronted goose	*Anser albifrons*
Whooper swan	*Cygnus cygnus*
Wigeon	*Anas penelope*
Wood sandpiper	*Tringa glareola*
Wren	*Troglodytes troglodytes*
Yellow wagtail	*Motacilla flava flavissina*

INVERTEBRATES	Scientific name
Brine shrimp	*Artemia salina*
Fen raft spider	*Dolomedes plantarius*
Great silver diving beetle	*Hydrophilus piceus*
Hairy dragonfly	*Brachytron pratense*
Harbour ragworm	*Nereis diversicolor*
King ragworm	*Nereis virens*
Limnetic fairy shrimp	*Polyartemia forcipata*
Lugworm	*Arenicola marina*
Peeling edible crab	*Cancer pagurus*
Shore crab	*Carcinus maenas*
Variable damselfly	*Coenagrion pulchellum*
Velvet swimming crab	*Macropipus puber*
White ragworm	*Nephthys caeca*

MAMMALS	Scientific name
Fox	*Vulpes vulpes*
Mink	*Mustela vison*

FISHES	Scientific name
Ameirurid catfish	*Ameiurus catus*
Arctic char	*Salvelinus alpinus*
Asp	*Aspius aspius*
Barbel	*Barbus barbus*
Big-head carp	*Aristichthus nobilis*
Big-mouth buffalo	*Ictiobus cyprinellus*
Bitterling	*Rhodeus sericeus*
Blageon	*Leuciscus souffia*
Blue bream	*Abramis ballerus*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Burbot	*Lota lota*
Char	*Salvelinus alpinus*
Chinese black carp	*Mylopharyngodon piceus*
Chub	*Leuciscus cephalus*
Common bream	*Abramis brama*
Common carp	*Cyprinus carpio*
Crucian carp	*Carassius carassius*
Dace	*Leuciscus leuciscus*
Danubian catfish/Wels	*Silurus glanis*
Danubian bleak	*Chalcaburnus chalcoides*
Eel	*Anguilla anguilla*

FISHES	Scientific name
Golden orfe	*Leuciscus idus*
Goldfish	*Carassius auratus*
Grass carp	*Ctenopharyngodon idella*
Grayling	*Thymallus thymallus*
Gudgeon	*Gobio gobio*
Landlocked salmon	*Salmo salar*
Large-mouth bass	*Micropterus salmoides*
Mediterranean barbel	*Barbus meridionalis*
Mosquitofish	*Gambusia affinis*
Nase	*Chondrostoma nasus*
Nile perch	*Lates niloticus*
Pacific salmon	*Oncorhynchus* (5 spp)
Pacific trout	*Salmo gairdnieri*
Paddlefish	*Polydon spathula*
Perch	*Perca fluviatilis*
Pike	*Esox lucius*
Pike-perch/Zander	*Stizostedion lucioperca*
Pumpkinseed	*Lepomis gibbosus*
Rainbow trout	*Salmo gairdneri*
Roach	*Rutilus rutilus*
Rock bass	*Ambloplites rupestris*
Rudd	*Scardinius erythropthalmus*
Salmon	*Salmo salar*
Schneider	*Alburnoides bipunctatus*
Sea trout	*Salmo trutta*
Silver carp	*Hypophthalmichthys malitrix*
Steelhead	*Onchorhynchus mykiss*
Sterlet	*Acipenser ruthenus*
Sturgeon	*Acipenser sturio*
Tench	*Tinca tinca*
Top-mouth gudgeon	*Pseudoraspora parva*
Toxostome	*Chondrostoma toxostoma*
Vimba	*Vimba vimba*
Walleye	*Stizostedion vitreum*
Wels catfish	*Silurus gianis*

PLANTS	Scientific name
Alder	*Alnus glutinosa*
Bur reed	*Sparganium emersum*
Canadian pondweed	*Elodea canadensis*
Creeping bent	*Agrostis stolonifera*
Curled pondweed	*Potamogeton crispus*
Fennel pondweed	*Potamogeton pectinatus*
Flexible naiad	*Najas flexilis*
Floating water-plantain	*Luronium natans*
Fool's water-cress	*Apium nodiflorum*
Grass-wrack pondweed	*Potamogeton compressus*
Norfolk reed	*Phragmites communis*
Reed canary grass	*Phalaris arundinacea*
Rigid hornwort	*Ceratophyllum demersum*
Sago pondweed	*Potamogeton pectinatus*
Sharp-leaved pondweed	*Potamogeton acutifolius*
Shore weed	*Littorella uniflora*
Spiked water-milfoil	*Myriophylum spicatum*
Water celery	*Berula erecta*
Water cress	*Rorippa nasturtium-aquaticum*
Water crowfoot	*Ranunculus spp.*
Wigeon grass	*Ruppia maritime*
Yellow water lily	*Nuphar lutea*

Appendix 2: Contacts in the UK

Organisation	Main address	Telephone	Web Address
Anglers' Conservation Association	Shelford Dairy, Shelford, Farm, Aldermaston, Reading RG7 4NB	0118 971 4770	www.icclaw.com
Association of Stillwater Game Fishery Managers	u/a	u/a	www.fisheries.co.uk
Atlantic Salmon Trust	Moulin, Pitlochry, Perthshire	01796 473 439	www.atlanticsalmontrust.org
British Association for Shooting & Conservation	Marford Mill, Rossett, Nr Wrexham, Clwyd, LL12 0HL	01244 573 000	www.basc.org.uk
British Canoe Union	Adbolton Lane, West Bridgford, Nottinghamshire, NG2 5AS.	0115 982 1100	www.bcu.org.uk
British Federation of Sand & Land Yacht Clubs	9 Derwent Park, Wheldrake, York YO4 6AT.	01904 448 618	www.britishlandsailing.org.uk
British Ornithologist's Union	c/o Natural History Museum, Akeman St., Tring, Herts. HP23 6AP	01442 890 080	www.bou.org.uk
British Sub-aqua Club	Telford Quay, South Pier Road, Ellesmere Port, Cheshire CH65 2FL	0151 350 6200	www.bsac.com
British Trust for Conservation Volunteers	36 St Mary's Street, Wallingford, Oxfordshire OX10 0EU	01491 839 766	www.bctv.org.uk
British Trust for Ornithology	The Nunnery, Thetford, Norfolk, IP24 2PU	01842 750 050	www.bto.org.uk
British Water Ski Federation	390 City Road, London EC1V 2QA	020 7833 2855	www.britishwaterski.co.uk
Centre for Aquatic Plant Management	Broadmoor Lane, Sonning, Nr Reading, Berks RG4 6TH	01189 690 072	www.aquatic.freeserve.co.uk
Commercial Coarse Fisheries Association	Tingrith Fishery, Tingrith, Bedfordshire MK17 9EW	01525 714012	www.fisheries.co.uk/ccfa
Countryside Agency	John Dower House, Crescent Place, Cheltenham, GL50 3RA.	01242 521 381	www.countryside.gov.uk
Countryside Council for Wales	Plas Penrhos, Fford Penrhos, Bangor, LL57 2LQ	01248 370 444	www.ccw.gov.uk
Department of Environment, Transport and the Regions (now Department for Environment, Food and Rural Affairs)	European Wildlife Division, Room 108, Temple Quay House, 2 The Square, Bristol BS1 6EB.	0117 372 6236	www.defra.gov.uk
Department of Agriculture and Rural Development (Northern Ireland)	Dundonald House, Upper Newtonards Road, Belfast BT4 3SB	02890 424 999	www.dani.gov.uk
English Nature	Northminster House, Peterborough, PE1 1UA	01733 455 000	www.english-nature.org.uk

Organisation	Main address	Telephone	Web Address
Environment Agency	Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS12 4UD.	01454 624 400	www.environment-agency.gov.uk
Game Conservancy Trust	Fordingbridge, Hampshire, SP6 1EF	01425 652 381	www.gct.org.uk
Joint Nature Conservation Committee	Monkstone house, City Road, Peterborough PE1 1JY.	01733 562 626	www.jncc.gov.uk
Institute of Fisheries Management	See DEFRA		
Inland Waterways Amenities Advisory Council	See DEFRA		
Ministry of Agriculture, Fisheries and Food (now DEFRA)	See DEFRA		
Just Ecology	The Old Wheelwrights, Ham, Berkeley, Gloucestershire GL13 9QJ	01453 811780	www.justecology.co.uk
National Association of Specialist Anglers	2 The Queensway, Old Dalby, Leicestershire LE14 3QH	01664 822 200	www.cygnet.co.uk/ukfw/nasa
The National Trust	Estates Department, 33 Sheep Street, Cirencester, Glos. GL7 1RQ.	01285 651 818	www.nationaltrust.org.uk
National Trust for Scotland	28 Charlotte Square, Edinburgh EH2 4ET	0131 243 9300	www.nts.org.uk
National Federation of Anglers	Halliday House, Eginton Junction, Derbyshire DE65 6GU	01283 734 735	www.the-nfa.org.uk
The River Restoration Centre	Silsoe Campus, Silsoe, Beds MK45 4DT	01525 863 341	www.qest.demon.co.uk/rrc
Royal Society for the Protection of Birds	The Lodge, Sandy, Beds SG19 2DL	01767 680 551	www.rspb.org.uk
Royal Yachting Association	4 Eaton Close, Beeston, Nottinghamshire NG9 2WB	0115 917 6995	www.rya.org.uk
Salmon and Trout Association	Fishmongers Hall, London Bridge, London EC4R 9EL	020 7283 5838	www.salmon-trout.org
Scottish National Heritage	12 Hope Terrace, Edinburgh EH9 2AS	0131 447 4784	www.snh.org.uk
Specialist Anglers' Conservation Group	See National Association of Specialist Anglers		
Water UK	1 Queen Anne's Gate, London SW1H 9BT	0171 344 1817	www.water.org.uk
Welsh Salmon and Trout Angling Association	Swyn Teifi, Pontrhydfendigaid, Ystrad Meirig, Ceredigion SY25 6EF		www.fishing-in-wales.com/wstaa
The Wildfowl & Wetlands Trust	Slimbridge, Gloucestershire, GL2 7BT	01453 891 900	www.wwt.org.uk
Wildlife Trusts	The Kiln, Waterside, Mather Road, Newark, Nottinghamshire NG24 1WT	0870 0367711	www.wildlifetrusts.org

References

African-Eurasian Waterfowl Agreement Interim Secretariat. 1995. *The African-Eurasian Waterfowl Agreement. The final act of the negotiation meeting (June 1995) and Agreement text with Action Plan.* African-Eurasian Waterfowl Agreement Interim Secretariat, The Hague

Ahlen, I. 1966. Studies on the distribution and ecology of the little grebe *Podiceps ruficolis* in Sweden. *Var Fagelvarld* 4: 1-45

Ahlund, M. & Gotmark, F. 1989. Gull predation on Eider ducklings *Somateria mollissima*: effects of human disturbance. *Biological Conservation* 48: 115-27

Alerstam, T. 1990. Bird migration. Cambridge University Press, Cambridge

Allan, J.R., Kirby, J.S. & Feare, C.J. 1995. The biology of Canada geese *Branta canadensis* in relation to the management of feral populations. *Wildlife Biology* 1: 129-143.

Allport, G., O'Brien, M. & Cadbury, C.J. 1986. *Survey of Redshank and other breeding birds on saltmarshes in Britain 1985.* Nature Conservancy Council, CSD Report No. 649

Anderson, J.M. 1950. Some aquatic changes following fish removal. *Journal of Wildlife Management* 14: 206-209

Anderson, D.R. & Burnham, K.P. 1976. *Population ecology of the mallard. VI. The effect of exploitation on survival.* US Fish & Wildl. Serv. Resource Publication. 128, Washington DC

Anderson, D.W. & Keith, J.O. 1980. The human influence on seabird nesting success: conservation implications. *Biological Conservation* 18: 65-80

Anderson, P., Edwards, P.J. & Tattersfield, P. 1987. *Runnymede retail development at the ARC gravel pits, Hythe End, Wraysbury.* Unpublished report

Andersson, A. 1977. *Andjakten I Hullsjon.* Report, Skogshogskolan, Uppsala

Andersson, G., Berggren, H., Cronberg, G. & Gelin, C. 1978. Effects of planktivorous and benthivorous fish on organisms and water chemistry in eutrophic lakes. *Hydrobiologia* 591: 9-15.

Andrews, J. & Kinsman, D. 1990. *Gravel Pit Restoration For Wildlife.* RSPB, Sandy, UK

Anon. 1997. Wildfowlers go lead-free on NNRs. *SiteLines* 21: 1-2

Appleton, T.P. 1982. Rutland Water Nature Reserve: concept, design and management. *Hyrdobiologia* 88: 211-224.

Appleton, T.P. 1993. The Management of Rutland Water for wildlife. In: *Proceedings of a Symposium on the Subject of Wildlife on Man-made Wetlands.* ARC Wildfowl Centre, Great Linford

Appleton, T. 1996. *Rutland Water - a case study. Integrating conservation and recreation.* Unpublished manuscript, Leicestershire Wildlife Trust.

Arctander, P., Fjeldsa, J. & Jensen, A. 1984. Sejlads med luftpudebade, jagt og andre forstyrrelser af fugle og saeler ved Saltholm maj-september 1984. Miljoministeriet, Fredningsstyrelsen, Denmark

Atkinson-Willes, G.L. 1969. Wildfowl and recreation: a balance of requirements. *British Water Supply* 11: 5-15.

Baccetti, N. & Cherubini, G. (eds.) 1997. IV European conference on cormorants. *Supplemento alle Ricerche di Biologia della Selvaggina XXVI*: 1-594

Baillie, S.M., Clark, N.A. & Ogilvie, M.A. 1986. *Cold weather movements of waterfowl and waders: an analysis of ringing recoveries.* Nature Conservancy Council CSD Report No. 650, Peterborough.

Bajkov, A. D. & Shortt, A. H. 1939. *Northern Pike Jackfish as predators on Waterfowl and Muskrats.* Ducks Unlimited. Winnipeg

Baldassare, G.A. & Bolen, E.G. 1994. *Waterfowl Ecology and Management.* John Wiley & Sons Inc., New York.

Balser, D.S., Dill, H.H. & Nelson, H.K. 1968. Effect of predator reduction on waterfowl nesting success. *Journal of Wildlife Management* 32: 669-682

Bannan, M., Adams, C. E. & Tippett, R. 1996. *The effects of powerboats on the aquatic environment of Loch Lomond.* Glasgow University Field Station, Rowardennan Annual Report 1994/5

Bardsley, L., Crofts, A & Giles, N. 2001. *The Wetland Restoration Manual.* The Wildlife Trusts, Newark, UK.

Bartelt, G.A. 1987. Effects of disturbance and hunting on the behaviour of Canada goose family groups in Wisconsin. *Journal of Wildlife Management* 51: 517-522

Batt, B.D.J. (ed) 1997. *Arctic ecosystems in peril: report of the Arctic goose habitat working group.* Arctic Goose Joint Venture Special Publication. US Fish and Wildlife Service, Washington DC, and Canadian Wildlife Service, Ottawa

Batt, B.D.J., Afton, A.D., Anderson, M.G., Ankney, C.D., Johnson, D.H., Kadlec, J.A., & Krapu, G.L. 1992. *Ecology and Management of Breeding Waterfowl.* Minnesota Press, USA

Batten, L.A. 1977. Sailing on reservoirs and its effects on waterbirds. *Biological Conservation* 11: 49-57

Batten, L.A., Bibby, C.J., Clement, P., Elliot, G.D. & Porter, R.F. 1990. *Red Data Birds in Britain.* Poyser, London

Belanger, L. & Bedard, J. 1989. Responses of staging Greater Snow Geese to human disturbance. *Journal of Wildlife Management* 53: 713-719

Belanger, L. & Bedard, J. 1990. Energetic cost of man-induced disturbance to staging Snow Geese. *Journal of Wildlife Management* 54: 36-41

Bell, D.V., Odin, N., Austin, L., Hayhow, S., Jones, A., Strong, A. & Torres, E. 1984. *The Impact of Anglers on Wildlife and Site Amenity.* Department of Applied Biology UWIST, Cardiff

Bell, D.V. & Austin, L. 1985. The game fishing season and its effects on over-wintering wildfowl. *Biological Conservation* 33: 65-80

Bell, D,V, & Owen, M. 1990. Shooting Disturbannce- a Review. Pp159-171 in Mattews, G.V.T. (ed) *Managing Waterfowl populations*. IWRB Special Publication No 12. , IWRB, Slimbridge.

Bell, D.V. & Fox, A.D. 1991. *Shooting Disturbance. An Assessment of its Impact and Effects on Over-wintering Waterfowl Populations and their Distribution in the United Kingdom*. Report by The Wildfowl & Wetlands Trust and the British Association for Shooting and Conservation

Bengtson, S. A. 1971a. Variations in clutch size in ducks in relation to the food supply. *Ibis* 113: 523-526.

Bengtson, S. A. 1971b. Food and feeding of diving ducks breeding at Lake Myvatn, Iceland. *Ornis Fennica* 48: 77-92

Bickmore, C. J. & Larard, P. J. 1989. Reconstructing freshwater habitats in development schemes. In: Buckley, G.P. (Ed.). *Biological Habitat Reconstruction*. Belhaven, London

Birkhead, M. & Perrins, C. 1985. *The Mute Swan*. Christopher Helm

Black, J.M. 1998. *Conservation and Management Plan for the Svalbard population of the Barnacle Goose*. Unpubl Rep. by The Wildfowl & Wetlands Trust toDirectorate of Nature Mangement, Norway and Scottish Natural Heritage

Brand, C.J. 1987. Duck plague. In: Friend, M. (ed.) *Field Guide to Wildlife Diseases: General Field Procedures and Diseases of Migratory Birds*. U.S. Fish & Wildlife Service Resource Publication 167. USFWS, Washington, D.C.

Brand, C.J. & Docherty, D.E. 1988. Post-epizootic surveys of waterfowl for duck plague (duck virus enteritis). *Avian Diseases* 32:722-730

Bregnballe, T., Goss-Custard, J.D. & Durell, S.E.A.l.v.d. 1997. Management of cormorant numbers on Europe: a second step towards a European conservation and management plan. In: van Dam, C. & Asbirk, S. (eds.). *Cormorants and human interests*. IKC natuur beheer, Wageningen, Netherlands. Pp 62-122

Brighton University 2002. *Water based sport and recreation: the facts*. Brighton University School of Environment, Brighton.

Brinkhurst, R.O. & Walsh, B. 1967. Rostherne Mere, England, a further instance of guanotrophy. *J. Fish. Res. Bd. Can.* 24: 1299-1309

Brodsky, L.M. & Weatherhead, P.J. 1984. Behavioural and ecological factors contributing to American Black Duck-Mallard hybridization. *Journal of Wildlife Management* 48: 846-852

Bryant, D.M. 1978. Moulting Shelducks on the Forth estuary. *Bird Study* 25: 103-108

Bryant, D.M. 1981. Moulting Shelducks on the Wash. *Bird Study* 28: 157-158

BTCV. 1991. *Waterways and Wetlands. A Practical Conservation Handbook*. BTCV, Reading

Buick, A.M., & Paton, D.C. 1989. Impact of off-road vehicles on the nesting success of Hooded Plovers *Charadrius rubricollis* in the Coorong Region of South Australia. *Emu* 89: 159-172

Burger, J. 1986. The effect of human activity on shorebirds in two coastal bays in north-eastern United States. *Environmental Conservation* 13: 123-130

Burger, J. & Gochfield, M. 1983. Behavioural responses to human intruders of Herring Gulls and Great Black-backed Gulls with varying exposure to human disturbance. *Behavioural Processes* 8: 327-344

Butterfield, J., Coulson, J.C., Kearsey, S.U., Monaghan, P., McCoy, J.H. & Spain, G.E. 1983. The Herring Gull *Larus argentatus* as a carrier of Salmonella. *J. Hygiene Camb.* 91: 429-436

Callaghan, D. 1996. Update on the IUCN/SSC Anatidae Action Plan. *Threatened Waterfowl Specialist Group News* 9: 5-6

Callaghan, D.A. & Green, A.J. 1993. Wildfowl at risk, 1993. *Wildfowl* 44:149-169

Callaghan, D.A., Kirby, J.S. & Hughes, B. 1995. *The effects of recreational waterfowl hunting on biodiversity: implications for sustainability*. Report to The World Wide Fund for Nature (International), The Wildfowl & Wetlands Trust, Slimbridge

Callaghan, D.A., Kirby, J.S. & Hughes, B. 1997. The effects of recreational waterfowl hunting on biodiversity: implications for sustainability. Pp. 507-574. In: Freese, C.H. (Ed.). *Harvesting Wild Species: Implications for Biodiversity Conservation*. Johns Hopkins Press, Baltimore and London

Campbell, L.H. & Mudge, G.P. 1989. Conservation of Black-throated Divers in Scotland. RSPB Conservation Review 3: 72-74.

Campredon, P. 1979. Quelques donnees concertant l'hivernage des limicoles sur le Bassin d'Arcachon (Gironde). *L'Oiseau* 49: 113-131

Carbone, C. 1995. Guidelines for estimating feeding performance of diving birds. *Wildfowl* 46: 119-128

Caron, J.A. Jr. & Robinson, W.L. 1994. Responses of breeding Common Loons to human activity in Upper Michigan. In: Kerekes, J.J. (Ed.). Aquatic birds in the trophic web of lakes. *Hydrobiologia* 279/280: 431-438

Carss, D.N. & Marquiss, M. 1996. *The feeding behaviour and impact of grey herons on fisheries: a literature review*. ITE, Banchory

CEED. 1993. *Water-skiing and the Environment : A literature review, UK Centre for Economic and Centre for Leisure Research 1986. Access to the countryside for recreation and sport*. Countryside Commission and Sports Council, London

CEFAS/EA undated. Controls on the keeping and release of non-native fish in England and Wales. Information leaflet. The Center for Environment, Fisheries & Aquaculture Science/Environment Agency

Childress, D. & Rothe, T. 1990. Management of Pacific Flyway geese: an exercise in complexity and frustration. *Trans. N. A. Wildl. & Nat. Res. Conf.* 55: 327-332

Coleman, A.E. Coleman, J.T., Coleman, P.A. & Minton, C.D.T. 2001. A 39 year study of a Mute Swan *Cygnus olor* population in the English Midlands. *Ardea* 89: 123-133.

Coleman, J.T., Spray, C.J., Percival, S.M., Rickeard, A.T., & Yeoman, P. 2002. The dynamics of a flock of Mute Swans at Berwick-upon-Tweed with particular reference to the effects of age, sex, social status and body condition on moult. *Waterbirds 25 Special Publication* 1: 346-351.

Coles, B. 1995. Wetland Management. *A Survey for English Heritage*. WARP Occasional Paper 9, University of Exeter

Cooch, E.G., Lank, D.B., Rockwell, R.F. & Cooke, F. 1991. Long-term decline in body size in a Snow Goose population: evidence of environmental degradation? Journal of Animal Ecology 60: 483-496

Cooke, A.S. 1977. *The birds of Grafham Water, Huntingdon*. Huntingdon Local Publications Group

Cooke, A.S. 1980. Observation on how close certain passerine species will tolerate an approaching human in rural and suburban areas. *Biological Conservation* 18: 85-88

Cooke, A.S. 1985. *Effects of Water Skiing upon Waterfowl*. Unpub. submission to the Bedfordshire and Huntingdonshire Naturalists Trust

Cooke, A.S. 1987. Disturbance by anglers of birds at Grafham Water. Pp. 15-22. In: Maitland & Turner (eds.) 1987. *Angling and Wildlife in Fresh Waters* ITE Symposium No. 9, ITE, Merlewood

Cowx, I.G. & Welcomme, R.L. 1998. *Rehabilitation of Rivers for Fish. A study undertaken by the European Inland Fisheries Advisory Commission of FAO*. Fishing News Books

Cranswick, P.A. 1995. *A Late Summer Survey of Wildfowl in Great Britain, 1993*. Report to the Joint Nature Conservation Committee, The Wildfowl & Wetlands Trust, Slimbridge

Cranswick, P.A., Waters, R.J., Evans, J., & Pollitt, M.S. 1996. *The Wetland Bird Survey 1994-95: Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge

Cranswick, P.A., Waters, R.J., Musgrove, A.J. & Pollitt, M.S. 1997. *The Wetland Bird Survey 1995-96: Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge

Cranswick, P., Pollitt, M., Musgrove, A. & Hughes, R. 1999. The Wetland Bird Survey 1997-98: Wildfowl and Wader Counts. BTO/WWT/RSPB/JNCC, Slimbridge

Cromie, R.L., Brown, M.J., Hughes, B. & Williams, G.M. 2002. *Prevalence of lead shot pellets in Mallard purchased from game dealers in England in wionter 2001/2002*. Unpubl. Rep to the RSPB. WWT, Slimbridge.

Cryer, M. & Edwards, R. W. 1987a. The impact of angler groundbait on benthic invertebrates and sediment respiration in a shallow eutrophic reservoir. *Environmental Pollution* 46: 137-150

Cryer, M. & Edwards, R. W., 1987b. Angling litter. In: Maitland, P. S. & Turner, A. (eds.). *Angling and wildlife in freshwaters*. NERC 1987

Cryer, M., Linley, N.W., Ward, R.M.,Stratford, J.O. & Anderson, P.F. 1987. Disturbance of overwintering wildfowl by anglers at two reservoirs in South Wales. *Bird Study* 34: 191-199.

Dahl, T.E. 1990. *Wetland losses in the United States, 1780s to 1980s*. U.S. Fish and Wildlife Service report, Washington D.C.

Dahlgren, R.B. & Korschgen, C.E. 1992. *Human disturbances of waterfowl: An annotated bibliography*. Resource Publication188. USDI Fish &Wildlife Service, Washington D.C.

Dannell, K. & Sjoberg, K. 1982. Seasonal and diet changes in the feeding behaviour of some dabbling duck species on a breeding lake in northern Sweden. *Ornis Scandinavica* 13: 129-134

Dartington Amenity Research Trust. 1973. *Rickmansworth Gravel Pits*. Sports Council No.4. The Sports Council, London

Davidson, N.C., Laffoley, D. d'A., Doody, J.P., Way, L.S., Gordon, J., Key, R., Drake, C.M., Pienkowski, M.W., Mitchell, R. & Duff, K.L. 1991. *Nature conservation and estuaries in Great Britain*. Nature Conservancy Council, Peterborough

Davidson, N.C. & Piersma, T. 1992. The migration of knots: conservation needs and implications. *Wader Study Group Bull*. 64, Suppl.: 198-209

Davidson, N. & Rothwell, P. 1993. Disturbance to waterfowl on estuaries. *Wader Study Group Bulletin* 68. Special Issue

Davidson, N.C., Rothwell, P.I. & Pienkowski, M.W. 1995. Towards a flyway conservation strategy for waders. *Wader Study Group Bulletin* 77: 70-81

Davidson, N.C. & Stroud, D.A. 1996. Conserving international coastal habitat networks on migratory waterfowl flyways. *Journal of Coastal Conservation* 2: 41-54

Davis, T.J. (ed.). 1994. *The Ramsar Convention Manual: A Guide to the Convention on Wetlands of International Importance especially as Waterfowl Habitat*. Ramsar Convention Bureau, Gland, Switzerland

Delany, S. &Scott, D.A. (eds) 2002. *Waterbird Population Estimates Third Edition*. Wetlands International Global Series no 12. Wageningen, The Netherlands

Delany, S.N., Greenwood, J.J.D., & Kirby, J.S. 1992. *National Mute Swan survey 1990*. Report to WWT/BTO. 26pp.

Department of Environment 1991. *Sport and Recreation*. Planning Policy Guidance Note 17. HMSO, London.

Department of Environment, Food and Rural Affairs 2003. *A biodiversity strategy for England. Measuring progress: baseline assessment*. DEFRA, Bristol

Department of Environment, Transport and the Regions 1999. *Quality of Life Counts: Indicators for a strategy for sustainable development for the United Kingdom*. HMSO, London

Department of Environment, Transport and the Regions 2000. *Waterways for tomorrow*. DETR, London.

Desgranges, J-L. & Rodrique, J. 1986. Influence of acidity and competition with the fish on the development of ducklings in Quebec. *Water, Air and Soil Pollution* 30: 743-750

Dodman, T., de Vaan, C., Hubert, E. & Nivet, C. 1997. *African Waterfowl Census 1997*. Wetlands International, Wageningen, The Netherlands

Duebbert, H.F. & Kantrud, H.A. 1974. Upland duck nesting related to land use and predator reduction. *Journal of Wildlife Management* 38: 257-265.

Duebbert, H.F. & Lokemoen, J.T. 1980. High duck nesting success in a predator reduced environment. *Journal of Wildlife Management* 44: 428-437

Dzubin, A. 1984. *A partially annotated bibliography of disturbance, noise and harassment effects on birds*. Canadian Wildlife Service, Saskatoon. 337pp.

Eadie, J. M. & Keast, A. 1982. Do Goldeneye and Perch compete for food? *Oecologia* 55: 225-230.

Ebbinge, B.S. 1991. The impact of hunting on mortality rates and spatial distribution of geese wintering in the Western Palearctic. *Ardea* 79: 197-204

EC COM. 1995. *Wise use and conservation of wetlands*. Communication from the Commission to the Council and the European Parliament. Com(95) 189 final. Commission of the European Communities, Brussels

Eddington, J.M. & Eddington, M.A. 1986. *Ecology, Recreation and Tourism*. Cambridge University Press, New York. 198pp.

Edwards, R.W. 1990. The impact of angling on conservation and water quality. *Proceedings of the Institute of Fisheries Management 21st Anniversary Conference*. pp 41-50

Elson, M.J., Heaney, D., Reynolds, G. & Sidaway, R. 1995. *Good practice in the planning and management of sport and active recreation in the countryside*. A report for the Countryside Commission and the Sports Council

Environment Agency. 1996. *Buyer Beware: Your Guide to Stocking Fish* EA, Bristol

English Nature/BASC. 1995. *Guidelines for the provision of refuges for waterfowl. Version 2*. English Nature, Peterborough

English Nature 2000. *Position Statement: Countryside Recreation*. EN, Peterborough.

Eriksson, M.O.G. 1978. Lake selection by Goldeneye ducklings in relation to the abundance of food. *Wildfowl* 29:81-85

Eriksson, M.O.G. 1979. Competition between freshwater fish and Goldeneye *Bucephala clangula L.* for common prey. *Oecologia* 41: 99-107

Eriksson, M.O.G. 1983. The role of fish in the selection of lakes by non-piscivorous ducks: Mallard, Teal and Goldeneye. *Wildfowl* 34: 27-32

Eriksson, M.O.G. 1984. Acidifiation of lakes. *Ambio* 3: 260-262

Evans. R.A. 1989. Response of limnetic insect populations of two acidic fishless lakes to liming and brook trout (*Salvelinus fontinalis*). *Canadian Journal of Fisheries and Aquatic Sciences* 46: 342-351

Evans, P.R., Goss-Custard, J.D. & Hale, W.G. (Eds.). 1984. *Coastal Waders and Wildfowl in Winter*. Cambridge University Press

Fabricius, E., Bylin, A., Ferno, A. & Radesater, T. 1974. Intra- and interspecific territorialism in mixed colonies of the Canada Goose *Branta canadensis* and the Greylag Goose *Anser anser*. *Ornis Scandinavica* 5: 25-35

Fennell, H., James, D.B. & Morris, J. 1974. Pollution of a storage reservoir by roosting gulls. Water Treatment and Examination 23: 5-20

Finlayson, C.M., Hollis, G.E. & Davis, T.J. (eds.) 1992. Managing Mediterranean Wetlands and Their Birds. *IWRB Special Publication 20*, Slimbridge, UK. 285 pp.

Finlayson, M. & Moser, M. 1991. *Wetlands. Facts On File*, Oxford & New York

Forbes, I.J. 1986. The quantity of lead shot, nylon fishing line and other litter discarded at a coarse fishing lake. *Biological Conservation* 38: 21-34

Forman, B. 1968. *Recreation in the countryside, impacts and opportunites*. Society for the Protection of Nature Reserves Handbook.

Fowler, S.L. 1992. *Survey of bait collection in Britain*. Joint Nature Conservation Committee Report No. 107.

Fox, A.D., Jones, A., Singleton, R. & Agnew, A.D.Q. 1994. Food supply and the effects of recreational disturbance on the abundance and distribution of wintering Pochard on a gravel pit complex in southern Britain. *Hydrobiologia* 279/280: 253-261

Fox, A.D. & Madsen, J. 1997. Behavioural and distributional effects of hunting disturbance: implications for refuge design. *Journal of Applied Ecology* 34: 1-13

Frazier, S. 1996. *An overview of the world's Ramsar sites*. Wetlands International Publication No. 39.

Frederick, R.B., Clark, W.H. & Kaas, E.E. 1987. Behaviour, energetics & management of refuging waterfowl: a simulation model. *Wildlife Monograph* 96:35

Frikke, J. & Laursen, K. 1994. Forlandsjagt I Vadehavet. Med en analyse af betydningen for andefugle. Danmarks Miljoundersogelser. *Faglig Rapport fra DMU*, No. 102

Furness, R.W. 1973. Roost site selection by waders. *Scottish Birds* 7: 281-287

Game Conservancy. 1981. *Wildfowl Management on inland waters*. pp108, Game Conservancy Trust, Fordingbridge.

Game Conservancy Trust. 1995. *The Impact of Hunting Disturbance on the Dynamics of Waterbird Populations: A Review*. A Critique by the Biometrics Department of the Game Conservancy Trust. Report to FACE. The Game Conservancy Trust, Fordingbridge

Gardarsson, A. & Einarsson, A. 1994. Responses of breeding duck populations to changes in food supply.In: Kerekes, J.J. (Ed.). *Aquatic Birds in the Trophic Web of Lakes Developments in Hydrobiology 96*. Kluwer Academic Publishers, Dordrecht. pp 15-28

Gawn, P. 1983. Landscape planning for wildlife in conjunction with recreational activity and other land uses in gravel quarries. In: *The proceedings of a symposium on the subject of Wildlife on Man-Made Wetlands*. ARC Wildfowl Centre, Great Linford, Milton Keynes. pp164-175

Gerdes, K. & Reepmayer, H. 1983. Zur raumlichen Verteilung uberwinternder Saatund Blessganse (*Anser fabilis* und *Anser albifrons*) in Abhangigkeit von naturschutzschadlichen und fordernden Einflussen. *Die Vogelwelt* 104: 141-153

Gerhard, M. 1994. Ursachen und kurzfristige Auswirkungen von Storungen auf den Wasservogelbestand des Biebersteiner Weihers. *Charadrius* 30: 70-76

Gibbons, D.W., Reid, J.B., & Chapman, R.A. 1993. *The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991*. BTO/ SOC/IWC. T. & A.D. Poyser, London

Gilbert, G., Gibbons, D.W. & Evans, J. 1998. *Bird Monitoring Methods. A Manual of Techniques for Key UK Species*. RSPB, Sandy

Giles, N. in press. *Feeding relationships between waterfowl and fish*. IWRB Special Publication. IWRB, Slimbridge, UK

Giles, N. 1990. Effects of increasing larval chironomid densities on the underwater feeding success of downy Tufted ducklings Aythya fuligula. *Wildfowl* 41: 99-106

Giles, N. 1992. *Wildlife After Gravel*. Game Consevancy Ltd, Hampshire. pp140

Giles, N. 1993. Tufted duck *Aythya fuligula* habitat use and brood survival increases after fish removal from gravel pit lakes. In: Kerekes, J.J. (Ed.). *Aquatic Birds in the Trophic Web of Lakes Developments in Hydrobiology* 96. Kluwer Academic Publishers, Dordrecht

Giles, N. 1998. *Freshwater Fisheries & Wildlife Conservation. A Good Practice Guide.* Environment Agency. 38 pp.

Giles, N., Street, M. & Wright, R.M. 1990. Diet composition and prey preference of Tench *Tinca tinca* L., Common Bream *Abramis brama* L., Perch *Perca fluviatilis* L. and Roach *Rutilus rutilus* L. in two contrasting gravel pit lakes. *Journal of Fish Biology* 37: 945-957

Giles, N. & Summers, D. W. 1996. *Helping fish in lowland rivers.* Game Conservancy Trust, Fordingbridge, England. pp 40

Gill, J.A., Sutherland, W.J. & Norris, K. 1998. The consequences of human disturbance for estuarine birds. RSPB *Conservation Review* 12: 67-72

Gill, J.A., Sutherland, W.J. & Watkinson, A.R. 1996. A method to quantify the effects of human disturbance on animal populations. *Journal of Applied Ecology* 33: 786-792

Gillespie, G.D. 1985. Hybridization, introgression and morphometric differentiation between Mallard *Anas platyrhynchos* and Grey Duck *Anas superciliosa* in Otago, New Zealand. *Auk* 102: 459-469.

Gilpin, A. 1995. *Environmental impact assessment: cutting edge for the 21st Century.* Cambridge University Press, Cambridge, UK

Ginn, H.B. & Melville, D.S. 1983. *Moult in Birds.* BTO Guide 19. British Trust for Ornithology, Tring

Giroux, J.F. 1981. Ducks nesting in association with Canada Geese. *Journal of Wildlife Management* 45: 778-782

Giroux, J.-F. & Patterson, I.J. 1995. Daily movements and habitat use by radio-tagged Pink-footed Geese *Anser brachyrhynchus* wintering in north-east Scotland. *Wildfowl* 46: 31-44

Gomes, R. 1981. *The effect of wildfowling on the waterfowl at Gayton Sands, 1980-1981.* Unpublished report, RSPB, Sandy

Gomes, R. 1982. *The effect of wildfowling on the waterfowl at Gayton Sands, 1981-1982.* Unpublished report, RSPB, Sandy

Goode, D.A. 1981. *Lead poisoning in Swans.* Report of the Nature Conservancy Council's Working Group. Nature Conservancy Council

Goransson, G. & Karlsson, J. 1976. Storningseffekter pa djur - med exempel fran gasjakten I Skane. *Anser* 15: 119-124

Goss-Custard, J.D. 1985. Foraging behaviour of wading birds and the carrying capacity of estuaries. pp 169-188. In: Sibly, R.M. & Smithy, R.H. (eds.) *Behavioural Ecology: Ecological Consequences of Adaptive Behaviour.* Oxford. Blackwell Scientific Publications

Goss-Custard, J.D. 1993. The effect of migration and scale on the study of bird populations. 1991 Witherby Lecture. *Bird Study* 40: 81-96

Goss-Custard, J.D. & Verboven, N. 1993. Disturbance and feeding shorebirds on the Exe Estuary. *Wader Study Group Bulletin* 68: 59-66

Goss-Custard, J.D., Caldow, R.W.G., Clarke, R.T., Le V Dit Durell, S.E.A., Urfi, J. & West, A.D. 1995a. Consequences of habitat loss and change to populations of wintering migratory birds: predicting the local and global effects from studies of individuals. *Ibis* 137: 56-66.

Goss-Custard, J.D., Clarke, R.T., Briggs, K.B., Ens, B.J., Exo, K-M., Smit, C., Beintema, A.J., Caldow, R.W.G., Catt, D.C., Clark, N., Le V Dit Durell, S.E.A., Harris, M.P., Hulscher, J.B., Meininger, P.L., Picozzi, N., Prys-Jones, R., Safriel, U. & West, A.D. 1995b. Population consequences of winter habitat loss in a migratory shorebird. I. Estimating model parameters. *Journal of Applied Ecology* 32: 320-336

Gough, R.E. 1984. Laboratory-confirmed outbreaks of duck virus enteritis (duck plague) in the United Kingdom from 1977 to 1982. *Veterinary Record* March 17: 262-265.

Gough, R.E. & Alexander, D.J. 1990. Duck virus enteritis in Great Britain, 1980 to 1989. *Veterinary Record* June 16: 595-597

Greenwood, R.J. 1986. Influence of Striped Skunk removal on upland duck nesting success in North Dakota. *Wildlife Society Bulletin* 14: 6-11

Gregory, R.D., Eaton, M.A., Noble, D.G., Robinson, J.A., Parsons, M., Baker, H., Austin, G. & Hilton, G.M. 2003. *The state of the UK's Birds 2002.* RSPB, BTO, WWT & JNCC, Sandy.

Greig, J.C. 1980. Duck hybridization: a threat to species integrity. *Bockmakierie* 32: 88-89

Grice, P. 1990. *The effect of sailing on the Tufted Duck of the Mid-Colne Valley SSSI.* MSc thesis, University College, London

Grice, P. 1993. Recreational disturbance on inland waters: assessing and reducing the effects on waterbirds. Information note from *Species Conservation Handbook.* English Nature, Peterborough

Gromadzki, M. & Gromadzka, J. (eds.) 1997. Cormorants in Europe. *Polish Journal of Ecology* XLV 1-334

Haddon, M. 1984. A re-analysis of hybridization between Mallards and Grey Ducks in New Zealand. *Auk* 101:190-191

Hagemeijer, W.J.M. & Blair, M. (eds.). 1997. *The EBCC Atlas of European Breeding Birds. Their distribution and abundance.* T & AD Poyser, London

Haland, A. 1983. Home range use and spacing in *Mallard Anas platyrynchos. Ornis Scandinavica.* 14: 24-35

Ham, S.H. 1992. Environmental interpretation: a practical guide for people with big ideas and small budgets

Hand, J.L. 1980. Human disturbance in western gull *Larus occidentalis livens* colonies and possible amplification by intraspecific predation. *Biological Conservation* 18: 59-64

Hanson M. A & Butler M. G. 1994. Responses to food web manipulation in a shallow waterfowl lake. *Hydrobiologia* 279/280: 457-466.

Harbinson, J. & Selwyn, J. 1993. *Water skiing and the environment - a literature review.* London, Sports Council

Hardman, J.R. & Cooper, D.R. 1980. Mute Swans on the Warweickshire Avon – a study of decline. *Wildfowl* 31: 29-36.

Harradine, J. 1983. Sport shooting in the United Kingdom: some facts and figures. In: Leeuwenber, F. & Hepburn, I. (eds.) *Working Group on Game Statistics.* Proceedings of 2nd meeting of IUGB. 6-7 Oct. 1982

Harris, H.J., Ladowski, J.A. & Worden, D.J. 1981. Water-quality problems and management of an urban waterfowl sanctuary. *Journal of Wildlife Management* 45: 501-507

Haslam, S. M. 1978. *River plants: the macrophyte vegetation of watercourses.* CUP, Cambridge

Hawke, C.J. & Jose, P.V. 1996. *Reedbed Management for Commercial and Wildlife Interests.* Royal Society for the Protection of Birds, Sandy, 212pp

Hawkins, P. 1991. *Environmental education and interpretation*. Peak Park Joint Planning Board

Heitmeyer, M.E., Nelson, J.W., Batt, B.D.J. & Caldwell, P.J. 1993. *Waterfowl conservation and biodiversity*. Midwest Fish & Wildlife Conference 1993, Missouri

Hendy, K. & Cragghine, D. 1996. *Restoration of riverine salmon habitats. Fisheries Technical Manual 4.* Environment Agency R&D Technical Report W144. Environment Agency, Bristol

Heredia, B., Rose, L. & Painter, M. (eds.)1996. *Globally Threatened Birds in Europe*. Council of Europe, Strasbourg

Hill, D.A. 1984a. Factors affecting nesting success in the Mallard and Tufted duck. *Ornis Scandinavica* 15: 115-122

Hill, D.A. 1984b. Population regulation in the Mallard *Anas platyrhynchos*. *Journal of Animal Ecology* 53: 191-202

Hill, D., Bloor, Pl. & Lambton, S. 1987a. *The effects of waterbased recreation on wildfowl*. Royal Society for the Protection of Birds, Sandy

Hill, D.A., Wright, R. M. & Street, M. 1987b. Survival of Mallard ducklings *Anas platyrhynchos* and competition with fish for invertebrates on a flooded gravel quarry in England. *Ibis* 129: 159-167

Hill, D., Hockin, D., Price, D., Tucker, G., & Morris, R. & Treweek, J. 1997. Bird disturbance: improving the quality and utility of disturbance research. *Journal of Applied Ecology* 34: 275-288

HMSO. 1994a. *Biodiversity. The UK Action Plan*. HMSO, London

HMSO. 1994b. *Sustainable Development. The UK Strategy*. HMSO, London

HMSO. 1995. *Biodiversity*. The UK Steering Group Report. Volumes 1 & 2. HMSO, London

Hockin, D., Ounsted, M., Gorman, M., Hill, D., Keller, V. & Barker, M.A. 1992. Examination of the effects of disturbance on birds with reference to its importance in ecological assessments. *Journal of Environmental Management* 36: 253-286

Hollis, G.E. & Jones, T.A. 1991. Europe and the Mediterranean Basin. In: Finlayson, M. & Moser, M. (eds.) *Wetlands*. IWRB, Slimbridge. Facts On File, Oxford

Holloway, S. 1996. *The Historical Atlas of Breeding Birds in Britain and Irelands: 1875-1900*. T. & A.D. Poyser, London

Holmes, J.S. & Clement, P. 1996. *Fish-eating birds: proceedings of a seminar to review status, interactions with fisheries and licensing issues*. UK Nature Conservation No. 15. JNCC, Peterborough

Hruska V. 1961. An attempt at a direct investigation of the influence of the Carp stock on the bottom fauna of two ponds. *Verh. Internat. Verein. Limnol.*, XIV, 732-736 119

Hughes, B. & Grussu, M. 1995. The ruddy duck in Europe and the threat to the White-headed Duck. *Britain's Birds in 1991-92*: 17-19

Hughes, B., Bevan, R.M., Bowler, J.M., Still, L., Carss, D.N., Marquiss, M., Hearn, R.D. & Bruce, J.H. 1999. *Feeding behaviour of fish-eating birds in Great Britain*. Wetlands Advisory Service/Institute of Terrestrial Ecology report to DETR. DETR, London

Huggett, D. 1992. *Foreshore Fishing for Shellfish and Bait*. Royal Society for the Protection of Birds, Sandy.

Huggett, D. 1995. *A review of Coastal Zone Management powers. A response to the Department of the Environment's review of byelaw making powers in the coastal zone*. Royal Society for the Protection of Birds, Sandy. 76pp.

Hurlbert, S. H., Loayza ,W. & Moreno, T. 1986. Fish-Flamingo-plankton interactions in the Peruvian Andes. *Limnol. & Oceanog*. 313: 457-468

Hume, R.A. 1976. Reactions of goldeneyes to boating. *British Birds* 69: 178-179

International Union for the Conservation of Nature. 1992. *Global Biodiversity. Status of the Earth's Living Resources*. Chapman & Hall (Kluwer). 614 pp.

Iversen, F.M. 1986. The impact of disturbance on the Lapwing's incubation. *Dansk Orn. Foren. Tidsskr.* 80: 97-102

IWAAC. 1983. *Water ecology and the design of recreational water craft*. Inland Waterways Amenity Advisory Council, British Waterways Board

Jakobsen, B. 1988. Skumringsjagten pa Skallingen. Naturpejlinger (ed. H. Meltofte), pp. 162-166. *Skov-of Naturstyrelsen*, Miljoministeriet, Denmark

Jakobsen, B. 1993. Indvirker jagt pa fuglebestandes traektider? *Var Fuglefauna Suppl*. 1: 62-64

James, T.J. 1992. The ecological approach to gravel pit restoration. *Mineral Planning* 53: 16-21

Jettka, H. 1986. Jagdstreckenauswertung der Stockenten (*Anas platyrhynchos*) in einem Revier des Munsterlandes in Nordrhein-Westfalen. *Zeitsschrift fur Jagdwissenschaft* 32: 90-96

Joensen, A.H. & Madsen, J. 1985. Waterfowl and raptors wintering in wetlands of western Greece, 1983-85. *Natura Jutlandica* 21: 169-200

Jones, T.A. 1989. *Shelduck in the Severn Estuary, May-August 1989*. Unpublished report, The Wildfowl & Wetlands Trust

Jungius, H. & Hirsch, U. 1979. Herzfrequenmzanderungen bei Brutvoglen in Galapagos als Folge von Storungen durch Besucher. *Journal of Ornithology* 120: 299-310

Kadlec, J.A. 1979. Nitrogen and phosphorus dynamics in inland freshwater wetlands. Pp. 17-41. In: Bookhout, T.A. (ed.). *Waterfowl and Wetlands - An Integrated Review*. La Cross Printing, Wisconsin

Kadlec, J.A. & Smith, L.M. 1992. Habitat management for breeding areas. In: Batt, B.D., Afton, A.D., Anderson, M.G., Davison-Ankney, C., Johnson, D.H., Kadlec, J.A. & Krapu, G.L. (eds). *Ecology and management of breeding waterfowl*. University of Minnesota Press, Minneapolis and London. pp. 590-610

Keller, V. 1989. Variations in the response of Great Crested Grebes *Podiceps cristatus* to human disturbance - a sign of adaptation? *Biological Conservation* 49:31-45

Keller, V. 1991a. Effects of human disturbance on Eider ducklings *Somateria mollissima* in an estuarine habitat in Scotland. *Biological Conservation* 58: 213-228

Keller, V. 1991b. The effect of disturbance from roads on the distribution of feeding sites of geese wintering in north-east Scotland. *Ardea* 79:229-232

Keller, V. 1995. Effects of human disturbance on birds - a literature review. *Der Ornithologische Beobachter* 92:3-38
Keller, V. 1996. Effects and management of disturbance by human recreational activities. In: Birkan, M., Vessem, J. van, Havet, P., Madsen, J., Trolliet, B. & Moser, M. (Eds.) Proceedings of the Anatidae 2000 Conference, Strasbourg, France, 5-9 December 1994. *Gibier Faune Sauvage, Game Wildlife* 13: 1039-1048
Keller, V.E., Gallo-Orsi, U., Patterson, I.J. & Naef-Beanzer, B. 1998. Feeding areas used by individual Pink-footed Geese around the Loch of Strathbeg, north-east Scotland. *Wildfowl* 48: 52-64
Kershaw, M. & Cranswick, P.A. 2003. Numbers of wintering waterbirds in Great Britain 1994/95 – 1998/99: I Wildfowl and selected waterbirds. *Biological Conservation* 111(1) 91-104
King, D. R. & Hunt, G. S. 1967. Effect of carp on vegetation in a Lake Erie Marsh. *Journal of Wildlife Management* 31: 181-188.
Kirby, J.S. 1995a. Winter populatio estimates for selected waterfowl species in Britain. *Biological Conservation* 73: 189-198
Kirby, J.S. 1995b. Distribution and dynamics of wintering waders in Britain with particular reference to weather. PhD thesis, Open University
Kirby, J.S., Austin, G.E., Rowcliffe, J.M., Pettifor, R.A. & Clark, N.A. 1996. *Population dynamics of Canada Geese in Great Britain and implications for future management.* Report to the Department of the Environment, The Wildfowl & Wetlands Trust/British Trust for Ornithology
Kirby, J., Clee, C. & Seager, V. 1993. Impact and extent of recreational disturbance to wader roosts on the Dee Estuary: some preliminary results. In: Davidson, N. & Rothwell, P. (eds.). Disturbance to Waterfowl on Estuaries. *Wader Study Group Bulletin* 68, Special Issue
Kirby, J.S., Delany, S. & Quinn, J.L. 1994. Mute Swans in Great Britain: a review, current status and long-term trends. *Hydrobiologia* 279/280: 467-482
Kirby, J.S., Holmes, J.S. & Sellers, R.M. 1996. Cormorants as fish predators: an appraisal of their conservation and management in Great Britain. *Biological Conservation* 75: 191-199
Kirby, J.S. & Lack, P.C. 1993. Spatial dynamics of wintering Lapwings and Golden Plovers in Britain and Ireland, 1981-82 to 1983-84. *Bird Study* 40: 38-50
Kirby, J.S., Salmon, D.G., Atkinson-Willes, G.L. & Cranswick, P.A. 1995. Index numbers for waterfowl populations. III. Long-term trends in the abundance of wintering wildfowl in Great Britain, 1966/67 to 1991/92. *Journal of Applied Ecology* 32: 536-551
Klein, M.L. 1993. Waterbird behavioural responses to human disturbances. *Wildlife Society Bulletin* 21: 31-39.
Koolhaas, A., Dekinga, A. & Piersma, T. 1993. Disturbance of foraging Knots by aircraft in the Dutch Wadden Sea in August-October 1992. *Wader Study Group Bulletin* 68: 20-22.
Korschgen, C.E. & Dahlgren, R.B. 1992. Human disturbances of waterfowl: causes, effects and management. In: Cross, D.H. (Ed.). *Waterfowl Management Handbook.* USDI Fish Wildlife Service La Crosse, WI, USA
Krapu, G. L. 1979. *Nutrition of female dabbling ducks during reproduction.* Proc. 1977 Symp. Madison, WI, NC Sec, The Wildlife Society.
Krementz, D.G., Conroy, M.J., Hines, J.E. & Percival, H.F. 1988. The effects of hunting on survival of American Black Ducks. *Journal of Wildlife Management* 52: 214-226
Lamarra, V. A. 1975. Digestive activities of Carp as a major contributor to the nutrient loading of lakes. *Verh. Internat. Verein Limnol.* 19: 2461-68
Land Use Consultants. 1994. *Impact of recreation on wildlife.* R&D Project 498. National Rivers Authority. 80pp.
Lane, B. & Parish, D. 1991. *Action Plan for the Asian/Australian Flyway. A component of the Asia-Pacific Waterbird Strategy.* www.wetlands.org/IWC/awc/waterbirdstrategy/
Laws, A.R. 1997. Waterfowl hunting and coastal zone management in the United Kingdom. *Gibier Faune Sauvage, Game Wildl.* 14: 237-244
Laws, T. & Lecocq, Y. 1996. The contribution of European hunting organisations in Anatidae conservation. In: Proceedings of the Anatidae 2000 Conference, Strasbourg, France, 5-9 December 1994, M. Birkan, J. van Vessem, P. Havet, J. Madsen, B. Trolliet & M. Moser, Eds. *Gibier Faune Sauvage, Game Wildl.*, 13: 1257-1260
Levenson, H. & Koplin, J.R. 1984. Effects of human activity on productivity of nesting ospreys. *Journal of Wildlife Management* 48: 1374-1377
Lewis, G. & Williams, G. 1984. *Rivers and Wildlife Handbook.* RSPB/RSNC, Lincoln
Liddle, M.J. & Scorgie, H.R. 1980. The effects of recreation on freshwater plants and animals - a review. *Biological Conservation* 17: 183-206
Little, B. & Furness, R.W. 1985. Long-distance moult migration by British Goosanders *Mergus merganser. Ringing & Migration* 6: 77-82
Lloyd-Griffith, R. G. 1975. *The ecological consequences of ground-baiting in the lentic waters of a gravel pit at Bradeslorton with particular reference to its effect on the distribution of the benthic invertebrate fauna.* Unpublished Ph. D. thesis University of Hull
Lopez, A. & Mundkur, T. (eds.). 1997. *The Asian Waterfowl Census 1994-1996.* Results of the Coordinated Waterbird Census and an Overview of the Status of Wetlands in Asia. Wetlands International, Kuala Lumpur.
Lundin, A. 1986. Tamnarens utveckling som fagelsjo efter 1977 ars reglering. *Faglar i Uppland* 13: 107-124.
Madsen, J. 1985. Impact of disturbance on field utilisation of Pink-footed Geese in west Jutland, Denmark. *Biological Conservation* 33: 53-63
Madsen, J. 1988. Autumn feeding ecology of herbivorous wildfowl in the Danish Wadden Sea and impact of food supplies and shooting on movements. *Danish Review of Game Biology* 13
Madsen, J. 1995. Impacts of disturbance on migratory waterfowl. *Ibis* 137: 67-74

Madsen, J. 1998a. Experimental refuges for migratory waterfowl in Danish wetlands. I. Baseline assessment of the disturbance effects of recreational activities. *Journal Applied Ecology* 35: 386-397

Madsen, J. 1998b. Experimental refuges for migratory waterfowl in Danish wetlands. II. Tests of hunting disturbance effects. *Journal Applied Ecology* 35: 398-417

Madsen, J., Bogebjerg, E., Hounisen, J.P., Kristensen, J.B. & Frikke, J. 1992. Forsogsreservat Ulvshale-Nyord: Resultater af eksperimenter 1989-91. *Danmarks Miljoundersogeser Faglig Rapport* 55: 1-61

Madsen, J. & Jepsen, P.U. 1992. Passing the buck: need for a flyway management plan for the Svalbard Pink-footed Goose. Pp. 109-110. In: van Roomen, M. & Madsen, J. (eds.). *Waterfowl and Agriculture: Review and Future Prospects of the Crop Damage Conflict in Europe.* IWRB Special Publication 21. IWRB, Slimbridge

Madsen, J. & Pihl, S. 1993. Jagt- og forstyrrelsesfrie kerneomrader for vandfugleIDanmark. Danmarks Miljoundersogelser. *Faglig Rapport fra DMU* No. 72.

Madsen, J., Fox, A.D., Moser, M. & Noer, H. 1995. *The Impact of Hunting Disturbance on the Dynamics of Waterbird Populations: A Review.* Report prepared for the Commission of the European Communities. National Environmental Research Institute/International Waterfowl and Wetlands Research Bureau.

Madsen, J., & Fox, A. D. 1995. Impacts of hunting disturbance on waterbirds - a review. *Wildlife Biology* 1: 193-203

Madsen, J., Cracknell, G. & Fox, A.D. (eds) 1999. *Goose Populations of the Western Palearctic: A review of status and distribution.* Wetlands International publ. No. 48. NERI, Kalo, Denmark

MAFF 1999. *Code of Practice for the Safe Use of Pesticides on Farms and Holdings.* MAFF/Health & Safety Commission/ DETR.

Maher, M. 1982. Response by waterfowl to hunting pressure: a preliminary study. *Australian Wildlife Research* 9: 527-531

Maltby, E. 1991. Wetlands and their values. In: Finlayson, M. & Moser, M. (eds.) *Wetlands.* International Waterfowl and Wetlands Research Bureau, Slimbridge. Facts On File, Oxford

Manny, B. A., Johnson, W. C. & Wetzel, R. G. 1994. Nutrient additions to lakes and reservoirs: predicting their effects on productivity and water quality. In: Kerekes, J. J. (Ed.). *Aquatic Birds in the Trophic Web of Lakes Developments in Hydrobiology 96.* Kluwer Academic Publishers, Dordrecht

Marchant, J. H., Hudson, R., Carter, S. P. & Whittington, P. 1990. *Population Trends in British Breeding Birds.* British Trust for Ornithology / Nature Conservancy Council

Marquiss, M. & Carss, D.N. 1994. *Avian Piscivores: Basis for Policy.* NRA R&D Note 267. NRA, Bristol

Marquiss, M., Carss, D.M, Armstrong, J.D. & Gardiner, R. 1998. *Fish-eating Birds and Salmonids in Scotland: report on fish-eating birds research (1990-97) to the Scottish Office Agriculture, Environment and Fisheries Department.* ITE, Banchory and Freshwater Fisheries Laboratory, Pitlochry

Masman, D., Dietz, M., & Daan, S. 1986. *Partitioning of energy for moult in the Kestrel Falco tinnunculus. In: The annual cycle of the Kestrel Falco tinnunculus*, ed. D. Masman, Ph.D. Thesis, University of Groningen, The Netherlands

Master, T.L. & Oplinger, C.S. 1984. Nesting and brood rearing ecology of an urban waterfowl population (*Anas platyrhynchos* and *Branta canadensis*) in Allentown Pennsylvania. *Proceedings of the Pennsylvania Academy of Science* 58: 175-180

Mathers, R.G., Watson, S., Stone, R. & Montgomery, W.I. 2000. A study of the impact of human disturbance on Wigeon *Anas penelope* and Brent Geese *Branta bernicla hrota* on an Irish sea Loch. *Wildfowl* 51: 67-81

Mayhew, P.W. 1985. *The feeding ecology and behaviour of Wigeon.* PhD Thesis, University of Glasgow

McIntyre, J. W. 1994. Loons in freshwater lakes. In: Kerekes, J. J. (Ed.). *Aquatic Birds in the Trophic Web of Lakes: Developments in Hydrobiology 96.* Kluwer Academic Publishers, Dordrecht. Pp393-414

McQueen, D. J. 1990. Manipualting lake community structure: where do we go from here? *Freshwater Biology* 23: 613-620

Meile, P. 1991. Die Bedeutung der <<Gemeinschaftlichen Wasserjagd>> fur uberwinternde Wasservogel am Ermatinger Becken. *Orn. Beob.* 88: 27-55

Meire, P. & Kuijken, E. 1991. Factors affecting the number and distribution of wintering geese and some implications for their conservation in Flanders, Belgium. *Ardea* 79: 143-158

Meltofte, H. 1980. Shooting disturbance of waterfowl. *Dansk ornithologisk Forenings Tidsskrift* 76: 21-35

Meltofte, H. 1994. Hunting registration on Vaernengene, West Jutland, 1928-1990. *Dansk Orn. Foren. Tidsskr.* 88: 23-32

Menendez, C.T. & Bell, M.C. 1996. *The development of Carsington Water's waterbird and invertebrate populations, with recommendations on the reservoir's management for recreation.* Report to Severn Trent Water Ltd., Wetlands Advisory Service, Slimbridge

Merritt, A. 1994. *Wetlands, Industry and Wildlife. A manual of principles and pracitices.* The Wildfowl & Wetlands Trust, Slimbridge

Mikola, H. & Lind, E.A. 1974. Hailuodon sorsista ja niiden kayttaytymisesta metastyskauden alkaessa. *Soumen Riista* 25: 20-28

Mikola, J., Miettinen, M., Lehikoinen, E. & Lehtila, K. 1994. The effects of disturbance caused by boating on survival and behaviour of Velvet Scoter Melanitta fusca ducklings. *Biological Conservation* 67:119-124

Milne, J.A. 1998. *Eutrophication at the Loch of Strathbeg: a review of existing literature and data.* Unpublished report, Royal Society for the Protection of Birds, Edinburgh

Ministry of Agriculture, Fisheries and Food 1999. *Guidelines for the use of herbiocides on weeds on or near watercourses and lakes.* MAFF, London

Mintel 1998. *Activity holidays, Mintel Marketing Intelligence.* Mintel International Group Limited, London.

Mitchell, C.D. 1994. The Trumpeter Swan *(Cygnus buccinator).* In: Poole, A. & Gill, F. (eds.) *The Birds of North America,* No. 105. The Academy of Natural Sciences & The American Ornithologists' Union

Mitchell, C., Cromie, R.L. & Brown, M.J. 1993. *Mallard as potential disease vectors: a case study at Slimbridge.* JNCC Report 162. A report by The Wildfowl & Wetlands Trust to the Joint Nature Conservation Committee, Peterborough, UK

Mitchell, J.R., Moser, M.E., & Kirby, J.S. 1988. Declines in the midwinter counts of waders roosting on the Dee estuary. *Bird Study* 35: 191-198

Moller, A.P. 1992. *Svalerne.* Naturhistorisk Museum Arhus, Denmark

Mooij, J. 1991. Numbers and distribution of grey geese (genus *Anser*) in the Federal Republic of Germany, with special reference to the Lower Rhine region. *Ardea* 79: 125-134

Morris, R. 1995. *An evaluation of the ornithological component of environmental statements and impact assessments.* MSc thesis. Oxford Brookes University

Morzer-Brujns, M.F. 1967. *The influence of recreational activities on aquatic biocoenoses. In: Towards a New Relationship of Man and Nature in Temperate Lands. Part 1. Ecological impact of recreation and tourism upon temperate environments.* IUCN Publication (new series) 7, part 1

Moss, B. 1983. The Norfolk Broadland: experiments in the restoration of a complex wetland. *Biological Revues* 58: 521-561

Moss, B., Madgwick, J. & Phillips, G. 1996. *A Guide to the Restoration of Nutrient-enriched Shallow Lakes.* W.W. Hawes, UK

Mudge, G.P. 1983. The incidence and significance of lead pellet poisoning in British wildfowl. *Biol. Cons.* 27: 333-372

Mudge, G.P. 1989. *Night shooting of wildfowl in Great Britain. An assessment of its prevalence, intensity and disturbance impact.* WWT report to the Nature Conservancy Council CSD Report No. 987

Murphy, K.J. & Pearce. 1987. Habitat modification associated with freshwater angling. pp 31-46. In: Maitland, P.S. & Turner, A.K. (eds.) 1987. *Angling and Wildlife in Freshwaters.* ITE symposium No 19.

Murphy, K. J., Willby, N. J. & North, R. 1995. Ecological impacts and management of boat traffic on navigable inland waterways. In: Harper, D.M. & Ferguson, A.J. D. (eds.) *The ecological basis for river management.* Wiley & Sons, Chichester

Musgrove, A, Pollitt, M., Hall, C., Hearn, R., Holloway, S., Marshall, P., Robinson, J., & Cranswick, P. 2001. *The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts.* Slinmbridge, BTO/WWT/RSPB/JNCC.

National Trust. 1995. Open Countryside. *Report of the Access Review Working Party. Parts A-C.* The National Trust, London

NCC/RSPB. 1988. *Review of the effects of recreation on waterbirds on enclosed water bodies.* NCC Chief Scientist Directorate Commissioned Research Report No 967

Nettleship, D.N. & Duffy, D.C. 1995. The Double-crested Cormorant: Biology, Conservation and Management. *Colonial Waterbirds* 18. Special Publication 1.Colonial Waterbird Society

Newbold, C. 1975. Herbicides in aquatic systems. *Biological Conservation* 7:97-118

Nichols, J.D. 1991. Responses of North American duck populations to exploitation. In: Perrins, C.M., Lebreton, J-D. & Hirons, G.J.M. (eds.) *Bird Population Studies; Their Relevance to Conservation and Management.* Oxford University Press

Nichols, J.D., Conroy, M.J., Anderson. D.R. & Burnham, K.P. 1984. Compensatory mortality in waterfowl populations: a review of the evidence and implication for research and management. *Trans. N. Amer. Nat. Res. Conf.* 49: 535-554

Nicolle, P. 1995. Shooting ahead with coastal initiatives in the UK. Pp. 91-96. In: Healy & Doody (Eds.). *Directions in European Coastal Management.* Samara Publishing Limited, Cardigan

Nilsson, L. 1972. Local distribution, food choice and food consumption of diving ducks on a South Swedish Lake. *Oikos* 23: 82-91

Norriss, D.W. & Wilson, H.J. 1988. Disturbance and flock size changes in White Fronted Geese wintering in Ireland. *Wildfowl* 39: 63-70

Northumbrian County Council. 1999. *Managing the Berwickshire and North Northumberland Coast European Marine site. Working Draft.* Northumbrian Water, Durham.

NRA. 1994a. *Impact of recreation on wildlife.* R & D Note 498. National Rivers Authority, Leeds, UK

NRA. 1994b. *Socio-economic review of Angling.* NOP Research. R&D Report 501/1/T. National Rivers Authority, Leeds, UK

Ogilvie, M.A. 1975. *Ducks of Britain and Europe.* T. & A.D. Poyser, Berkhamsted

Owen, M. 1993. The UK shooting disturbance project. *Wader Study Group Bulletin* 68: 35-46

Owen, M., Atkinson-Willes, G.L. & Salmon, D.G. 1986. (2nd Ed.). *Wildfowl in Great Britain.* Cambridge University Press, Cambridge

Owen, M. & Black, J.M. 1990. *Waterfowl Ecology.* Blackie & Son Ltd., Glasgow & London

Owen, M. & Thomas, G.J. 1979. The feeding ecology and conservation of wigeon wintering at the Ouse Washes, England. *Journal of Applied Ecology* 16: 795-809

Owen, M. & Williams, G. 1976. Winter distribution and habitat requirements of Wigeon in Britain. *Wildfowl* 27: 83-90

Owens, N.W. 1977. Responses of wintering Brent Geese to human disturbance. *Wildfowl* 28: 5-14

Pain, D.J. 1992. Lead poisoning in waterfowl: a review. In: D.J. Pain (Ed.). *Lead poisoning in waterfowl.* Proceedings of the International Waterfowl and Wetlands Research Bureau Workshop, Brussels, Belgium. IWRB Special Publication 16. Slimbridge, UK

Pamplin, W.L. 1986. Cooperative efforts to halt population declines of geese nesting on Alaska's Yukon-Kuskokwim Delta. *Trans. N. Amer. Wildl. & Nat. Resour. Conf.* 51: 487-506

Parr, D. 1974 The effect on wildfowl of sailing at Island Barn Reservoir. *Surrey Bird Report* 1973: 74-78

Paton, J.B., Storr, R., Delroy, L. & Best, L. 1992. Patterns to the distribution and abundance of Mallards, Pacific Black Ducks and their hybrids in South Australia in 1987. *South Australian Ornithology* 31:103-110

Patterson, I.J. 1997. Input of nutrients to the St. Fergus Winter Loch by roosting birds. Pp. 15-20. In: Ritchie, W. & Kingham, L. (eds.) *The St. Fergus Coastal Environment: Monitoring and Assessment of the Coastal Dunes at the North Sea Gas Terminals, St. Fergus.* Aberdeen University Research & Industrial Services Ltd, Abredeen.

Patterson, I.J., Cosgrove, P. & Doyle, P. 1996. *Water quality and input of nutrients in winter by roosting birds at the Winter Loch, St. Fergus, winter 1995/96.* Unpublished report, Aberdeen University

Pedroli, J.-C. 1982. Activity and time budget of Tufted Ducks on Swiss lakes during winter. *Wildfowl* 33: 105-112

Pehrsson, O. 1974. Nutrition of small ducklings regulating breeding and area reproductive output in the Long-tailed Duck Clangula hyemalis. *Proceedings of 11th International Congress of Game Biologists, Stockholm,* VII, 259-64

Pehrsson, O. 1982. An experimental study of egg and duckling size and subsequent survival and growth rate as a result of food quality of laying Mallards. *Trans. Intern. Cong. Game Biol.* 14:193-202

Pehrsson, O.1988. Produktion av elstrom eller fagelfoda I den framtida Hornborgasjon ? *Var Fagelvarld* 47:252-262. (English summary)

Percival, S. M., Anderson, G. Q. A., Davey, P. R. & Percival, T. 1996. *Trends in wildfowl numbers and hunting activity at Lindisfarne, NE England.* Unpublished manuscript, University of Sunderland,.

Per-Olov, J. 1993. *Cost-benefit analysis of environmental change.* Cambridge University Press, Cambridge, UK

Phillips, V. E. 1991. Pochard use of chironomid-rich feeding habitat in winter. *Bird Study* 38:118-122.

Pienkowski, M.W. 1983. The impact of tourism on coastal breeding shorebirds in western and southern Europe: an introduction to general discussion. In: *Shorebirds and Large Waterbirds Conservation.* Commission of the European Community, Brussels.

Pienkowski, M.W. 1993. The impact of tourism on coastal breeding waders in western and southern Europe: an overview. *Wader Study Group Bulletin* 68: 92-96

Pienkowski, M.W. & Pienkowski, A. 1983. WSG project on the movement of wader populations in western Europe, eight progress report. *Wader Study Group Bulletin* 38: 13-22

Pierce, G.J., Spray, C.J. & Stuart, E. 1993. The effect of fishing on the distribution and behaviour of waterbirds in the Kukut area of Lake Sonkla, southerm Thailand. *Biol. Cons.* 66: 23-34.

Pierce, H.G. 1989. Water skiing and the environment. Proc. World Water Skiing Union. 4[th] Seminar on European Water Skiing, Athens, Greece

Piersma, T. 1987a. Population turnover in groups of wing-moulting waterbirds: the use of a natural marker in Great Crested Grebes. *Wildfowl* 39: 37-45

Piersma, T. 1987b. Hop, skip or jump? Constraints on migration of Arctic waders by feeding, fattening and flight speed. *Limosa* 60: 185-191

Piersma, T. R., Lindeboom, H, & Van eerden, M. R. 1993. Foraging rhythm of Great Crested Grebes *Podiceps cristatus* adjusted to diet variations in the vertical distribution of their prey *Osmerus eperlanus* in a shallow eutrophic lake in The Netherlands. *Oecologia* 76:481-486

Piersma, T., Gudmundsson, G.A., Davidson, N.C. & Morrison, R.I.G. 1996. Do Arctic-breeding Red Knots (Calidris canutus) accumulate skeletal calcium before egg-laying? *Canadian Journal of Zoology* 74: 2257-2261.

Platteeuw, M. & Henkens, R. 1998a. Waterbirds and aquatic recreation at Lake Ijsselmeer, The Netherlands: the potential for conflict. *Wildfowl* 48: 210-224

Platteeuw, M., & Henkens, R. 1998b. Possible impacts of disturbance of waterbirds: individuals, carrying capacity and populations. *Wildfowl* 48: 225-236

Pollitt, M., Cranswick, P. Musgrove, A, Hall, C., Hearn, R., Robinson, J. & Holloway, S. 2003. *The Wetland Bird Survey 2000-01 Wildfowl and Wader Counts.* Slimbridge, BTO/WWT/RSPB/JNCC.

Pollitt, M., Hall, C., , Holloway, S., Hearn, R. Marshall, P. Musgrove, A,, Robinson, J., & Cranswick, P. 2003. *The Wetland Bird Survey 1999-2000 Wildfowl and Wader Counts.* Slimbridge, BTO/WWT/RSPB/JNCC.

Prater, A.J. 1981. *Estuary birds of Britain and Ireland.* T. & A.D. Poyser, Calton

Prater, A.J. 1989. Ringed Plover *Charadrius hiaticula* breeding population of the United Kingdom in 1984. Bird Study 36: 154-159

Prevett, J.P. & MacInnes, C.D. 1980. Family and other social groups in Snow Geese. *Wildlife Monographs* 71: 1-46

Pritchard, D.E., Housden, S.D., Mudge, G.P., Galbraith, C.A. & Pienkowski, M.W. (eds.) 1992. *Important Bird Areas in the UK including the Channel Islands and the Isle of Man.* RSPB, Sandy

Ramsar Convention Bureau. 1988. *Convention on Wetlands of International Importance Especially as Waterfowl Habitat. Proceedings of the third meeting of the Conference of the Contracting Parties, Regina, Canada, 1987.* Ramsar Convention Bureau, Switzerland

Ramsar Convention Bureau. 1990. *Proceedings of the Fourth Meeting of the Conference of the Contracting Parties (Montreux).* Ramsar Convention Bureau, Gland, Switzerland

Ramsar Convention Bureau 1993. *Proceedings of the Fifth Meeting of the Conference of Contracting Parties (Kushiro).* Ramsar Convention Bureau, Gland, Switzerland

Ramsar Convention Bureau 2000. *Wetland Values and Functions.* Ramsar Convention Bureau, Glamnd, Switzerland

Ratcliffe, D.A. 1977. *A nature conservation review* Cambridge University Press, Cambridge

Raveling, D.G. 1984. Geese and hunters of Alaska's Yukon Delta: Management problems and political dilemmas. *Trans. N. Amer. Wildl. & Nat. Resour. Conf.* 49: 555-575

Rees, E.C. & Rowcliffe, J.M. 1995. *Comparative analysis of the extent to which shooting mortality is compensatory or additive in different populations and circumstances.* Report to the Joint Nature Conservation Committee, The Wildfowl & Wetlands Trust, Slimbridge

Reeves, H.M., Dill, H.H. & Hawkins, A.S. 1968. A case study in Canada Goose management: the Mississippi Valley population. In: Hine, H.L. & Schoenfeld, C. (eds.). *Canada Goose Management.* Dembar Educational Inc., Madison

Rehfisch, M.M., Clark, N.A., Langston, R.H.W. & Greenwood, J.J.D. 1996. A guide to the provision of refuges for waders: an analysis of 30 years of ringing data from the Wash, England. *Journal of Applied Ecology* 33: 673-687

Reichholf, J. 1973. Begrundung einer okologischen Strategie der Jagd auf Enten. Anz. Orn. Ges. Bayern 12: 237-247

Reitergen-McCracken, J. 1998. *Participation in practice.* World Bank, USA

Riddington, R., Hassall, M., Lane, S.J., Turner, P.A. & Walters, R. 1996. The impact of disturbance on the behaviour and energy budgets of Brent Geese *Branta b. bernicla. Bird Study* 43: 269-279

Ridgill, S.C. & Fox, A.D. 1990. *Cold weather movements of waterfowl in western Europe.* IWRB Special Publication No. 13
River Restoration Centre 1999. *Manual of River Restoration.* River Restoration Centre, Silsoe, Beds. UK
Robertson, R.J. & Flood, N.J. 1980. Effects of recreational use of shorelines on breeding bird populations. *Canadian Field Naturalist* 94:131-138
Rose, P. M. & Scott, D. A. 1994. Waterfowl Population Estimates. *IWRB Publications 29*, IWRB Slimbridge
Rose, P.M. & Scott, D.A. 1997. Waterfowl Population Estimates. Second Edition. *Wetlands International Publication 44.* Wetlands International, Wageningen
RRC 1999. *Manual of River Restoration Techniques.* www.therrc.co.uk/manual.php.
Ross, D. A. 1940. *Jackfish Investigation, 1940 Athabaska Delta, Alberta.* Ducks Unlimited Canada, Winnipeg.
RSPB/EN/ITE. 1997. *The Wet Grassland Guide: Managing Floodplain and Coastal Wet Grasslands for Wildlife.* Royal Society for the Protection of Birds, Sandy, 254pp.
RSPB/NRA/RSNC. 1994. The New Rivers and Wildlife Handbook. Royal Society for the Protection of Birds, Sandy
RSPB/BTO/WWT/JNCC 2003. *The state of the UK's birds 2002.* RSPB, Sandy,
Russell, I.C., Dare, P.J., Eaton, D.R. & Armstrong, J.D. 1996. *Assessment of the problem of fish-eating birds in inland fisheries in England and Wales.* Directorate of Fisheries Research, Lowestoft
Salathé, T. (ed.) 1991. Conserving Migratory Birds. *ICBP Technical Publ. No. 12.* International Council for Bird Preservation, Cambridge
Salmon, D.G. 1988. A late summer survey of Britain's wildfowl. *Wildfowl* 39: 155-163
Salomonsen, F. 1968. The moult migration. *Wildfowl* 19: 5-24
Salvig, J., Laursen, K. & Frikke, J. 1994. Surveys of human activities and their effects on numbers and distribution of waterfowl in the Danish Wadden Sea. *Ophelia Suppl.* 6: 333-337
Sauer, J.R., Lawrence, J.S., Carr, E.L., Cook, G.W. & Anderson, V. 1990. Experimental September duck hunting seasons in Kentucky and Tennesee. In: Fredrickson, L.H., Burger, G.V., Havera, S.D., Graber, D.A., Kirby, R.E. & Taylor, T.S. (eds.) *Proceedings of the North American Wood Duck Symposium*, St Louis, Minnesota.
Schneider-Jacoby, M., Frenzel, P., Jacoby, H., Knötzsch, G. & Kolb, K.H. 1991. The impact of hunting disturbance on a protected species, the Whooper Swan at Lake Constance. *Wildfowl Supplement* 1: 378-382
Schrike, V. 1985. Impact des activites humaines sur le stattionnement hivernal des anatides en Baie du Mont Saint-Michel. Le arrangement nocturne, *Office Nationale de la Chasse Monthly Bulletin* 92: 11-23.
Schulz, R. & Stock, M. 1993. Kentish Plovers and tourists: competitors on sandy coasts? *Wader Study Group Bulletin* 68: 83-91
Scott, D.A. & Rose, P.M. 1996. Atlas of Anatidae Populations in Africa and Western Eurasia. *Wetlands International Publication 41*
Scott, R. 1983. The management of gravel quarries for wildlife at Dungeness, Kent. In: *The proceedings of a symposium on the subject of Wildlife on Man-Made Wetlands.* ARC Wildfowl Centre, Great Linford, Milton Keynes
Seagrave, C. 1988. *Aquatic weed control.* Fishing News Books, Farnham
Sears, J. 1988. Regional and seasonal variations in the incidence of lead poisoning in the Mute Swan, *Cygnus olor*, in relation to the distribution of lead weights in the Thames area, England. *Biological Conservation* 46: 115-134
Sears, J. & Hunt, A. 1991. Lead poisoning in Mute Swans, *Cygnus olor*, in England. In: Sears, J. & Bacon, P.J. (eds.). Proc. third IWRB International Swan Symposium, Oxford 1989. *Wildfowl Supplement* 1: 383-388
Sharrock, J.T.R. 1976. *The Atlas of Breeding Birds in Britain and Ireland.* BTO, Tring
Sidaway, R. 1988. Sport, recreation and nature conservation: Conflict or Co-operation? *Sports Council Study 32*, Sports Council London
Sidaway, R. 1994. Recreation and the natural heritage: a research review. *Scottish Natural Heritage Review No. 25*
Sidaway, R.M. & Thompson, D.B.A. 1991. Upland recreation: the limits of acceptable change. *Ecos* 12: 31-39
Smit, C. & Piersma, T. 1989. Numbers, midwinter distribution and migration of wader populations using the East Atlantic Flyway. Pp 24-63 in Boyd, H. & Pirot, J-Y (eds)
Smit, C.J. & Visser, G.J.M. 1993. Effects of disturbance on *shFlyways and reserve networks for waterbirds.* IWRB Special Publication 9. IWRB, Slimbridge.*orebirds*: a summary of existing knowledge from the Dutch Wadden Sea and Delta area. Pp. 6-19. In: Davidson, N. & Rothwell, P. (eds.) Disturbance to Waterfowl On Estuaries. *Wader Study Group Bulletin 68, Special Issue*
Smith, K.W. 1983. The status and distribution of waders breeding on wet lowland grasslands in England and Wales. *Bird Study* 30: 177-192
Smith, L.M., Pederson, R.L. & Kaminski, R.M. 1989. *Habitat management for migrating and wintering waterfowl in North America.* Texas Tech. University Press, Texas
Solman, V.E.F. 1945. The ecological relations of pike, *Esox lucius*, and waterfowl. *Ecology* 26: 157-170
Sports Council. 1991. *A digest of sports statistics for the UK.* 3rd Edition
Sports Council 1992. *A countryside for Sport. A Policy for Sport and Recreation.* Sports Council, London.
Spray, C.J. 1997. Freshwater Quality: defining the indefinable? pp 389-405.In Boom, P.J.,& Howell, D.L. (eds) *Assessing the recreation value of fresh waters: the UK experience.*
Spray, C.J. & Bacon, A. 1997. A water companies' perspective. – a personal view. pp 45-52 in *Access to Water. Sharing access on rivers and reservoirs.* Countryside Recreation Network, Cardiff.
Spray, C.J. & Milne, H.. 1988. The incidence of lead poisoning among Whooper and Mute Swans *Cygnus cygnus* and *C. olor* in Scotland. *Biol. Cons.* 64: 265-281
Spray, C.J., Coleman, A.E. & Coleman, J.T. 2003. Mute Swan *Cygnus olor.* pp 146-148 in Wernham,. C.V., Toms, M.P., Marchant, J.H, Clark, J.A., Siriwardena, G.M & Baillie, S.R. (eds) *The Migration Atlas: Movements of the Birds of Britain and Ireland.*T & A.D. Poyser, London.

Stock, M. 1993. Studies on the effects of disturbance on staging Brent Geese: a progress report. *Wader Study Group Bulletin* 68: 29-34

Stone, B.H., Sears, J., Cranswick, P.A., Gregory, R.D., Gibbons, D.W., Rehfisch, M.M., Aebischer, N.J. & Reid, J.B. 1997. Population estimates of birds in Britain and in the United Kingdom. *British Birds* 90: 1-22

Stroud, D.A. 1992a. *Statutory suspension of wildfowling in severe weather: review of past winter weather and actions*. Joint Nature Conservation Committee Report No. 75

Stroud, D.A. 1992b. *Greenland White-fronted Goose conservation plan*. UK Joint Nature Conservation Committee, Peterborough.

Stroud, D.A. 1997. Proposal for international action plan and specialist network for globally threatened waders. *Wader Study Group Bulletin* 82: 34-37

Stroud, D.A. in press. Waterfowl disturbance in Europe: problems and solutions. *The Stilt* x: x-x.

Stroud, D.A., Mudge, G.P. & Pienkowski, M.W. 1990. *Protecting Internationally Important Bird Sites. A Review of the EEC Special Protection Area Network in Great Britain*. Nature Conservancy Council, Peterborough.

Sukopp, H. 1971. Effects of man, especially recreational activities, on littoral macrophytes. *Hydrobiologia* 12: 331-340

Summers, D.W., Giles, N. & Willis, D.J. 1997. *Restoration of riverine trout habitats. Fisheries Technical Manual 1*. Environment Agency R&D Technical Report W18. Environment Agency, Bristol

Swales, S. & O'Hara, K. 1983. A short-term study of the effects of a habitat improvement programme on the distribution and abundance of fish stocks in a small lowland river in Shropshire. *Fisheries Management* 14:135-144

Swennen, C., Leopold, M.F. & de Bruijn, L.L.M. 1989. Time-stressed Oystercatchers, *Haematopus ostralegus*, can increase their intake rate. *Animal Behaviour* 38: 8-22

Symonds, F.L., Langslow, D. & Pienkowski, M.W. 1984. Movements of wintering shorebirds within the Firth of Forth: species differences in usage of an intertidal complex. *Biological Conservation* 28: 187-215

Taapken, J. 1982. De surfsport en de vogels. *Vogeljaar* 30: 194-197

Talent, L. G., Krapu, G. L. & Jarvis, R. L. 1982. Habitat use by Mallard broods in South Central North Dakota. *Journal of Wildlife Management* 463: 629-635

Tamisier, A. 1974. Etho-ecological studies of Teal wintering in the Camargue (Rhone Delta, France). *Wildfowl* 25: 123-133

Tamisier, A. 1976. Diurnal activities of Green-winged Teal and Pintail wintering in Louisiana. *Wildfowl* 27: 19-32

Tamisier, A. & Saint-Gerand, T. 1981. Stationnements d'oiseaux d'eau et chasse de nuit dans les departements cotiers de France. *Alauda* 49: 81-93

Tanner, M.F. 1976. *Water resources and wetlands in England and Wales*. Proceedings of Conference on Recreation and Conservation in water areas. Royal Society for the Encouragement of Arts

Tanner, M.F. 1979. *Wildfowl, Reservoirs and Recreation*. A report to the Water Space Amenity Commission. Report No.5

Temple Lang, J. 1982. The European Community Directive on bird conservation. *Biological Conservation* 22: 11-25

Thomas, G.J. 1978. *Breeding and feeding ecology of waterfowl at the Ouse Washes, England*. PhD thesis, CNAA

Thomas, G.J. 1982. Management of vegetation at wetlands. In: Scott, D.A. *Managing wetlands and their birds*. IWRB, Slimbridge, UK

Thomas, G.J., Perrins, C.M. & Sears, J. 1987. Lead poisoning and waterfowl. In: Maitland & Turner (eds.). 1987. *Angling and Wildlife in Freshwaters*

Thomas, V.G. & Owen, M. 1995. Transition towards use of non-toxic shot in the United Kingdom. *Wildfowl* 46: 157-160

Thomas, V.G. & Pokras, M.A. 1993. International analysis of non-toxic shot adoption for waterfowling. In: Thompson, I.D. (Ed.). *Proceedings of the 21st International Union of Game Biologists' Congress, Halifax, Nova Scotia. Canadian Forest Service, Chalk River, Ontario*. Vol. 2: 35-40

Titus, J.R. & Vandruff, L.W. 1981. Response of the common loon to recreational pressure in the boundary waters canoe area, northeastern Minnesota. *Wildlife Monographs* 79: 3-59

Townshend, D.J. 1982. The Lazarus syndrome in Grey Plovers. *Wader Study Group Bulletin* 40: 51-54

Townshend, D. & O'Connor D. 1993. Some effects of disturbance to waterfowl from bait-digging and wildfowling at Lindisfarne National Nature Reserve, north-east England. In: Davidson, N. & Rothwell, P. 1993. Disturbance to waterfowl on estuaries. *Wader Study Group Bulletin* 68: 47-53

Trost, R.E. 1990. An examination of the relationship between harvest and survival rates of North American wood ducks: 1966-85. In: Fredrickson, L.H., Burger, G.V., Havera, S.D., Graber, D.A., Kirby, R.E. & Taylor, T.S. (eds.). *Proceedings of the North American Wood Duck Symposium*, St Louis, Minnesota.

Trump, D.P.C., Stone, D.A., Coombs, C.F.B. & Feare, C.J. 1994. Mute swans in the Wylye Valley: population dynamics and habitat use. International *Journal of Pest Management* 40: 88-93

Tryon, C.A. 1954. The effect of carp exclosures on growth of submerged aquatic vegetation in Pymatuning Lake, Pennsylvania. *Journal of Wildlife Management* 18: 251-254

Tucker, G.M. & Heath, M.F. 1994. *Birds in Europe: their conservation status*. BirdLife Conservation Series 3. BirdLife International, Cambridge

Tuite, C.H. 1982. *The impact of water-based recreation on the waterfowl of enclosed inland waters in Britain*. Report to the Nature conservancy Council, Wildfowl Trust, Slimbridge.

Tuite, C. H., Owen, M. & Paynter, D. 1983. Interaction between wildfowl and recreation at Llangorse Lake and Talybont Reservoir, South Wales. *Wildfowl* 34: 48-63

Tuite, C.H., Hanson, P.R. & Owen, M. 1984. Some ecological factors affecting winter wildfowl distribution on inland waters in England and Wales and the influence of water-based recreation. *Journal of Applied Ecology* 21: 41-62

Tydeman, C.F. 1977. The importance of the close fishing season to breeding bird communities. *Journal of Environmental Management* 5: 289-296

Tydeman, C.F. 1978. *Gravel Pits as conservation areas for breeding bird communities*. PhD thesis. Bedford College

UK Biodiversity Action Group 2001. *Sustaining the variety of life: 5 years of the UK Biodiversity Action Plan*. DETR, London

Underhill, M.C., Kirby, J.S., Bell, M.C. & Robinthwaite, J. 1993. *Use of waterbodies in south-west London by waterfowl. An investigation of the factors affecting distribution, abundance and community structure*. Report to Thames Water Utilities Ltd and English Nature. WWT Wetlands Advisory Service Ltd, Slimbridge

University of Brighton 2002. *Water-Based Sport and Recreation: the facts*. Report to the Department of Agriculture, Food and Rural Affairs, Brighton.

van Dam, C. & Asbirk, S. (eds.). 1997. *Cormorants and human interests*. IKC natuur beheer, Wageningen, Netherlands

van de Heiligenberg, T. 1987. Effects of mechanical and manual harvesting of lugworms Arenicola marina on the benthic fauna of tidal flats in the Dutch wadden sea. *Biological Conservation* 39: 165-178

van Eerden, M.R., Koffijberg, K. & Platteeuw, M. (eds.). 1995. Riding on the crest of a wave: possibilities and limitations for a thriving population of cormorants in man-dominated wetlands. *Ardea* 83: 1-338

van Eerden, M. R., Piersma, T. & Lindeboom, R. 1993. Competitive food exploitation of smelt Osmerus eperlanus by Great Crested Grebes *Podiceps cristatus* and perch *Perca fluviatilis* at Lake IJsselmeer, The Netherlands. *Oecologia* 93: 463-474

Varney, H. & Crookes, J.A. 1989. *The effects of recreation on wildfowl at Llangorse lake, August-September 1989*. Unpublished report

Vinicombe, K.E. 1975. *The management of recreation and conservation at Chew Valley Lake, Avon*. Unpublished thesis. University College of Swansea.

Vos, P. 1986. *The impact of shore-based recreation on the Meadow birds of the Polders next to the shores. In: IUFRO s6.01, report on the Third Intercongress Meeting 1984 in The Netherlands, Denmark and Sweden, State Forest Service in The Netherlands*, Utrech

Vos, P., Pelzer, R.H.M. & Orleans, A.B.M. 1987. Recreatie en broedvogels in heidegebieden – strabrechse en groote heide. *Bos en Recreatie* 15. Afdeling Scociologisch Onderzoek t.b.v. Bos, Natuur & Landschaop, Staatsbosbeheer, Utrecht.

Wader Study Group. 1992. The Odessa Protocol. *Wader Study Group Bull*. 65: 10-12

Ward, D. 1990. Recreation on inland lowland waterbodies: Does it affect birds? *RSPB Conservation Review* 1990. RSPB

Ward, D. & Andrews, J. 1993. Waterfowl and recreational disturbance on inland waters. *British Wildlife* 4: 221-229

Watmough, B.R. 1983a. The effects of recreation activities on wintering waterfowl. *Proceeding of a Symposium on the subject of wildlife on man-made wetlands*. ARC Wildfowl Centre, Great Linford.

Watmough, B.R. 1983b. *The effects on wildfowl of recreation at reservoirs in the mid-Trent valley*. Severn Trent Water Authority.

Welch, H. 1996. Managing Water. *Conservation techniques for lowland wetlands*. RSPB, Sandy.

Weller, M.W. 1978. Management of freshwater marshes for wildlife. In: Good, R., Whigham, D. & Simpson, R. (eds.). *Freshwater wetlands*. Academic Press, New York

Westerberg, A.E., Muirhead, L.B., Donnison, A. & Bell, M.C. 1994. *An assessment of the past and present ornithological importance of Northumbrian Water Ltd.'s reservoirs and the effects of disturbance on waterbirds with particular reference to Bakethin, Balderhead and Scaling Dam Reservoirs*. The Wildfowl & Wetlands Trust, Slimbridge

Westerberg , A.E. & Spray, C.J. 1996. *Investigating the effects of angling and other recreational activities on waterbirds at reservoirs in North-east England*. Unpublished manuscript, The Wildfowl & Wetlands Trust, Slimbridge

White, G.J.1986. KGV Reservoir. Effect of boardsailing. Unpublished report

White, P. S. & Pickett, S. T. A. 1985. Natural disturbance and patch dynamics: an introduction. p. 3-13. In: S. T. A. Pickett & P. S. White (eds) *The Ecology of Natural Disturbance and Patch Dynamics*. Academic Press, New York

White, G. 1993. *An assessment of the wetland resource of the Lee Valley Park with special reference to waterbirds*. Lee Valley Regional Park Authority, London.

White-Robinson, R. 1982. Inland and saltmarsh feeding of wintering Brent Geese in Essex. *Wildfowl* 33: 113-118

Whitmore, T.N., Ransome, M & Wolstenholme, R. 1995. *Influence of recreational use of reservoirs upon the microbiological quality of water*. Unpublished Report, Marlow, WRc PLC.

Williams, M.J. 1994. Progress in the conservation of New Zealand's threatened waterfowl. *IWRB Threatened Waterfowl Research Group Newsletter* 5:3-6. IWRB, Slimbridge, UK

Williams, M.J. & Roderick, C. 1973. Breeding performance of the Grey Duck *Anas superciliosa*, Mallard *Anas platyrhynchos* and their hybrids in captivity. *International Zoo Yearbook* 13: 2-69

Winfield, D.K. & Winfield, I.J. 1994. Possible competitive interactions between overwintering tufted duck (*Aythya fuligula*) and fish populations of Lough Neagh, Northern Ireland: evidence from diet studies. *Hydrobiologia* 279/280: 377-386.

Wolf, W.J., Reijenders, P.J.H. & Smit, C.J. 1982. The effects of recreation on the Wadden Sea ecosystem: many questions but few answers. In Luck, G. & Michaelis, H. (eds) *Schrifteenreihe M.E.L.F., Reihe A: Agnew Wissensch* 275: 85-107.

Wood, H. & Oates, R. 1999. *Leap Forward for Wildlife: promoting biodiversity through Local Environment Agency Action Plans*. RSPB, Sandy.

Wright, R. M. 1990 Aspects of the ecology of Bream *Abramis brama* L. in a gravel pit lake and the effects of reducing population density. *Journal of Fish Biology* 37: 629-634

Wright, R.M. 1991. Alternative strategies of pike *Esox lucius* management. In: *Interactions between fisheries and the environment. IFM Study Course 22*, University of Aberdeen, September 1991

Wright, R. M. & Phillips, V. E. 1992. Changes in the aquatic vegetation of two gravel pit lakes after reducing the fish population density. *Aquatic Botany* 43: 43-49

Yalden, D.W. 1992. The influence of recreational disturbance on common sandpipers Actitis hypoleuncos breeding by an upland reservoir in England. *Biological Conservation* 61: 1-49

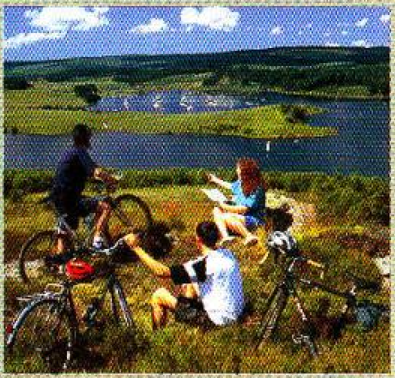
Yalden, D.W. & Yalden, P.E. 1989a. *Golden Plovers and recreational disturbance.* Contract Survey Report No. 64, Nature Conservancy Council, Edinburgh

Yalden, P.E. & Yalden, D.W. 1989b. The sensitivity of breeding Golden Plovers Pluvialis apricarius to human intruders. *Bird Study* 36: 49-55

Yalden, D.W. & Yalden, P.E. 1990. Recreational disturbance of breeding Golden Plovers *Pluvialis apricarius. Biolgoical Conservation* 51: 243-262

Zegers P. M. 1973. invloed van verstoring op het gedrag van wadvogels. *Waddenbull* 8 3:3-7

Zwarts. 1972. *Verstoring van wadvogels. Waddenbull* 7: 7-12



About WWT

The Wildfowl & Wetlands Trust (WWT) manages nine wetland visitor centres around the UK, including award-winning developments at Slimbridge and in London. With partnerships all around the world and vital ecological, conservation and research achievements to its credit, WWT is now the largest UK charity dedicated to saving wetlands and their wildlife on an international scale.

WWT has over 100,000 members and achieves its mission, to conserve wetlands and their biodiversity, by carrying out and promoting direct species and habitat conservation action, raising awareness of wetlands and wetland issues amongst key policy makers, organisations and the public in general and carrying out sound research, principally on waterbirds and their habitats, as a means of supporting all WWT's conservation works.

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About WAS

The Wetlands Advisory Service (WAS) was established by WWT in 1989 to give well-informed, impartial and professional advice on how to conserve, improve and manage wetlands. Since this time, WAS has become the leading specialist wetland related consultancy in the UK.

Through its expertise in species surveys, habitat creation, wetland management, environmental education and interpretation, WAS provides a one-stop shop for all wetland management needs. All WAS profits are covenanted to The Wildfowl & Wetlands Trust to support its conservation programmes.

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