JOINT NATURE CONSERVATION COMMITTEE

Coasts and seas of the United Kingdom

Region 14 South-west Scotland: Ballantrae to Mull

edited by
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This volume has been produced by the Coastal Directories Project of the JNCC on behalf of the project Steering Group.

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Recommended citation for this volume:

Barne, J.H., Robson, C.F., Kaznowska, S.S., Doody, J.P., Davidson, N.C., & Buck, A.L., *eds*. 1997. *Coasts and seas of the United Kingdom. Region 14 South-west Scotland: Ballantrae to Mull.* Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series.)

Recommended citation for a chapter in this volume (example):

Davidson, N.C. 1997. Chapter 4.1 Estuaries. *In: Coasts and seas of the United Kingdom. Region 14 South-west Scotland: Ballantrae to Mull*, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody, N.C. Davidson & A.L. Buck, 65-68. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series.)

Region 1: ISBN 1 873701 75 6
Region 2: ISBN 1 873701 76 4
Region 3: ISBN 1 873701 77 2
Region 4: ISBN 1 873701 78 0
Region 5: ISBN 1 873701 79 9
Region 6: ISBN 1 873701 80 2
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Region 14: ISBN 1 873701 88 8
Regions 15 & 16: ISBN 1 873701 89 6
Region 17: ISBN 1 873701 92 6

Set of 17 regions: ISBN 1 873701 91 8

Contents

Foreword

Information is vital for sound policy formulation. Decision makers at national and local level need to know more than just the scale, location and importance of natural resources that are of value to humans. They have to understand how human activities affect the value of those resources and how to conduct those activities in an environmentally sustainable way. This is true for virtually every activity that impinges on the natural environment. In the coastal zone the complexity of the relationships between the physical and biological systems adds another dimension to the problems of formulating management policy.

I am pleased, therefore, to be introducing the *Coasts and seas of the United Kingdom* series. The Coastal Directories project, of which this series of seventeen regional reports, covering the whole of the UK coast, is an important product, has brought together an encyclopaedic range of information on our coastal resources and the human activities that are associated with them. Amongst the topics covered are the basic geology of the coasts around the United Kingdom and measures taken for coast defence and sea protection, the distribution and importance of the wildlife and habitats of our coasts and seas, including fish and fisheries, and the climate and sea level changes to which they all are subject.

In addition to the value of the information itself, the way the project has been run and the data collected has made an important contribution to the quality of the product. A wide range of individuals and organisations concerned with the conservation and use of the coastal margin have collaborated in collating the information, their variety reflecting the extent of the interplay between the coastal environment and human activities. These organisations included the Ministry of Agriculture, Fisheries and Food, the Scottish Office, the Department of the Environment (Northern Ireland), the National Rivers Authority (now the Environment Agency), the Countryside Commission, the Welsh Office, the Department of the Environment, the Sea Fisheries Committees, English Nature, Scottish Natural Heritage and the Countryside Council for Wales, together with local authorities, voluntary conservation organisations and private companies (notably those in the oil industry, through the UK Offshore Operators Association). I am also pleased to be able to acknowledge the contribution made by the staff of the Joint Nature Conservation Committee. As the work has evolved since the first meetings of the Steering Group in 1990, the value of involving such a broad span of interests has been highlighted by the extent to which it has allowed new approaches and information sources to be identified.

The regional reports will be of value to all who live and work in the maritime areas of the UK, where informed management is the key to the sustainable use of resources. The reports should become indispensable reference sources for organisations shouldering new or expanded responsibilities for the management of Special Areas of Conservation under the EC Habitats Directive. In addition, the reports will make an important contribution to the implementation of the UK Biodiversity Action Plan.

The Earl of Selborne
Chairman, Joint Nature Conservation Committee

How to use this book

These notes provide some general guidance about finding and interpreting the information in this book.

Structure

The book is divided into ten chapters, each split into sections containing summary data on the topics shown in the Contents list. Chapter 2 provides a general physical background to the region. Sections in Chapters 3, 4 and 5 have been compiled to the following standard format:

- **Introduction**: presents the important features of the topic as it relates to the region and sets the region in a national context.
- **Important locations and species**: gives more detail on the region's features in relation to the topic.
- **Human activities**: describes management and other activities that can have an effect on the resource in the region.
- **Information sources used**: describes the sources of information, including surveys, on which the section is based, and notes any limitations on their use or interpretation.
- **Acknowledgements**
- **Further sources of information**: lists references cited, recommended further reading, and names, addresses and telephone numbers of contacts able to give more detailed information.

Sections in the remaining chapters all have the last three subsections and follow the other elements as closely as practicable, given their subject nature.

At the end of the book there is a list of the addresses and telephone numbers of organisations most frequently cited as contacts, as well as a core reading list of books that cover the region or the subject matter particularly well. Finally there is a full list of authors' names and addresses.

Definitions and contexts

The word 'region' (as in 'Region 14') is used throughout this book to refer to the coastal and nearshore zone, broadly defined, between the two points given in the title of this book. The area covered varies between chapter sections, depending on the form in which data are available. Coverage is usually either coastal 10 km squares, sites within one kilometre of Mean High Water Mark, or an offshore area that may extend out to the median line between the UK and neighbouring states. Areas inland of these limits are not included unless specifically stated. Information is presented in the context of the local authority units existing before April 1996, except where data are very recent, making reference to the new local authority units possible.

'Britain' here means Great Britain, i.e. including only England, Scotland and Wales. 'United Kingdom' also includes Northern Ireland.

The term 'North Sea Coast', as used here, means the coast of Britain from Cape Wrath (longitude 5°W) along the east and south coasts of Britain to Falmouth (again longitude 5°W), and including Orkney and Shetland.

The 'West Coast', as used here, normally includes the coast and seas from Falmouth to Cape Wrath along the west coast of Britain. Only where explicitly stated have data for the Isle of Man and/or Northern Ireland been included in West Coast descriptions.

Sites within each chapter section are described in clockwise order around the coast, incorporating islands within the sequence. Maps and tables are numbered sequentially within their chapter section; for example in section 5.4, Map 5.4.1 is the first map referred to and Table 5.4.2 is the second table.

Throughout the book, the information given is a summary of the best available knowledge. The sites mentioned as important, the numbers and distributions of species, archaeological features discovered and information on all the other elements of the natural and man-made environment are as known at December 1994, unless otherwise stated. The fact that no information is presented about a topic in relation to a locality should not be taken to mean that there are no features of interest there, and fuller details should be sought from the further sources of information listed at the end of each section. Note, however, that under the Environmental Information Regulations (1992; Statutory Instrument No. 3240) you may be asked to pay for information provided by organisations.

Acknowledgements

This regional report is one of a series of products from the Coastal Directories Project of the JNCC. The compilation and publication of the series has been made possible by generous contributions from the members of the Coastal Directories Funding Consortium listed below:

Arco British Ltd[1]
Ards District Council
Avon County Council
Banff and Buchan District Council
BHP Petroleum Ltd[1]
Ceredigion District Council
Cheshire County Council
Chevron UK Ltd[1]
Cleveland County Council
Clwyd County Council
Clyde River Purification Board
Colwyn Borough Council
Copeland Borough Council
Countryside Commission
Countryside Council For Wales
Cumbria County Council
Cunninghame District Council
Delyn Borough Council
Department of the Environment (DoE)
DoE (Northern Ireland) Environment & Heritage Service
DoE (Northern Ireland) Water Service
Derry City Council
Devon County Council
Dorset County Council
Down District Council
Dumfries and Galloway Regional Council
Dyfed County Council
Eastbourne Borough Council
English Nature
Essex County Council
Fife Regional Council
Forest of Dean District Council
Gwynedd County Council
Hampshire County Council
Highland River Purification Board
Humber Forum
Isle of Man Government, Department of Industry
Isle of Man Government, Department of Local Government and the Environment
Isle of Man Government, Department of Transport
Kyle and Carrick District Council
Lancashire County Counci
Lincolnshire County Council
Marathon Oil UK Ltd[1]
Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research
National Rivers Authority
Neath Borough Council
Newry and Mourne District Council
Newtownabbey Borough Council
Norfolk County Council
North Cornwall District Council
North East Fife District Council
Nuclear Electric plc
Preseli Pembrokeshire District Council
Restormel Borough Council
Samara Consulting
SCOPAC (Standing Conference on Problems Associated with the Coastline)
Scottish Natural Heritage
Scottish Office Agriculture, Environment and Fisheries Department
Scottish Salmon Growers Association Ltd
Sefton Borough Council
Shepway District Council
Solway River Purification Board
Somerset County Council
South Pembrokeshire District Council
Standing Conference on Regional Policy In South Wales
Stroud District Council
Tayside Regional Council
Torridge District Council
UK Offshore Operators Association[2]
Vale of Glamorgan Borough Council
Water Services Association
Welsh Office
World Wide Fund For Nature - UK

Notes

[1]Funding from these companies was given to the Cardigan Bay Forum to fund the supply of information to the Project.

[2]The UK Offshore Operators Association is the representative organisation for the British offshore oil and gas industry. Its 34 members are the companies licensed by HM Government to explore for and produce oil and gas in UK waters.

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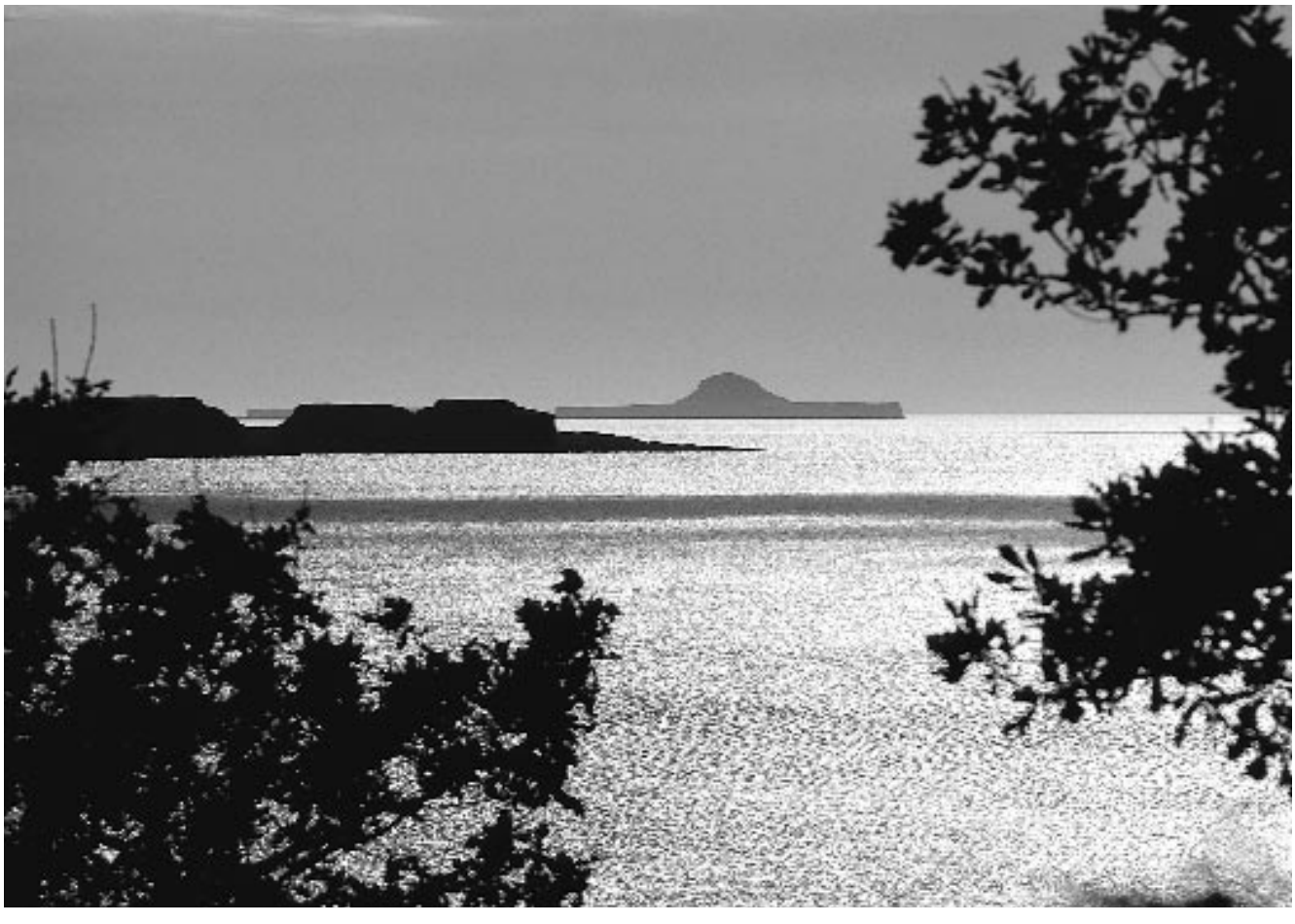
This collaborative project involved many other staff of JNCC in addition to the project team listed on page 2. They were: Deirdre Craddock, Steve Gibson, Tim Hill, Keith Hiscock, Nick Hodgetts, Alan Law, Becci May, Deborah Procter, Bill Sanderson, David Stroud, Mark Tasker, Andy Webb and Martin Wigginton. We thank them all for their help and support.

The project has also received widespread support from the country conservation agencies: Countryside Council for Wales, English Nature, Scottish Natural Heritage and the Department of the Environment (Northern Ireland). We are grateful to the many local and headquarters staff who contributed as well as the representatives on the Core Steering Group.

The editors would like to thank the many people who have provided information for the project or gave their time to comment on drafts, as well as those who gave editorial assistance:

Patrick Ashmore, Historic Scotland; Tricia Bradley, RSPB; Roger Broad, RSPB; Marsailidh Chisholm, Scottish Sports Council; Martyn Cox, The Crown Estate; Kathy Duncan, SNH; Euan Dunn, RSPB; Ian Fernie, West Dunbartonshire Council; John Gage, Dunstaffnage Marine Laboratory; John Gordon, Dunstaffnage Marine Laboratory; Andrew Haig, SEPA; Paul Harding, Institute of Terrestrial Ecology; Robin Harvey, Dunstaffnage Marine Laboratory; Steve Hay, Marine Laboratory Aberdeen; Michael Hayes, City of Glasgow Council; Richard Henry, North Ayrshire Council; Ian Johnson, South Ayrshire Council; W.J. Lart, Seafish Technology; George Lees, SNH; Derek Moore, Marine Laboratory Aberdeen; Diana Murray, Royal Commission on the Ancient and Historic Monuments of Scotland; T.D. Nickell, Dunstaffnage Marine Laboratory; The Scottish Tourist Board; Anthony Payne, Argyll and Bute Council; Richard Pollit, SNH; Martin Sayer, Dunstaffnage Marine Laboratory; G.H. Singleton, British Marine Aggregate Producers Association; Pauline Simpson, Institute of Oceanographic Sciences; Nigel Smith, SNH; Patrick Stewart, Clyde Fishermen's Association; Chris Sydes, SNH; University Marine Biological Station, Millport; Chris Vivian, MAFF; and Sarah Welton, Marine Conservation Society.

Where appropriate, individual acknowledgements are also given at the end of each section.



Bac Mor ('Dutchman's Cap'), Treshnish Isles. Islands off the west coast of Mull display their Tertiary volcanic origins, with the flat tops of lava flows contrasting with the more resistant igneous features. Photo: Pat Doody, JNCC.

Chapter 1 Overview

1.1 The Coastal Directories Project

Dr J.P. Doody

1.1.1 Introduction

Developing sound policies for coastal environmental management depends on wide ranging contextual information being available. Collecting such information is always time-consuming and difficult, especially ensuring that all relevant aspects are covered.

This problem is widely recognised. Nevertheless the solution - amassing the encyclopaedic knowledge required, collating it in useable form and disseminating it to potential users while the information is still current - has until recently been too daunting a project for any single organisation to tackle. However, with the help of sponsorship from a large number of organisations and support and practical help from many bodies, ranging from government departments to voluntary organisations, and using numerous experts as writers and consultees, the Joint Nature Conservation Committee has undertaken to prepare such a compendium of information for the coast of the whole United Kingdom.

This undertaking - the Coastal Directories Project - collates existing information on the United Kingdom and Isle of Man coastal zone to provide national and regional overviews of its natural resources and human activities, and indexes more detailed sources of information. The project uses a broad definition of the coastal margin that encompasses all the main habitats from offshore waters through to dry land, including any habitat forming part of the functioning coastal system; in addition areas of former tidal land now enclosed from the sea and lowland wet grassland alongside tidal rivers are included. At times it can be either unhelpful or impossible to set precise limits on the geographic areas that need to be covered, for example in the marine environment, such as when discussing fisheries or sources of contamination. However, where possible, coverage is of coastal 10 km squares, or sites within one kilometre of Mean High Water Mark, or (for marine topics) from the landward limit of high tides out to the median line between the UK and neighbouring states. Areas inland of these limits are not included unless specifically stated.

The relationships between the many and varied components of the coastal zone, that is, between the physical functioning of the zone, its biological components and the human activities that take place there, are complex. With this in mind, a wide-ranging approach to collating coastal information has been adopted in the project; information has been drawn from many sources, from national databases and nation-wide published surveys to the personal observations of field specialists and the newsletters of amateur societies. The approach has also served to highlight the interactions and interdependence between the environmental components (and between the various bodies and individuals) involved. This should help to ensure that users of the information develop policies and adopt strategies that secure the integrated, sustainable use and management of the coastal zone while maintaining biological diversity - a key element of Agenda 21 of the Rio Earth Summit in 1992.

1.1.2 Origins and early development of the project

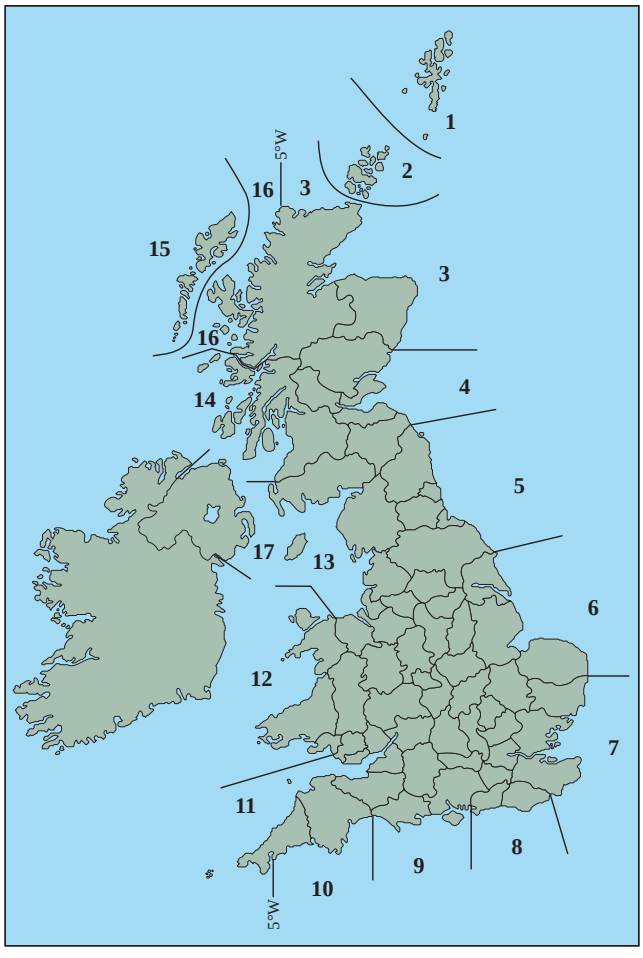
The concept of providing integrated coastal information took a long time to evolve into the Coastal Directories Project. As early as 1984, the need for such data was acknowledged at the first International Conference on the Protection of the North Sea. In 1987, recognising the significant gaps that existed in the scientific understanding of the North Sea, the Second International Conference on the Protection of the North Sea established the North Sea Task Force (NSTF). Under the guidance of the International Council for the Exploration of the Sea (ICES) and the Oslo and Paris Commissions, the NSTF organised a programme of study with the primary aim of producing a (mainly marine) assessment of the North Sea (the *North Sea Quality Status Report* (QSR)) by 1993.

In 1989 at the second meeting of the NSTF the UK suggested that the North Sea QSR should include consideration of terrestrial habitats and species. This was to involve the collection of information dealing with the coastal margin of the North Sea (defined as being east of longitude 5° West - i.e. from Cape Wrath in northern Scotland around the North Sea and the English Channel coasts to the Fal Estuary in Cornwall) and the collation of this information into book form. A project was set up by the Nature Conservancy Council (NCC) and, after 1991, the Joint Nature Conservation Committee (JNCC) to produce this information, with part funding from the Department of the Environment (DoE). A small group was invited to steer the project and to help identify information sources, including the DoE, the Ministry of Agriculture, Fisheries and Food (MAFF), the National Rivers Authority (NRA) (now the Environment Agency (EA)), the Countryside Commission (CC), the Scottish Office (SO), the Welsh Office (WO) and the country conservation agencies (English Nature, Scottish Natural Heritage, Countryside Council for Wales). With its help, a draft text was prepared in 1990-91; the resulting *Directory of the North Sea coastal margin* - the first product of the Coastal Directories Project, as it was to become - was presented to Ministers at the Intermediate Ministerial Meeting on the North Sea held in Denmark in December 1993 (Doody *et al.* 1993).

The principal aims of the *Directory* were to produce "a comprehensive description of the North Sea coastal margin, its habitats, species and human activities, as an example to other North Sea states" (North Sea Task Force 1993), and thus to help to ensure that terrestrial habitats and species were considered in the QSR. In this it succeeded, and the QSR, also published in 1993, included descriptions of terrestrial habitats and species in several of the sub-regional reports, together with comments on the human impacts on the ecosystems.

The North Sea Task Force was wound up in December 1993, following completion of the *North Sea QSR*, and its work is now carried on by a new Assessment and Monitoring Committee (ASMO), under the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (the OSPAR Convention). This convention requires that assessments similar to the North Sea QSR be produced for all the constituent parts of the north-east Atlantic, and for that area as a whole, by the year 2000. The Celtic Seas, including the Irish Sea and the west coast of Britain, are one of the first areas to be subject to assessment.

In the UK during the period 1990 - 1993 there was a considerable upsurge of interest in the principles of coastal management. For example, between November 1991 and February 1992 the House of Commons Environment Committee examined the issues for England; their report on *Coastal zone protection and planning* was published in March 1992 (House of Commons Environment Committee 1992). This report, together with initiatives at UK and European levels, encourages a more integrated, local approach to management issues. At the same time, as the work on the *Directory of the North Sea coastal margin* proceeded, the emphasis of the approach changed. The main aim had been the collection of information, but gradually the process of working with people to gather the data threw the spotlight more on the benefits of a partnership approach and its value for promoting coastal zone management, with which the Coastal Directories Project became more directly linked.



Map 1.1.1 Regions in the series. Region names are given in Table 1.1.2.

1.1.3 Recent developments

These developments in coastal management fostered interest in the Coastal Directories Project and increased demand for information at a regional level, as well as at the level of whole seaboards (the approach adopted for the *Directory of the North Sea coastal margin*). In 1992, therefore, it was proposed to produce a *West Coast Directory* to cover the remainder of the coast of Great Britain, the Isle of Man and, by later agreement, Northern Ireland, as well as a series of regional volumes to cover the whole coast of the UK. Regions were defined, wherever possible, by the current local or national government coastal boundaries that most closely approximated to the limits of major coastal process cells (see section 2.4), to ensure that pragmatic management requirements were matched by an ecologically coherent information base. Volumes covering seventeen regions have been or are now being prepared: the areas that they cover are shown in Map 1.1.1. Regions 1 - 10 cover the area of the *Directory of the North Sea coastal margin*; Regions 11 - 17 deal with the west coast of the United Kingdom and the Isle of Man. These regional volumes provide a more detailed level of information than the *Directory of the North Sea coastal margin*, to help set each region in a national context and facilitate the preparation of regional plans. Discussions in the main steering group (see below) in February 1996 resulted in a decision to make the completion of the regional volumes the priority, rather than the production of the overview *West Coast Directory*.

Whereas work for the *Directory of the North Sea coastal margin* was funded principally by the DoE and the NCC/JNCC, it was decided to seek funding for the extended project from a consortium of private organisations and public bodies, including the original steering group members, as well as coastal local authorities (see page 7). In the event more than 200 organisations, from government departments and oil, water and power companies to nature conservation organisations, both statutory and voluntary, have contributed either money or information or both to the project. Those organisations that contributed money - the funding consortium - and a number of others comprise the main steering group, and from this group a smaller number were identified to form the core steering group (Table 1.1.1).

Interest in the project has been reflected in the level of sponsorship that the project has received and in the commitment shown by members of the steering groups, which meet regularly. The main steering group meets annually for a seminar: so far it has considered the *Role of the Directories in the development of coastal zone management* (January 1994), the *Use of electronic storage and retrieval mechanisms for data publication* (February 1995) and *The tide turns for coastal zone management: Coastal Directories users report back on their experiences* (February 1996). In addition the core steering group also meets at least annually.

Table 1.1.1 Coastal Directories Project management structure

Group	*Role*	*Undertaken by*
JNCC Coastal Directories Project Team	Day to day management	Head of Coastal Directories Project Team, project coordinators
Project management board	Liaison & executive decisions	Country conservation agencies (English Nature, Scottish Natural Heritage, Countryside Council for Wales), JNCC Coastal Directories Project Team, Department of the Environment (Northern Ireland)
Core steering group	Steer work, provide information and support	See page 2
Main steering group (includes, amongst others, all funding consortium members)	Review progress, consider new developments, provide expert advice and act as consultees	All members, through an annual steering group seminar and individually

1.1.4 The contribution of the project to coastal management

At the outset it was agreed that the work should involve as many as possible of the individuals and organisations concerned with the use of the coastal margin, to reflect the complex nature of the habitats and species and the wide-ranging influence of human activities. As the project evolved, the value of this approach has been highlighted by the extent to which new approaches and information sources have been identified. The dialogue between the Coastal Directories Project funding consortium members has confirmed the importance of the project in providing basic resource information to support new approaches to coastal management.

Increasingly, the regional volumes are seen as providing essential information to inform the development of coastal zone management policy at a national level. They provide information that complements the approach currently being promoted by a range of government reports. These include PPG 20: *Planning Policy Guidelines: coastal planning* (DoE/ Welsh Office 1992), the *Policy guidelines for the coast* (DoE 1995) and the two consultation documents that followed up the House of Commons Environment Committee report: *Development below low water mark* (DoE/Welsh Office 1993a) and *Managing the coast* (DoE/Welsh Office 1993b) (note that these reports do not cover Scotland, Northern Ireland or the Isle of Man). MAFF too has promoted the setting up of flood and coastal defence 'coastal cell groups', to encourage sustainable shoreline management.

It has also been recognised that the summary information in the regional volumes is valuable in preparing and assessing applications for oil and gas licensing around the coastal margin. An injection of funds from the United Kingdom Offshore Operators Association (UKOOA) made possible the early production of draft regional reports for most of the potential licensing areas in the 16th Offshore Oil and Gas Licensing Round in 1994.

1.1.5 Outputs

The regional volumes are being published as hardback books. In addition a first release of coastal conservation data, covering national surveys of terrestrial habitats and coastal Sites of Special Scientific Interest (SSSIs), and a

Table 1.1.2 (Provisional) titles and publication dates of products of the Coastal Directories Project

Product	*Publication date*
Book editions	
Directory of the North Sea coastal margin	1993
Region 1. Shetland	Due 1997
Region 2. Orkney	Due 1997
Region 3. North-east Scotland: Cape Wrath to St. Cyrus	1996
Region 4. South-east Scotland: Montrose to Eyemouth	Due 1997
Region 5. North-east England: Berwick-on-Tweed to Filey Bay	1995
Region 6. Eastern England: Flamborough Head to Great Yarmouth	1995
Region 7. South-east England: Lowestoft to Dungeness	Due 1997
Region 8. Sussex: Rye Bay to Chichester Harbour	Due 1997
Region 9. Southern England: Hayling Island to Lyme Regis	1996
Region 10. South-west England: Seaton to the Roseland Peninsula	1996
Region 11. The Western Approaches: Falmouth Bay to Kenfig	1996
Region 12. Wales: Margam to Little Orme	1995
Region 13. Northern Irish Sea: Colwyn Bay to Stranraer including the Isle of Man	1996
Region 14. South-west Scotland: Ballantrae to Mull	1997
Regions 15 & 16. North-west Scotland: the Western Isles and west Highland	Due 1997
Region 17. Northern Ireland	Due 1997
Electronic editions	
Coastal and marine UKDMAP datasets: Version 1	1994
Regions 3, 5, 6, 9, 10, 11, 12, 13	1996
Region 14	1997
Other regions	Following book publication

second release of marine conservation data, covering marine benthic surveys, have been published in electronic format (Barne *et al.* 1994) compatible with UKDMAP, the electronic atlas developed by the British Oceanographic Data Centre, Birkenhead (BODC 1992). Electronic editions of the published Regional volumes are also available. The current position on the publication of book and electronic editions is shown in Table 1.1.2.

1.1.6 Further sources of information

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House of Commons Environment Committee. 1992. *Coastal zone protection and planning. Second Report.* 2 volumes. London, HMSO.

North Sea Task Force. 1993. *North Sea quality status report.* London, Oslo and Paris Commissions.

B. Further reading

Bird, E.C.F. 1984. *Coasts - an introduction to coastal geomorphology.* 3rd ed. Oxford, Blackwell.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Information about the Coastal Directories project and UKDMAP version; sales of electronic editions of the regional volumes	*Project Co-ordinator, Coastal Directories Project Team, JNCC, Peterborough, tel: 01733 62626
Sales outlet for book editions of the regional volumes, the Directory of the North Sea coastal margin, and other JNCC publications	Natural History Book Service Ltd, 2-3 Wills Road, Totnes, Devon TQ9 5XN, tel: 01803 865913

*Starred contact addresses are given in full in the Appendix.

Ferries are vital to life on the islands, both for residents and for tourism, which underpins the economy. From the harbour at Port Askaig, Islay, car ferries ply to Jura, Colonsay and the Kintyre mainland at Kennacraig. Photo: Pat Doody, JNCC.

1.2 Introduction to the region

Dr J.P. Doody

1.2.1 Introduction

This section gives a brief introduction to the character of the region, its wildlife and the extent of its human use and development, synthesising information presented in Chapters 2-10. The main coastal locations are shown on Map 1.2.1. Map 1.2.2 shows the coastal 10 km squares in the region.

Region 14 covers the major part of the coastline of south-west Scotland. The coastline is long - 2,761 km - because of the numerous islands off the mainland shore. These include the large islands of Arran, Islay, Jura and Mull as well other smaller islands, notably Bute, Colonsay, Coll and Tiree. Together they represent 23.5% of the total coastline of Scotland and 14.7% of that of Great Britain. The coast is relatively unindented and low in relief to the south of the Highland Boundary Fault, which runs diagonally across Scotland from the Firth of Clyde to Stonehaven on the east coast, dividing the region geologically. To the north of the fault the geology is dominated by schists and, on Mull, volcanic rocks, which render the coastline resistant to erosion, dramatic in scenery and often inaccessible by land.

The whole area was heavily glaciated in the last ice age, and the subsequent removal of the ice and the resulting upward movement of the land, which continues today, has had a major influence on the nature of the coast. In this region the ice sheets were probably at their thickest and the depression of the land surface greater than anywhere else in the UK. With the melting of the ice at the end of the last glaciation the land surface began to re-adjust upwards, but the rate of rise in sea level was much faster, resulting in coastal land being covered by the sea. The effect was the creation of raised shorelines and the development of raised beaches at much higher levels (up to 40 m higher) than today. As the rate of sea-level rise slowed and the land continued to rise, a series of beaches was formed at progressively lower levels: these survive today, with excellent examples on the Island of Jura. On less elevated sections of coast, for example in the vicinity of the Crinan Canal, a coastal plain that includes the peatland of Moine Mhor stretches some 4.8-6.4 km inland to an ancient cliff line.

As with much of the rest of Scotland, the land is still rising, in this region at approximately 3 mm per year. Thus, although global sea level rise is approximately 1-2 mm per year overall, relative sea level is falling throughout the region. The tidal range is small, being only 1 m at spring tides in the waters between Islay and Kintyre. Tidal ranges increase to the north-west and south-east but still reach only 3.5-4.0 m off the west coast of Mull. The threat of flooding and erosion affects only a relatively small number of low-lying areas in the region, because of the combined effects of land uplift, the rocky shorelines and the absence of major areas of land claim.

Because of the presence of the large islands and the highly indented nature of the coastline, many areas, such as the Firth of Clyde, are sheltered. However, much of the coast in the north of the region is exposed to the Atlantic Ocean, which has a major influence on the nature of the environment, giving a great variation in maritime influence across the region. Generally the wind is from the south-west and many of the islands are exposed to its full force, although the irregular shape of the coast and the presence of mountains causes a great deal of local variation in the wind climate. Some of the windiest parts of Great Britain are found along the western margins of the region, especially near headlands. The coast of Tiree, for example, experiences much greater wind speeds than are experienced around Prestwick, where the coast is sheltered by Arran and the Mull of Kintyre.

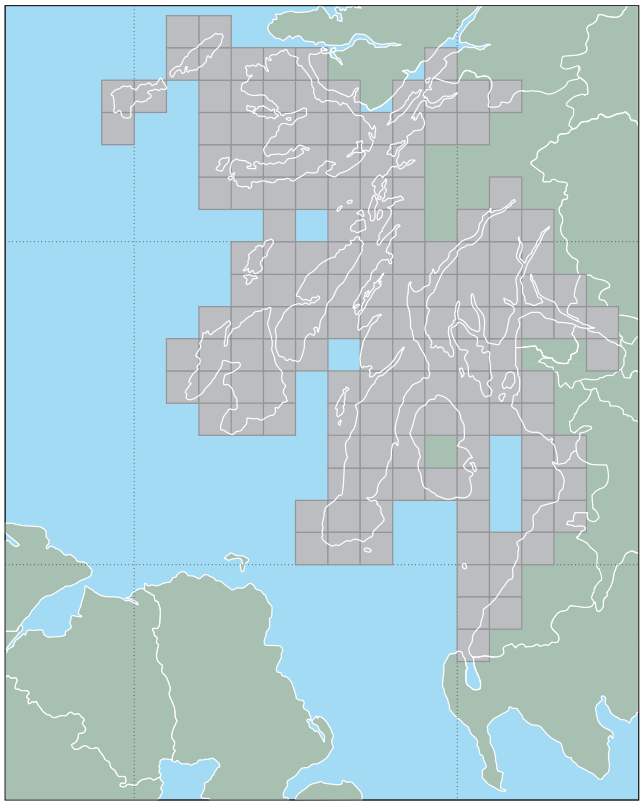
Low-intensity agriculture is a major land use, with stock rearing, notably sheep farming, predominating in the north. In the south and around the Clyde farming is more intensive and dairy herds are common. Major industrial developments, including some built on former tidal lands, are restricted to the banks of the Clyde Estuary, especially around Greenock, Port Glasgow, Glasgow, Clydebank and Dumbarton. There are many fishing ports in the region, with Ayr, Campbeltown, Loch Tarbert, Oban and Loch Scridain (on Mull) being the ports where most fish and shellfish are landed. Shellfish species such as *Nephrops*, crabs *Cancer pagurus* and *Maja squinado*, scallops *Pecten maximus* and periwinkles *Littorina littorea* represent the majority of the region's landings. Basking sharks used to be caught for their liver oil from around the Clyde Sea, but are now no longer fished.

There are several traditional holiday resorts, and the towns on the Ayrshire coast, the Isle of Arran and around Oban have many small hotels and guest houses; the Clyde itself provides a centre for water-based recreation. Throughout the area there are important holiday destinations for tourists, including attractions such as Fingal's Cave (on Staffa) and the holy island of Iona. Generally the islands are of great interest to wildlife enthusiasts.

1.2.2 Structure and landscape

The geology of the region provides the basis for much of the landscape and comprises some of the oldest rocks found in the UK. The region is divided geologically into three sections by the major faults that transect Scotland: the Southern Uplands Fault (which roughly coincides with the southern border of the region), the Highland Boundary Fault (marking the northern shore of the Firth of Clyde) and the Great Glen Fault (following the northern shore of the Firth of Lorn and separating Colonsay and Jura, and east and west Islay). Lower Palaeozoic rocks (500-400 million years old) are found to the south of the Southern Uplands Fault and to a limited extent in the Midland Valley, which is mostly formed of sediments and igneous rocks of Devonian and Carboniferous age (408-286 million years). To the north of the Highland Boundary Fault the rocks are mainly of the Dalradian Supergroup, largely Precambrian in age (>540 million years old). The intrusion of volcanic material during the more recent Tertiary period (some 60 million years ago) has had a profound effect on the geology and the landscape, with the islands of Arran and Mull having been centres of volcanic activity. Like much of the rest of the UK the land

Map 1.2.1 Rivers, major towns and other coastal locations in the region.



Map 1.2.2 National grid 10 km by 10 km squares included as 'coastal' for this region.

surface of the area was completely covered by ice for most of the Pleistocene glacial period, which lasted for 1.6 million years. The scouring by ice of the valleys steepened them and helped create the fjords that are significant features of much of the region.

1.2.3 The natural environment

The coast of Region 14 includes all the main coastal habitat types. This is one of the most naturally wooded coastlines in the UK, with extensive deciduous woodlands on steep slopes running to the water's edge, especially on the banks of the sea lochs. The northern part of the region is characterised by a fjordic coastline with many large sea lochs. The combination of tidal waters, fringing saltmarshes and rocky or shingle shores, with deciduous woodland clothing the banks against a backdrop of mountains, makes these some of the most beautiful areas in the UK. The oceanic climate and in particular the influence of the Gulf Stream have helped the establishment of the rich epiphytic lichen and moss communities that blanket the trees in some localities.

Because of the wide range of habitats, the relatively low intensity of use of adjacent agricultural land, the remoteness of much of the area, traditional agricultural land uses, low levels of industrial activity and the presence of often inaccessible sea cliffs, the region includes a number of animals which are not confined to the coast but have some of their most important populations there: these include otters *Lutra lutra*, pine martens *Martes martes*, wildcats *Felis silvestris* and red squirrels *Sciurus vulgaris*. The numerous islands, large and small, are significant features in their own right and include a wide variety of rare plants and animals. The presence of birds of prey, such as peregrine falcons *Falco peregrinus* and eagles, and the thriving otter population testify to the relative freedom of much of the region from pollution and human disturbance. Six seabird colonies are of European importance for holding more than 20,000 birds, and a further nine colonies are nationally important, holding more than 1% of the Great Britain population of a species.

The sea and sea bed

The nature of the sea bed has been considerably altered by the glaciers that scoured the sea lochs and major channels, creating deep inshore waters with shallow 'sills' at their seaward limits. These effects are exaggerated in places by the differential resistance of the rocks. Offshore, the sea bed reaches a depth of 40-80 m, while the narrow, deep channels between the islands may reach depths of 200 m or more, as in the Sound of Jura. The sea bed is covered in places by extensive deposits of Pleistocene sediments up to 200 m thick. The present-day Holocene sediments are derived largely from the rivers flowing into the sea. The stronger currents winnow out the mud and silt, creating thin deposits of gravel and sand that are locally shell-rich. Sand deposits predominate near the coast and help to feed the sandy beaches that occur throughout the region.

Region 14 supports a good range of sea-bed plant and animal communities, considering its northerly location. This is a reflection of the range and types of substrata, the variation in exposure, particularly around islands, and the presence of the warm waters of the Gulf Stream. Many of the rarer species, including sea fans, cup corals and soft corals, typically have a northerly distribution, but species from warmer southern areas also reach this region. The coastal nearshore areas around the islands are among some of the most diverse marine areas in Europe, and the region supports thirteen rare and 27 scarce marine benthic species.

The combination of clear water, tidal sills and the salinity gradients within the sea lochs make them of considerable marine importance. Loch Sween, for example, is one of the richest marine sites in the UK. Overall the diversity of the region's fish species in the coastal waters is slightly lower than might be expected, compared with other regions (148 species present out of the national total of 336); the number recorded in the Clyde Estuary is about average for a UK estuary. The inshore areas have populations of exploited sea-bed species such as queen scallops *Aequipecten opercularis*, scallops *Pecten maximus* and *Nephrops*.

Seals, dolphins, porpoises, whales and basking sharks *Cetorhinus maximus* are often seen offshore and generally the coastal waters are richer in these species than areas of southern Britain. Overall, fifteen species of cetacean have been recorded, of which eight (30% of the 27 British species) are present throughout the year or regularly seen on an annual basis. Common seals *Phoca vitulina* are found throughout the region and represent approximately 18% of the GB population, based on numbers of moulting individuals. Breeding occurs on many of the western islands and accounts for approximately 9% of the pups born in Great Britain. Grey seals *Halichoerus grypus* have many haul-out sites in the west of the region and also breed there.

Offshore the region is important for a wide variety of feeding seabirds, including divers, petrels and shearwaters,

which breed further afield, as well as other species, such as guillemot *Uria aalge*, that nest on cliffs nearby. In winter some areas off the Ayrshire coast are of national importance for waterfowl, notably eider *Somateria mollissima* and goldeneye *Bucephala clangula*. The Inner Clyde is also significant in winter for eider, which come from their breeding areas in the north and west of Scotland.

Estuarine shores

The eight estuaries in this region identified in the NCC's Estuaries Review represent only 1.6% by area of the UK estuarine resource (Davidson *et al*. 1991). Many of the fjords (steep, narrow glaciated inlets) and fjards (low-lying, shallow glaciated inlets) that characterise the coast, especially in the north of the region, have narrow shores composed of shingle and do not qualify as estuaries under the definition used for inclusion in the review. The Clyde is the only major estuary in the region, stretching far inland from the Firth of Clyde to the city of Glasgow; it has an overall area of 5,485 ha, of which 1,841 ha are intertidal. The next biggest site, Loch Gruinart, is much smaller at only 973 ha, although it has a proportionally larger intertidal area - 876 ha. Several of the estuaries have considerable geomorphological or wildlife and nature conservation importance; this is reflected in national and international conservation designations on part or all of each estuary. The Clyde Estuary and the two estuarine inlets on Islay (Traigh Cill-a-Rubha and Loch Gruinart) are of international importance for migrant and wintering waterfowl. Loch Gruinart, Loch Indaal and adjacent farmland form an area that is the winter home to internationally important numbers of barnacle geese *Branta leucopsis* and Greenland white-fronted geese *Anser albifrons flavirostris*, and almost the whole world population of Greenland barnacle geese uses Loch Gruinart as a staging post on their migration from East Greenland to their widely-dispersed wintering areas.

Some of the tidal land around the estuary of the Clyde has been enclosed to accommodate the growth of industry in Glasgow and the surrounding towns. Undeveloped shores predominate in much of the rest of the region, reflected in the presence of fringing saltmarsh, which borders the estuaries and sea lochs. Overall the total area of saltmarsh in the region is not large - only 549 ha or 1.2% of the GB resource. The loch-head saltmarsh areas are usually small (<10 ha), with little sediment input, and therefore have a relatively low proportion of pioneer and low-mid marsh saltmarsh communities: less than 7% of the total extent of saltmarsh in the region is dominated by common cord-grass *Spartina anglica* (which is restricted by the northerly climate) or is classed as low-mid marsh, whilst approximately 56% is classified as mid-upper marsh - a much higher proportion than the average for saltmarshes on the west coast of Britain. A further 28% forms a transition to adjacent grasslands, wet grassland and brackish swamp. The grassland often includes yellow iris *Iris pseudacorus*, a characteristic species on the margins of many of the sea lochs. The majority of upper marshes are grazed and have important plant communities confined to this habitat. Perhaps the most significant transition between saltmarsh and a non-tidal community occurs on the Ruel Estuary, where there is one of the very few examples in Britain of a transition from tidal saltmarsh to woodland, although in this case the 'woodland' consists of a few scattered alder trees growing in tidal upper saltmarsh.

Non-estuarine shores

Sea cliffs make up a high proportion - 15% (421 km) - of the total length of the region's coastline, although some 51% are less than 20 m high. The total represents 10% by length of the British resource. The cliffs often form a dramatic component of the landscape, with mountains rising inland in places such as North Arran, the Paps of Jura and on Mull. Some of the most spectacular cliff landscapes are associated with the volcanic rocks that extruded through the older rocks some 60 million years ago. In the north the major volcanic activity, centred on Mull, formed high and precipitous cliffs: near-vertical cliffs (up to 80 m high) occur on, for example, the South Mull coast, Ardmeanach and Staffa. The cliffs of the Mull of Kintyre (more than 90 m high), whilst not vertical, are also spectacular.

Cliff habitats are varied and extensive, ranging from extensive exposed maritime communities (including spray zone crevice communitiesh) to neutral grassland and heath. On steep slopes at the Mull of Kintyre, for example, vegetation with maritime species such as thrift *Armeria maritima* and sea campion *Silene maritima* grades into heath with heather *Calluna vulgaris* and cross-leaved heath *Erica tetralix* to form a natural rock garden. No nationally rare higher plant species and only two nationally scarce species (thyme broomrape *Orobanche alba* and Isle of Man cabbage *Coincya monensis*) occur on the cliffs of this region. Several arctic-alpine species occur at or near sea level on the exposed cliffs and rocky shores. The hard rock cliffs also support characteristic assemblages of lichens, which are particularly diverse on the limestone rocks of Lismore.

Many cliff sites in the region have nationally- or internationally-important seabird numbers, either overall or of individual species. Three cliff sites have been designated as Special Protection Areas for their breeding seabirds: Ailsa Craig, Rhinns of Islay and Treshnish Isles. Ailsa Craig has two species, gannet *Sula bassana* and lesser black-backed gull *Larus fuscus*, in internationally important numbers (more than 1% of their European population); the gannetry is the fourth largest in Britain. The cliffs of the Mull of Kintyre and the more inaccessible areas to the north are the haunt of rare birds of prey, including peregrine falcon and golden eagle *Aquila chrysaetos*. The chough *Pyrrhocorax pyrrhocorax*, which has been lost at sites elsewhere in Britain, breeds on cliffs in the region, where exposure to wind and salt spray has helped to maintain the open grassland thought to be important for this species. The cliff tops and rocky coasts also provide habitat for some of the more widespread reptiles, including adders *Vipera berus*, slow worms *Anguis fragilis* and lizards *Lacerta vivipara* and *L. agilis*, although the grass snake *Natrix natrix* does not occur this far north. The region supports a rich invertebrate fauna, for which coastal cliffs are especially important. Species include the New Forest burnet moth *Zygaena viciae argyllensis*, which is among Britain's most threatened species (with only one small colony), and the slender Scotch burnet *Z. loti scotica*, which is virtually restricted to the coast of Mull.

Sand dunes representing approximately 18% of the national resource occur within the region. Altogether there are estimated to be 176 separate sand dune sites, including those associated with the bays and areas where sand is blown over hard rock outcrops. These sites include the large areas of blown sand on Coll and Tiree, where there are

extensive examples of the rare machair dune landscape, which is restricted to the western and northern shores of Scotland and the west of Ireland. Machair, a particular form of the hindshore dune, develops where the prevailing westerly winds drive plentiful supplies of sand inland of a wide beach. Continual landward progression and depression of the surface, probably influenced by human use, has led to the creation of flat, sandy plains and transitions to wet grassland, calcareous wetlands and peat. Here, as in western Ireland, the land is used largely for grazing sheep and cattle, a management regime that is important for the maintenance of conservation interest, as the grassland is rich in plant species and supports breeding waders. The dunes on Islay are particularly noteworthy for their dune slacks (wet depressions), which support marsh helleborine *Epipactis palustris* at its only Scottish site. The region's machair dune habitats, together with the adjacent crofting land, provide important feeding areas for the chough, one of Britain's rarest birds, and the corncrake *Crex crex*. The former favours sandy pastures, as for example some of the small dunes on Islay, where cattle dung provides a rich source of invertebrates. The corncrake depends on crofting lands with iris beds, rushy pastures, hayfields and wet machair to provide feeding and nesting sites. Both Coll and Tiree have all these interests and are identified as potential sites for designation as Special Areas of Conservation (SACs) under the EC Habitats & Species Directive. Further north these rich machair plains are cultivated on a traditional crop rotation as well as being grazed.

Of the other sand dune sites, those in the low-lying bays in the south of the region include spit dunes (at Irvine Bay and around Ayr). These and other hindshore dunes have been modified by human activity, including the development of golf courses. The dunes adjacent to Bogside Flats, in the Irvine Estuary, are the site of a large chemical and explosives factory. Several of the dune systems are unusual in that they include 'climbing' dunes, which have developed in response to strong prevailing winds blowing sand up and over a cliff, for example at the Heads of Ayr. On west Coll, where sand has been blown over low rocky outcrops, the lichen flora is of national interest.

Within the region there are extensive shingle shores. These include the present shores as well as those deposited at the end of the last glaciation, when sea levels were some metres higher, and which are now out of reach of normal tides. At a number of sites these shores have been piled up against one another to form shingle structures; two of them, at Ballantrae and Rhunahaorine Point, are nationally important. The latter is a raised cuspate foreland similar to Dungeness in Kent, although much smaller; it appears to have been laid down in at least two distinct phases, possibly associated with changing sea levels in the area. Associated with shingle shores is a highly distinctive flora that is very well-developed in the region and includes the oysterplant *Mertensia maritima*, a declining northern species characteristic of this unstable habitat.

1.2.4 Landscape and nature conservation

The value of the region for landscape and nature conservation is shown by the number and combined extent of sites afforded official protection, especially designations reflecting national or international importance. These include 112 Sites of Special Scientific Interest and five National Nature Reserves. There are ten Special Protection Areas (including Ailsa Craig and six sites on Islay, including Loch Gruinart) and seven Ramsar sites, a high number compared with most other regions. The region also includes all or part of eleven sites proposed as Special Areas of Conservation for their coastal or marine biological interest. The total numbers of sites and total areas of the main designations are given in Table 1.2.1.

There are also many sites owned and managed by non-governmental organisations, including the RSPB and Wildlife Trusts, as well as a significant area of land owned by the National Trust for Scotland. There are eight National Scenic Areas (one only partly in the region), representing 18.8% by area of those in Scotland (to which they are restricted). Much of the coastline is also covered by Regional Landscape Designations such as Regional Scenic Areas and Regional Scenic Coasts. The region also includes nine sites identified by Scottish Natural Heritage as Marine Consultation Areas on account of their marine interest, including Loch Sween, which is considered to be of national importance.

Table 1.2.1 Summary of main designations

Designation	*No. of sites in region*	*Total area in this region (ha)*	*% of GB coast total in region*
Biosphere Reserves	1	362	1.3
Sites of Special Scientific Interest (SSSIs)	112	63,243	8.8
National Nature Reserves (NNRs)	5	1,589	1.8
Ramsar sites	7	9,828	3.4
Special Protection Areas (SPAs)	10	11,524	3.8
Candidate SACs	10.5*	n/av	n/av
Environmentally Sensitive Areas	1.5+	339,857	24.3
National Scenic Areas	7.5*	140,000	18.8
Marine Consultation Areas	8.5^{+}	56,016	50.1
Regional Scenic Area	10	367,866	72.5
Regional Scenic Coast	9	391 km	100

Source: JNCC. Key: SAC = Special Area of Conservation; n/av = not available; *sites lying partly within Region 16; and $^{+}$sites lying partly within Region 13; half the relevant site area has been included in the total. In this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

1.2.5 Human activities, past and present

Hunter-gatherers were probably the first people to use the region after the last glaciation. The earliest Scottish settlement and cave occupation sites date back to about 7,000 BC. Remains from the island of Bute show some of the main stages in the occupation of this region: long cairns from early Neolithic farmers, burial cairns and standing stones from the Bronze Age and duns (dry stone wall enclosures) from the Iron Age and Dark Ages span a period of about 4,000 years. Today the progress of agricultural development is illustrated by the large and prosperous modern farms found on the west side of Bute. The fact that a considerable part of the region remains in pastoral use plays an important part in its continuing scenic value, although planting of non-native conifers has taken its toll on the landscape and wildlife since the 1930s.

Maritime trade was important but localised until the 18th century. Access to the area improved with the building of roads, and many coastal areas became less isolated. The dredging of the estuary of the Clyde to provide access up-river provided a spur to the growth of Glasgow, but the most significant development took place in and around the coal fields to the south. The export of coal inderpinned the development of industry in the area, which included the major shipbuilding yards. In their heyday in the early 1900s the yards stretched from Govan, in the heart of Glasgow, to beyond Greenock, and three-quarters of the ships built in Great Britain at the time were launched on the Clyde. Despite a brief upsurge in ship building just after the Second World War, the Clyde's share of the world's shipping orders had dropped to only 3% by the 1970s.

Fishing is an important industry in the region, although the total landings of fish and shellfish species are not as significant as in some other parts of the country. However, the total tonnage of shellfish species landed in the region, such as *Nephrops*, crabs and scallops, represents 9.8% of the British total and 22.3% of the Scottish total. Herring *Clupea harengus* and sprats *Sprattus sprattus* are exploited in the Firth of Clyde by a small number of local trawlers, but herring are not as abundant as they were and the fishery has declined substantially. Landings of demersal species such as cod *Gadus morhua*, haddock *Melanogrammus aeglefinus* and whiting *Merlangius merlangus* from the Firth of Clyde are greatest in winter. The deep waters of the Firth of Clyde also provide excellent fishing grounds for hake *Merluccius merluccius*, which is targeted in the summer months. Three diadromous species - salmon *Salmo salar*, sea trout *S. trutta* and eel *Anguilla anguilla* - support both net and rod and line fisheries in the region, the most important of which are for salmon (and grilse, which are salmon that have spent not more than one winter at sea before maturing) and sea trout. Fish and shellfish farming is a significant industry and there are many sites located in the lochs and coastal waters of the region.

Glasgow and the towns of the River Clyde are the only centres of major industrial activity in the region. Despite the demise of shipbuilding, the shores of the Clyde are still among some of the most heavily developed in Great Britain. Industrial pollution remains a significant issue and the estuary is second only to the Thames as a disposal site for sewage sludge, although this is being phased out. Whisky distilling is also an important activity in the region: the presence of pure water and peat used to roast the barley has resulted in the growth of many important distilleries such as those on the island of Islay. However, this industry has also declined: for example the 34 distilleries in Campbeltown 100 years ago have been reduced to one. The coalfields of the Midland Valley have played an important part in the development of the region, although they have now largely ceased to operate. The mine at Machrihanish, for example, closed in the 1960s. Coastal slate quarries were scattered along the coast and were in use for 200 years, yielding mainly roofing slates. The last quarry closed in 1965.

Only a small proportion of the coast both in this region and in Scotland as a whole has coast protection or sea defence structures. The majority of defences are concentrated along the banks of the Clyde Estuary. Along the Ayrshire coast sandy shorelines and sand dunes are eroding in several places, threatening tourist areas and golf courses; piecemeal attempts at protection have been made at a number of sites, although the techniques adopted have not been entirely successful. Elsewhere artificial structures are restricted to ports, harbours and other urban locations.

The close proximity of relatively unspoilt countryside, including the islands, to the major conurbation of Glasgow has made the area accessible for leisure use. Tourism began in the 19th century, and the Firth of Clyde, the Isle of Arran and towns such as Oban have long attracted visitors. Today they continue as centres for traditional family holidays; it is claimed that the stretch of coast that includes Ardrossan and Saltcoats is the most frequently-visited stretch of beach anywhere in Scotland, with up to half a million visitors a year. Elsewhere resorts based on fishing ports have developed: Girvan, which two centuries ago depended on the herring industry, is now a holiday resort. The region is host to a wide range of leisure activities, including golf at two championship courses. Walking and natural history are important leisure pursuits in the region, and Islay and some of the other islands are regular destinations for botanists and birdwatchers.

1.2.6 Further sources of information

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Chapter 2 Geology and physical environment

2.1 Coastal geology

British Geological Survey

2.1.1 Introduction

Most of the region is composed of Precambrian and Palaeozoic rocks, with some small but geologically significant Mesozoic outliers (isolated overlying exposures). Tertiary dykes are common along the coast, especially in the north, and the geology of Arran and Mull is dominated by major Tertiary volcanic centres and basic lava sheets (Map 2.1.1; Table 2.1.1).

The region is divisible geologically into three: the Southern Uplands, the Midland Valley and the Highlands, separated by major NE-SW trending faults: the Southern Uplands Fault and the Highland Boundary Fault. The Great Glen Fault is at the northern limit of the region, although Mull, north-west of the fault, is included in the region.

2.1.2 Stratigraphy

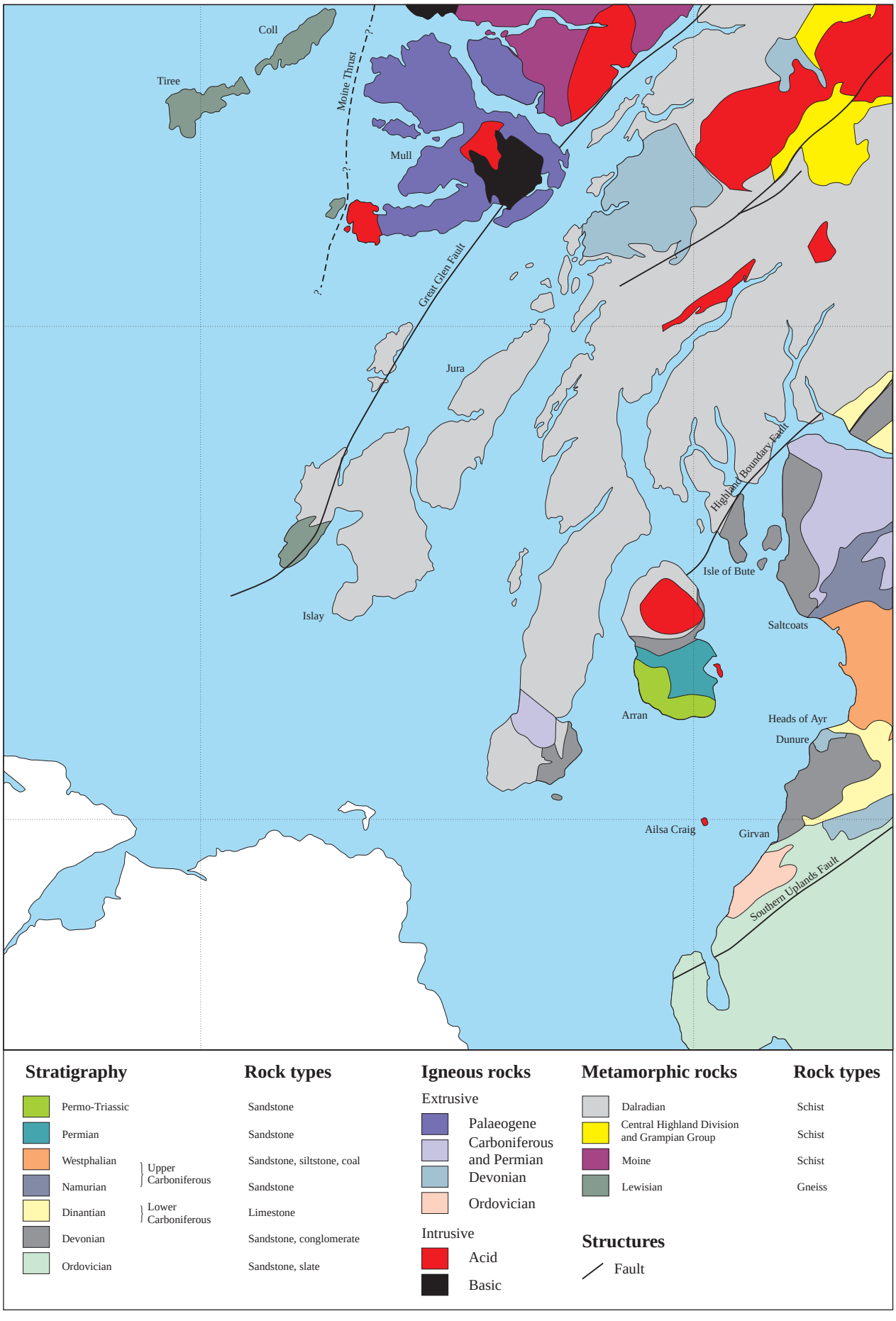
The Southern Uplands

The bulk of the Southern Uplands lie in Region 13, but they also extend into the extreme south of Region 14. They consist of deep-water marine sandstones and slates of Ordovician age that have suffered complex folding and faulting. The Southern Uplands are terminated to the north by the Southern Uplands Fault, but rocks of the same age are seen to the north of the Southern Uplands Fault, between the mouth of Loch Ryan and Girvan. Of particular interest along this part of the coast are the igneous rocks of the Ballantrae Igneous Complex, which are associated with

Table 2.1.1 Geological column

Era	*Period*	*Epoch*	*Age of start (million yrs)*	*Stratigraphic units mentioned in the text*	*Significant geological events*
Cenozoic	Quaternary	Holocene	0.01		Rapid rise in sea level
		Pleistocene	1.6	Devensian ice sheet	Series of ice sheets cover the region
	Tertiary (Neogene)	Pliocene	5.1		
		Miocene	25		
	Tertiary (Palaeogene)	Oligocene	38		Uplift and erosion in the western part of the region
		Eocene	55		Intrusion of Tertiary Igneous Complexes
		Palaeocene	65		
Mesozoic	Cretaceous		144	Chalk Greensand	
	Jurassic		213	Lias	Deposition in offshore basins; some deposition extended on land
	Triassic		248	Rhaetic Beds	
Palaeozoic (Upper)	Permian		286		
	Carboniferous	Stephanian		'Barren Red Measures'	Deposition in isolated basins
		Westphalian		Coal Measures	Deposition in isolated basins
		Namurian			
		Dinantian	360		
	Devonian		408	Old Red Sandstone	Caledonian Orogeny Closure of Iapetus Ocean
Palaeozoic (Lower)	Silurian		438		
	Ordovician		505	Ballantrae Igneous Complex	Ocean floor sediments and emplacement of igneous rocks
	Cambrian		540		
Precambrian				Dalradian - Southern Highland Group, Argyll Group, Appin Group Moinian Torridonian Lewisian	Major metamorphic and structural events affect parts of Moinian. Series of major metamorphic events modified Lewisian rocks

Notes: shaded boxes show ages of rocks with important or extensive exposures in the region.



Map 2.1.1 Onshore coastal geology. Source: British Geological Survey (1991).

Arenig (Early Ordovician) shales: at Bennane Head, red and green chert is interlayered with volcanic rocks, black fossiliferous shales and spilitic pillow lavas (formed underwater). Serpentinite (an ultrabasic igneous rock composed of altered olivine crystals) crops out as a broad band extending inland from Bennane Head and Lendalfoot; minor gabbro and dolerite intrusions occur within it. The rocks of the complex, laid down under oceanic conditions, are an indication that during early Palaeozoic times a major ocean (the Iapetus Ocean) separated the provinces of northern and southern Britain, which are now joined together at the Southern Uplands Fault.

The Midland Valley

Devonian rocks belonging to the Midland Valley province crop out along the coast from Girvan to Heads of Ayr, resting unconformably on the underlying Lower Palaeozoic rocks. These Devonian sediments were formed by the erosion of the mountains that emerged when the Iapetus Ocean closed up, and were deposited under continental conditions. They consist of reddish, micaceous and feldspathic sandstones and conglomerates, containing a variety of pebbles derived from the underlying rocks. A thick sequence of Devonian basalt and andesite lavas is exposed along the coast at Dunure, overlying the sediments.

The coast from Ayr to Saltcoats is formed of Carboniferous rocks, mainly Coal Measures but including, at Prestwick, exposures of the upper part of the 'Barren Red Measures'. The Coal Measures consist of well-bedded alternations of sandstone, siltstone (with numerous ironstone horizons), coals and seat earths (fossil soils). In places basalt lava flows and intrusive sill complexes are exposed. Dinantian (Lower Carboniferous) limestones and sandstones underlie the Coal Measures north of Saltcoats, and the coast northwards to Lunderston Bay is formed of gently folded Old Red Sandstone sediments traversed by numerous suites of dykes.

The Highland Boundary Fault crosses the mouth of the Clyde, about 2 km north of Toward Point, and continues south-westwards to Rothesay and Arran. The Isle of Bute to the south-east of the fault is composed of Devonian sediments.

The Isle of Arran is an area of great geological interest embracing a wide range of rock types. The northern part of the island is dominated by the early Tertiary 'Northern Granite', intruded primarily into Dalradian schists. The southern part of the island is formed predominantly of Permo-Triassic sandstones, intruded by sills and dykes of early Tertiary age. The early Tertiary Central Ring Complex, south of the granite, was formed by a volcanic explosion leading to subsidence, causing younger rocks to subside and form a caldera (crater). The minor Mesozoic outcrops of Rhaetic, Lias and Chalk formations recognised within the complex give an indication of the sedimentary cover which overlay the island at the time of the subsidence. Along the north coast of the island is an unconformity where Carboniferous sediments, dipping gently to the north-west, rest on Dalradian schist.

There are numerous islands in the Firth of Clyde, of which the most famous, geologically speaking, is Ailsa Craig, a 340 m high peak which lies some 15 km WNW of Girvan. The island is formed of microgranite rich in riebeckite (an unusual amphibole mineral), which was intruded into surrounding sediments during the Carboniferous. The rock from the island is commonly used to make the stones used in the sport of curling.

The Highlands

The northern part of Region 14 is mountainous and deeply incised with numerous fjords. Deep glacial erosion has produced a rugged coastline, commonly with a well-exposed rocky foreshore. The coast displays a varied range of well-exposed metamorphic rocks, which have been studied in detail by geologists for over a century.

North of the Highland Boundary Fault most of the rocks of the region belong to the Dalradian Supergroup. These are mostly metamorphosed marine sediments of Precambrian age (Stephenson & Gould 1995). Harris & Pitcher (1975) divided the unit into a number of groups, which indicate that the rocks are older to the north. The youngest group is the Southern Highland Group which outcrops along the coast south of Loch Fyne and along the southern shores of Kintyre. The older Argyll Group is exposed along the north coast of Kintyre and north-eastwards to Glen Creran, and the oldest group, the Appin Group, outcrops along the southern shores of Loch Linnhe and parts of Islay. The unit as a whole consists of a complex mixture of quartzites, sandstones, limestones, and phyllites with volcanics in the younger groups. Of particular interest is the Port Askaig Tillite (at the base of the Argyll Group), which is up to 750 m thick, deposited during a glacial episode. The early folds within the Dalradian Supergroup include huge recumbent folds or nappes, which can be deduced only from regional mapping; however, later episodes of smaller-scale folding may be recognised within outcrops.

Small outliers of younger rocks are found within the Dalradian rocks, generally as fault-bounded basins. Typical of such a basin is the Machrihanish Coalfield on the western coast of Kintyre. Though the outlier is only a few kilometres across, it contains a wide range of Carboniferous strata and lavas, and coal was extracted from the area until the 1920s. A suite of NNW/SSE-trending Tertiary basic dykes traverse the area; they are generally best exposed along the coast.

The island of Jura is formed mostly of Dalradian quartzite, although there is a more varied succession, including phyllites and metamorphosed dolomites, along the eastern coast. Islay and Colonsay have exposures of red, green and grey grits of probable Dalradian age, which at the Rhinns of Islay overlie acid and basic gneisses thought to be of Lewisian age. Caledonian movements have shattered the gneisses into microbreccias and mylonites, and they were intruded later by a series of hornblende- and augite-rich bodies. Lewisian rocks are also thought to form the islands of Coll and Tiree.

The eastern part of the island of Mull is dominated by the circular Central Intrusive Complex, in which three caldera structures have been recognised. The coastal sections of the complex consist of lavas intruded by acid bodies and later basic dykes. Tertiary lavas cover most of the western and northern part of the island, though the Ross of Mull in the south-west is formed of a Caledonian biotite-rich granite with a distinctive pink or red colour. The Lower Devonian lavas and Upper Cretaceous greensand at Loch Don, and the Rhaetic (Lower Jurassic) Beds in western Mull, give a glimpse of the complex geological history of the region, now extremely difficult to unravel because of the

almost complete erosion of the units and the thick cover of Tertiary basalt.

The Moine Thrust, a major structural feature of north-west Scotland, is thought to lie close to the west of Mull, and may run between Mull and Iona. The rocks to the west of this line are generally older than those to the east.

2.1.3 Further sources of information

A. Maps

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Stephenson, D., & Gould, D. 1995. *The Grampian Highlands.* Keyworth, British Geological Survey. (Regional Geology Guide.)

C. Further reading

Section 7.4 lists the Geological Conservation Review (GCR) sites occurring in the region. Detailed descriptions of GCR sites in the region can be found in volumes of the Geological Conservation Review series.

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Richey, J.E. 1961. *The Tertiary volcanic districts*. 3rd ed. Edinburgh, HMSO. (British Regional Geology, Institute of Geological Sciences.)

D. Contact names and addresses

Type of information	*Contact address and telephone no.*
Geological information for Region 14 and the whole of Britain; 1:50,000 scale map sheets	Coastal Geology Group, British Geological Survey, Keyworth, Nottingham NG12 5GG, tel: 0115 936 3100
Isle of Arran	Dr E. Robinson, The Geologists' Association, Burlington House, Piccadilly, London W1V 9AG
Geological Conservation Review (GCR) sites in the region	*SNH South West Region Office, Clydebank, tel: 0141 951 4488

*Starred contact addresses are given in full in the Appendix.

2.2 Offshore geology

British Geological Survey

This section deals briefly with the geology of the rocks and sediments at and below the sea bed. The bulk of the information is shown on the maps, with some additional explanation provided by the text.

The offshore environment of the region is one of great variability, brought about largely by the wide range of rock types exposed offshore and the scouring effects of the Late Devensian ice tongues which flowed across the area. The complexity of the coastline introduces rapid changes in tidal and wave conditions across the area, which are reflected in the variations in lithology and thickness of the Holocene sea-bed sediments.

2.2.1 Holocene sea-bed sediments

Sea-bed sediments are defined here as the unconsolidated sediments at sea bed laid down since the sea transgressed across the area during the Holocene. The lithology (rock types) and thickness of the sediments have been determined by sampling, high resolution seismic profiling and sidescan sonar.

The Holocene sea-bed sediments of the region are highly variable in both lithology and thickness; the strength of the tidal currents at the sea bed is a primary determinant of the sediment type (Map 2.2.1). Abundant sediment is supplied from the rivers that flow from the rugged inland areas, and some is supplied by erosion of the fringing raised beach deposits and boulder clay. Erosion rates are slow compared with those along the coasts of, for example, south-east England (Regions 6 - 9).

Thin gravels and sands predominate in the North Channel, where tidal currents are strongest. These gravels are locally shell-rich, and shell gravel pavements may develop on bedrock. Sand is predominant near the coast, leading to a profusion of small, sandy beaches across the region. Tidal currents are weakest within the glacially-deepened lochs, leading to the accumulation of thick sequences of mud. Observations from a submersible in lower Loch Fyne showed mud occupying a central channel less than 0.5 km wide between rock walls up to 80 m high. Manganese nodules, first discovered in the nineteenth century, are found on and just below the surface of the sea floor. Similar nodules have been collected in many of the sea lochs around the Firth of Clyde. Calcareous dunes are locally cemented on Coll, the cementation locally picking out 'fossilised' hoof prints.

2.2.2 Pleistocene geology

Onshore across the region Pleistocene sediments are mainly restricted to those associated with the Late Devensian glaciation, although some of the shore platforms, notably those on Mull, Islay and Jura, were incised prior to this (Map 2.2.2). Offshore the Pleistocene succession is significantly thicker but is largely restricted to broad channels, where the sequence is locally over 200 m thick and stratigraphically more complex than onshore.

Shallow seismic profiling and drilling have revealed the full complexity of the succession, and a number of glaciomarine, fluvioglacial and glacial formations have been defined from these investigations. The basal formations are not represented on land, and correlation with Pleistocene sequences in the North Sea is uncertain. At the top of some boreholes is a thick succession of soft, muddy sand (up to 34 m thick), in which is preserved a full post-glacial (late Pleistocene to Holocene) sequence.

The succession in the Firth of Clyde is simpler than that further west and north, with only a single Late Devensian till unit, up to 30 m thick, resting on bedrock. Also present are the Clyde Beds, late-glacial marine deposits associated with deglaciation and accompanying sea-level change.

2.2.3 Solid (pre-Quaternary) geology

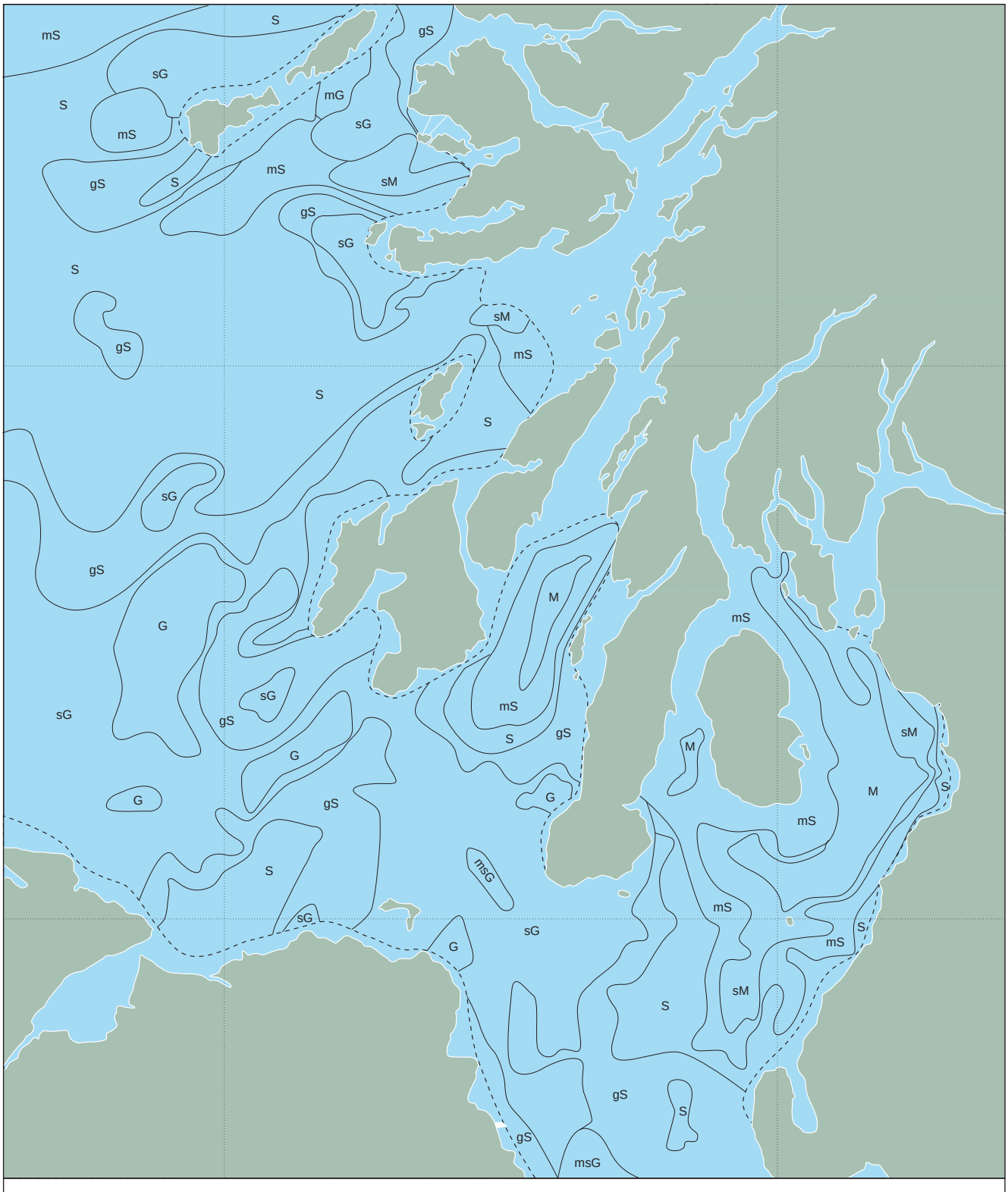
The major north-east/south-west faults, which divide the onshore geology into distinct sectors, continue across the offshore part of the region. Thus the Great Glen Fault may be traced as a series of faults, along Loch Linnhe to the north-western part of Islay and further to Donegal (Republic of Ireland) (Map 2.2.3). These faults were most active during Precambrian and Paleozoic times, but later tensions in the earth's crust reactivated the faults, and they had a significant influence on the sites of Mesozoic basins and Tertiary igneous centres across the region.

Fault-bounded sedimentary basins developed across the region during the Mesozoic. These are now preserved offshore as Permo-Triassic to Cretaceous infilled basins in the North Channel, in the Firth of Clyde and to the south-west of Mull. Small outliers of these Mesozoic sediments are preserved within the calderas of the Tertiary igneous complexes and locally beneath the thick Tertiary lava sheets. These exposures show that during the late Mesozoic the region was one of more gentle relief than at present and had an extensive cover of Mesozoic rocks.

The Tertiary igneous complexes, found in the region on Arran and Mull but extending outside the region from Lundy in the south to Skye in the north, were associated with outpourings of thick basaltic lavas and the intrusion of a north-west/south-east-trending suite of dykes. The lavas extend offshore west of Mull and reappear to form the island of Staffa, where the columnar jointing in the basalt at Fingal's Cave is world famous.

The Blackstones Bank some 30 km south-west of Mull is a submerged Tertiary igneous centre, first recognised from gravity and magnetic anomalies and later proved by samples collected from the sea bed. The bulk of the bank consists of gabbro with some granophyre; it is surrounded by metamorphosed Mesozoic rocks.

South-west of the Blackstones Bank are the Blackstones and Colonsay Basins, containing up to 400 m of sediment inferred to be of mid-Tertiary age. Similar basins are found in Lough Neagh (Northern Ireland) and in north-eastern Cardigan Bay. They were formed when, during the uplift of the British mainland, basins in areas presently offshore suffered subsidence (Muir Wood 1989). During the mid-



Key to sea-bed sediment symbols

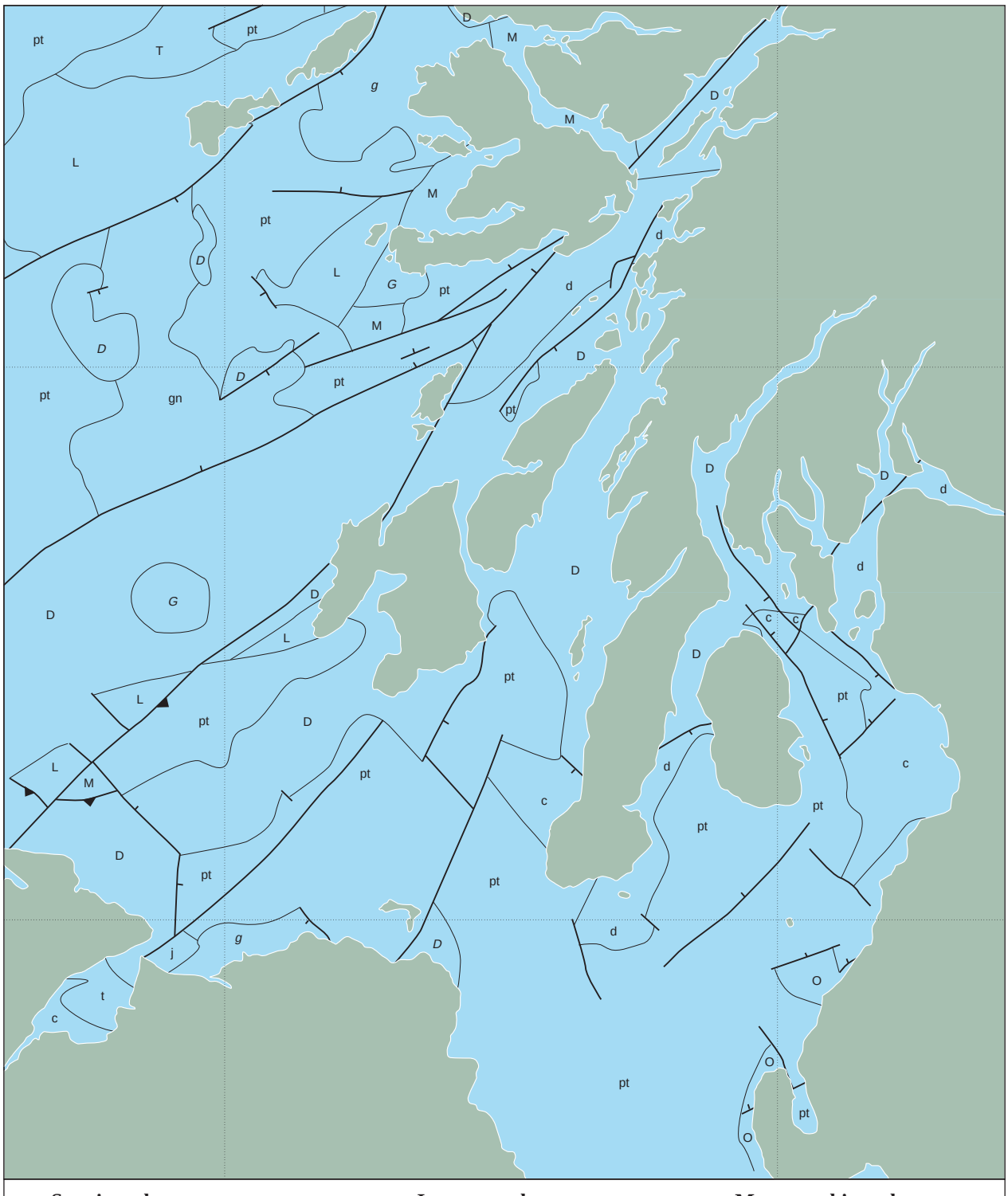
M	Mud	mS	Muddy sand	mG	Muddy gravel		No information landward of line
sM	Sandy mud	gS	Gravelly sand	msG	Muddy sandy gravel		
S	Sand	G	Gravel	sG	Sandy gravel		

Map 2.2.1 Sea-bed sediments. Sources: British Geological Survey (1991); sediment classification modified after Folk (1954).

Key to sea-bed sediment symbols

QLP	Late Pleistocene to Early Holocene	2	Predominantly mud		No significant Pleistocene cover
QMP	Middle Pleistocene	3	Predominantly interbedded mud and sand		
Q	Quaternary, undivided	6	Predominantly incision and channel deposits	- - -	No information landward of line
Q<5	Quaternary generally < 5 m thick	7	Predominantly sand		

Map 2.2.2 Offshore Pleistocene deposits. Source: British Geological Survey (1994).



Stratigraphy

- gn Tertiary
- j Jurassic
- t Triassic
- pt Permo-Triassic
- c Carboniferous
- d Devonian
- O Ordovician
- T Torridonian

Igneous rocks

Extrusive

- *g* Palaeogene

Intrusive

- *G* Acid
- *D* Basic

Metamorphic rocks

- D Dalradian
- M Moine
- L Lewisian

Structures

- Fault, tick on downthrow side

Map 2.2.3 Offshore solid (pre-Quaternary) geology. Source: British Geological Survey (1991).

Tertiary there was extensive erosion across the region of the former cover of Mesozoic sediments and Tertiary lavas.

2.2.4 Further sources of information

A. Maps

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D. Contact names and addresses

Type of information	*Contact address and telephone no.*
Geological information for region and the whole of Britain	Coastal Geology Group, British Geological Survey, Keyworth, Nottingham NG12 5GG, tel: 0115 936 3100
Geological information for region	*SNH, Earth Science Branch, RASD, Edinburgh, tel: 0131 554 9797
UKDMAP 1992. Version 2. United Kingdom digital marine atlas. Oceanographic maps.	*British Oceanographic Data Centre, Birkenhead, tel: 0151 652 3950

*Starred contact addresses are given in full in the Appendix.

2.3 Wind and water

British Geological Survey

2.3.1 Wind

The irregular form of the coastline and the mountainous nature of the interior cause great variation in the wind climate across the region. Windspeeds in the region are typically intermediate between those of the sheltered Irish Sea and the very exposed coast of north-west Scotland. The standard wind maps produced by the Meteorological Office (Caton 1976) show that mean wind speeds exceeded for 75% of the time are about 4 m/s across the western part of the region and about 3 m/s along the mainland coast (Map 2.3.1). In contrast, the wind speed exceeded for 0.1% of the time is in excess of 20 m/s (Force 8) across the western part of Islay and Mull, decreasing to 18 m/s east of a line between Loch Ryan and Loch Linnhe (Map 2.3.2). These are average values and more local information may be obtained from records at specific stations.

The wind directions recorded at Prestwick Airport show only a moderate bias towards the south-west, as the site is open to winds from the east (Figure 2.3.1). In contrast, Abbotsinch Airport, Glasgow, is sheltered from winds from northerly and south-easterly quarters. The difference in the percentage of calms at Abbotsinch (18.1%) and Prestwick (7.6%) reflects the breezy conditions associated with all shorelines (Smith 1986). The difference in mean wind speed at Prestwick (about 4.75 m/s) and Tiree (7.6 m/s) reflects the sheltering effect of Arran and Kintyre, compared with the more windy conditions experienced on exposed westernmost coasts. The gale of January 1968 generated winds of 44.6 m/s at Prestwick, compared with the average annual maximum there of 31.7 m/s; such extreme events are estimated to occur at Prestwick once every 75 years.

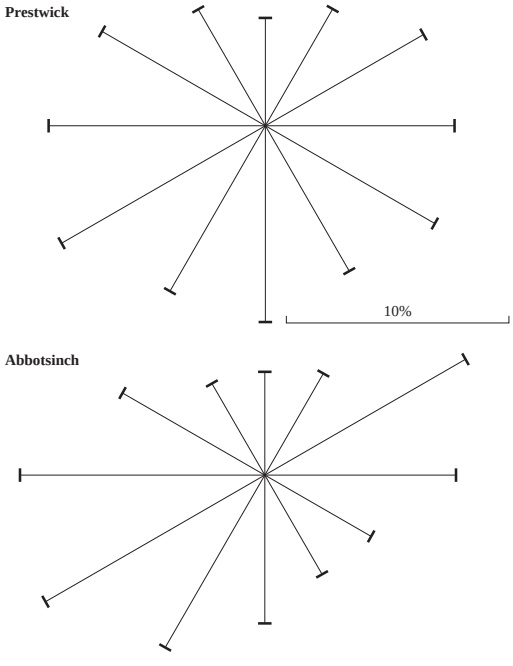
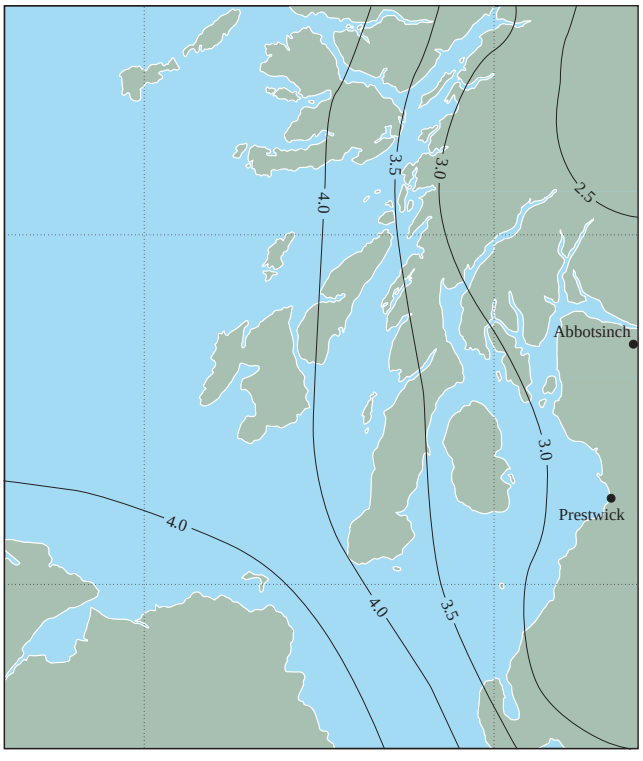
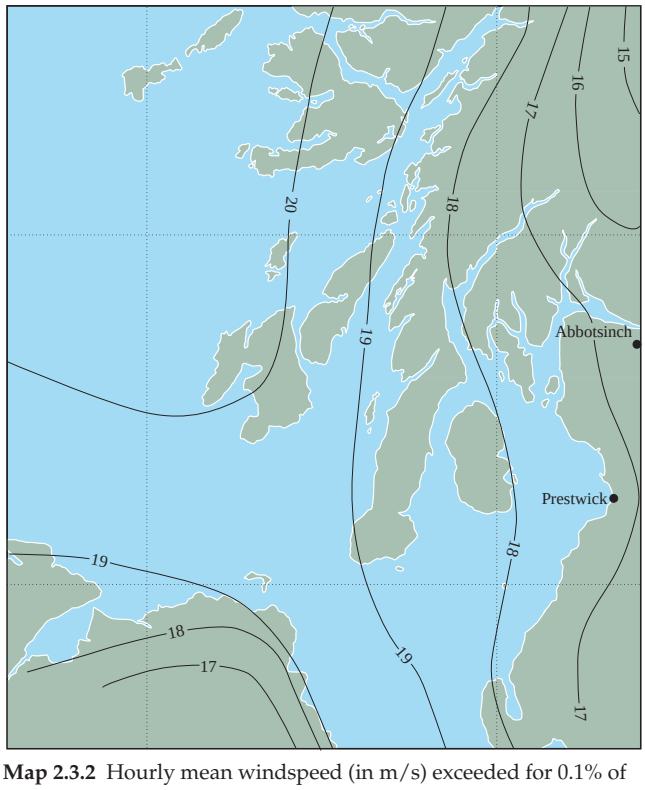


Figure 2.3.1 Wind directions at Prestwick and Abbotsinch shown as % of observations during the years 1916 - 1950. Flat calm (% of observations) = Prestwick (7.6%); Abbotsinch (18.1%). Source: Hydrographic Office (1960).



Map 2.3.1 Hourly mean windspeed (in m/s) exceeded for 75% of the time. Source: Caton (1976).



Map 2.3.2 Hourly mean windspeed (in m/s) exceeded for 0.1% of the time. Source: Caton (1976).

2.3.2 Water depth

The region is one of complex bathymetry; Map 2.3.3 gives only a simplified picture. The main reason for the complexity is the deepening of sea lochs and major channels by the scouring action of ice, which created locally-enclosed deeps with shallower seaward terminations ('sills'). Another reason for the complex sea-floor bathymetry is the variation in lithology within the bedrock and the common occurrence of local bodies of highly resistant rocks. Blackstones Bank, a Tertiary igneous body south-west of Mull, is one such isolated feature.

Across the seaward part of the area, to the west of Islay and Mull, the sea floor is generally flat and lies at a depth of between 40-80 m. To the east there are narrow, deep channels which separate the islands and continue the lochs. The channel west of the island of Lismore in Loch Linnhe is over 200 m deep, as is the channel in the Sound of Jura. The deepest waters in the region occur at the northern end of the North Channel, near Rathlin Island, where depths exceed 240 m.

Map 2.3.3 Bathymetry. Source: Admiralty chart.

2.3.3 Tidal currents

Maximum tidal currents run at more than 4.0 m/s off Rathlin island near the Northern Ireland coast and decrease in all directions away from this zone (Map 2.3.4). Within the Firth of Clyde maximum velocities are generally less than 0.5 m/s, and off the west coast of Mull they generally range between 0.5 to 1.0 m/s. Velocities within the sea lochs are generally low, attaining about 0.2 m/s in the centre of Loch Linnhe and 0.25 m/s off the north coast of the Ross of Mull. An exception to this is in the Gulf of Corryvreckan, the narrow channel between the islands of Jura and Scarba, where a tidal race may reach a speed of 4.3 m/s.

2.3.4 Tidal range

Map 2.3.5 shows tidal range values taken from Lee & Ramster (1981). The tidal range at mean spring tides is less than 1 m in the waters between Islay and Kintyre. The value increases to the north-west and south-east such that the range is approximately 3.5 m off the west coast of Mull and about 3.0 m across the narrowest part of the North Channel.

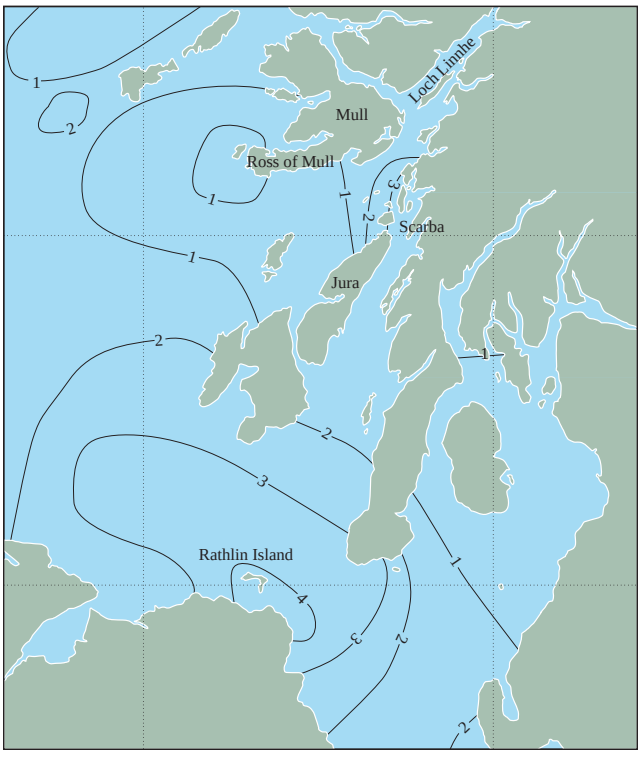
Storm surges may occur in the Firth of Clyde: Townson & Collar (1986) suggest a magnitude of less than 1 m, significantly lower than during similar events in the southern North Sea. Computer modelling described by Flather (1992) suggests that a 50-year storm surge in the Firth of Clyde would exceed 2 m in height.

2.3.5 Wave exposure and sea state

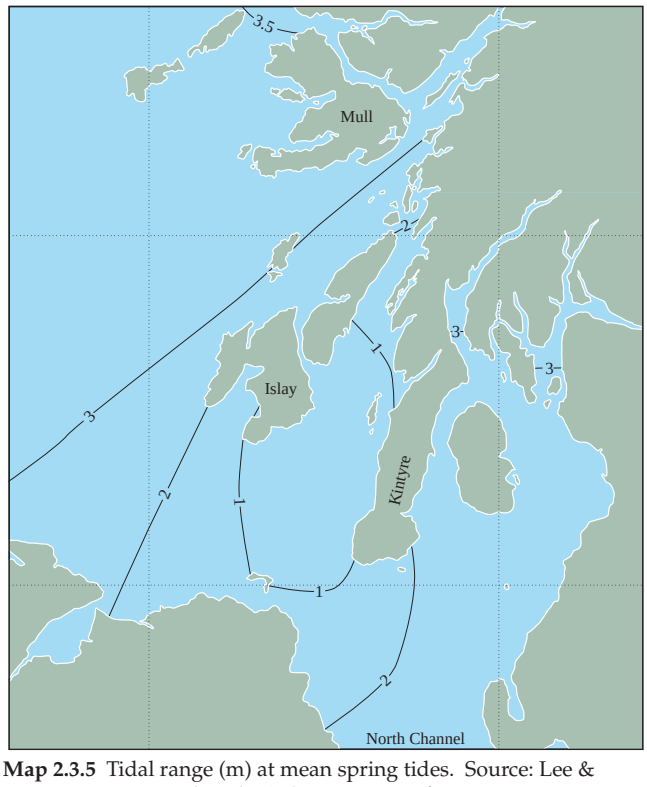
The irregular form of the coastline, with the numerous islands and sea lochs, results in great variability in the wave energy experienced at the coast. The westernmost part of the region is open to prevailing westerly and south-westerly winds, but nearer to the shore the shallow and often rough sea bed limits wave heights, compared with those experienced to the north off the Outer Hebrides. During winter the significant wave height exceeds 3.0 m only along the west coast of Islay and Kintyre. During summer the significant wave height along the same coast is generally less than 2.5 m. Wave heights within the sea lochs are significantly less than these values: Draper (1991) shows that summer wave heights in the Firth of Clyde exceed 0.5 m for only 10% of the time. Map 2.3.6 shows the significant wave height (in metres) exceeded for 10% and 75% of the year.

2.3.6 Water characteristics

Hydrographic conditions within the Clyde Sea are more complex than those off the open coasts of the region (Edwards *et al.* 1986). The broad sill termed the Great Plateau (Map 2.3.3), which has a maximum depth of about 50 m, lies across the mouth of the Clyde Sea south of Arran and marks the site of a hydrographic front, separating well-mixed water to the south from stratified water to the north. Similar, smaller, sills occur further north at the entrances to the sea lochs. Above the level of the top of the sills there is

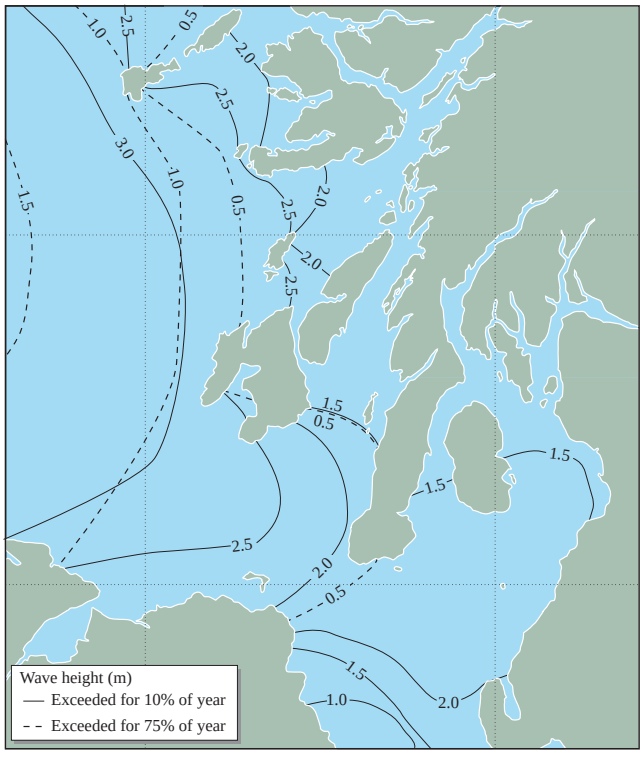


Map 2.3.4 Maximum tidal current speed (in m/s) at mean spring tides. Source: Sager & Sammler (1968).

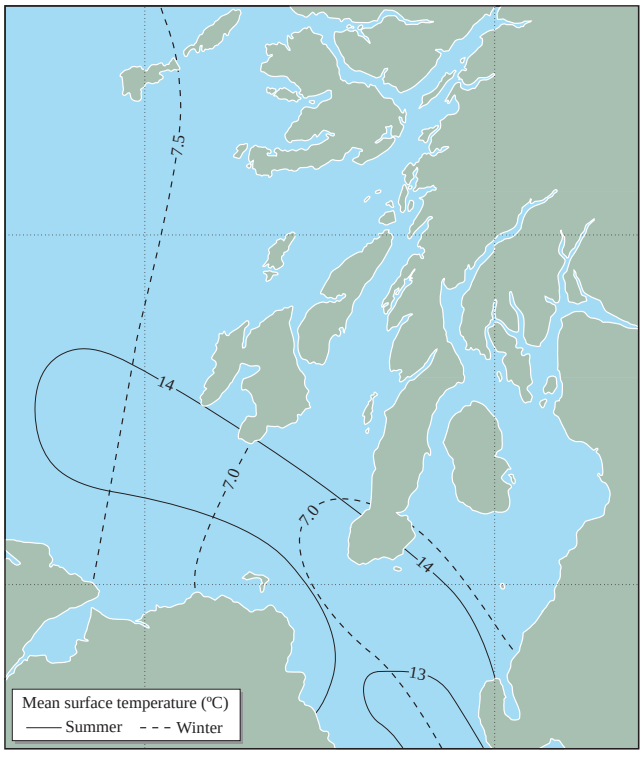


Map 2.3.5 Tidal range (m) at mean spring tides. Source: Lee & Ramster (1981). © Crown copyright.

free movement of water, dominated by the tides, the wind and freshwater outflows. Below the level of the sills, weak diffusion processes may predominate, along with downward flows of the densest (most saline) water, which in turn lift water towards the more energetic surface layers. Bottom water stagnation and nutrient build-up occurs within the lower levels of the sea lochs.



Map 2.3.6 Significant wave height (m) exceeded for 10% and 75% of the year. Source: Draper (1991).



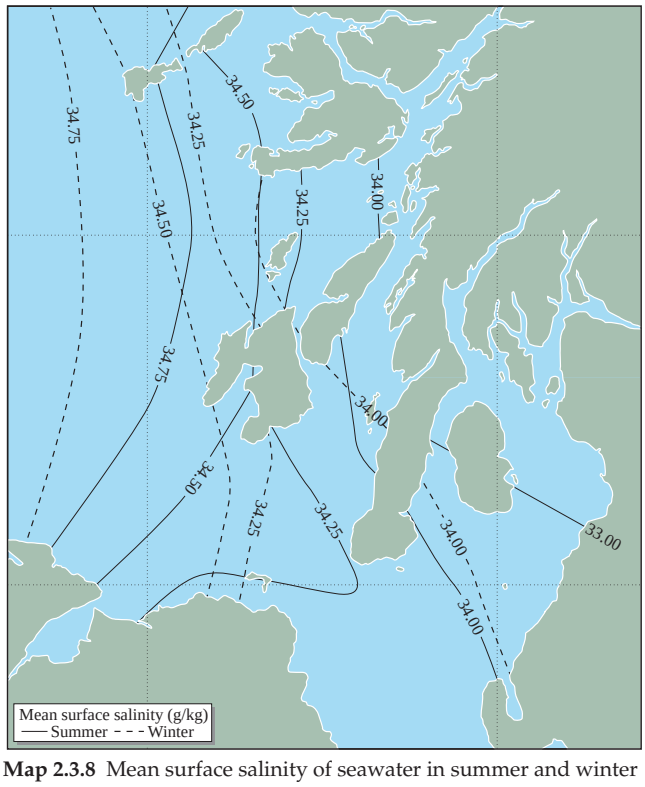
Map 2.3.7 Mean surface water temperature in summer and winter (°C). Source: Lee & Ramster (1981). © Crown copyright.

Water temperature

Map 2.3.7 shows the summer and winter sea surface temperatures across the region. Summer temperatures in the south of the region are among the lowest on the west coast of Britain because Ireland obstructs the warm flow of the Gulf Stream. In winter on the west coast of Britain, only the eastern part of the Irish Sea is colder. Temperatures are higher in the northern part of the region. More detailed work in the Clyde Sea shows that in winter the Great Plateau to the south of Arran marks a well-defined temperature boundary, with temperatures to the north being between 7.4°C and 7.6°C, while those to the south range between 8.0°C and 8.4°C. In the summer this effect is not so well displayed and the warmest area is east of Arran (13.25°C), while the more open sea to the south is around 12°C. Extreme monthly means in the region range from 5.1°C to 15.2°C (Ellett & Edwards 1983).

Salinity

The term salinity is used to describe the total weight of dissolved salts present in seawater, and is expressed in g/kg, with the salinity of normal sea water being 35 g/kg. Mean surface salinity in winter across the outer part of the region is about 34 g/kg, decreasing landward owing to the influx of riverine fresh water (Map 2.3.8). Summer values are generally similar. Edwards *et al.* (1986) show that values decrease north-east of Arran to less than 32.5 g/kg, owing to the diluting effect of freshwater.



Map 2.3.8 Mean surface salinity of seawater in summer and winter in g/kg of total dissolved salt. Source: Lee & Ramster (1981). © Crown copyright.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
UKDMAP (United Kingdom digital marine atlas) Version 2. Oceanographic maps.	*British Oceanographic Data Centre, Birkenhead, tel: 0151 652 3950
Monthly, seasonal and annual windroses	J. Hammond, Meteorological Office Marine Enquiry Service, Johnstone House, London Road, Bracknell RG12 2SY, tel: 01344 854979

*Starred contact addresses are given in full in the Appendix.

2.4 Sediment transport

British Geological Survey

2.4.1 Description

Sediment transport is described within the context of coastal cells and sub-cells. These divide the coastline into sections within which sediment erosion and accretion are inter-related and largely independent of other cells (Motyka & Brampton 1993). HR Wallingford (1995) have divided the coast of mainland Scotland into seven major littoral cells. This region includes parts of two coastal cells: Cell 6, stretching from the Mull of Galloway to the Mull of Kintyre and Cell 5, from the Mull of Kintyre to Cape Wrath.

In the north-west of this region, the complex form of the coastline in relation to the prevailing winds, and thus the wave climate, results in a highly variable sediment transport regime, which restricts littoral transport to specific bays, between which there is little or no interchange of material. Tidal currents are generally weak and net sediment transport offshore is generally northwards, as determined by residual currents. Additional factors, such as exposure and physical character, have therefore also been taken into account in the defining of the cells and sub-cells (HR Wallingford 1995). Sub-cells are described below and shown on Map 2.4.1; note that the sediment transport shown is of sand and gravel 'bed load', not suspended sediments.

Sub-cell 6d: Mull of Galloway to Bennane Head

In this sub-cell there is little sign of any net drift, except at Ballantrae, where drift is to the south. There are thin shingle beaches overlying rock platforms along much of the coast and a more substantial shingle beach at Ballantrae. Offshore, an examination of side-scan profiles led Caston (1976) to propose a divergence of net transport directions for sandy sediment within the North Channel, to the north-west in the northern part of the channel and to the south-east in the southern part.

Sub-cell 6c: Bennane Head to Farland Head

Sediment transport directions appear to be determined by the orientation of the coast relative to the prevailing onshore winds, although on most beaches there is no obvious indication of longshore drift. Between the rocky headlands at the Heads of Ayr, Troon and Saltcoats, the curve of the long, sandy beaches at Ayr, Prestwick and Irvine suggests onshore transport of sediment between the headlands, although rates are low. To the north and south of this area beaches are often thinner, with an underlying rock platform. There is severe erosion between Troon and Saltcoats in Irvine Bay.

Sub-cell 6b: Farland Head to Inner Firth of Clyde

As elsewhere in this region tidal streams are weak, and wave action is reduced here because of the more sheltered conditions and restricted wave 'fetch' (the extent of open water upwind). There is possibly a low rate of northward drift along both sides of the Firth of Clyde. Erosion at Inverkip is being addressed by coast protection measures.

Sub-cell 6a: Inner Firth of Clyde to Mull of Kintyre

Littoral drift is dependent on wind direction and there is little evidence of any net movement. Erosion and accretion are both minimal. Sand and shingle beaches lie within small bays and there is a continuous shingle fringe along the edges of most of the sea lochs, with large intertidal sand and gravel deposits at the loch heads.

A study of sediment transport directions around north Bute (Lamont 1945) showed that the 'fetch' of the waves determined the direction of net sediment transport. The fetch changes markedly around the coast, thus introducing equally abrupt changes in the direction and magnitude of net sediment transport. It is probable that the broad conclusions of this study apply elsewhere along the deeply indented coasts of the region and around the islands.

Sub-cell 5c: Mull of Kintyre to Ardnamurchan Point

The western coasts of this sub-cell, such as at Machrihanish, where there is a large, exposed sandy beach, are fully exposed to Atlantic wave action; many other beaches are protected by offshore islands and their location at the heads of lochs. There are also extensive intertidal flats at the heads of some lochs, for example at Loch Caolisport. Erosion and accretion are not substantial, except during storms that blow up along the lochs.

Sandy beaches make up about 6% of the western open coasts of Argyll, typically as small pocket beaches. Sediment accumulations are most extensive where islands protect a section of shoreline from wave attack. At Rhunahaorine Point, east of Gigha Island, off north-west Kintyre, a cusp-shaped accumulation of shingle has formed. Sandy and gravelly accumulations are more commonly found at the heads of the sea lochs and are formed from both marine and alluvial sediments.

Map 2.4.1 Sediment transport. Source: Motyka & Brampton (1993). Adapted with permission from MAFF Flood and Coastal Defence Division.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Coast protection policy; sediment cells	*Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD), Edinburgh, tel: 0131 244 0213
Sediment cells	HR Wallingford Ltd, Howbury Park, Wallingford, Oxfordshire OX10 8BA, tel: 01491 835381
Coastal defence, sediment cells, erosion and deposition	*SNH, Earth Science Branch, RASD, Edinburgh, tel: 0131 446 2400
Review of erosion, deposition and flooding in Great Britain (maps and database)	Minerals Division, Room C15/19, Department of the Environment, 2 Marsham Street, London SW1P 3EB, tel: 0171 276 0900

*Starred contact addresses are given in full in the Appendix.

2.5 Sea-level rise and flooding

British Geological Survey

2.5.1 Sea-level changes in the region

Apparent sea-level change in the region is the combined effect of local crustal movements (Scotland is rising whereas southern England is sinking, owing to the removal of the weight of ice since the last glacial period) and global rises in sea level. Global sea level fell to about 120 m below the current level some 18,000 years ago, owing to the abstraction of water into ice sheets that depressed the level of the land surface. With the melting of the ice sheets, sea level rose to its present level about 5,000 years BP. The removal of the weight of the ice caused the earth's crust to rise to its original level, but more slowly than sea level. The region has risen some 25 to 35 m since 9,500 years ago (Boulton 1992) and the results of this initial flooding and subsequent uplift have been the formation of raised beaches around the coast and the deposit of Late Pleistocene (post-glacial) and/or Holocene marine sediments.

There are a number of detailed studies of the evidence for sea-level rise and crustal movement in Britain (e.g. Shennan (1989), Carter (1989), Woodworth (1987) and Emery & Aubrey (1991)). Tide gauge measurements made over the last few decades suggest that sea level is rising globally due to global warming by 1-2 mm/year, but on a national scale the evidence can be contradictory and difficult to interpret (Woodworth 1987). Evaluation of tide gauge data by Emery & Aubrey (1985) showed a fall in sea level across the region relative to the land surface, ranging between 2 mm/yr across the Mull of Galloway to over 6 mm/yr across the mouth of the River Clyde (Map 2.5.1). Tide gauge readings at Portpatrick (Mull of Galloway) from 1968 to 1987 suggest that sea level is changing at a rate that can vary from one year to the next by amounts ranging from a rise of 6.61 mm/yr to a fall of 1.23 mm/yr (Woodworth 1992). This fluctuation is also shown in the longer-term graphs presented in Woodworth (1987) for other parts of the UK. However, it appears that relative sea level in the region has fallen by an average of at least 1 mm/yr across the region throughout the late Holocene, in spite of the current global sea-level rise. However, if global warming increases the rate of global sea-level rise, as it is predicted to do, the situation may be reversed.

2.5.2 Flooding risk

With the relative fall in sea level, the threat of flooding is not of widespread importance in the region. There are low-lying areas (less than 5 m above Ordnance Datum), notably in Irvine Bay between Ayr and Saltcoats and along the banks of the River Garnock (which meets the sea at Irvine), that can be considered to be at some risk. Further north in the Firth of Clyde some coastal areas are liable to flooding from high tides and storm surges. Elsewhere coastal flooding is a possibility at the heads of some lochs and in some low-lying river valleys.

Map 2.5.1 Estimated rates of crustal movement and sea-level rise. Source: after Emery & Aubrey (1985).

2.5.3 Further sources of information

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Flood defence	*Local authorities, see Appendix A.2
Flood warning	*SEPA, West Region, East Kilbride, tel: 01355 238181
Flood and coastal defence policy (see also section 8.4)	*SOAEFD, Edinburgh, tel: 0131 556 8400
Sea-level rise and flooding information for region	*SNH, Earth Science Branch, RASD, Edinburgh, tel: 0131 554 9797
Review of erosion, deposition and flooding in Great Britain (maps and database)	Minerals Division, Room C15/19, Department of the Environment, 2 Marsham Street, London SW1P 3EB, tel: 0171 276 0900
Tide gauge data	*British Oceanographic Data Centre, Birkenhead, tel: 0151 652 3950

*Starred contact addresses are given in full in the Appendix.

2.6 Coastal landforms

British Geological Survey

2.6.1 Description

The coastal landforms of the region are the product of a range of factors, including the geological structures and rock types, the physiographic development of the region through the Tertiary Era, the Pleistocene glaciation of the region, and Holocene sea-level changes and associated coastal processes. Major coastal landforms are shown on Map 2.6.1.

The Highland Boundary Fault divides the coast of the region into two physiographic zones: to the south of the fault, which runs just north of the River Clyde (see Map 2.1.1), the coastline is generally straight and cuts across the structural grain of the onshore bedrock. To the north of the fault the land is generally mountainous and the coast rocky and in places deeply fiorded, with the structural grain of the bedrock imposing strong control on the form of the coastline.

Loch Ryan to the Clyde

Between Loch Ryan and Heads of Ayr the coast is predominantly rocky and cliffed with extensive raised beach sections. South of Ballantrae the coast is steep, with usually only a narrow platform separating the old cliff line from the sea. River valleys reach the coast at Ballantrae and Girvan, and the extensive sand dunes at Turnberry are the site of the famous golf course. The full geological complexity of the rocks in this stretch is revealed in the wave-cut platforms, and locally the more resistant rocks form sea stacks. Ailsa Craig rises steeply from the sea, although a spit of coarse shingle has accumulated along its eastern coast.

Between Ayr and Saltcoats the coast is low-lying, with several levels of raised beach, generally at heights of between 7 m to 24 m, though locally extending up to 33 m above OD. The seaward limit of the raised beaches is commonly a low cliff cut into boulder clay. The low ridges and swales (depressions) in the raised beach between Troon and Irvine reflect the development of an accretionary barrier coast in Holocene times. A number of rivers reach the coast in the large bays and there are extensive lengths of sand dune, locally over 2 km wide, fronted by wide, sandy foreshores.

Raised beaches continue almost unbroken to Lunderston Bay at the mouth of the Clyde and are well developed almost all the way round Great and Little Cumbrae Islands. The sandy bays between Ardrossan and Farland Head and at Hunterston are replaced further north by land rising more steeply from the sea, leaving little intertidal area.

The Isle of Arran is surrounded by a raised beach platform which is only absent at some of the headlands. The main platform is at an elevation of about 8 m, though higher platforms can also be traced at 12 m and 30 m OD. The land slopes steeply into the sea in most parts of the island, especially in the north, where high mountains lie close to the coast.

The inner part of the Clyde Estuary has large intertidal areas of mud and sand flats, particularly on the northern shore. On the south side the shoreline of Port Glasgow and Greenock is largely artificial.

The Clyde to Mull

North and west of the Firth of Clyde the coastline shows the strong influence of glacial action, with many long, narrow, steep-sided fiordic inlets, such as Loch Long and Loch Fyne. The orientation of the Dalradian rocks generally trends north-east/south-west, giving the coast its 'grain'.

The raised beaches continue along the deeply indented coastline of Loch Striven and Loch Fyne, and in places more resistant rocks are preserved as former sea stacks on these platforms. The long sand and shingle spit of Oitir stretches halfway across Loch Fyne. Typically, along the east coast of Kintyre wave erosion has led to the formation of a cliff, but no beach has formed because the material has been moved offshore (Crofts & Ritchie 1973). There is a shingle beach at Skipness and a sandy beach at Carradale. Along the 'dipping' coasts typical of the Mull of Kintyre, the land descends smoothly into the sea, with no beach development and only rare cliff erosion.

The beaches of western Kintyre illustrate a type identified by Crofts & Ritchie (1973) as being sandy with gravelly and muddy areas, usually with rock outcrops in the intertidal and above-tidal areas. The upper beach may progress landward into sand dunes, which commonly cover the raised beach terraces, backed in turn by rock cliffs with a variable cover of glacial deposits. At Machrihanish there is a long sandy beach backed by dune and machair (see section 3.2), and at Rhunahaorine there is an excellent example of a large cuspate shingle foreland (section 3.3).

The south-westerly grain of the coast is particularly evident around Loch Sween and Loch Craignish, where much of the land surface slopes into the sea without any change in gradient and there are many elongate islands. In between these two lochs lies Loch Crinan, which has a contrasting character with considerable intertidal sediment, backed by the wide expanse of raised bog of Moine Mhor.

A fiardic landscape, where glacial action has left the coast rocky and island-studded and the water shallow, may be seen in the north of the region, between Jura, Loch Melfort and Oban. On this section of coast glacial outwash gravels have created distinctive coastal landforms, for example the Moss of Achnacree, a spread of gravel and peat at the mouth of Loch Etive, north of Oban. There are also extensive gravel deposits at Benderloch on Ardmucknish Bay. A sandy beach backed by dunes is found at Tralee.

Jura has an almost completely rocky coastline, with only small areas of intertidal sediment, mostly in the south-east of the island. The raised shingle beaches are regarded as being of international importance (Gordon & Sutherland 1993) and there are many caves associated with them. On Islay the soft shores of Laggan Bay and Traigh Cill an Rubha and the large estuarine system of Loch Gruinart interrupt an otherwise rocky coastline characterised by low cliffs terminating a dipping land surface. Colonsay is a low island with a number of small sandy bays and, in the south, a larger area of intertidal flats known as The Strand.

The coast of Mull is also mainly rocky, with only small areas of intertidal sediment, usually at the heads of lochs. The most extensive areas of sediment are in Duart Bay and

Map 2.6.1 Major coastal landforms.

Loch Don, in the east of the island, and the sand flats sheltered by the island of Erraid in the south-west. In certain places there are high cliffs, particularly on the south and west coasts. Staffa, off the west coast of Mull, is the site of the well-known Fingal's Cave, formed in a lava flow with columnar jointing.

Coll and Tiree have predominantly low, rocky coastlines with a large number of sandy bays ranging up to about 3 km across. There are large areas of blown sand on both islands. Raised shingle spits have been recognised on the raised beach platforms of Coll, and locally peat covers some of these platforms. Fine, calcareous sand, locally cemented into a soft limestone, is common along the north coast of the island.

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Steers, J.A. 1973. *The coastline of Scotland*. Cambridge, Cambridge University Press.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Coast protection policy; sediment cells	*Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD), Edinburgh, tel: 0131 244 0213
Sea defence	*Local authorities: see Appendix A2
Geomorphology of the region	*SNH, Earth Science Branch, RASD, Edinburgh, tel: 0131 554 9797
Coastal geomorphology; 1:50,000 scale 'solid' and 'drift' maps	Coastal Geology Group, British Geological Survey, Keyworth, Nottingham NG12 5GG, tel: 0115 936 3100

*Starred contact addresses are given in full in the Appendix.

The coast of Ardmeanach, Mull, descends in a dramatic series of vertical and steeply shelving steps of Tertiary lava, over which small streams cascade in numerous waterfalls. Photo: Pat Doody, JNCC.

Chapter 3 Terrestrial coastal habitats

This chapter covers terrestrial habitats that are maritime influenced, i.e. are distinctive because of their association with the coast and coastal processes. Adjacent to some parts of the coast there are other semi-natural habitats of importance that are not directly influenced by the sea, including in this region principally montane areas, peat bogs, ancient semi-natural woodland and freshwater lochs.

The region contains some important montane areas supporting bryophyte and lichen assemblages that include species found only in these extreme conditions. Summit ridges, cliffs and rock ledges, high-altitude flushes and other montane habitats all support their own distinctive lower plant communities. Areas of wet heath at medium altitude sometimes support a community of large oceanic liverworts that is virtually confined to the west coast of Scotland and Ireland.

Actively growing blanket bog is a priority habitat for protection under the EC Habitats & Species Directive. The UK and Ireland hold the entire European resource. Feur Lochain, Glac na Criche and Eilean na Muice Duibhe, on Islay, are candidate Special Areas of Conservation (SACs) under the Directive, and Duich Moss, Argyll & Bute, is an internationally important wetland designated under the Ramsar Convention. Peat bogs, and other wetland habitats such as small lochs, flood plain marshes and flushes, contain populations of many scarce invertebrates species, sometimes including boreal or arctic species, as well as breeding amphibians. Some coastal freshwater lochs support populations of the protected species medicinal leech *Hirudo medicinalis*. Lismore Lochs, on Lismore Island, Argyll & Bute, are a candidate SAC for their rare freshwater stonewort populations. The rare and protected water plant slender naiad *Najas flexilis* is found in clear, unacidified lowland lakes. In Britain it occurs almost exclusively in Scotland, and the best colonies are in two machair lochs on the island of Coll.

Old oak woods with holly *Ilex aquifolium* and hard fern *Blechnum spicant*, such as at Loch Etive Woods and Taynish Woods (candidate SACs), are a Habitats & Species Directive priority habitat that in Europe is confined to the British Isles. Woods of this type occur as part of a rich habitat mosaic with other types of woodland and have characteristic animal, bird, higher plant and bryophyte associates. Indeed, in this region, oceanic woodland is probably the single most important habitat for lower plants. On some sheltered cliffs in the region, woodlands with very important Atlantic bryophyte floras are present, and fossil cliffs above raised beaches are notable for their woodland interest and mire development at their base. Much ancient semi-natural oak-birch woodland remains in the highland parts of the region, often in small patches confined to ravines, but also covering more extensive areas. This is a very rich habitat for lower plants, with an exceptionally high diversity of bryophytes, lichens and fungi, particularly myxomycetes (slime moulds). Woodland habitats in the region also support several nationally rare or scarce invertebrate species, many of them restricted to Scotland.

In addition to the importance of ancient semi-natural woodland, conifer plantations in the region are also important habitat for wildlife, especially mammals. The wildcat *Felis sylvestris* is restricted to Scotland; its distribution in the region is linked to that of forestry plantations. Parts of the region support pine martens *Martes martes,* also of national significance; they too depend on large, mixed conifer plantations. The red squirrel *Sciurus vulgaris* is extinct over much of England and Wales but is still widespread in wooded parts of Scotland. In this region red squirrels are known from the forests of Argyll and from a few scattered locations in forestry plantations along the south of the region.

The region has countless pocket sandy beaches interspersed with the more extensive rocky shores. Here at Ardskenish on Colonsay, the tides have created a broad swathe of rippled sand, to which the distant Paps of Jura form the backdrop. Photo: Pat Doody, JNCC.

3.1 Cliffs and cliff-top vegetation

Dr T.C.D. Dargie

3.1.1 Introduction

Geology and environmental history - past and present marine erosion and glacial processes - determine cliff form (see also Chapter 2). The most distinctive cliff types are 'consolidated' - hard cliffs developed from resistant bedrock - and 'unconsolidated' - soft cliffs developed in easily-eroded, predominantly Quaternary (Pleistocene and Holocene) deposits.

The region has a total cliff length of 421 km (Table 3.1.1), almost all of it hard cliff. This represents 10% of the British resource, the fourth largest of any Coastal Directories region, and is therefore of great importance in the national context. The cliffs show great diversity of form, from very tall, vertical or near-vertical cliff faces, through long, steep slopes with a vertical face restricted to the base, to low cliffs with a great variety of local slope forms above intertidal rock platforms. The most extensive cliffs (51% of the total length) are low (<20 m) vertical types, which are evenly distributed throughout the region.

Cliff and cliff-top vegetation in the region varies markedly even over short distances, changing in relation to slope angle, soil type and salt spray deposition, with much local variability possible with changing exposure around headlands. Very sheltered cliffs and cliff-top sectors that receive little salt spray input are not here treated as coastal habitats. The major natural and semi-natural cliff and cliff-top habitats in the region are: bare ground, spray-zone lichen-covered rock, rock crevice, cliff-ledge, seabird colony, maritime grassland and maritime heath; however, the full extent of cliff-top habitats in the region has not been surveyed. Seabird colonies may contribute a high level of nutrient enrichment to the soil, affecting the vegetation.

The National Vegetation Classification (NVC - Rodwell in prep.) covers twelve maritime cliff communities, though almost all refer to hard cliff habitats, of which two are probably confined to Scotland (MC2 thrift *Armeria maritima* - Scots lovage *Ligusticum scoticum* maritime rock crevice, MC3 roseroot *Sedum rosea* - thrift *Armeria maritima* cliff ledge). Of the twelve National Vegetation Classification (NVC) maritime cliff vegetation communities in the UK, eight are recorded for the region, together with perched saltmarsh on spray-soaked cliff-tops and spray-affected variants of inland vegetation types, including maritime heath (Rodwell in press). Maritime heath is probably very extensive on most cliffed coast in the region. No lichen heath of national or regional importance is recorded for cliffs in the region (Fletcher *et al*. 1984).

The scenic contribution of sea cliffs within the region is outstanding. For example, all Argyll island cliffs fall within the Argyll Islands Environmentally Sensitive Area (see section 7.2.5). Cliffs form a dramatic landscape component of the Scarba-Lunga-Garvellachs National Scenic Area (NSA) and important features in the North Arran, Knapdale, Jura, Lynn of Lorn and Loch na Keal NSAs (see section 7.3.4).

3.1.2 Important locations and species

The cliffs of the region are particularly noted for their exposures of Tertiary volcanic rocks (e.g. South Mull Coast SSSI, Ardmeanach SSSI, Staffa SSSI). High (>80 m), near-vertical cliffs are present at Ceann a' Mhara (Tiree), Cnoc Uamh nam Peal, Mull of Oa, Beinn Mhor (all Islay), North Colonsay, Garbh Eileach (Garvellachs) and Ailsa Craig. The more extensive non-vertical high cliffs (e.g. Mull of Kintyre) are more spectacular, especially the complex stepped Tertiary volcanic cliffs of Mull (Ardmeanach, South Mull Coast). The region is particularly noted for headlands (e.g. Mull of Kintyre), caves (e.g. Fingal's Cave, Boat Cave, Goat Cave on Staffa) and cliffed islands (e.g. Ailsa Craig), as well as for raised beaches bearing low modern cliffs on their seaward side and taller striking fossil cliffs inland (best developed on the western coast of Jura). Blown sand from adjacent beaches is also present on the flanks of sea cliffs in a few locations (e.g. Ceann a' Mhara, Tiree) (see also section 3.2).

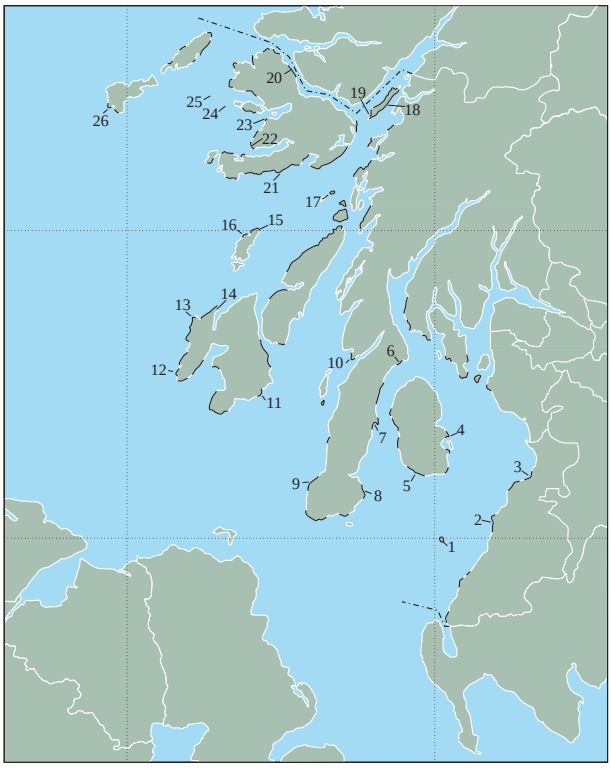
The large extent and the great diversity of cliff and cliff-top habitats make the region also of great biological interest. This is reflected in the presence of 26 Sites of Special Scientific Interest (SSSI) containing maritime cliff and cliff-top habitat (Table 3.1.2; Map 3.1.1). The SSSIs in the region with the largest areas (>50 ha) of maritime cliff habitats are Ardmeanach, South Mull Coast, Garvellachs, Glac na Criche, Rhinns of Islay and Dun Ban. The maritime cliff vegetation at South Mull Coast, Ardmeanach and Gribun Shore & Crags grades into arctic-alpine communities.

In Great Britain nine nationally rare and four nationally scarce species or subspecies of higher plant are found

Table 3.1.1 Lengths (km) of cliff types

	Vertical >20 m height		*Vertical <20 m height*		*Non-vertical >20 m height*		*Non-vertical <20 m height*		*Total*	
Area	*Length (km)*	*% of total length in region*	*Length (km)*	*% of total length in region*	*Length (km)*	*% of total length in region*	*Length (km)*	*% of total length in region*	*Length (km)*	*% of total length in region*
Region 14	25.5	-	216.0	-	122.0	-	57.5	-	421.0	-
Scotland	676.6	3.8	723.5	29.9	633.0	19.3	339.5	16.9	2,372.5	17.7
West Coast	724.5	3.5	438.5	49.3	812.5	15.0	284.0	20.2	2,259.5	18.6
GB	***1,325.0***	***1.9***	***818.0***	***26.4***	***1,371.0***	***8.9***	***545.0***	***10.6***	***4,059.0***	***10.4***

Source: JNCC Coastal Resources Database



Map 3.1.1 Cliffs and cliff-top habitat. Numbers refer to Table 3.1.2. Marked sectors have >90% cliffed coast. Source: JNCC Coastal Database.

mainly or exclusively on cliffs, although none is present in this region. (Most are restricted to cliff habitats in the south and west of Britain.) Two nationally scarce species more typical of non-cliff habitats (thyme broomrape *Orobanche alba*, Isle of Man cabbage *Coincya monensis*) are present in the region (see also section 5.2).

The bird fauna of the region's cliffs is of national and in places international importance (see also section 5.10). Bird numbers, either in total or for individual species, are sufficiently high at three sites to warrant Special Protection Area (SPA) status: Ailsa Craig, Rhinns of Islay and Treshnish Isles (see also section 7.2.3). The gannetry on Ailsa Craig is the fourth largest in Britain. An island polymorph population of house mouse *Mus musculus* and a seal population of regional importance are also present on the Treshnish Isles. Chough *Pyrrhocorax pyrrhocorax* use cliff-top habitat for feeding at Glac na Criche and West Colonsay Bird Cliffs and also breed in small numbers at Dun Ban. No systematic survey of invertebrates in cliff and cliff-top habitats has been carried out, but because of their rich habitat diversity these environments generally support large numbers of species (see also section 5.3) (Mitchley & Malloch 1991). No cliffs in the region have good invertebrate lists, although a few notable species are present at Ardmeanach (endemic moths) and South Mull Cliffs.

3.1.3 Human activities

Cliffs are among the least modified of terrestrial habitats, although the cliff-top zone, especially its inner sectors, has been affected by a variety of human impacts, sometimes

Table 3.1.2 Region 14 biological SSSIs noted for their cliff and cliff-top habitat

No. on Map 3.1.1	*Location*	*Grid ref.*	*Habitats (approx. areas)*
1	Ailsa Craig	NX020998	Hard cliff (7 ha), maritime grassland (20 ha), maritime heath (4 ha)
2	Turnberry Dunes	NS199062	Hard cliff (1 ha), maritime grassland (1 ha)
3	Maidens - Doonfoot	NS316194	Hard cliff (2 ha), maritime grassland (7 ha), maritime heath (8 ha)
4	Clauchlands Point - Corrygills	NS048338	Hard cliff (1 ha), maritime grassland (4 ha), maritime heath (1 ha)
5	South Coast of Arran	NR951208	Hard cliff (7 ha), maritime grassland (2 ha)
6	Claonaig Wood	NR864555	Hard cliff (1 ha)
7	Torrisdale Cliff	NR798348	Hard cliff (3 ha)
8	Balnabraid Glen	NR760154	Crevice/ledge (4 ha)
9	Dun Ban	NR595141	Maritime grassland (64 ha), maritime heath (7 ha)
10	Ardpatrick & Dumore Woods	NR765610	Maritime grassland (4 ha)
11	Ardmore, Kildalton & Callumkill Woodlands	NR450495	Soft cliff (2 ha), crevice/ledge (4 ha)
12	Rhinns of Islay	NR235620	Maritime heath (247 ha)
13	Glac na Criche	NR225708	Maritime grassland (48 ha), maritime heath (48 ha)
14	Gruinart Flats	NR285665	Maritime grassland (38 ha)
15	North Colonsay	NR415985	Maritime grassland (14 ha)
16	West Colonsay Bird Cliffs	NR370970	Crevice/ledge (13 ha), maritime grassland (12 ha)
17	Garvellachs	NM670120	Bird cliff (61 ha), maritime grassland (158 ha)
18	Lynn of Lorn Small Islands	NM860400	Crevice/ledge (1 ha), bird cliff (1 ha), maritime grassland (1 ha)
19	Bernera Island	NM795395	Bird cliff (3 ha)
20	Sound of Mull Cliffs	NM535517	Maritime grassland (3 ha)
21	South Mull Coast	NM523204	Hard cliff (1 ha), crevice/ledge (67 ha), maritime grassland (1 ha)
22	Ardmeanach	NM440290	Crevice/ledge (30 ha), maritime grassland (96 ha), maritime heath (32 ha)
23	Gribun Shore & Crags	NM456355	Crevice/ledge (28 ha)
24	Staffa	NM325355	Crevice/ledge (4 ha)
25	Treshnish Isles	NM274412	Maritime grassland (14 ha)
26	Ceann a' Mhara	NL934405	Bird cliff (14 ha)

Source: Research and Advisory Services Directorate, SNH.

leading to major habitat loss. At a national scale the most extensive influences on hard cliff vegetation are grazing and burning, the major management techniques for cliff-top habitat (Mitchley & Malloch 1991). Little is known of their role in the region, though grazing is common on maritime grassland and heath in many areas and few sites have low grazing pressure. Some of the cliffed coast is developed for agriculture, especially crofting. Large coastal settlements on cliffs are absent, and there is no industrial development on the region's cliffs. There is little caravan park development close to cliffs and there are few car parks. In general path erosion and wildlife disturbance are the only impacts of note and these are rarely serious.

Virtually none of the regional cliff base has been protected by coastal defences and hence natural coastal erosion is prevalent. Although localised problems do occur, cliff recession on the mainland coastline is not a significant problem. The island coastlines, however, are characterised by hard rock cliffs prone to rockfalls, for example in the Wilderness area of south Mull and the sandstone cliffs of south Arran.

3.1.4 Information sources used

Maritime cliff vegetation has been mapped using the NVC on parts of Coll (Dargie & Dargie 1993), Tiree (Dargie 1994) and South Mull (Averis & Averis 1995). The areas of different NVC vegetation types have not been measured at any site in the region, apart from simple habitat extents for SSSIs, and no other detailed surveys exist for the region. Existing information is insufficient to detail the regional extent of individual cliff and cliff-top habitats.

3.1.5 Acknowledgements

Assistance with sources was kindly provided by Kathy Duncan (SNH Research and Advisory Services Directorate) and by Deborah Proctor and John Barne (JNCC). Thanks also go to Rendel Geotechnics for information on landsliding and cliff erosion.

3.1.6 Further sources of information

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B. Further reading

Further details on coastal habitat sites, including cliffs, are available on the *Coastal & Marine UKDMAP datatsets module* disseminated by JNCC Coastal Directories Team, Peterborough (Barne *et al.* 1994).

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Flora, fauna, habitat information, site management	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Flora, fauna, habitat information, site management: Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Flora, fauna, habitat information, site management in the south of the region	*Conservation Officer, SNH, Mid and South Strathclyde Area Office, Clydebank, tel: 0141 951 4488
National Landslide Databank	Rendel Geotechnics, Norfolk House, Smallbrook Queensway, Birmingham B5 4LJ, tel: 0121 627 1777
Cliff conservation	*Geology/Coastal Advisor, JNCC, Peterborough, tel: 01733 62626
Invertebrate fauna	*Species Advisor, JNCC, Peterborough, tel: 01733 62626

*Starred contact addresses are given in full in the Appendix.

3.2 Sand dunes

Dr T.C.D. Dargie

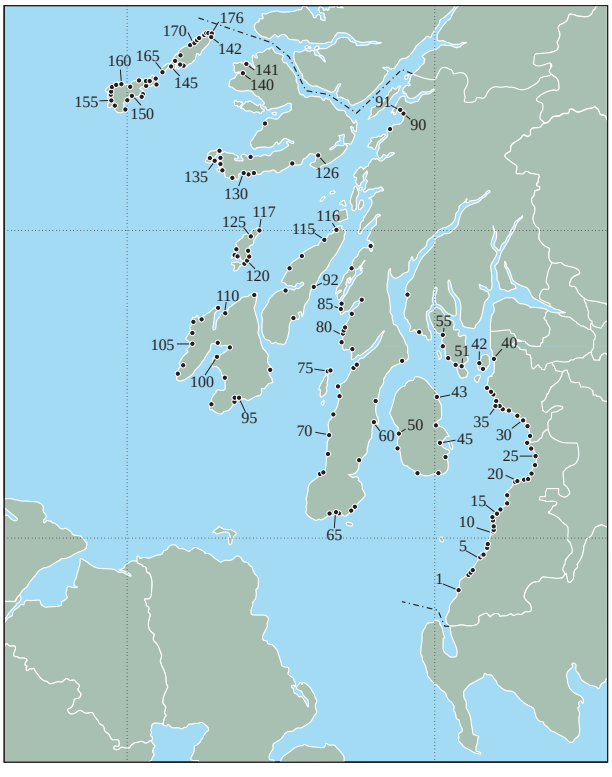
3.2.1 Introduction

The region contains a large and varied set of sand dune systems, many associated with bays and hard cliffs. There are 176 dune sites in Region 14 (Map 3.2.1) - the largest total for any British region - containing around 8,942 ha of vegetated sand and other land cover (JNCC Coastal Resources database). Together they represent nearly 18% of the British vegetated sand dune resource (Table 3.2.1). The region is therefore of national importance for its contribution to the GB sand dune resource. The precise size of most sites is unknown, but the region contains few systems larger than 250 ha in extent. Larger extents of vegetated windblown sand occur on the offshore islands of Islay, Tiree and Coll, with scattered small areas widely distributed along most of the mainland and other islands (Map 3.2.2).

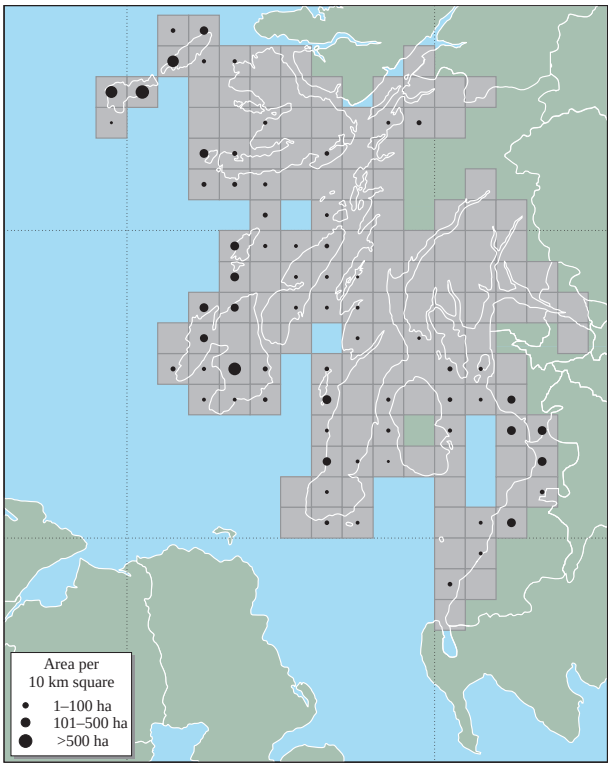
Table 3.2.1 Region 14 vegetated dune resource[a] in context

	Total area (ha)	*% of total in region*
Region 14	8,942*	-
Scotland	31,540	28.4
West Coast	31,308	28.6
GB	***50,200***	***17.8***

Sources: Dargie (1993, 1995), Radley (1994), JNCC Coastal Resources Database. Key: [a]to the nearest whole hectare; *provisional estimate based on a sample of dunes representing 23.7% of the regional resource. Note: survey data for Scotland are incomplete and therefore totals for Scotland and thus the West Coast and Great Britain are provisional estimates.



Map 3.2.1 Sand dune sites. Numbers refer to Table 3.2.3. Source: JNCC Coastal Database.



Map 3.2.2 Extent of vegetated windblown sand. Source: Coastal Resources Database.

Table 3.2.2 Areas (ha)* of dune vegetation types in the region

	Strand and embryo dune	*Mobile and semi-fixed dune*	*Acidic fixed dune grassland*	*Neutral and calcareous fixed dune grassland*	*Dune heath and bracken*	*Dune slack*	*Other dune wetland*	*Dune woodland and scrub*	*Trans-itions to saltmarsh*	*Trans-itions to maritime cliff*	*Other land cover*
Region 14	0	2,635	223	5,418	152	211	278	25	0	0	0
Scotland	61	4,059	4,125	10,513	2,113	1,095	3,817	5,500	217	41	neg
West Coast	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
GB	340	8,504	4,953	15,228	2,615	2,175	4,114	8,965	836	64	2,406

Sources: Dargie (1993, 1995), Radley (1994), JNCC Coastal Resources Database. Key: *provisional estimates (to the nearest whole hectare) based on a sample of dunes representing 23.7% of the regional resource; n/a = not available; neg = negligible. Note: survey data for Scotland are incomplete and therefore totals for Scotland and thus the West Coast and Great Britain are provisional estimates.

On the basis of estimates derived from a survey of a sample of dune sites in the region, representing 23.7% of the total area of the regional resource, the region has a very large proportion of the Great Britain totals of mobile and semi-fixed dunes (31%) and neutral and calcareous fixed dune grassland (36%) (Table 3.2.2).

Their large extent and diverse habitats make the sand dunes of the region of great biological interest. This is reflected by the inclusion of 37 sand dune sites in Sites of Special Scientific Interest (SSSIs), two in the North Arran National Scenic Area and 87 within the Argyll Islands Environmentally Sensitive Area (see Chapter 7). The total area of dune vegetation of SSSI status is at least 2,114 ha (around a quarter of the regional dune resource).

3.2.2 Important locations and species

Sand dune sites in the region are summarised in Table 3.2.3.

The largest dunes are hindshore types, developed above beaches with a good sand supply and an onshore prevailing wind, which drives sand inland as a series of dune ridges or mobile parabolic (crescent) dunes. The region has a distinctive hindshore variant termed machair, with comparatively low outer, mobile, dunes (which may be absent) and an extensive inland dune plain with low relief (Ritchie 1975), the result of the highest average windspeeds affecting British coastal dunes. The machair plain can include extensive wet grassland, machair fen and machair lochs, with the best regional examples of these habitats occurring on Tiree. The machair hindshore type is probably restricted world-wide to Scotland and western Ireland, with the region containing the southernmost Scottish examples. The largest regional examples (>250 ha) include several bay sites on Tiree (Balephuil to Greenhill, Barrapol to Kilkenneth and the Balephetrish/Traigh Bhagh/Hynish complex occupying the entire centre of the island) and Coll (the Feall Bay/CrossapolBay/Port ant Saoir complex). Ness/foreland dunes develop on shores with sand supply coming from two directions and gradually extend seawards. There is only one regional example, at Killinallan (Islay). Spit dunes develop at the mouths of estuaries and are also regionally rare (Prestwick and Irvine Bay). Bay dunes are very widespread in the region but most are small sites, developed upon sand trapped within the shelter of rock headlands. The only site larger than 250 ha is at Machrihanish, Kintyre. Climbing dunes are sand blown up onto terrain inland and on the edge of the main dune system, forming a variable but often thin sand layer over bedrock. They are restricted to the most exposed dune systems in the region, usually at the edge of larger hindshore machair systems (e.g. Oronsay). Two sites (Ardnave on Islay, and North Iona) are complete climbing dune systems that appear to have lost their original sand supplies from cliff-foot beaches.

The larger dune systems in the region develop a watertable which influences the vegetation of depressions, forming a distinctive and nationally rare type of wetland termed dune slack. In hindshore machair, slacks form either in depressions in the rear of dune blowouts, which are initiated by storms and migrate across a site, or in extensive low-lying ground within the machair plain. The best regional example is The Reef, Tiree (Balephetrish/raigh Bhagh complex), which has extensive gradations from wet grassland through machair fen to swamp and open water.

Some 85 National Vegetation Classification (NVC) communities have been recorded for surveyed Scottish dunes, with a total of 116 types for communities and sub-communities combined, not all of them exclusive to dunes (Rodwell in press). Strandlines are usually characterised by the SD2 sea rocket *Cakile maritima* - sea sandwort *Honkenya peploides* community. Further up the beach occasional areas of SD4 sand couch *Elymus farctus* embryo dunes are found, often merging with SD6 marram *Ammophila arenaria* mobile dune, which is rapidly stabilised in a moist climate with moderate inblow of beach sand, forming SD7 marram - red fescue *Festuca rubra* semi-fixed dune. Western Scotland is particularly notable for its very large extents of species-rich grazed dune, SD8 red fescue - lady's bedstraw *Galium verum* fixed grassland, which replaces SD7 semi-fixed dune under grazing on calcareous sands and can extend inland for a great distance. Scotland is also distinctive in the large variety of wetland types (mire, swamp, wet neutral grassland) which replace most of the types of dune slack vegetation found in England and Wales. Only the SD17 silverweed *Potentilla anserina* - common sedge *Carex nigra* slack community is common. Several NVC sub-communities are largely restricted to western Scotland and reflect a cool, oceanic climate with high rainfall. It is also important to note that vegetation that does not closely resemble published NVC types and which may represent potential new NVC sub-communities has been found in Scottish NVC dune surveys. Strandline, semi-fixed dune, fixed dune, mire and scrub examples are described by Dargie (1993, 1994), with much evidence drawn from Coll and Tiree.

In Great Britain, four nationally rare and thirteen nationally scarce higher plants are found mainly or exclusively on dunes. Only one nationally rare species, dune gentian *Gentianella uliginosa*, is present in the region. Formerly thought to be confined to Wales, it has recently been found on Colonsay. Portland spurge *Euphorbia portlandica*, seaside centaury *Centaurium littorale* and Baltic rush *Juncus balticus* are nationally scarce species present on regional dunes. Other nationally scarce species more typical of other habitats also occur on dunes in the region, including brackish water-crowfoot *Ranunculus baudotii*, Isle of Man cabbage *Coincya monensis* and sea radish *Raphanus maritimus*. The lichen flora of climbing dunes adjoining machair on Coll is rated of international interest, and similar habitat on Colonsay is of national importance (Fletcher *et al*. 1984) (see also section 5.1).

Detailed ecological studies on animal populations other than birds have not been undertaken for dunes in the region. Machair on Islay is important feeding habitat for chough *Pyrrhocorax pyrrhocorax* belonging to the most northerly chough population in the world (Bignal *et al.* 1988), and on Tiree and Coll machair supports large populations of breeding waders, especially at The Reef on Tiree (Cadbury 1989; Stroud 1989). Crofting land with iris beds, rush pastures, hayfields and some wet machair in the region, especially on Tiree, provides essential habitat for breeding corncrake *Crex crex* (Shepherd 1989). Possible Special Areas of Conservation under the EC Habitats & Species Directive have been proposed for the machair areas of Coll and Tiree (see section 7.2.4). Northern and western dune sites on Islay form part of Ramsar sites and Special Protection Areas, with other dunes at Machrahanish and on

Table 3.2.3 Sand dune sites in region

No. on Map 3.2.1	*Location*	*Grid ref.*	*Area (ha*)*	*Dune type*	*Conservation status*	*Survey type*
1	Ballantrae Bay	NX080830	-	Bay		CCS
2	The Whilk	NX117890	-	Bay		CCS
3	Carleton Bay	NX122894	-	Bay		CCS
4	Lendalfoot	NX130900	-	Bay		CCS
5	Ardwell Bay	NX160942	-	Bay		CCS
6	Ardmillan	NX168950	-	Bay		CCS
7	Woodland Bay	NX174953	-	Bay		CCS
8	Girvan	NX182978	-	Bay		CCS
9	Girvan North	NX183985	-	Bay		CCS
10	Dipple	NS200026	-	Bay		CCS
11	Dowhill Port	NS200031	-	Bay		CCS
12	Matthews Port	NS201036	-	Bay		CCS
13	Turnberry Bay	NS200056	16	Bay	SSSI	CCS, SDVSGB
14	Broad Sands	NS197067	-	Bay		CCS
15	Maidenhead Bay	NS215083	-	Bay		CCS
16	Port Carrick	NS221097	-	Bay		CCS
17	Culzean Bay	NS244116	-	Bay		CCS
18	Croy Brae	NS245134	-	Bay		CCS
19	Bracken Bay	NS275182	-	Bay	SSSI	CCS
20	Heads of Ayr	NS283187	-	Bay	SSSI	CCS
21	Greenan	NS310193	-	Bay	SSSI	CCS
22	Doonfoot	NS320194	-	Bay		CCS
23	Ayr South	NS329210	-	Bay		CCS
24	Ayr Newton	NS339235	-	Bay		CCS
25	Prestwick Bay (Prestwick)	NS345260	-	Bay, spit		CCS
26	Prestwick Bay (Troon)	NS329290	84	Bay	SSSI	CCS, SDVSGB
27	South Bay (Troon)	NS320307	-	Bay		CCS
28	Barassie	NS325330	-	Bay		CCS
29	Irvine Bay (Gailes)	NS317360	-	Bay	SSSI	CCS
30	Irvine Bay (Irvine)	NS306377	-	Bay		CCS
31	Irvine Bay (Ardeer)	NS285395	-	Bay, spit		CCS
32	Stevenston	NS260411	-	Bay		CCS
33	South Bay (Saltcoats)	NS235420	-	Bay		CCS
34	Horse Isle	NS212428	-	Bay		CCS
35	North Bay (Ardrossan)	NS229430	-	Bay		CCS
36	Seamill-Ardrossan	NS217448	-	Bay		CCS
37	Seamill South	NS203467	-	Bay		CCS
38	Seamill	NS192478	-	Bay		CCS
39	Ardneil Bay	NS185485	-	Bay		CCS
40	Largs Bowen Craigs	NS207578	-	Bay		CCS
41	Millport	NS171550	-	Bay		CCS
42	Fintray	NS158567	-	Bay		CCS
43	Sannox	NS018455	-	Bay		CCS
44	Brodick	NS015362	-	Bay	NSA	CCS
45	Lamlash	NS027305	-	Bay	NSA	CCS
46	Whiting Bay	NS046260	-	Bay		CCS
47	Kildonan	NS023209	-	Bay	SSSI	CCS
48	Torrylinnwater Foot	NR953208	-	Bay	SSSI	CCS
49	Drumadoon	NR885287	-	Bay		CCS
50	Machrie	NR892340	-	Bay		CCS
51	Kilchattan Bay	NS098555	-	Bay		CCS
52	Stravanan Bay	NS079561	-	Bay		CCS
53	Scalspie Bay	NS057584	-	Bay		CCS
54	St. Ninian's Bay	NS040618	-	Bay		CCS
55	Ettrick Bay	NS039661	-	Bay		CCS
56	Kilbride	NR960669	-	Bay		CCS
57	Kilfinan	NR922786	-	Bay		CCS
58	Skipness	NR902576	-	Bay		CCS
59	Grogport	NR810444	-	Bay		CCS
60	Carradale	NR809375	-	Bay		CCS
61	Ardnacross	NR760250	-	Bay		CCS
62	Polliwilline	NR743098	-	Bay		CCS
63	Macharioch	NR737090	-	Bay		CCS
64	Brunerican	NR695077	-	Bay		CCS

Table 3.2.3 Sand dune sites in region (continued)

No. on Map 3.2.1	*Location*	*Grid ref.*	*Area (ha*)*	*Dune type*	*Conservation status*	*Survey type*
65	Dunaverty	NR685079	-	Bay		CCS
66	Carskey	NR660077	-	Bay		CCS
67	Lossit	NR626207	-	Bay		CCS
68	Machrihanish	NR642210	-	Bay	SSSI	CCS, ITE
69	Port nam Marbh	NR655271	-	Bay		CCS
70	South Glenbarr-Bellochantuy	NR663335	-	Bay		CCS
71	Muasdale	NR678400	-	Bay		CCS
72	Tayinloan	NR693460	-	Bay		CCS
73	Rhunahaorine	NR690493	-	Bay		CCS
74	An Doirlinn	NR655541	-	Bay	ESA	CCS
75	Port Mor	NR666542	-	Bay	ESA	CCS
76	Ronachan	NR742552	-	Bay		CCS
77	Dunskeig	NR753564	-	Bay		CCS
78	Loch Stornoway	NR738613	-	Bay		CCS
79	Kilberry	NR703637	-	Bay	SSSI	CCS
80	Cretshengan	NR707665	-	Bay		CCS
81	Millers Bay	NR708675	-	Bay		CCS
82	Stotfield	NR713683	-	Bay	SSSI	CCS
83	Ormsary	NR737726	-	Bay		CCS
84	Loch Caolisport	NR766770	-	Bay		CCS
85	Kilmory	NR699747	-	Bay	NSA	CCS
86	Bagh na Doide	NR702763	-	Bay	NSA	CCS
87	Carsaig	NR735877	-	Bay	NSA	CCS
88	Crinan	NR800950	-	Bay	NSA	CCS
89	Ganavan	NM862328	-	Bay		CCS
90	Ledaig	NM904376	-	Bay		CCS
91	Tralee Bay	NM894388	-	Bay		CCS
92	Tarbert Bay	NR609820	-	Bay	ESA, NSA	CCS
93	Corran	NR540711	-	Bay, spit	ESA, NSA	CCS
94	Ardtalla	NR465544	-	Bay	ESA	CCS
95	Port Ellen	NR364455	-	Bay	ESA	CCS
96	Kilnaughton	NR346455	-	Bay	ESA	CCS
97	Traigh Bhan Oa	NR346442	-	Bay	ESA	CCS
98	Killeyan	NR274435	-	Bay	ESA	CCS
99	Laggan Bay	NR315520	203	Bay	ESA, SSSI	CCS, ITE, SDVSGB
100	Gartbreck-Ardlarach	NR290586	-	Bay	ESA, SSSI	CCS
101	Bridgend	NR330620	-	Bay	ESA	CCS
102	Uisgeantuidhe	NR290633	-	Bay	ESA	CCS
103	Claddich	NR162532	-	Bay	ESA, SSSI	CCS
104	Lossit Bay	NR178560	-	Bay	ESA, SSSI	CCS
105	Machair Bay	NR205630	-	Hindshore machair	ESA, SSSI	CCS, ITE
106	Saligo Bay	NR208665	-	Hindshore machair	ESA, SSSI	CCS, ITE
107	Traigh Ban	NR213699	-	Bay	ESA, SSSI	CCS
108	Sanaigmore Bay	NR239710	-	Bay	ESA, SSSI	CCS
109	Ardnave	NR294749	256	Climbing dune	ESA, SSSI	CCS, ITE, SDVSGB
110	Killinallan	NR315731	262	Ness/foreland	ESA, SSSI	CCS, ITE, SDVSGB
111	Bagh an da Dhoruis	NR413789	-	Bay	ESA	CCS
112	Glenbatrick	NR515802	-	Bay	ESA, NSA, SSSI	CCS
113	Shian Bay	NR530876	-	Bay	ESA, SSSI	CCS
114	Corpach Bay	NR569917	-	Bay	ESA, SSSI	CCS
115	Glengarrisdale Bay	NR646970	-	Hindshore machair	ESA, SSSI	CCS
116	Bagh Gleann nam Muc	NM687003	-	Bay	ESA, SSSI	CCS
117	Croisebrig	NM428001	-	Hindshore machair	ESA, SSSI	CCS
118	Loch Staosnaig	NR389933	-	Bay	ESA	CCS
119	Cable Bay	NR393916	-	Bay	ESA	CCS
120	Port a Chapuil	NR383903	-	Bay	ESA	CCS
121	Oronsay	NR377894	-	Bay, hindshore machair, climbing dune	ESA, SSSI	CCS, ITE
122	Traigh nam Barc	NR355916	-	Hindshore machair	ESA	CCS, ITE
123	Ardskenish	NR346918	-	Bay, hindshore machair	ESA	CCS, ITE
124	Machrins	NR357937	-	Hindshore machair	ESA	CCS
125	Kiloran Bay	NR400980	-	Hindshore machair, climbing dune	ESA, SSSI	CCS, ITE
126	Loch Buie	NM624244	-	Bay	ESA	CCS
127	Carsaig Bay	NM538217	-	Bay	ESA	CCS

Table 3.2.3 Sand dune sites in region (continued)

No. on Map 3.2.1	*Location*	*Grid ref.*	*Area (ha*)*	*Dune type*	*Conservation status*	*Survey type*
128	Traigh Cill Mhic Eoghainn	NM410187	-	Bay	ESA	CCS, ONVC
129	Port Uisken	NM393182	-	Bay	ESA	CCS, ONVC
130	Ardalanish Bay	NM375188	-	Hindshore machair	ESA	CCS, ONVC
131	Traigh Gheal	NM340174	-	Bay	ESA	CCS, ONVC
132	Knockvoligan	NM310197	-	Bay	ESA	CCS, ONVC
133	Fidden	NM300215	-	Hindshore machair	ESA	CCS, ONVC
134	Fionnphort	NM301234	-	Bay	ESA	CCS, ONVC
135	Traigh Mhor Iona	NM280229	-	Bay	ESA	CCS, ONVC
136	A'Machair Iona	NM267237	-	Hindshore machair	ESA	CCS, ONVC
137	North Iona	NM294261	-	Climbing dune	ESA	CCS, ONVC
138	Traigh ant Santachaidh	NM396237	-	Bay	ESA	CCS, ONVC
139	Gribun	NM450345	-	Bay	ESA, NSA	CCS
140	Calgary Bay	NM372512	-	Hindshore machair	ESA	CCS, ITE
141	Baigh Chrossapol	NM383540	-	Bay	ESA	CCS
142	Sorisdale	NM273633	-	Bay	ESA	CCS
143	Loch Gorten	NM176536	-	Bay	ESA	CCS
144	Loch Breachacha	NM162540	-	Hindshore machair	ESA	CCS
145	Feall/Crossapol Bay	NM135533	317	Hindshore machair	ESA, SSSI	CCS, ITE, SDVSGB
146	Brock	NM086476	-	Bay	ESA	CCS, ONVC
147	Gott Bay	NM050472	-	Hindshore machair	ESA	CCS, ONVC
148	Scarinish area	NM043445	-	Bay	ESA	CCS, ONVC
149	Baugh Heanish	NM039436	-	Bay, climbing dune	ESA	CCS, ONVC
150	Traigh Bhagh	NM005438	-	Hindshore machair, climbing dune	ESA, SSSI	CCS, ITE, ONVC
151	Sorobaidh	NL990425	-	Hindshore machair	ESA	CCS, ITE, ONVC
152	Hynish area	NL985395	-	Bay	ESA	CCS, ONVC
153	Balephuil	NL950406	-	Hindshore machair, climbing dune	ESA	CCS, ITE, ONVC
154	Bharrapol	NL939420	-	Hindshore machair, climbing dune	ESA	CCS, ITE, ONVC
155	Greenhill	NL939440	-	Hindshore machair	ESA	CCS, ITE, ONVC
156	Kilkenneth	NL937450	166	Hindshore machair, climbing dune	ESA, SSSI	CCS, ITE, SDVSGB
157	Hough	NL938466	153	Hindshore machair, climbing dune	ESA, SSSI	CCS, ITE, SDVSGB
158	Sraid Ruadh	NL955476	66	Hindshore machair	ESA, SSSI	CCS, SDVSGB
159	Bhasapoll	NL973480	120	Hindshore machair	ESA, SSSI	CCS, ITE, SDVSGB
160	Balephetrish	NM001469	-	Hindshore machair	ESA	CCS, ONVC
161	Creagan Coast	NM030490	-	Bay	ESA	CCS, ONVC
162	Vaul	NM053485	-	Hindshore machair	ESA	CCS, ONVC
163	Salum	NM066490	-	Hindshore machair	ESA	CCS, ONVC
164	Caolas Urvaig	NM085495	-	Bay	ESA	CCS, ONVC
165	Gunna	NM106514	19	Climbing dune	ESA, SSSI	CCS, ITE, SDVSGB
166	Caolas Ban	NM109516	236	Hindshore machair, climbing dune	ESA, SSSI	CCS, ITE, SDVSGB
167	Port ant Saoir	NM149551	7	Hindshore machair	ESA, RSPB	CCS, ITE, SDVSGB
168	Hogh Bay	NM167572	-	Hindshore machair	ESA, SSSI, RSPB	CCS, ITE, ONVC
169	Cliad Bay	NM199602	-	Hindshore machair	ESA	CCS
170	Bagh na Trailleich	NM214614	-	Hindshore machair	ESA	CCS, ITE
171	Traigh Cill Ionnaig	NM218621	-	Hindshore machair	ESA	CCS, ITE
172	Traigh Thorastain	NM232629	-	Bay, climbing dune	ESA	CCS, ITE
173	Traigh nan Uan	NM240635	-	Bay, climbing dune	ESA	CCS, ITE
174	Traigh Bhousd	NM255640	-	Hindshore machair	ESA	CCS
175	Traigh Logabhaisg	NM261640	-	Bay	ESA	CCS
176	Traigh Tuath	NM271640	-	Bay, climbing dune	ESA	CCS

Sources: Averis & Averis (1995); Dargie (1993, 1994), Dargie & Dargie (1993); Mather & Crofts (1972); Crofts & Ritchie (1973); Mather (1972); Ritchie (1975); Ritchie & Crofts (1974); Ritchie & Mather (1984); Research and Advisory Services Directorate, Scottish Natural Heritage. Key: *to nearest hectare; - = area not known. Key to conservation status: ESA = Environmentally Sensitive Area; NSA = National Scenic Area; RSPB = Royal Society for the Protection of Birds Reserve; SSSI = Site of Special Scientific Interest. Key to survey type: CCS = Countryside Commission for Scotland (University of Aberdeen beach reports); ITE = Institute of Terrestrial Ecology Scottish Coastal Survey; ONVC = other NVC survey (RSPB, SNH); SDVSGB = Sand Dune Vegetation Survey of Great Britain (NCC/JNCC).

Colonsay, Tiree and Coll forming part of proposed Ramsar sites (Stroud *et al.* 1990). No dune site is outstanding in terms of Invertebrate Site Register records, although machair on Colonsay, Oronsay, Gunna and the Ross of Mull coasts support invertebrate faunas of regional importance, as do other habitats.

3.2.3 Human activities

In general, sand dunes are among the least heavily modified of terrestrial habitats. Very little of the regional dune resource has been affected by human impacts leading to major habitat loss or conversion to common vegetation

lacking dune species. The primary use of most sites is as non-intensive grazing for sheep and cattle. Relatively low grazing pressure, especially the traditional use of machair for cattle grazing in winter only, encourages diversity in dune plant communities and thus high breeding bird numbers at island dune sites lacking mammal predators (the Reef on Tiree is perhaps the best example). Year-long grazing by sheep is more common. It produces a dune sward with a lower plant diversity, less cover for breeding birds and often an increase in erosion caused by the presence of sheep sheltering in blowouts, preventing their stabilisation (e.g. at Port ant Saoir on Coll and Hynish on Tiree). Cultivation of the machair was formerly common but is now rare in the region, limiting the occurrence of wasteland plants that spring up on fallow ground. A few beaches have been affected by sand and shingle extraction, often on a small scale on islands and more seriously on beaches on the Clyde coast (e.g. at Brodick and Girvan). The scale of impacts is uncertain, but serious effects have occurred elsewhere in Britain (Carter *et al.* 1992). Dunes along short stretches of the Clyde coast have undergone development for industrial use (Ritchie & Mather 1984).

Formal car parks, caravan and camp sites are rare on offshore islands and uncommon away from the Clyde coast, Bute and Cumbrae, where dunes probably receive large visitor numbers (Ritchie & Mather 1984). Informal car parking with associated small areas of turf trampling and erosion is common on both island and mainland dune sites. Beach parking is rare (occurring at, for example, Culzean Bay, south of Ayr). Golf courses are common, especially on the Clyde coast, where there are major championship courses at Troon and Turnberry. In many cases, vegetation is only slightly modified by course management, but on the best courses the vegetation of the fairways and greens is highly modified. Coastal erosion by storm waves is very widespread and there is much anecdotal evidence of a slow retreat inland of the outer dune edge. Sea defences are uncommon on beaches in the region (Davidson *et al*. 1991), but examples include revetments and sand stabilisation at Irvine, a lengthy stretch of gabions to protect fairways at Royal Troon Golf Club, and construction of protective bunds around storm-exposed landfill material in a former coastal sand quarry in Prestwick Bay (ASH Consulting Group 1994).

3.2.4 Information sources used

Survey of dunes in Scotland is still in progress and it is not possible to give precise figures on extent for Scotland, the West Coast or Great Britain. An estimate of dune habitats for Scotland, based on a sample set of sites (Dargie 1993), is used here to allow some form of GB context to be indicated. Details of site coverage by survey type are given in Table 3.2.1. Three main sets of surveys cover the region: first, dune geomorphology is covered in Aberdeen University beach reports sponsored by the Countryside Commission for Scotland (Mather & Crofts 1972; Crofts & Ritchie 1973; Ritchie & Crofts 1974; Ritchie 1975; Mather 1972; Ritchie & Mather 1984). Secondly, vegetation has been examined by the Institute of Terrestrial Ecology (ITE) (Shaw *et al.* 1983) for selected areas covering 28 sites. The vegetation categories employed are broad and not easily related to the finer detail available in the NVC (Dargie 1992). Thirdly, thirteen sites have been surveyed as part of the Sand Dune Vegetation Survey of Great Britain (Dargie 1993), which was initiated by the Nature Conservancy Council in 1987 and continued after 1991 by the JNCC on behalf of country conservation agencies. These studies used the National Vegetation Classification (NVC) (Rodwell 1991a, b, 1992, 1995, in press). NVC surveys use a reliable, consistent methodology yielding very detailed information. The vegetation is mapped and described, and information on coastal erosion and accretion, atypical vegetation and adjoining land use is also recorded. The data represent a sound baseline for future dune vegetation studies and both strategic and local management of the dune resource. Individual site reports are available for sites covered in the Sand Dune Vegetation Survey of Great Britain, as well as a national report covering a sample set of sites (Dargie 1993). More recent NVC surveys have been completed on Coll, Tiree and Mull (Dargie & Dargie 1993; Dargie 1994; Averis & Averis 1995). Scottish Natural Heritage has recently commissioned a project aiming to complete the NVC survey of all Scottish dunes by 1998.

No other comprehensive surveys exist for the region, though a small number of sites have specific information on invertebrates (Institute of Terrestrial Ecology 1979).

3.2.5 Acknowledgements

Assistance with sources was kindly provided by Patrick Cashman (SNH SW Region), Kathy Duncan (SNH Research and Advisory Services Directorate), and Deborah Proctor and John Barne (JNCC).

3.2.6 Further sources of information

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B. Further reading

Further details of coastal habitat sites are given in the *Coastal & Marine UKDMAP datasets module*, available from JNCC Coastal Directories Team, Peterborough (Barne *et al.* 1994).

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Flora, fauna, habitat information, site management	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Flora, fauna, habitat information, site management: Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Flora, fauna, habitat information, site management in the south of the region	*Conservation Officer, SNH, Mid and South Strathclyde Area Office, Clydebank, tel: 0141 951 4488
National and international policy and advice on dune conservation	*Geology/Coastal Advisor, JNCC, Peterborough, tel: 01733 62626
Invertebrate fauna	*Species Advisor, JNCC, Peterborough, tel: 01733 62626

*Starred contact addresses are given in full in the Appendix.

3.3 Vegetated shingle structures and shorelines

Dr R.E. Randall

3.3.1 Introduction

Shingle means sediments larger than sand but smaller than boulders: that is, between 2-200 mm in diameter. Where the coast features shingle, it is often mixed with large amounts of sand, or else sand dunes may have developed on it. Shingle sites where the sand cover is greater than 20 cm in depth are covered in section 3.2. Shingle sites include both simple fringing beaches and also more complex structures where the shingle is vegetated yet not buried by more than 20 cm of sand. Shingle plant communities around Britain are distinctive (Sneddon & Randall 1993a), with some communities being widespread and others limited to a particular region or substrate.

There are two nationally important vegetated shingle structures in the region, at Ballantrae and Rhunahaorine. The latter is the second most important shingle structure in Scotland, after Kingston, and the second most important cuspate foreland in Britain, after Dungeness. The region also has a number of fringing shingle beaches, mostly along west-facing shores. On the western shore of Arran occur some of the best examples of raised beach shingle in Britain.

Rhunahaorine offers examples of very varied plant communities, seven of which are unique to shingle at this site. This region is a significant area of overlap for species assemblages, having three representative northern communities, two north-western and three western, as well as eleven that are cosmopolitan in distribution. These range from pioneer communities at the foreshore, through grassland and heath to gorse, bramble and scrub communities on the more inland shingle. Thus the region as a whole has a wide and rich representation of shingle vegetation.

The scale of the region's shingle resource in a national context is shown in Table 3.3.1. Locations of the major sites are shown on Map 3.3.1.

Table 3.3.1 Areas of vegetated shingle structures in Region 14 in context

	Area (ha)	*% of total in region*
Region 14	367.6	-
West Coast	656.8	55.0
Scotland	672.6	54.7
Great Britain	***5,129.1***	***7.2***

Source: Sneddon & Randall (1993a, b, 1994), JNCC Coastal Database.

3.3.2 Important locations and species

The geology of the southern part of the region is such that shingle is absent from most of the eastern shore of the Firth of Clyde (Steers 1973). However, the fine-grained granites of Ailsa Craig produce the shingle found along the spits at Ballantrae and northwards to Pinbain Burn (Fuller 1973). Small fringing beaches are present near river mouths in the Gare Loch, Loch Long and Loch Fyne (Lamont 1945). There are several raised beaches and much foreshore shingle on the west coast of Arran, with some apposition beach

Map 3.3.1 Vegetated shingle structures and fringing shingle beaches. Source: Sneddon & Randall (1993).

development (successive beaches built by waves from different directions) at Torrylinnwater Foot in the south. This shingle results in part from pebbles from the Dalradian schists of the island, but much is also glacial in origin. East Kintyre has a series of boulder and shingle fringing storm beaches and a boulder and shingle spit linking Davaar island to the mainland.

From the Mull of Kintyre up the west coast the shingle beaches have a sandy matrix. Rhunahaorine Point, in the lee of Gigha Island, comprises a series of apposition banks of sandy shingle deposited at times of different sea-levels and by waves from different directions. The source of this massive spread of shingle and that on Gigha is thought to have been glacial streams draining a decaying ice lobe in West Loch Tarbert, immediately to the north. In contrast the fringing beach at Ardpatrick Point, Knapdale, has developed from locally derived quartzite pebbles.

Details of sites are given in Tables 3.3.2 and 3.3.3. Western Jura and northern Islay have some of the highest and largest spreads of late-glacial raised beach shingle in Scotland (McCann 1964), but their exposure to the open sea results in a rather sparse vegetation cover. At Machir Bay and Rhinns Point, Islay, the shingle has a more sandy matrix. Raised beach shingle is also present in Seil Sound, but on the south shore of Loch Linnhe the shingle is primarily glacial outwash gravels (McCann 1966). At Kilcheran, Lismore, the raised beach shingle includes local black and white limestone and quartzite pebbles. On Mull there are fringing beaches of basalt shingle, best developed near Salen and on the north shore of Treshnish Point, and several extensive basalt shingle tombolas joining pairs of the Treshnish Isles. The most

Table 3.3.2 Surveyed shingle structures

Site	*Grid ref.*	*Area surveyed (ha)*	*Site type*	*Conservation status*	*Activities, management, disturbances*
Ballantrae	NX080818	16.7	Granitic shingle spit	SSSI, LNR, SWT	Partially wardened, dumping
Torrylinnwater Foot	NR956207	2.1	Sandy, raised apposition beach	SSSI	Gravel extraction, trampling, vehicular access to east of river
Machrie Bay	NR890330	4.9	Fringing beach and sandy shingle spit	None	Light grazing, recreation, parking
Dougarie	NR880370	2.1	Raised shingle beach	None	Active erosion, vehicular access
North of Dougarie-Imachar	NR870390	3.0	Raised shingle beach	None	Drainage, vehicular access, erosion
Imachar	NR865402	4.0	Raised shingle beach	None	Vehicular access, past gravel extraction, cattle grazing
Pirnmill	NR870440	2.7	Raised shingle beach	None	Drainage, grazing
Rubha Airigh Bheirg	NR887480	4.1	Multiple raised apposition beaches	None	Vehicular access, camping, past excavation, turf cutting, grazing
Catacol Bay	NR920490	2.2	Raised apposition beach	None	Vehicular access, gravel extraction, grazing
Rhunahaorine	NR695493	325.8	Raised cuspate foreland	SSSI	Caravan park, past and present gravel extraction, agriculture, drainage, tree plantation

Source: Sneddon & Randall (1993a, 1994). Key: SSSI = Site of Special Scientific Interest, SWT = Scottish Wildlife Trust, LNR = Local Nature Reserve.

Table 3.3.3 Fringing shingle beaches

Site name	*Grid ref.*	*Length of shore (km)*	*Site type*	*Site name*	*Grid ref.*	*Length of shore (km)*	*Site type*
Pinbain Burn	NX1391	2.0	Sandy shingle	Claddach	NR1652	0.5	Sandy shingle
Loch Ranza	NR9451	0.5	Sandy and silty shingle	Machir Bay	NR2062	0.5	Sandy shingle
Ardmore	NS3178	0.5	Silty shingle, gravel	Gortanoid Point	NR3374	3.0	Raised beach cobbles and boulders
The Gare Loch	NS2583	0.5	Silty shingle				
Ardentinny	NS1987	0.5	Silty shingle	Loch Tarbert	NR5381	11.0	Raised beach quartz pebbles and boulders
Kilfinan Bay	NR9279	1.0	Sandy and silty shingle				
Saddell	NR7933	0.5	Shingle and boulders	Corpach Bay	NR5692	2.5	Raised beach shingle and boulders
Campbeltown	NR7420	0.5	Shingle and boulders				
Davaar	NR7619	1.0	Shingle and boulders	Seil Sound	NM7819	0.5	Wrack-rich shingle and cobbles
Kiel Point	NR6808	1.5	Sandy shingle				
Carskey Bay	NR6707	1.0	Sandy shingle	Connel	NM9139	1.0	Outwash gravels and shingle
Machrihanish Bay	NR6422	0.5	Sandy shingle				
Killean	NR6845	1.5	Sandy shingle	Taynuilt	NN0132	0.5	Cobbles and shingle
Gigha Island	NR6357	0.5	Sandy shingle	Kilcheran	NM8238	0.5	Limestone and quartzite shingle
Ardpatrick Point	NR7457	1.5	Quartz pebbles				
Leargybreck	NR5472	0.5	Raised beach shingle and boulders	Tralee Bay	NM8939	1.5	Shingle and cobbles
				Loch Creran	NM9643	0.5	Outwash gravels and shingle
Feolin Ferry	NR4469	1.0	Raised beach shingle and boulders				
				Salen	NM5743	1.0	Basalt shingle
Whitefarland Bay	NR4470	4.0	Raised beach shingle and boulders	Treshnish Isles	NM2742	1.0	Basalt shingle cobbles and boulders
Claggain Bay	NR4653	0.5	Raised beach shingle and boulders	Treshnish Point	NM3448	0.5	Basalt shingle

Source: Randall (unpublished survey, early 1980s)

extensive is that between Lunga and Sgeir a'Chaisteil.

Shingle communities around Britain have been defined by Sneddon & Randall (1993a), with some communities being widespread and others limited to a particular region or substrate. The sandy or silty nature of the matrix at several sites in the region is strongly represented in the vegetation, as is the wrack-enrichment of some fringing beaches and the absence of matrix over parts of Arran, Islay and Jura. A common pioneer assemblage in the region on sandy shingle strands is a community dominated by sea sandwort *Honkenya peploides* and sea campion *Silene maritima*, with a range of associates including red fescue *Festuca rubra* and marram *Ammophila arenaria*. A related community limited to western Scotland and common at Ballantrae is a very open sea sandwort-sea campion community with few other species except sea mayweed *Tripleurospermum maritimum*. On raised beaches, many varieties of herb-rich grassland are present, with Yorkshire fog *Holcus lanatus*, smooth meadow-grass *Poa pratensis*, sweet vernal-grass *Anthoxanthum odoratum* and creeping bent *Agrostis stolonifera* as important

grass species. At Ballantrae and west Arran a silty matrix results in some areas of saltmarsh-influenced grassland, with creeping bent the major grass, but salt-tolerant species such as saltmarsh rush *Juncus gerardii,* scurvy grass *Cochlearia officinalis,* thrift *Armeria maritima* and sea arrowgrass *Triglochin maritima* also present. To the rear of some raised beaches and other poorly drained shingle this vegetation merges into a freshwater fen or marsh (Gillham 1957), with herbs such as meadowsweet *Filipendula ulmaria*, marsh cinquefoil *Potentilla palustris* and yellow flag *Iris pseudacorus*.

Rhunahaorine and west Arran are especially significant for their heath communities, which range from wet, acid reed *Phragmites australis*-dominated areas to drier heather *Calluna vulgaris* heaths, with bell heather *Erica cinerea*, tormentil *Potentilla erecta* and mosses. Unique to the shingle of Rhunahaorine are seven heath communities, with such species as purple moor-grass *Molinia caerulea*, bog-myrtle *Myrica gale*, wavy hair-grass *Deschampsia flexuosa*, bracken *Pteridium aquilinum* and jointed rush *Juncus articulatus* as co-dominant species. On the more stable parts of Rhunahaorine foreshore there is a secondary pioneer community with sea mayweed, curled dock *Rumex crispus* and prostrate orache *Atriplex prostrata,* with several grasses and ruderal herbs. This too is specifically western in character. On the more sandy, southern part of the site there is a marram-sand sedge *Carex arenaria*-red fescue grassland rich in herbs and grasses and close in type to sand dune vegetation. Drier, disturbed areas of Rhunahaorine and Arran have gorse *Ulex europaeus* and bramble *Rubus fruticosus* scrub with common bent *Agrostis capillaris*. In places this community is replaced by one with false oat-grass *Arrhenatherum elatius*, cocksfoot *Dactylis glomerata* and elder *Sambucus niger*. In Arran there is also blackthorn *Prunus spinosa* scrub in the Dougarie-Imachar area, where disturbance is minimal.

The most important plant species in the region is the oyster plant *Mertensia maritima*. The wrack-matrix fringing beaches of the region contain the largest populations of oyster plant outside Orkney (Randall 1988), but severe storms in 1988 drastically reduced several of its populations (Sneddon 1992). This region also has the most northerly or north-westerly sites for Isle of Man cabbage *Coincya monensis* (Stirling 1983), sea kale *Crambe maritima* (Scott & Randall 1976), yellow horned-poppy *Glaucium flavum* and extensive areas of sea radish *Raphanus maritimus.* On Islay, Treshnish Isles and Kintyre Scots lovage *Ligusticum scoticum* grows extensively; it reaches the southern limit of its distribution just to the south of this region on the Solway Firth (Region 13).

Shingle at Ballantrae supports the only mainland breeding site for little tern *Sterna albifrons* in this region. The corncrake *Crex crex* is sometimes found in the iris beds on Islay and Mull. Greenland barnacle geese *Branta leucopsis* are to be found on the Islay shingle in winter. The tombolas of the Treshnish Isles provide nesting sites for important numbers of storm petrels *Hydrobates pelagicus* and are important roosting and nesting sites for gulls, whose droppings may in places influence the nature of the vegetation. The invertebrate ecology of shingle in the region has not been recorded.

3.3.3 Human activities

Most of the fringing beaches of this region have no conservation status and a small number are subject to recreational pressure or building disturbance. However, Ballantrae, Torrylinnwater Foot and Rhunahaorine are Sites of Special Scientific Interest (SSSIs), and Ballantrae is also a seasonally-wardened Scottish Wildlife Trust reserve.

Much of the coast is grazed by sheep and cattle and grazing intensity on most shingle beaches has increased in recent years in response to EU subsidies. High stocking levels of cattle and sheep over much of the foreland of Rhunahaorine are resulting in overgrazing and trampling, increasing nutrient levels in an otherwise nutrient-poor environment. Much of the land on the lower, younger ridges has been improved and reseeded and other areas have been drained. The natural vegetation near the road has been lost to crop cultivation, and around Rhunahaorine House there is a conifer plantation. There is also a caravan park and fish farm and shingle is extracted for local use.

South of the Stinchar river, dumping of farm organic waste has led to local nutrient enrichment of the shingle, although the dumping has now ceased. Much of the west Arran coast raised beach is open to vehicular access and parts have been set aside as car parks. In some areas drains have been dug to improve drainage to the rear of beaches. Gravel extraction occurs at Tralee Bay, Rubha Airigh Bheirg and Pirnmil, and turf cutting also takes place, leading to instability of the shingle.

3.3.4 Information sources used

Not all shingle sites are vegetated, especially not those on exposed high-energy coasts or where disturbance is great. Unvegetated sites have not been surveyed. All the vegetated shingle structures of the region were surveyed during the national shingle structures survey undertaken by the Nature Conservancy Council (NCC) between July and September 1989, which used the National Vegetation Classification (NVC) framework (Sneddon & Randall 1993a, b, 1994). Not all shingle sites fall into the category of shingle structures. Many of the fringing beaches in this region were examined by the author in 1986-1987 as part of the NCC's rare species monitoring scheme (Randall 1988). The beaches of Arran were surveyed by Adam *et al.* (1977) and those of Mull by Gillham (1957) and Jermy & Crabbe (1978). The beaches of Islay and Jura were surveyed by Ritchie & Crofts (1974).

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B. Further reading

Further details of coastal habitat sites, including shingle structures and shorelines, are available on the *Coastal & marine UKDMAP datasets* module disseminated by JNCC Coastal Conservation Branch, Peterborough (Barne *et al.* 1994).

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Ballantrae	Scottish Wildlife Trust, Pollock Yard, Station Road, Mauchline KA5 5EU, tel: 01290 52668
Flora, fauna, habitat information, site management	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Flora, fauna, habitat information, site management: Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Flora, fauna, habitat information, site management in the south of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488

*Starred contact addresses are given in full in the Appendix.

3.4 Coastal lagoons

Dr R.S.K. Barnes & Dr R.N. Bamber

3.4.1 Introduction

The term coastal lagoons is used here to include true lagoons, i.e. those wholly or partially separated from the sea by a natural sedimentary barrier, and also artificial brackish ponds and coastal pools, of a similarly restricted tidal range and often containing comparable lagoonal wildlife. Lagoons are commonly shallow, often with a varying salinity ranging from above to below normal sea-water levels (35 g/kg). Freshwater systems are not considered here, nor are fully flushed tidal pools. The extensively studied and complex sea loch systems of the region comprise essentially marine habitats and are therefore not discussed here (see sections 4.2 and 5.4).

The single natural lagoon system present in the region, at Ballantrae, is an estuarine lagoon totaling 3 ha in area, amounting to less than 0.1% of Britain's total lagoonal resource. There are no nationally noteworthy (*sensu* Barnes 1989) lagoonal areas in the region. The region is therefore not significant in the national context. However, lagoons are a nationally rare habitat and a 'priority habitat type' under Annex 1 of the EC Habitats & Species Directive. Therefore, although the region's lagoonal resource is not significant nationally in terms of its extent, the habitat type is of national and international importance wherever it occurs and in whatever quantity. The contribution of the region's lagoons to the size of the British resource as a whole is shown in Table 3.4.1.

Table 3.4.1 Lagoonal areas[a] for region in context

Region	*Lagoonal area (ha)*	*Overall % of GB total*	*% of GB total excl. the Fleet*
Region 14	11	<0.1	<0.1
West Coast	839	32	38
Great Britain	2,658	-	-

Sources: Barnes (1989); figures for the West Coast and for Great Britain include areas recently identified as lagoons (Covey *et al.* in prep.). Key: [a]to the nearest hectare.

3.4.2 Important locations and species

Map 3.4.1 shows the location of the single lagoon in the region. True lagoons support only three types of aquatic vegetation, namely stands of green algae (*Chaetomorpha* spp., *Ulva* spp. and *Enteromorpha* spp.), of seagrasses and similar plants (predominantly tasselweeds *Ruppia* spp.) and, much more rarely, of stoneworts (especially *Lamprothamnium* spp.). Much of the area of their beds, however, is in the form of bare sediment, devoid of vegetation cover. Fringing stands of reeds *Phragmites* spp., saltmarsh plants and/or sea club-rush *Scirpus maritimus* are usual. The Ballantrae lagoon supports only these algal and saltmarsh communities.

Lagoons possess a characteristic invertebrate fauna that shows little regional variation, even within Europe. In Britain, several of these species are very rare and are protected under the Wildlife & Countryside Act 1981. None of these species occurs in Ballantrae lagoon.

Map 3.4.1 Coastal lagoons.

3.4.3 Human activities

Little or no active management is applied to the coastal lagoon in the region.

3.4.4 Information sources used

The potential lagoons in the region were surveyed as part of the NCC's national lagoon survey. A detailed report of these surveys is available, including maps of the habitats and species lists. The data are summarised in Barnes (1988), from which the data given here are derived. Other saline pools were surveyed more recently (1994/5) by the JNCC's Marine Nature Conservation Review team. Reports on these surveys are currently in preparation; these surveys looked in some detail at sub-littoral habitats (Covey *et al.* in prep.).

3.4.5 Further sources of information

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NERC. 1991. *United Kingdom Digital Marine Atlas (UKDMAP).* Birkenhead, British Oceanographic Data Centre.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
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Flora, fauna, habitat information, site management	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Flora, fauna, habitat information, site management: Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Flora, fauna, habitat information, site management in the south of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488

*Starred contact addresses are given in full in the Appendix.

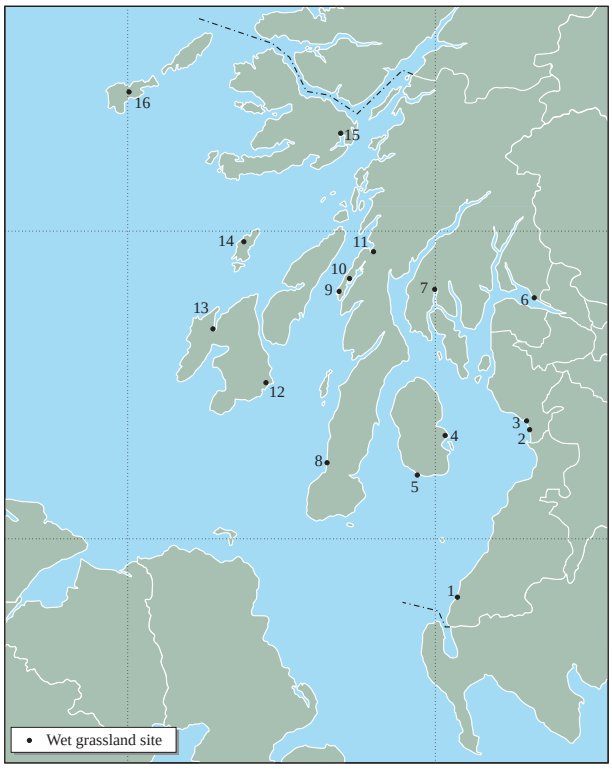
3.5 Wet grassland

Dr H.T. Gee

3.5.1 Introduction

Wet grassland includes both coastal grazing marsh subject to maritime influence and lowland wet grassland adjacent to tidal reaches of estuaries. Coastal grazing marsh is a distinctive habitat consisting of low-lying grassland drained by a series of ditches that may be either brackish or freshwater. Much grazing marsh was formed by the enclosure of saltmarsh behind sea walls. Smaller areas of freshwater grazing marsh have been created landward of natural barriers such as sand dunes or shingle beaches. Wet grassland sites may remain wet throughout the year and may be managed for stock grazing and/or as hay meadow. No national survey exists of wet grassland as here defined, or indeed of coastal grazing marsh or lowland wet grassland separately, so detailed inter-region comparisons are not possible.

Grazing marsh is generally considered to be a rare habitat in Scotland (Doody *et al.* 1993). However, extensive stretches of the coast of this region are bounded by wet grassland, which is of significant conservation interest. It has developed on the small raised coastal platforms present along much of the coast of Argyll and islands such as Arran.



Map 3.5.1 Wet grassland sites. See Table 3.5.1.

3.5.2 Important locations and species

Wet grassland sites in the region are listed in Table 3.5.1 and shown on Map 3.5.1. The most significant area in terms of size is the claimed land on the Kintyre peninsula at Machrihanish. Although smaller, the wet grassland included in the Loch Gruinart Flats SSSI on Islay is, however, possibly the most important such area in the region in terms of its nature conservation value. There are also small but significant areas of wet grassland on Tiree at An Fhaodhail.

The wet grassland at Loch Gruinart is grazed by geese and is of international importance for barnacle geese *Branta leucopsis* and Greenland white-fronted geese *Anser albifrons flavirostris* (see also section 5.12). It supports an important and rich assemblage of breeding waders and a small population of corncrakes *Crex crex* in those areas managed as hay meadows (see also section 5.11). The site is also of known conservation value for the aquatic and terrestrial plant species it supports. Similar habitats in the area support pipewort *Eriocaulon aquaticon,* which is a British Red Data Book species, restricted in distribution to the inner Hebrides and western Ireland. However, little is known of the site's invertebrate interest.

Wet grassland at Machrihanish also supports internationally-important numbers of grazing and roosting Greenland white-fronted geese during the winter. However, much of the grassland has been improved for agriculture and is of little botanical conservation value. The aquatic flora and invertebrate fauna of the ditches is unknown, and any interest may have been reduced by emergency overflows of oil from the adjacent airfield.

Areas of wet grassland are included in or lie next to sixteen of the SSSIs in the region (Table 3.5.1). At some sites, such as Ardmore Point, the grassland is incidental to the interest of the SSSI and of very limited extent. At several sites the grassland forms a continuum of estuarine habitats in association with sand dune (Western Gailes), shingle (Ballantrae Shingle Beach) or saltmarsh (Bogside Flats, Ruel Estuary).

Six SSSIs in the region contain good examples of the coastal rock platform wet grassland communities that typify the raised beaches of this coastline and are often found as part of the transition from beach-head saltmarsh to dry grassland or carr woodland. The coastal edge of the platform experiences direct maritime influence, as it lies within the spray zone, and is often strewn with storm debris. The raised beach wet grassland is of recognised conservation value for both its flora and fauna. It is often grazed and frequently supports a rush pasture community grading into more marshy habitat supporting yellow flag *Iris pseudacorus*, hemlock water-dropwort *Oenanthe crocata* and other marsh species on the coastal edge. The vegetation of the wet grassland is dominated by fen communities such as soft-rush *Juncus effusus* or sharp-flowered rush *J. acutiflorus* with common marsh-bedstraw *Galium palustre* and star sedge flushes *Carex echinata* with the mosses *Sphagnum recurvum* and *S. auriculatum,* as observed at Taynish and Ulva, Danna and the McCormaig Isles SSSIs. The nationally scarce keeled skimmer dragonfly *Orthetrum coerulescens* is a characteristic species of these fens. The wet grassland of the raised beaches is also known to be a stronghold of the marsh fritillary butterfly *Euphydryas aurinia* in Scotland. The herb-rich fen meadows of the old raised beach in the Taynish Woods SSSI is particularly noted

Table 3.5.1 Wet grassland sites in or adjacent to SSSIs in Region 14

No. on Map 3.5.1	*Site*	*Grid ref.*	*Conservation status*	*Notes*
1	Ballantrae	NX080818	Undesignated; adjacent to SSSI	Behind shingle spit
2	Western Gailes	NS320358	Undesignated; adjacent to SSSI	Behind dune system
3	Bogside Flats	NS305394	SSSI	
4	Clauchlands Point to Corrygills, Isle of Arran	NS048338	SSSI	On coastal rock platform
5	South coast of Arran	NR951208-NS042213	SSSI	On coastal rock platform
6	Ardmore Point	NS314785	Part SSSI, part undesignated	Adjacent to mudflats
7	Ruel Estuary	NS010800	SSSI	
8	Machrihanish	NR653238	Undesignated; adjacent to SSSI	
9	Ulva, Danna and the McCormaig Isles	NR700799	SSSI	On coastal rock platform
10	Taynish Woods	NR735850	SSSI	On coastal rock platform
11	Moine Mhor	NR815925-NR829950	Partl SSSI, part undesignated	Drained peat bog
12	Ardmore, Kildalton and Callumkill Woodlands	NR450495	SSSI	On coastal rock platform
13	Gruinart Flats	NR287672	SSSI, SPA and Ramsar site	
14	Loch Fada, Colonsay	NR383956	SSSI	
15	Ardura-Auchnacraig	NM705290	SSSI	On coastal rock platform
16	An Fhaodhail and the Reef	NM014454	SSSI	

Source: SNH. Key: SSSI = Site of Special Scientific Interest; SPA = Special Protection Area for birds; Ramsar site = internationally important wetland.

for its characteristic vegetation, including purple moor-grass *Molinia caerulea* meadows, which are the preferred habitat of the Scotch argus butterfly *Erebia aethiops*.

At Moine Mhor on the Crinan Estuary lowland coastal raised bog has been partially converted through ditch drainage to form wet grassland. This site supports typical species of humid heath and bog. At An Fhaodhail and the Reef, a partially-effective tidal flap has reduced tidal influence from a tidal inlet. Areas of the saltmarsh have been partially claimed, creating brackish and freshwater wet grassland. This site is of particular interest both for its breeding wildfowl and waders and for the rich assemblages of aquatic plants in the extensive wetland habitat. It is also of international importance for wintering Greenland white-fronted geese.

The marshy, ditch-drained pastures fringing the lochs at Loch Fada on Colonsay are noted for their floral richness, especially their orchids and sedges.

3.5.3 Human activities

Management for conservation is an important factor affecting the remnants of wet grassland in this region. The RSPB has a management agreement at Gruinart Flats SSSI, under which the wet grassland is flooded on a seasonal basis for the benefit of waterfowl such as wintering teal *Anas crecca*. The site at An Fhaodhail and the Reef is managed directly by the RSPB, who are committed to maintaining the existing drainage regime. This guarantees the future of the mosaic of brackish communities present, which would be threatened if the tidal flap were to be allowed to fall further into disrepair.

3.5.4 Information sources used

More surveys are needed to establish the extent of wet grassland in this region and its conservation interest. Information on aquatic flora and invertebrate fauna is particularly inadequate. The RSPB have survey data for the breeding, passage and wintering birds on the sites they manage, notably at Gruinart Flats SSSI. There are Phase 2 vegetation survey data for some sites, and the RSPB completed an National Vegetation Classification (NVC - Rodwell 1995) survey of the ditch communities of Gruinart Marsh in 1995.

3.5.5 Acknowledgements

Thanks are due to the Regional and Area staff of Scottish Natural Heritage for their considerable help in providing information for this region.

3.5.6 Further sources of information

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Flora, fauna, habitat information, site management	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Flora, fauna, habitat information, site management: Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Flora, fauna, habitat information, site management in the south of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488

*Starred contact addresses are given in full in the Appendix.

There is relatively little saltmarsh in the region, and what there is has mostly accumulated at the heads of lochs on the mainland. However, between Colonsay and Oronsay is an extensive stretch of intertidal habitats, including saltmarsh, known as The Strand. The Paps of Jura punctuate the skyline. Photo: Pat Doody, JNCC.

3.6 Saltmarsh

Dr M.I. Hill

3.6.1 Introduction

There are 549 ha of saltmarsh in Region 14, representing approximately 2.4% of the resource on the West Coast, 9% of that in Scotland and 1.2% of the British total (Table 3.6.1) (Burd 1989a, b). Of this, 447 ha occur in small (<10 ha) scattered sites on the mainland and islands of Argyll and Bute. Elsewhere, significant areas of saltmarsh are found only in the inner Clyde and the Irvine/Garnock Estuary. In addition, very small (<1 ha) patches of saltmarsh vegetation are widely distributed on shingle beaches and rocky shores (Gillham 1957; Gimingham 1964), although these were not included in the national survey (Burd 1989a). Only 1.3% of the region's coast supports saltmarsh.

Most of the region's saltmarshes are of the loch head type. There are also some fringing marshes in the Inner Clyde Estuary, at the margins of bays and at the mouths of streams (Pye & French 1993). With the exception of the more estuarine marshes in the south of the region, most of the sites have a low input of tide-borne sediment, and even in the low marsh zones the organic content of the saltmarsh sediments is high. The saltmarshes tend not to show rapid changes in extent and morphology, with stability, slow extension seawards or slow erosion being the norm (Pye & French 1993). Often the landward progression to non-tidal conditions is very gradual and it can be difficult to define the landward limit of the saltmarsh. Transitions from saltmarsh to other habitats such as freshwater swamps, grasslands, bogs and woodlands are a feature of the region's saltmarshes, as rainfall in the region is high and freshwater seepage from adjacent land has a strong influence.

As a result of these factors, a high proportion of the saltmarsh area is in the higher and more mature saltmarsh zones: 56% of the saltmarsh area is mid-upper marsh and 28% transitions to other habitats (Table 3.6.1), much higher proportions than the average for the West Coast or Britain as a whole. The proportion of low and pioneer saltmarsh zones is correspondingly small.

Map 3.6.1 Saltmarsh sites surveyed in National Saltmarsh Survey (see Table 3.6.2). Source: JNCC Coastal Database.

3.6.2 Important locations and species

The main saltmarsh sites surveyed during the national survey (Burd 1989b) are shown on Map 3.6.1 and listed in Table 3.6.2. The most extensive saltmarshes are at Loch Beg (Mull), Loch Gruinart and Bridgend Flats/Loch Indaal (Islay), Loch Crinan, the inner Clyde and the Irvine/Garnock Estuary.

The most important saltmarshes for nature conservation show a wide range of plant communities, in this region notably including transitions between saltmarsh and other habitats. Such sites include Bogside Flats (Irvine/Garnock Estuary) and Loch Gruinart, which both have transitions to grassland, and the Inner Clyde, which has transitions to both freshwater swamps and grassland. Loch Crinan has a particularly interesting range of plant communities, including one of the few examples in Britain of transition from saltmarsh to raised bog (Moine Mhor). The Loch Ruel saltmarshes are nationally important for the range of vegetation they feature, including a transition from saltmarsh through freshwater marsh, wet grassland and alder scrub to oak woodland, including both grazed and ungrazed sections (Doody 1986).

SSSIs in the region containing saltmarsh are listed in Table 3.6.3. In some cases the saltmarsh is only a small part of the site and may not have been the main reason for designation. However, such sites provide additional and

Table 3.6.1 Areas (ha[a]) of saltmarsh communities in region compared with national totals

	Spartina	*Pioneer*	*Low-mid*	*Mid-upper*	*Driftline*	*Upper swamp*	*Transition*	*Wet depression*	*Total*	*% in region*
Region 14	10	5	22	306	4	44	156	<1	549	-
West Coast	3,487	1,340	4,159	11,270	473	410	1,327	<1	22,582	2.4
Scotland	102	361	499	3,608	63	587	748	2	6,089	9.0
Great Britain	***6,948***	***3,470***	***12,353***	***16,042***	***1,824***	***1,475***	***1,670***	***2***	***44,370***	***1.2***

Sources: Burd (1989a, b). Key: [a]to the nearest hectare.

Table 3.6.2 Main saltmarsh sites surveyed*

Name	*Grid ref.*	*Area (ha[a])*
Pow Burn, Troon	NS342278	3
Irvine/Garnock Estuary	NS318389	30
Brodick Bay (Arran)	NS013365	2
Inner Clyde	NS322788, NS463723, NS450736	67
Holy Loch (Firth of Clyde)	NS153817	16
Loch Striven (Firth of Clyde)	NS055845	7
Ruel Estuary/Loch Ridden (Firth of Clyde)	NS010811	7
Auchalick Bay (outer Loch Fyne)	NR913746	7
Loch Fyne	NN192126	8
West Loch Tarbert (Jura Sound)	NR796603, NR818622	5
Loch Stornoway (Jura Sound)	NR738613	9
Loch Caolisport (Jura Sound)	NR766777	20
Linne Mhuirich (Jura Sound)	NR725846	7
Loch Crinan (Jura Sound)	NR804925	47
Loch Craignish (Jura Sound)	NM823054	3
Loch Melfort (Jura Sound)	NM844124	7
Torsa, Luing (Jura Sound)	NM757126	2
Loch Feochan (Firth of Lorn)	NM824222, NM 873245	24
Dunstaffnage (Firth of Lorn)	NM877338	9
An Seilean (Firth of Lorn)	NM895402	24
Ardentiny (Firth of Lorn)	NM888418	4
Loch Creran (Firth of Lorn)	NM902418, NM937410, NM976441, NN006452	29
Loch Laich (Firth of Lorn)	NM928466	15
Loch an t-Sailein (Islay)	NR430470	7
Bridgend Flats (Islay)	NR332623	40
Gruinart Flats (Islay)	NR287672	51
Gleann Aoistail (Jura)	NR597840	4
The Strand (Colonsay)	NR372911	7
Loch Don (Mull)	NM725323	16
Ardura (Mull)	NM690307	5
Loch Beg (Mull)	NM540287	60
Dervaig (Mull)	NM429515	3

Source: Burd (1988a, b). Key: *all sites with more than 1 ha of saltmarsh; [a]to the nearest hectare.

Table 3.6.3 SSSIs containing saltmarsh

Name	*Grid ref.*	*Other designation*
Ballantrae Shingle Beach	NX080818	-
Bogside Flats, Irvine	NS305394	-
Clauchlands Point to Corrygills, Arran	NS048338	-
South coast of Arran	NR951208, NS042213	-
Erskine to Langbank (Inner Clyde)	NS395734	RSPB reserve
Dumbuck foreshore to Pillar Bank (Inner Clyde)	NS350760	-
Ardmore Point (Inner Clyde)	NS314785	-
Ruel Estuary	NS010800	-
Taynish Woods (Linne Mhuirich)	NR735850	Biosphere Reserve, pSAC, NNR
Ulva, Danna, and the McCormaig Isles	NR700799	-
Moine Mhor (Crinan Estuary)	NR815925	pSAC, NNR
Doire Dhonn, Jura	NR655890	-
Ardmore, Kildalton, and Callumkill, Islay	NR450495	-
Bridgend Flats, Islay	NR330620	SPA, Ramsar
Gruinart Flats, Islay	NR285665	SPA, Ramsar, RSPB reserve
Ardura to Auchnacraig, Mull	NM705290	-

Source: JNCC Coastal Database. Key: SSSI - Site of Special Scientific Interest; Ramsar site = internationally important wetland under the Ramsar Convention; SPA = Special Protection Area for birds under the EC Birds Directive; pSAC = possible Special Area of Conservation under the EC Habitats & Species Directive; NNR = National Nature Reserve; RSPB = Royal Society for the Protection of Birds.

interesting examples of transitions from saltmarsh to other habitats, for example Ardura-Auchnacraig SSSI (saltmarsh to wet grassland); Doire Dhonn SSSI (saltmarsh to woodland); Clauchlands Point to Corrygills and the south coast of Arran SSSIs (saltmarsh through wet grassland and fen to alder/willow scrub); Loch an t-Sailein in Ardmore, Kildalton and Callumkill SSSI (saltmarsh through fen and wet heath to oak/sallow woodland); and Linne Mhuirich in Taynish Woods SSSI (saltmarsh to fen).

Saltmarshes on the west coast of Scotland are characterised by a limited number of plant communities but a high species diversity in the upper marsh, owing to the influence of freshwater seepage and high rainfall, and unbroken transition to non-tidal areas. Several widespread British saltmarsh species, such as sea-purslane *Halimione portulacoides*, sea wormwood *Artemisia maritima* and common sea-lavender *Limonium vulgare*, are absent, as their northern climatic limit is at the Solway (Region 13) (Adam 1990). Common cord-grass *Spartina anglica* is not an important pioneer species here and is found at only a few sites, such as An Seilean (Ardmucknish Bay) and the Balure of Shian (mouth of Loch Creran) (Bibby 1985).

A typical saltmarsh in the region comprises a grazed grassy turf, with common saltmarsh-grass *Puccinellia maritima* as the dominant species. Thrift *Armeria maritima*, sea plantain *Plantago maritima*, red fescue *Festuca rubra*, sea-milkwort *Glaux maritima*, autumn hawkbit *Leontodon autumnalis* and saltmarsh rush *Juncus gerardii* are also abundant. This relates to the National Vegetation Classification (NVC - Rodwell in prep.) plant community SM13 common saltmarsh-grass saltmarsh (common saltmarsh-grass - thrift or turf fucoid subcommunity) or SM16 red fescue saltmarsh (sea-milkwort or autumn hawkbit subcommunity). There is some evidence from the Firth of Clyde that in ungrazed or less heavily grazed sites red fescue can be more dominant, and the NVC communities are SM16 red fescue saltmarsh (common saltmarsh-grass, tall red fescue or saltmarsh rush subcommunity) (Doody 1986).

Upper marsh swamps of common reed *Phragmites australis* and sea club-rush *Scirpus maritimus* are found at the landward edge of many marshes. Where the freshwater influence is high, there may be a diverse fen vegetation often with yellow flag *Iris pseudacorus* and meadowsweet *Filipendula ulmaria*. A species-rich grassland with glaucous sedge *Carex flacca* as a constant species is found near the tidal limit of saltmarshes in this region (Adam 1981; Rodwell in prep.). Within this vegetation type, at the highest levels of the marsh, plants characteristic of moorland and bogs may be present and mosses abundant. In more open parts of the upper marsh, especially rocky or

shingle areas flushed by freshwater, saltmarsh flat-sedge *Blysmus rufus* and slender spike-rush *Eleocharis uniglumis* are found. These are northern elements in the saltmarsh flora and occur mainly on the west coast of Britain from mid Wales northwards. Whilst neither saltmarsh flat-sedge nor slender spike-rush is regarded as nationally scarce, they are not extensive as a vegetation type on British saltmarshes and this region holds a high proportion of the total resource.

The three British species of eelgrass *Zostera* spp., all nationally scarce, are present in intertidal and subtidal zones in the region, but their distributions are not known in detail. Narrow-leaved eelgrass *Z. angustifolia* appears to be less widespread than eelgrass *Z. marina* and dwarf eelgrass *Z. noltii* (Stewart *et al.* 1994). Some sites, such as Loch na Cille, are known to contain all three species.

Saltmarshes in the region provide roosts for wintering and migrant waders and food for wildfowl (see also section 5.12). Bogside Flats, Bridgend Flats and Gruinart Flats hold saltmarshes of recognised importance for shorebirds. Generally, the short turf of saltmarshes in the region means that they are of lesser importance for breeding birds (see also section 5.11).

3.6.3 Human activities

Saltmarshes in the region have experienced less anthropogenic change than those elsewhere in Britain. Although most of the marshes are grazed, or have been grazed until fairly recently, it has been suggested that, compared with most British saltmarshes, grazing on the saltmarshes of the region has had less impact on the vegetation, since many of the species that are sensitive to grazing are absent from the area for climatic reasons (Adam 1978). The region's saltmarshes are also used for turf cutting.

Land claim of saltmarshes has been less widespread in this region than in many parts of Britain. However, in the inner Clyde and Irvine/Garnock Estuaries there has been major land claim for industry. Other sites where significant areas have been claimed are Lochs Gruinart, Caolisport, Crinan, Creran, Laich and Holy Loch (Pye & French 1993).

3.6.4 Information sources used

Saltmarshes in the region were surveyed between 1984 and 1986 as part of the Nature Conservancy Council's national saltmarsh survey. Detailed reports of the national saltmarsh survey are available and results are summarised in Bibby (1985) and Burd (1989a, b). Data presented here are derived from that database. The national saltmarsh survey provided an intermediate level of detail between Phase 1 habitat survey and the National Vegetation Classification (NVC: Rodwell in press). It did not include all areas of transition to other habitats, such as sand dune, shingle and freshwater marsh. Saltmarsh vegetation in non-tidal, land-claimed marshes and areas of eelgrass were not covered.

Other saltmarsh studies and surveys have been carried out in the Firth of Clyde (Doody 1986), Mull and Iona (Gillham 1957) and Arran (Adam *et al.* 1977). New surveys of the saltmarshes and especially their transition zones are needed to give a proper assessment of their nature conservation value.

3.6.5 Acknowledgements

Staff of Scottish Natural Heritage kindly provided information and reference material.

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Stewart, A., Pearman, D.A., & Preston, C.D., *eds.* 1994. *Scarce plants in Britain*. Peterborough, Joint Nature Conservation Committee.

B. Further reading

Further details of coastal habitat sites, including saltmarshes, are available on the *Coastal & marine UKDMAP datasets* module disseminated by JNCC Coastal Conservation Branch, Peterborough (Barne *et al.* 1994).

Barne, J., Davidson, N.C., Hill, T.O., & Jones, M. 1994. *Coastal and marine UKDMAP datasets: a user manual*. Peterborough, Joint Nature Conservation Committee.

British Oceanographic Data Centre. 1992. *United Kingdom digital marine atlas. User guide. Version 2.0*. Birkenhead, Natural Environment Research Council, British Oceanographic Data Centre.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
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Flora, fauna, habitat information, site management	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Flora, fauna, habitat information, site management: Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Flora, fauna, habitat information, site management in the south of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488

*Starred contact addresses are given in full in the Appendix.

Estuarine habitats are uncommon in the region. However, the head of Loch Riddon, a fjordic sea loch on the mainland north of the Isle of Bute, has become infilled with sediments since the end of the last ice age, creating the estuary of the Ruel. Photo: Pat Doody, JNCC.

Chapter 4 Marine and estuarine environments

4.1 Estuaries

Dr N.C. Davidson

4.1.1 Introduction

Estuaries are "partially enclosed tidal areas at least partly composed of soft tidal shores, open to saline water from the sea, and receiving fresh water from rivers, land run-off or seepage" (Davidson *et al*. 1991). They comprise both aquatic (marine, brackish and fresh water) and terrestrial habitats, including adjacent sand dunes, coastal grasslands and maritime heaths. All the estuaries discussed here are covered by the NCC's Estuaries Review (Davidson *et al.* 1991) and have at least 2 km of tidal channel or 2 km of shoreline over 0.5 km wide at low tide, either now or historically. This section gives an overview of the main features of the estuarine resource in Region 14; for further details of habitats, species and human uses refer to relevant sections in Chapters 3, 5 and 9 respectively.

In this glacially-influenced region of predominantly rocky coasts and islands and deep-water fjords there are few places shallow and sheltered enough for soft intertidal sediments to accumulate. The eight locations in this region that are estuarine in character, although forming only a small part of the national estuarine resource, nevertheless make an important contribution to the habitat diversity of the region.

The contribution of Region 14 estuaries to the wider resource is summarised in Table 4.1.1. Over 200 km of the region's shoreline is estuarine, although this forms only 7% of the region's coastline. The 8,540 ha of the region's estuarine area forms 2.6% of the West Coast resource and 1.5% of the UK resource. At around 5,500 ha the Clyde is the largest estuary in the region, with none of the other estuaries exceeding 1,000 ha in total area. Although the total area of saltmarsh in the region is small, forming only 0.6% of the British resource, individual marshes are some of the most extensive in western Scotland. Since there has been little land-claim, except of the more industrialised estuaries in the south, the region's saltmarshes are particularly notable for their natural transitions at upper tidal levels to terrestrial habitats (see section 3.6).

Map 4.1.1 Estuaries. Source: JNCC Coastal Database.

4.1.2 Important locations and species

Table 4.1.2 lists the estuaries in the region (Map 4.1.1) and summarises their main physical characteristics.

Table 4.1.1 Contributions of Region 14 estuaries to the national resource

Resource	*Regional total*	*West Coast total*	*% West Coast*	*GB total*	*% GB*	*UK total*	*% UK*
Intertidal area (ha)	3,950	195,770	2.0	321,050	1.2	332,350	1.2
Saltmarsh area (ha)	240[a]	20,710	1.2	48,380	0.6	*	*
Total estuarine area (ha)	8,540	323,180	2.6	525,650	1.6	581,290	1.5
Shoreline length (km)	226	14,546	1.6	9,054	1.2	9,727	1.1
Longest channel lengths (km)	75	1,335	5.6	2,461	2.8	2,640	2.7

Sources: Buck (1993); Davidson & Buck (in prep.). Key: *areas of saltmarsh were not available for Northern Ireland and so estuarine saltmarsh area comparisons are not made for the UK; [a]significant saltmarsh areas occur outside estuaries as defined in this section (see section 3.6 for full saltmarsh distribution). Note: areas rounded to the nearest 10 ha; lengths rounded to the nearest 1 km.

Table 4.1.2 Physical characteristics of Region 14 estuaries

Estuary	*Centre grid ref.*	*Geomorphological type*	*Total area (ha)*	*Inter-tidal area (ha)*	*Salt-marsh (ha)*	*Shore-line length (km)*	*Main channel length (km)*	*Spring tidal range (m)*	*Sub-tidal %*
47. Garnock Estuary	NS3039	Bar-built	204	161	30	14.7	5.6	3.2	21.1
48. Hunterston Sands	NS1953	Linear shore	291	291	0	16.4	n/a	2.9	0
49. Inner Clyde Estuary	NS3675	Fjord	5,485	1,841	67	129.7	41.9	3.0	66.4
50. Ruel Estuary	NS0079	Fjord	426	184	7	15.4	6.7	3.0	56.8
51. Loch Gilp	NS8687	Fjord	245	143	0	6.8	3.4	3.1	41.6
52. Traigh Cill-a-Rubha	NS3362	Embayment	639	288	40	8.6	3.0	1.5	54.9
53. Loch Gruinart	NR2971	Fjard	973	876	51	18.7	8.1	3.1	10.0
54. Loch Crinan	NR7993	Fjard	280	168	47	15.3	6.2	3.7	40.0

Sources: Buck (1993); JNCC Integrated Coastal Database. Notes: all area figures have been rounded to the nearest whole hectare; estuary numbers are those used in Davidson *et al.* (1991); 'geomorphological type' relates to nine estuary categories, described further in Chapter 5.7 of Davidson *et al.* (1991) and Chapter 4.5 of Davidson & Buck (in press); 'spring tidal ranges' are for the monitoring station closest to the mouth of the estuary. Key: n/a = not applicable.

Many of the region's estuarine areas are strongly marine in character, with only limited freshwater inflows into their inner parts: only the Garnock and Clyde Estuaries have a substantial freshwater influence, although most estuaries in the region have at least small rivers and streams discharging into them. Many, particularly in the northern part of the region, are fjordic in type and are included here because sufficient river-borne sediments have accumulated in their upper parts to create substantial areas of tidal flats. These are predominantly sandy, with mudflats forming only in the more sheltered areas such as in the Inner Clyde Estuary. Several of the sites in this region, notably the Clyde and Ruel Estuaries and Traigh Cill-a-Rubha, remain predominantly inundated at low tide. The only substantial areas of intertidal sediments are in the Inner Clyde Estuary (over 1,800 ha) and Loch Gruinart (almost 900 ha).

Tidal ranges in the region are small compared with in estuaries further south on the West Coast. All but one of the estuaries are mesotidal (2-4 m spring tidal range), the largest tidal ranges being 3.2 m in the Garnock Estuary and 3.7 m in Loch Crinan, the region's most northerly estuary. Traigh Cill-a-Rubha is the only microtidal estuary in the region, with a spring tidal range of only 1.5 m.

Several of the estuaries have considerable geomorphological, wildlife and nature conservation importance, notably the Clyde Estuary and the two estuarine inlets on Islay (Traigh Cill-a-Rubha and Loch Gruinart). These are of international importance for migrant and wintering waterfowl and this is reflected in national and international conservation designations on part or all of these estuaries (see also section 5.12 and Chapter 7).

In the south of the region the small, muddy Garnock Estuary is the common estuary of the Garnock and Irvine rivers. The estuary discharges through a narrow channel and despite a long history of pollution from surrounding industry has retained wildlife interest, notably for its saltmarshes, used by nationally important populations of waterfowl.

Further north, Hunterston Sands is the largest remaining area of intertidal flats in the outer Firth of Clyde; the substrate comprises a mixture of chiefly sand with some areas of shingle and muddier habitat. The Inner Clyde Estuary is the largest of the region's estuaries, forming the inner part of the fjordic Firth of Clyde. Downstream of Glasgow the estuary broadens and the river channel has fringing mudflats and saltmarshes, much of which, despite the extensive land-claim in the estuary, retains natural upper transitions to freshwater wetland and grassland. The estuary also supports large numbers of wintering waterfowl, notably redshank *Tringa totanus*, although numbers have declined in recent years.

Two sea-lochs, the Ruel Estuary at the head of Loch Riddon and Loch Gilp to the north-west of the Clyde, have become secondarily filled with sediments; the outer parts of the lochs have narrower, rocky shores. The Ruel Estuary has saltmarsh transitions to the surrounding oak, ash and alder woodland, a situation scarce in Britain. The head of Loch Gilp has an area of fine intertidal sands. Loch Crinan, the small, shallow estuary of the River Add at the western end of the Crinan Canal, is predominantly muddy with substantial areas of saltmarsh in the upper estuary. These saltmarshes include one of the very few examples in Britain of saltmarsh transition to raised bog.

Two inlets on Islay have large areas of mud and sand flats with small river inflows. These are Traigh Cill-a-Rubha at the head off Loch Indaal and Loch Gruinart on the north coast. As well as sandflats, Loch Gruinart has areas of shingle, some vegetated, and at its head one on the largest areas of saltmarsh in western Scotland. At the mouth of the estuary are the sand dunes of Killinallan Point. Both these inlets are of major importance as part of the network of habitats used by internationally important goose populations, notably a very large proportion of the Greenland population of barnacle geese *Branta leucopsis*, as well as Greenland white-fronted geese *Anser albifrons flavirostris* in Loch Gruinart.

4.1.3 Human activities

The estuaries in the south of the region (Garnock Estuary, Hunterston Sands and Clyde Estuary) are heavily industrialised, although some urban and industrial restoration is now taking place on the estuary shores. Substantial parts of the intertidal area of these estuaries have been land-claimed or other wise modified, e.g. through canalisation of upper reaches and construction of docks and jetties. The Garnock has industrial areas around its mouth, and much of the southern part of Hunterston Sands has been developed for a terminal, oil rig construction site (no

longer used) and for power stations. The Inner Clyde Estuary is the most extensively developed and industrialised estuary in the region and has a long history of industrial and port-related developments, initially in the inner part of the estuary associated with the expanding city of Glasgow. The Clyde has large ports further downstream at Greenock, manufacturing industry in several areas, shipbuilding yards and oil terminals.

Estuaries further north remain some of the most natural in the UK. In these there is only limited exploitation of natural resources or recreational use. Urbanisation is limited to small towns and villages and ports and industries to small harbours and boat repair yards, e.g. at Ardrishaig (Loch Gilp) and Bowmore (Traigh Cill-a-Rubha), with a distillery at Bowmore.

Land-claim has mainly affected the urban estuaries. About 37% of Hunterston Sands has been lost to land-claim for industrial developments since 1970. There has been extensive canalisation and land claim in the inner Clyde Estuary and at various localities in the outer estuary, associated with docks and industry.

Estuarine water quality is higher in the rural northern estuaries than in the more industrialised southern estuaries, especially the inner reaches of the Clyde Estuary. There have been recent improvements to the water quality of the formerly highly polluted Garnock Estuary. Improvements to sewage treatment in the Clyde Estuary over the last 20 years have improved water quality there, but reduced enrichment is thought to have led to decreases in wintering waterfowl populations through reduced food supply (Furness *et al*. 1986). In the region 55% of estuarine waters have recently been classified as Class A (good quality) and only 17% are classed as poor or bad quality (SEPA pers. comm.) (see also section 9.6).

Recreational use of the region's estuaries is generally not extensive, in most being informal leisure use (walking, horse riding, bird watching etc.) and some sailing and wind-surfing. A wide range of leisure pursuits take place on the Clyde, especially in the outer parts of the northern shore, at peak times involving substantial areas of the estuary. Exploitation of natural resources is not intensive and is largely restricted to grazing of saltmarshes and angling. The cultivation of shellfish and other species in the region's estuaries is outlined in section 9.2. Bait-digging and wildfowling take place at generally low intensity in parts of the Garnock and Clyde Estuaries, Loch Gilp and Loch Crinan.

4.1.4 Information sources used

This section is summarised chiefly from JNCC's *An inventory of UK estuaries*, being published in six regional volumes along with an introductory and methods volume. Estuaries in Region 14 are included in *Volume 3. North-west Britain* (Buck 1993). Data presented in the inventory are drawn largely from material collected during 1989-90 (updated to 1994 where appropriate) for the NCC's Estuaries Review (Davidson *et al*. 1991). Saltmarsh data come originally from Burd (1989a, b), whose surveys covered mostly saltmarshes of >0.5 ha.

Hydrological data, e.g. catchment areas and river flows, are available for some but not all estuaries as defined here. Catchment areas and river flows are summarised in a five-year catalogue of river flow gauging stations (Marsh & Lees 1993), but note that for whole estuary data further interpretation is usually necessary.

4.1.5 Acknowledgements

Thanks are due to Dr Pat Doody and John Barne (JNCC), Andrew Haig (SEPA) and the Director of Planning, City of Glasgow, for helpful comments on draft texts.

4.1.6 Further sources of information

A. References cited

Buck, A.L. 1993. *An inventory of UK estuaries. 3. North-west Britain.* Peterborough, Joint Nature Conservation Committee.

Burd, F. 1989a. *The saltmarsh survey of Great Britain.* Peterborough, Nature Conservancy Council. (Research & survey in nature conservation, No. 17.)

Burd, F. 1989b. *Saltmarsh survey of Great Britain. Regional Supplement No. 12. South-west Scotland.* Peterborough, Nature Conservancy Council.

Davidson, N.C., & Buck, A.L. In prep. *An inventory of UK estuaries. 1. Introduction and methods.* Peterborough, Joint Nature Conservation Committee.

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.M., & Duff, K.L. 1991. *Nature conservation and estuaries in Great Britain.* Peterborough, Nature Conservancy Council.

Furness, R.W., Galbraith, H., Gibson, I.P., & Metcalfe, N.B. 1986. Recent changes in numbers of waders on the Clyde Estuary, and their significance for conservation. *Proceedings of the Royal Society of Edinburgh, 90B:* 171-184.

Marsh, T.J., & Lees, M.L., *eds.* 1993. *Hydrometric register and statistics 1986-90.* Wallingford, Institute of Hydrology.

Table 4.1.3 Human influences on Region 14 estuaries

Estuary	*Centre grid ref.*	*Human use type:* *urban*	*industrial*	*rural**	*recreational*
47. Garnock Estuary	NS3039	●	●	○	○
48. Hunterston Sands	NS1953	○	●	○	○
49. Inner Clyde Estuary	NS3675	●	●	○	○
50. Ruel Estuary (Loch Riddon)	NS0079			●	○
51. Loch Gilp	NS8687			●	○
52. Traigh Cill-a-Rubha (Bridgend Flats)	NS3362	○	○	●	○
53. Loch Gruinart	NR2971			●	○
54. Loch Crinan	NR7993			●	○

Source: Buck (1993). Key: *includes natural resource exploitation; ● = major human use; ○ = minor human use.

B. Further reading

Further details of estuaries are in the *Coastal & marine UKDMAP datasets* module (Barne *et al.* 1994), available from JNCC Coastal Directories Team, Peterborough. A list of selected further reading for each estuary discussed is given in Buck (1993) (above).

Barne, J., Davidson, N.C., Hill, T.O., & Jones, M. 1994. *Coastal and marine UKDMAP datasets: a user manual.* Peterborough, Joint Nature Conservation Committee.

British Oceanographic Data Centre. 1992. *United Kingdom Digital Marine Atlas. User Guide. Version 2.0.* Birkenhead, Natural Environment Research Council, British Oceanographic Data Centre.

Davidson, N.C. 1991. *Estuaries, wildlife and man.* Peterborough, Nature Conservancy Council.

Noble, L., *ed.* 1995. *Estuaries and coastal waters of the British Isles. An annual bibliography of recent scientific papers. No. 19.* Plymouth, Plymouth Marine Laboratory and Marine Biological Association.

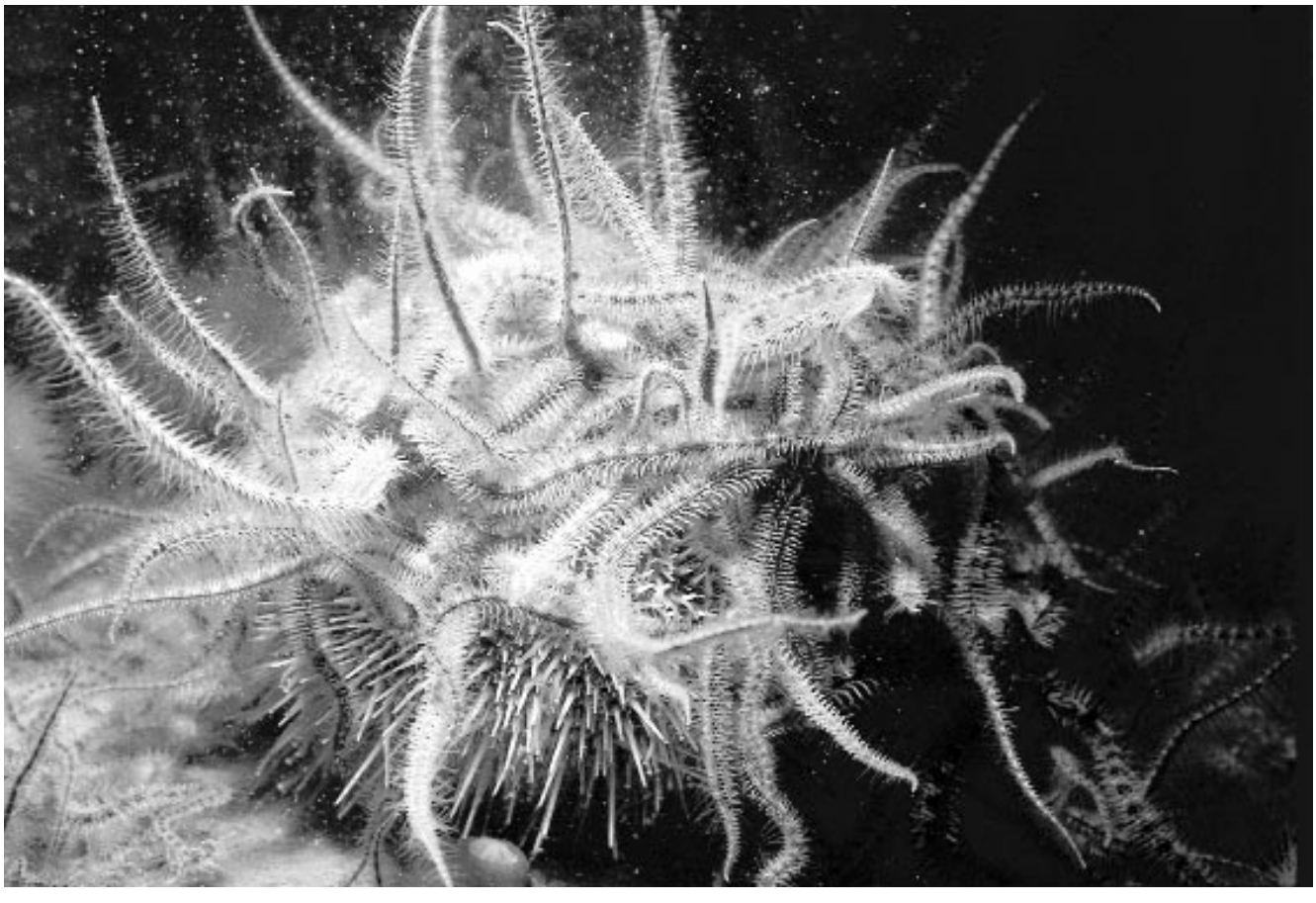
Peck, K. 1993. Estuaries Inventory - research towards a better understanding of the interactions between birds and human activities on UK estuaries. *RSPB Conservation Review, 7:* 42-46.

Scottish Office Environment Department. 1992. *Water quality survey of Scotland 1990.* Edinburgh, HMSO.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Integrated Coastal Database: national database of estuaries; coastal habitats; statutory & non-statutory protected sites	*Marine & Coastal Data Custodian, JNCC, Peterborough, tel: 01733 62626
Statutory protected sites; detailed wildlife site information; coastal geomorphology. Estuaries Initiative & estuary management plans. Numerical and some digitised data.	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
RSPB Estuaries Inventory: mapped and numerical information on land use and selected human activities for 57 major UK estuaries. In Region 14 the Inventory covers the Clyde Estuary.	*Research Data Manager, RSPB, Sandy, tel: 01767 680551
National River Flow Archive: catchments and river flows from upstream gauging stations; interpreted analyses for whole estuaries.	National Water Archive Manager, Institute of Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB, tel: 01491 838800

*Starred contact addresses are given in full in the Appendix.



The Cumbraes are a Marine Consultation Area on account of the richness and importance of their marine wildlife; amongst other species groups in the sublittoral zone are large populations of brittlestars. Pictured is a group of the species *Ophiothrix fragilis,* surmounting a sea urchin *Echinus esculentus.* Photo: Bill Sanderson, JNCC.

4.2 The sea bed

R.A. Irving

4.2.1 Introduction

This section covers the occurrence and distribution of sea-bed habitats and groups of species that live on the sea bed (benthic communities, collectively called the benthos), both in the intertidal zone and subtidally; the distribution and occurrence of individually rare and scarce species is covered in section 5.4. Information on the precise extent of shore and sea-bed types in a national context is not yet available.

The shores and near-shore areas within this region are extremely varied, reflecting a wide range of geology, wave and current exposure, salinity and turbidity. Numerous islands, rocks and headlands shelter some shores, while themselves being exposed to the open sea. The mainland coast is dissected by a series of sea lochs, which in general are oriented on a south-west/north-east axis. Many of these are situated in remote locations far from sources of possible pollution. The benthic communities present in these lochs are also diverse.

A number of wrecks (ships, aircraft and other solid material) occur off the coast of this region (see also section 6.1). These objects offer hard substrata in areas that may be largely sedimentary, thus providing discrete new habitats for opportunistic colonising species that otherwise would not be present.

There are eight Marine Consultation Areas (MCAs) in the region (see also section 7.4). This is a non-statutory designation of areas identified by Scottish Natural Heritage (and prior to 1991 by the Nature Conservancy Council (NCC 1990b)) as being of particular importance on account of the quality and sensitivity of the marine environment within them (see also section 7.4.3).

Map 4.2.1 Locations of marine biological interest described in the text. Numbered sites are listed in Table 4.2.1.

Table 4.2.1 Locations of marine interest mentioned in the text

No. on Map 4.2.1	*Location*	*Grid ref.*	*No. on Map 4.2.1*	*Location*	*Grid ref.*
1	Turnberry Light	NS1907	25	Toberonochy, Luing	NM7508
2	Heads of Ayr	NS2918	26	Degnish Point, Loch Melfort	NM7712
3	Seamill, West Kilbride	NS1947	27	Loch Feochan (upper section & head)	NM8624
4	Kames Bay (within Millport Bay), Great Cumbrae	NS1755	28	Bonawe, Loch Etive	NN0133
5	Ballochmartin Bay, Great Cumbrae	NS1856	29	Falls of Lora, Loch Etive	NM9134
6	Lamlash Bay, Arran	NS0430	30	Loch Creran	NM9543
7	South coast of Arran	NR9820	31	Port Appin, Loch Linnhe	NM9046
8	Lochranza, Arran	NR9350	32	Sound of Shuna, Loch Linnhe	NM9249
9	Lamont Shelf, Loch Fyne	NR9764	33	Clachan Sound, Seil	NM7820
10	Lamont Shelf, Loch Fyne	NS0064	34	Fraoch Eilean, Luing	NM7311
11	Ardlamont Point, West Kyle of Bute	NR9964	35	Sound of Luing	NM7209
12	East Kyle of Bute	NS0473	36	Rubh' Aird Luing, Luing	NM7405
13	Oitir Narrows, Loch Fyne	NR9185	37	Gulf of Corryvreckan, Jura	NM7002
14	Loch Shira, off Loch Fyne	NN1109	38	Loch Tarbert, Jura	NR5682
15	Head waters of Loch Fyne	NN1610	39	Loch an t-Sailein, Islay	NR4246
16	Loch Gilp, off Loch Fyne	NR8686	40	Mull of Oa, Islay	NR2742
17	East Loch Tarbert, Loch Fyne	NR8869	41	Loch Indaal, Islay	NR2963
18	Carradale Point, Kintyre	NR8136	42	Sound of Islay	NR4369
19	West Loch Tarbert, Kintyre	NR8467	43	Calve Island, Mull	NM5355
20	Loch Sween (centre)	NR7383	44	Sound of Iona, Mull	NM2924
21	Linne Mhuirich rapids, Loch Sween	NR7282	45	Head of Loch Scridain, Mull	NM5228
22	Loch na Cille, Loch Sween	NR6980	46	Clachandu, Loch na Keal, Mull	NM4535
23	Ardnoe Point, Loch Crinan	NR7794	47	Loch Tuath, Mull	NM4243
24	Loch Craignish	NR7798	48	Calgary Bay, Mull	NM3551

4.2.2 Important locations and communities

Table 4.2.1 shows the locations of marine interest mentioned in the text (Map 4.2.1).

The Clyde Sea area: Ballantrae to the Mull of Kintyre

The Clyde Sea, defined as the area enclosed by a line drawn from the Rhinns of Galloway to the Mull of Kintyre, encompasses a wide variety of habitats, ranging from the estuarine mudflats of the Clyde Estuary upstream of Greenock to the deep fjordic sea lochs such as Loch Fyne, and the open coast of the Mull of Kintyre. Much of the area is sheltered from wave action and some areas are very sheltered. The area generally lacks the very strong currents found on the coast further north, but strong tidal streams run in the Kyles of Bute and in the two stretches of narrows of Loch Fyne. There appears to be a biogeographic separation of the area both from the Irish Sea to the south and from the coast to the north, which may be linked to a salinity barrier (Connor & Little in prep. a) and to a bathymetric sill marking the edge of the 'Great Plateau' (see also section 2.3.6). Found in this area are the spiny spider crab *Lithodes maia* and the large anemone *Bolocera tuediae* (Davies 1989), both of which are cold-water species more commonly recorded around Shetland and in the North Sea, but quite rare on Scotland's west coast. There are fewer red algae but more brown algae than would be expected for this part of the British Isles, and a number of conspicuous and generally widespread red algae are apparently absent (Maggs 1986).

Within this part of the region there is a mix of rock and sediment shores which range from moderately exposed (in the outer Firth of Clyde) to sheltered (within the sea lochs). Most common are the sheltered bedrock and boulder shores, which Paisley College of Technology (1979) divided into four main types: i) open-coast, flat boulder and broken bedrock shores, with a dense kelp *Laminaria* spp. zone and often the greatest variety of habitat types; ii) open-coast, steep or smooth rocky shores, with a less diverse biota than the more broken rocky shores; iii) sea loch boulder shores, common throughout the lochs and dominated by a dense band of knotted wrack *Ascophyllum nodosum*; and iv) sea loch rocky shores, with a distinct zonation pattern.

An irregular rocky shore occurs at Turnberry Light, to the north of Turnberry itself, with numerous platforms, channels and pools at all levels on the shore, providing a variety of habitats. There is both a high cover of algae and a rich fauna present, particularly under boulders within rockpools, featuring various anemones, scale worms, crabs, starfish and brittlestars. Further north along this coast, flat rocky platforms backed by a thin strip of sand occur beneath the Heads of Ayr cliffs. Small amounts of eelgrass *Zostera* spp. were recorded in the rockpools here in 1978, though the shore at that time was thought to be affected by a nearby sewage outfall. The shore at Seamill, West Kilbride, has exposures of Old Red Sandstone, forming a number of rockpools and crevices, with a scattering of boulders. Both the flora and fauna on the shore here are relatively rich (Paisley College of Technology 1979).

On the island of Great Cumbrae, the marine biological interest of Kames Bay SSSI (within Millport Bay) made it a classic study site for early shore studies. Ballochmartin Bay on the east coast is important for its sedimentary habitats, with populations of the burrowing anemone *Cerianthus lloydi* and phoronid worms, both rarely found intertidally (Davies *et al*. 1990). In the sublittoral zone around the Cumbraes there are large populations of brittlestars, the most widely distributed of which is *Ophiocomina nigra*. The Cumbraes are a Marine Consultation Area (NCC 1990b).

To the north of Largs, Old Red Sandstone forms a series of ridges on the shore at Red Rocks. The fucoid algae were reported to be in a poor condition here in 1978, with limpets, barnacles, winkles and whelks dominating the fauna (Paisley College of Technology 1979). The richest sedimentary shores of this area occur in the more sheltered parts of the Firth of Clyde, in Lochs Fyne, Riddon, Striven and the Gare Loch. The infauna at most sites is dominated by bivalves (e.g. thin tellin *Angulus tenuis* and cockle *Cerastoderma edule*), amphipods (*Bathyporeia* spp.) and polychaete worms (e.g. *Scoloplos armiger*, *Nephtys hombergi* and lugworm *Arenicola marina*) (Paisley College of Technology 1979).

The large mud and sand flats of the lower Clyde Estuary are dominated by the amphipod *Corophium volutator*, the mud snail *Hydrobia ulvae*, mussels *Mytilus edulis* and king ragworm *Hediste diversicolor*. The broken rocky shores of the lower estuary support fucoids and associated red algae (Wilkinson 1973), while the shores of the upper estuary (upstream of West Ferry) lack red algae and are characterised by blue-green algae and high densities of the diatom *Melosira nummuloides*.

Both littoral and sublittoral communities in the turbid waters of the Gare Loch, Loch Long, Loch Goil and Holy Loch, particularly the Gare Loch and Holy Loch, are impoverished (Holt & Davies 1991). Algal diversity below low water mark is low, possible because of high grazing pressure by echinoderms (especially the urchin *Psammechinus miliaris*) and chitons, although there are abundant coralline algal crusts. At depths beyond the algal-dominated zone, several sites feature steeply-sloping and vertical bedrock with a characteristic community dominated by the anemone *Protanthea simplex*, the brachiopod *Neocrania anomala*, the ascidian *Ciona intestinalis* and the fan worm *Sabella pavonina*. Two benthic communities present on deep muddy ground in Loch Goil are nationally important, one supporting a dense population of the rare sea cucumber *Oncus planci* and the other a rich ascidian fauna, featuring the rare *Styela gelatinosa*, unknown elsewhere in the British Isles (see section 5.4).

Of note in the sublittoral of Loch Striven and Loch Riddon are the dense populations of burrowing holothurians, mainly *Psolus phantapus* and *Trachythyone elongata* (Holt & Davies 1991). The estuarine fauna at the head of Loch Riddon is dominated by small mud snails *Hydrobia ulvae*, king ragworm *Hediste diversicolor* and the amphipod *Corophium volutator*; the middle reaches are dominated by burrowing bivalves, and the coarser sands of the lower part by mussels (McLusky & Hunter 1985). There are shallow, tideswept narrows at the entrance to the loch and also within the east Kyle of Bute, where the sea bed is of tideswept pebbles with beds of maerl *Lithothamnion glaciale*, an unusual nodule-forming calcareous alga. Off Ardlamont Point at the southern tip of the west Kyle of Bute, a bank of dead maerl gravel was reported by Davies (1989).

At 70 km, Loch Fyne is the longest of all the Scottish sea lochs and, with a maximum charted depth of 200 m, the deepest (Edwards & Sharples 1986). In general, both the intertidal (littoral) and sublittoral habitat diversity in Loch

Fyne is relatively low (Davies 1989). However, at the head of the loch one of the densest populations in the British Isles of the large burrowing anemone *Pachycerianthus multiplicatus* has been recorded, together with large numbers of the burrowing echiuran *Maxmuelleria lankesteri*. Deep bedrock here features a community characterised by the anemone *Protanthea simplex* and the brachiopod *Neocrania anomala*. The upper loch, from a line between Dalchenna Point and Creag a' Phuill to the head, is a Marine Consultation Area (NCC 1990b).

In the middle reaches of Loch Fyne, where tidal currents are accelerated at the central Oitir Narrows, the sediments are pebbles and gravel and support a rich community (Davies 1989). Brittlestar beds cover most of the surface, though there is also a large (>1 sq km) bed of the gaping file shell *Limaria hians*. At the head of Loch Gilp the estuarine shore sediments support a fauna composed principally of polychaetes and oligochaetes (McLusky 1986), although there are also extensive areas of eelgrass *Zostera marina*, which is also present as scattered plants in Loch Shira. In the outer reaches of Loch Fyne, the sandier sediment on the Lamont Shelf holds a bed of the thalassinidean shrimp *Callianassa subterranea* and the echiuran *Amalosoma eddystonense*, the latter species being rarely recorded elsewhere in the country (Howson & Davies 1991). Reefs of boulders and bedrock occur at depths of 56-75 m in all parts of the loch, with nationally important numbers of the cold water anemone *Bolocera tuediae* (Howson & Davies 1991).

There is little information available on the marine biological interest of the Isle of Arran and Kilbrannan Sound. The richest areas in terms of habitat diversity and species abundance, particularly for molluscs, are thought to be Loch Ranza, Lamlash Bay and the southern shores of Arran (Smith 1984a). At Carradale Point on the east coast of Kintyre the mudstone shore was described by Paisley College of Technology (1979) as having an exceptional variety of habitats with an associated rich flora and fauna. Eelgrass *Z. marina* was recorded in some intertidal pools and also as dense beds in the shallows. There is a large bed of the file shell *Limaria hians* off the south-east Kintyre coast (Deegan *et al*. 1973).

Sound of Jura: Mull of Kintyre to Loch Craignish (including Islay, Jura & Colonsay)

With its highly dissected coast and offshore islands, this section of the coast experiences a wide range of physical conditions, which in turn lead to a high diversity of habitats. The west-facing coasts of the offshore islands are fully exposed to the force of the Atlantic, while the sea lochs of the mainland are protected from the prevailing winds and are for the most part sheltered from wave action (Connor & Little in prep. b). During the summer months a distinct frontal system, known as the Islay front, lies between Islay and Malin Head in Co. Donegal, Republic of Ireland (see also section 4.3.1). This may be important in the biogeographical distribution of species within this region (Connor & Little in prep. b).

Little marine biological information has been recorded from the shores of this section of the coast, with most work concentrated in the sea lochs. West Loch Tarbert, which divides the Kintyre peninsula from Knapdale, is a very sheltered loch with soft mud sediment featuring beds of the sea pen *Virgularia mirabilis* and the gastropod *Philine aperta*. Dwarf eelgrass *Z. noltii*, a species far more common on the east coast of Scotland, occurs on the mud flats near the head of the loch (Howson *et al*. 1994). A little further north, strong tidal streams occur at the entrance to Loch Caolisport, where relatively coarse sublittoral sediments are present, with burrowing species such as the heart urchin *Echinocardium cordatum* and the sea cucumber *Neopentadactyla mixta* (Howson 1990).

Of all the sea lochs in this area Loch Sween is by far the most thoroughly studied (Connor & Little in prep. b). The rocky shores of the loch are considered to be of national or even international importance for their unusually clear zonation patterns, particularly well shown on the steep rocky slopes of Loch na Cille (Harvey *et al*. 1980). The shores are notable for the abundance of the barnacle *Chthamalus montagui*, which is considered more typical of exposed coasts, and for the development of a turf of the filamentous algae '*Trailliella*' and '*Falkenbergia*' (phases of *Bonnemaisonia hamifera* and *Asparagopsis armata* respectively). The very rich sponge-dominated communities at the Linne Mhuirich rapids are nationally important, as are the adjacent populations of maerl and a loose-lying growth of the calcareous alga *Corallina officinalis*.

In the sublittoral, Loch Sween has a range of habitats and communities typical of a sheltered sea loch (Earll 1984; Lumb 1986; Lumb & Hiscock 1990). There are several beds of eelgrass *Z. marina* in the upper parts of the loch, while coarser sediments at the mouth of the loch support populations of the heart urchin *Echinocardium cordatum*. Brackish areas have stands of tasselweeds *Ruppia* spp. and the lagoon cockle *Cerastoderma glaucum*. The loch also supports rich megafaunal burrowing communities (Atkinson 1989). The loch, together with the open coast north to Ardnoe Point by Loch Crinan, is a Marine Consultation Area (NCC 1990b).

Strong tidal streams at the entrance to Lochs Crinan and Craignish increase the diversity of the sublittoral communities. On moderately exposed rock below the algal-dominated zone at Ardnoe Point a species-rich community is characterised by large numbers of the sea fan *Swiftia pallida*, the ascidian *Diazona violacea* and the sponges *Axinella infundibuliformis* and *Mycale lingua*. The Mediterranean cup coral *Caryophyllia inornata*, rare in British waters, reaches its most northerly known limit here (Howson 1990). Particularly good examples of tide-swept bedrock with forests of the kelp *Laminaria hyperborea* are found in Loch Craignish. The community includes several rare species, such as the brown alga *Desmerestia dresnayi* and the red alga *Callophyllis cristata*, and also features the featherstar *Leptometra celtica*. Aggregations of the sea cucumber *Oncus planci* occur on muddy sediment in the inner basin of Loch Craignish (Gubbay & Loretto 1991).

A relatively low total of 93 species of mollusc occur on the shores of Islay and Jura, reflecting the lack of variety of microhabitats in the more sheltered shores of the islands (Smith 1982). Loch Tarbert is likely to have the most interesting shoreline on Jura; on Islay the extensive rocky platforms of the north coast and the mixed sheltered shore at Loch an t-Sailein on the south-east coast, with its population of the lagoon cockle *Cerastoderma glaucum*, are of interest. The shores of Islay's west coast have a surprisingly diverse fauna and flora for such an exposed area (Smith 1982), and the brown alga *Fucus distichus anceps* probably reaches its southern limit here. Rich sublittoral algal

communities associated with eelgrass *Z. marina* occur in Loch Indaal (Hiscock 1983), the reason for the loch's status as a Marine Conservation Area (NCC 1990b). In general, the sublittoral algal communities around Islay and Jura are rich, but the numbers of attached animal species are kept low by intense grazing pressure from sea urchins *Echinus esculentus* and widespread cover by the barnacle *Balanus crenatus* (Hiscock 1983). The central section of the Sound of Islay features bedrock, maerl (mostly dead), sand and tide-swept pebbles, the latter being richly colonised by hydroids and bryozoans, of which several species have not been found elsewhere on Jura or Islay (Hiscock 1983). Little information is available for either the shores or the sublittoral zones of Colonsay, although Powell *et al*. (1977) did not consider the shores to be of particular marine biological interest.

Firth of Lorn & Loch Linnhe: Loch Craignish to Rubha an Ridire

The area around the Firth of Lorn, containing the islands of Scarba, Luing, Seil, the Garvellachs and Kerrera, has a complex hydrography and a high diversity of habitats and supports some of the richest and most varied marine life in western Scotland (Connor & Little in prep. b). The Firth of Lorn Marine Consultation Area stretches from the Gulf of Corryvreckan to Loch Feochan and reflects the marine biological importance of the area (NCC 1990b).

The narrow sound between Scarba and Jura, known as the Gulf of Corryvreckan, experiences the strongest tidal currents of anywhere on the open coast of Britain, reaching 4 m/s or more. Species which normally thrive in current-swept areas, such as the soft coral *Alcyonium digitatum*, are here confined to relatively sheltered places on a pinnacle that rises to within 27 m of the surface in the middle of the sound. Large boulders and bedrock gullies are dominated by dense turfs of the hydroid *Tubularia indivisa*, the bushy bryozoan *Securiflustra securifrons* and the hydroid *Sertularia cupressina*, together with extensive cover of the barnacles *Balanus crenatus* and *B. hameri* (Hiscock 1983). Strong currents greatly influence the sublittoral communities present on steep rock faces, deep channels and coarse sediments around Scarba (Picton *et al*. 1982), with the high diversity of hydroid species being of note.

Loch Melfort is the deepest and most sheltered of the group of sea lochs along this stretch of coast (Howson *et al*. 1994), its entrance being protected by a sill and by the islands of Seil and Luing. Sheltered sublittoral bedrock is colonised by the anemone *Protanthea simplex* and the brachiopod *Neocrania anomala* (Howson 1990). The brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra* dominate outcrops of barren rock and are commonly found throughout the loch. An important feature is the distinct band of the rare green alga *Codium adhaerens* at Degnish Point (Powell *et al*. 1977).

Strong tidal currents pass through Clachan Sound between the mainland and Seil Island, leading to a rich and diverse range of communities (Powell *et al*. 1977). Some algae exhibit unusual growth forms in the strong currents, for example the sugar kelp *Laminaria saccharina* grows to up to 4 m in length and shows unusual breadth; and thongweed *Himanthalia elongata* also grows to a considerable length. The shores at Toberonochy, Rubh' Aird Luing and Eilean Fraoch on Luing are thought to be the richest of those surveyed on Luing and the Garvellachs (Smith 1984b). The high species diversity was attributed to the large number of rock crevices and the high water movement in the area. Several species normally confined to below low water mark are found on these shores, including the clam *Pallioloum striatum*, the file shell *Limaria hians* and the brachiopod *Neocrania anomala*. A wide range of sublittoral communities are also present amongst the islands, including a number of rare algae (Picton *et al*. 1982). Rocky areas are particularly rich in red algae, hydroids and bryozoans and are often characterised by the presence of the cup sponge *Axinella infundibuliformis* and the sea fan *Swiftia pallida*. The range of communities reflects the variation in habitat, from wave-exposed to very sheltered conditions, with a wide variety of tidal velocities.

Further north, in Loch Feochan, Howson (1990) reported a small sublittoral cliff in the upper loch, dominated by sponges and ascidians, which supported a diverse community including large numbers of the anemones *Edwardsiella carnea* and *Epizoanthus couchii*, a biotope not found elsewhere in the MNCR sea loch surveys (Howson *et al*. 1994). At the head of the loch there is an extensive bed of the unusual free-living brown alga *Ascophyllum nodosum* in its environmentally-modified form *mackaii*; this is thought to be one of the largest beds of this species in the world (Powell *et al*. 1977).

The loch complex that makes up Loch Linnhe is the largest in western Scotland and at nearly 70 km from the head of Loch Eil to the tip of Lismore it is the second longest sea loch. The rocky sublittoral habitats support a greater variety of hydroids and bryozoans than is typical for sea lochs, reflecting the area's proximity to the rich hydroid and bryozoan turf communities of the Firth of Lorn (Connor 1990b). Muddy sublittoral gravels in lower Loch Linnhe support high densities of file shell *Limaria hians*. Although this species is widely distributed, dense beds are relatively restricted in their distribution.

Loch Etive receives an unusually large input of fresh water and has a salinity regime unlike that of any other Scottish sea loch (Holt 1991). The shallow entrance sill at the Falls of Lora, across which there is a spectacularly strong water flow, restricts the rate of seawater exchange with the deeper inner basins. Thus the loch's communities have a marked brackish character, the main justification for the loch's Marine Consultation Area status. The rocky shores of Loch Etive are considered by some to be nationally important because of the wide range of salinity conditions, reflected in a diverse fauna and flora (Harvey *et al*. (1980). Howson *et al*. (1994), however, describe the shores as being impoverished, with a very compressed zonation, although they noted the extensive beds of the brackish-water brown alga *Fucus ceranoides* near Bonawe. In the sublittoral zone, the shallow sediments contain brackish-water species such as Baltic tellin *Macoma balthica*, the mud snail *Hydrobia ulvae* and the amphipod *Corophium volutator,* while deeper sediment areas are characterised by sea pens *Funiculina quadrangularis* and brittlestars *Amphiura* spp. Several of the biotopes described by Holt (1991) are unique to the loch, for instance the 'very sheltered impoverished sublittoral boulders in low salinity with ascidians'. In Loch Etive there are extensive populations of several species, such as the sponge *Mycale lobata* and the hydroid *Eudendrium arbusculum*, that are far less common in other sea lochs.

Loch Creran to the north is also a Marine Consultation Area, largely on account of its well-developed reefs of the

calcareous tubeworm *Serpula vermicularis*, a species that usually occurs only as isolated individuals (Connor 1990b). The *Serpula* clumps have a rich associated fauna of ascidians and hydroids. Elsewhere in the loch are beds of horse mussels *Modiolus modiolus* and, in shallow areas, beds of eelgrass *Z. marina*. The loch has rich sediment shores, whilst coarse sublittoral sediments in the entrance channel have high numbers of the rare anemone *Edwardsia timida* (Connor 1990b).

Mull, Tiree & Coll (including the Sound of Mull)

Shores on the east coast of Mull have a smaller variety of habitats (and therefore species) than those on the north-west coast (Smith & Gault 1983). Spectacular cliffs are found in the sublittoral zone of the Sound of Mull, particularly off Calve Island, where there are high densities of sponges, hydroids, anthozoans and erect bryozoans (Bishop 1984). The Sound of Iona was selected as an Marine Consultation Area because of the extensive beds of maerl throughout the channel. The richest intertidal site identified by Smith & Gault (1983) was at Rubhya Baile na-h-Airde, to the south-west of Loch na Keal, where boulders on gravel and sloping slabs of limestone with pools provide a great variety of microhabitats. These also occur at the head of Loch Scridain. The shore at Clachandu, immediately to the north, is thought to be of national marine biological importance (Powell *et al*. 1977). It consists of an area of shallow pools, shingle flats and boulders, where the brown alga *Cystoseira nodicaulis* and the crab *Xantho incisus* are close to their northern limits. In the sublittoral, spectacular cliffs are found in Loch na Keal, on which Davies (1990) reported an unusual community featuring the sea fan *Swiftia pallida* (normally associated with moderately exposed sites) and the anemone *Protanthea simplex* (normally confined to very sheltered sites). The shore at Torr an Ard in Loch Tuath is of considerable interest, with basalt cliffs, rock platforms, boulder slopes and gullies providing a wide range of habitats (Smith & Gault 1983). Calgary Bay, further to the north, is of particular importance, with a rich variety of algae present on the rocky shore. Small, isolated populations of the purple sea urchin *Paracentrotus lividus*, near the northern edge of their range, occur around the islands (D. McKenzie pers. comm. 1996).

Coll's shores remain to be surveyed. Tiree's shores consist mainly of exposed clean sand beaches or irregular rocky shores, often subject to some sand-scour. The intertidal molluscan fauna from Tiree is generally poor, with only 70 species being recorded (Smith 1983). In the sublittoral zone of Tiree and the south coast of Col, the relatively exposed nature of the area restricted sedimentary habitats to coarser sands and gravels, in which the large cerianthid anemone *Arachnanthus sarsi* has been recorded for the first time in Britain (Dipper 1981). Additionally, extensive maerl beds occur in Hynish Bay and Gott Bay off Tiree's east coast, and a small bed of eelgrass *Z. marina* on a sandy plain at Eileann nan Gobhar between the two larger bays.

Offshore (defined as beyond 3 km or 50 m depth, excluding sea lochs)

Far less information is available on benthic habitats and communities from offshore locations than for near-shore and intertidal areas. Most deep-water communities within the Firth of Clyde match the 'brittlestar *Amphiura*', 'bivalve *Abra*' or 'boreal offshore' communities of Thorson (1957) and Jones (1950) cited in Pearson *et al.* (1986), while the shallower sediments are similar to the 'bivalve *Venus*/horse mussel *Modiolus*' or 'sand/gravel' communities. Sparse brittlestar populations (*Ophiothrix fragilis* and *Ophiocomina nigra*) were present on the Stanton grounds, and the erect bryozoan *Pentapora foliacea*, known from only a few outlying sites in western Scotland, occurs on the Blackstones Bank (Connor & Little in prep. b).

4.2.3 Human activities

The benthic fauna of Irvine Bay, an area receiving both industrial and urban effluents, has been regularly monitored by the Clyde River Purification Board (CRPB) since 1973 to study long-term pollution effects on benthic communities (e.g. CRPB 1976). Norton (1986) reviewed a number of algal studies within the Firth of Clyde and discussed a possible reduction in the flora resulting from industrial pollution. The Clyde Estuary has been subject to considerable pollution pressures from both industry and the sewage effluent from the dense human population of its shores (see also section 9.6). However, several long-term monitoring studies, such as Henderson (1980), have indicated an improvement in water quality, particularly during the 1970s and 1980s, and in 1983 salmon returned to the Clyde after an absence of 120 years (Mackay 1990). The Gare Loch, Loch Long, Loch Goil and Holy Loch in the Clyde are subject to the greatest environmental pressures of any sea lochs in Scotland, with nearby sources of pollution in the Clyde Estuary, large numbers of pleasure craft moorings and, until recently, a considerable number of naval installations. Sewage sludge has been disposed of for many years at the Garnock Head sewage disposal site off the southern tip of Bute, although the effects on the marine benthos have been a matter of dispute. This disposal is to be phased out in the near future (see also section 9.4). Other human activities that affect sea-bed habitats and communities in the region include fisheries, mariculture and the disposal of dredge spoil (see also sections 9.1, 9.2 and 9.4).

4.2.4 Information sources used

JNCC's Marine Nature Conservation Review (MNCR) team has surveyed all the sea lochs within this region as part of their programme of investigating Scotland's sea lochs, undertaken between 1988-1992. The MNCR team and their contractors use a standard recording methodology for both littoral and sublittoral surveys, which includes descriptions of both habitats and their associated communities (Connor & Hiscock 1996). Survey information from other sources varies considerably in its methodology and coverage. Table 4.2.2 shows the number of sites in the region with marine benthic habitat and species information held on the MNCR database, and Maps 4.2.2 and 4.2.3 show, respectively, littoral and near-shore sublittoral surveys recorded on the JNCC's MNCR database.

The shores of the Firth of Clyde were surveyed by Paisley College of Technology (1979), who examined 90 rock and sediment shores, both within the sea lochs and on the open coasts of the Firth. Other studies in this area include

Map 4.2.2 Littoral surveys recorded on the MNCR database. Source: JNCC.

Map 4.2.3 Near-shore sublittoral surveys recorded on the MNCR database. Source: JNCC.

Table 4.2.2 Number of sites with marine benthic habitat and species information held on the MNCR database

Littoral	*Near-shore sublittoral*	*Offshore*	*Total*
356	872	0	1,228

Source: MNCR Field Database 1994. Note: these figures are not comprehensive; additional records may exist in sources that were not consulted.

those carried out by the Marine Biological Station at Millport, Great Cumbrae, and those associated with the Hunterston power station (see Connor & Little in prep. a). The sea lochs adjoining the firth were investigated by an MNCR team in 1989 (Davies 1989; Holt & Davies 1991; Howson & Davies 1991). The water quality, habitats and conservation status of the Clyde Estuary have been summarised by Buck (1993).

The Dunstaffnage Marine Laboratory near Oban is the main centre for marine research on the Scottish west coast, with many ecological surveys of benthic sediment communities in open sea areas and sea lochs near to the laboratory. Based at the laboratory, the Scottish Marine Biological Association (now the Scottish Association for Marine Science), in conjunction with the Marine Biological Association in Plymouth, undertook a major survey of the shores of Great Britain for the Nature Conservancy Council (NCC) in the late 1970s (Bishop & Holme 1980; Harvey *et al*. 1980). Loch Sween has been studied extensively since the 1930s (see Lewis & Powell (1960), in particular), with much recent work contributing to NCC's proposal for Marine Nature Reserve status for the loch (NCC 1990b). The littoral biology of Loch Sween was summarised by Hiscock & Smith (1986), while Atkinson (1989) reported on studies of the burrowing megafaunal mud communities in the loch. Connor (1990a) has reviewed the conservation importance of Loch Sween's communities in detail. Other NCC surveys within this region have included an intertidal survey (Smith 1982) and a sublittoral survey (Hiscock 1983) of Jura and Islay. The south-east coast of Islay was surveyed by Easton & Pagett (1984) to assess the possible impact of fish-farm development. Price & Tittley (1978) described the intertidal and subtidal flora from many sites around Mull.

The Institute of Geological Sciences conducted a series of surveys with a manned submersible in certain offshore and deep-water trenches in western Scotland (Eden *et al*. 1971). Although primarily aimed at geological investigations of the sea bed, photographs taken during the surveys revealed biological details for many hard bottom areas for which access is generally not possible by SCUBA diving. Within this region, they surveyed sites in the Firth of Lorn and on the offshore Stanton and Blackstones Banks, respectively 180 km and 110 km west of Colonsay.

Studies of the marine benthos are carried out by oil companies in the course of hydrocarbon exploration, including in this region a block in the Sea of the Hebrides, north of Coll. These are not normally published in the public domain. Limited offshore habitat information is given on Admiralty charts and British Geological Survey maps.

4.2.5 Acknowledgements

The author acknowledges the help of JNCC's Marine Nature Conservation Review team (particularly Dr Tim Hill) in compiling and presenting the information given here. The MNCR literature reviews by David Connor and Mike Little (in prep. a & b) have been widely consulted.

4.2.6 Further sources of information

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B. Further reading

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Wood, E., *ed*. 1988. *Sea life of Britain and Ireland*. London, Immel, for Marine Conservation Society.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Marine nature conservation issues in Scotland	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Marine nature conservation issues in Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Marine nature conservation issues in the south of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
MNCR database	*MNCR Team, JNCC, Peterborough, tel: 01733 62626
Marine biological surveys of Scottish sea lochs	Christine Howson, Amisfield, Main Street, Ormiston, East Lothian EH35 5HS, tel: 01875 613256
Coastal water quality and surveys	*SEPA West Region HQ, East Kilbride, tel: 01355 238181
Marine biological research	University Marine Biological Station, Millport, Isle of Cumbrae KA28 0EG, tel: 01475 530581
Marine biological research	Scottish Association for Marine Science (formerly the Scottish Marine Biological Association), Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244
Littoral and sublittoral surveys, especially of marine algae	Sue Scott, Strome House, North Strome, Lochcarron, Highland IV54 8YJ

*Starred contact addresses are given in full in the Appendix.

4.3 Plankton

M. Edwards & A.W.G. John

4.3.1 Introduction

Plankton include the bacteria (bacterio-), plant (phyto-) and animal (zoo-) plankton. In temperate continental shelf seas, as in this region, the phytoplankton assemblage is dominated by diatoms and dinoflagellates, and the zooplankton, although containing representatives of most marine animal phyla at some stage, is dominated by crustaceans, principally copepods. The plankton's abundance is strongly influenced by factors such as depth, tidal mixing and temperature stratification, which determine the vertical stability of the water column. The distribution of species, here and elsewhere, is influenced directly by salinity, temperature and water flows into the area (see section 2.3), as well as by the presence of local benthic (bottom-dwelling) and littoral (shoreline) communities (see section 4.2). Many of the species of these communities, including commercially important fish and shellfish (see sections 5.5 and 5.7), have temporary planktonic larval forms (meroplankton). Tidal fronts (boundary zones between stratified and well-mixed water masses) in this region are likely to be of significant biological importance, since they are usually rich in plankton, which attracts other marine life. Phytoplankton blooms (transient, unsustainable growths, usually of a single species and often associated with a visible discoloration of the water) are a normal feature in the seasonal development of plankton. Some blooms may reach exceptional proportions (>10^6 cells/l) or contain species (principally dinoflagellates) that can be toxic to humans and possibly have an important economic impact on mariculture, fisheries and tourism.

In Region 14, as elsewhere, the plankton has a fundamental role in the food chain of both benthic (sea-bed) organisms (see sections 4.2, 5.4 and 5.5) and pelagic (water column) organisms, e.g. fish (see sections 5.7 - 5.9). For both ecosystems, the availability of food and nutrients, larval survival, maintaining populations and timing of egg production are highly dependent on the amount of phyto/zooplankton available. Any environmental stress imposed on the plankton will have consequences throughout the food chain and may affect the amount of food available to fish, birds, marine mammals etc. In coastal management, plankton can give early warnings of adverse human impacts (e.g. the effects of eutrophication) and highlight different water masses.

Waters in Region 14 range in depth from 20-100 m. Mean surface temperature and salinity vary quite considerably (depending on season) from 7-14 °C and from <30-34.75 g/kg respectively. Water from the Irish and Clyde Seas generally travels northwards to meet eastward-flowing Atlantic water immediately to the north of Ireland (Ellet 1979), and a 'front' - the Islay Front - may form between the two water masses, reflecting their contrasting densities and structures. Infra-red satellite photographs have indicated the possible presence of three other frontal boundaries within this region, at the entrance to the major firths and sounds (Map 4.3.1) (Gowen 1987). The timing of the spring bloom is earlier than in the northern North Sea, but overall abundance and duration of

Map 4.3.1 Plankton surveys and 'fronts'. See Table 4.3.2 for identification of symbols.

peak phytoplankton numbers is quite low compared with the central and southern North Sea. Levels of chlorophyll *a* are typically around 1-2 mg m^{-3}, except in sea lochs, where higher values are found, and at the Islay Front, where levels are >5.6 mg m^{-3} (Simpson *et al.* 1979). The abundance of copepods in this region is quite high compared with other

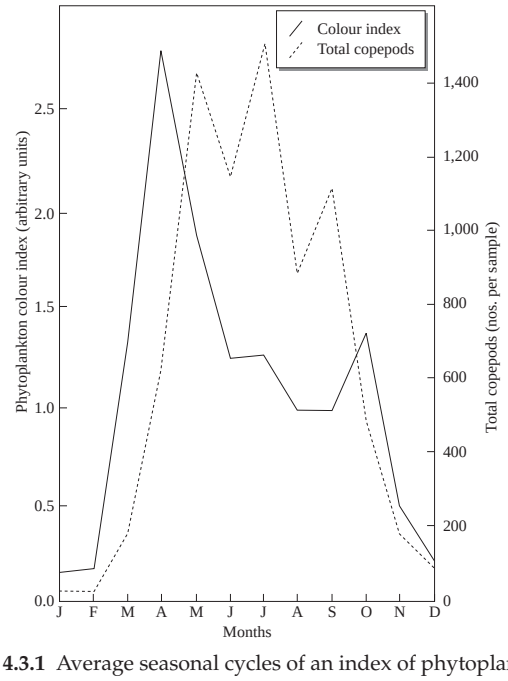

Figure 4.3.1 Average seasonal cycles of an index of phytoplankton colour (a visual estimate of chlorophyll) and numbers of copepods per sample (approximately 3 m^3 of water filtered). Source: Continuous Plankton Recorder data for 1958-1992.

areas, except the Celtic Sea, and the duration of seasonal abundance is quite prolonged compared with the northern North Sea. Figure 4.3.1 shows the seasonal cycles of an index of phytoplankton colour (a visual estimate of chlorophyll) and numbers of copepods per sample (approximately 3 m^3 of water filtered) derived from Continuous Plankton Recorder (CPR) data for 1958-92 for Region 14.

4.3.2 Important locations and species

Evidence from the CPR surveys indicates that the planktonic assemblage is made up mainly of northern intermediate (mixed water) species, with occasional oceanic species being carried into the area. The spring increase in phytoplankton begins in March, with diatoms reaching a peak in May, the dominant species being *Chaetoceros* spp. After the diatom peak in May, dinoflagellates show a steady increase through the summer until September, when abundance declines to low winter levels. The main components of the zooplankton are small copepods such as *Pseudocalanus elongatus*, *Acartia clausi* and *Temora longicornis*, although the larger copepod *Calanus helgolandicus* can be very abundant at times. Copepod numbers start increasing by March, with highest numbers found between May and September; after October copepod numbers decrease to low winter levels. Copepods are the group with the highest diversity in the zooplankton, with overall biodiversity increasing towards the open sea. Other commonly found zooplankton include euphausiids, decapod larvae, echinoderm larvae, ctenophores, fish larvae and the chaetognath *Sagitta elegans* (a species indicative of oceanic water masses). Hydromedusae and scyphomedusae are frequently abundant in the summer and early autumn. These plankton predators have been known to clog cooling water intakes to power stations and may be harmful to farmed salmon in cages.

4.3.3 Human activities

Dinoflagellates are of particular importance to the coastal manager in this region because a number of toxic blooms have occurred (Table 4.3.1). *Gyrodinium aureolum* and an unidentified dinoflagellate 'flagellate X' have been known to cause severe mortalities in farmed salmon, and *Alexandrium tamarense* has been associated with Paralytic Shellfish Poisoning (PSP). PSP occurs in shellfish and is toxic to humans as well as other marine life. For the purposes of management and insurance, Gowen (1987) distinguished two possible areas where the likelihood of toxic blooms has increased: (a) areas near frontal boundaries, which exist at the entrance to most firths and sounds (Map 4.3.1), and (b) sea lochs that have high levels of dissolved inorganic nitrate and a lengthy flushing time. Monitoring of these harmful algal blooms is currently conducted by SOAEFD Marine Laboratory, Aberdeen.

Table 4.3.1 Distribution of toxic species and occurrence of blooms in Region 14

Species	*Date*	*Location*	*Maximum no. of cells*
'Flagellate X'	May 1979	Loch Striven	8×10^6 cells/l
'Flagellate X'	May 1982	Loch Fyne	34×10^6 cells/l
Gyrodinium aureolum	July 1978	Islay Front	-
Gyrodinium aureolum	Sept 1980	Clyde	21×10^6 cells/l
Alexandrium tamarense	May 1983	Loch Creran	1.5×10^4 cells/l
Alexandrium tamarense	June 1983	Sound of Jura & Firth of Lorn	$0.5\text{-}7 \times 10^3$ cells/l

Source: Gowen (1987)

4.3.4 Information sources used

This part of Scotland has undergone numerous plankton surveys due the proximity of Dunstaffnage Marine Research Laboratory. Many of the sea lochs in this region have been specifically investigated, together with the major firths of Clyde and Lorn. Further offshore, the CPR survey is important because it provides long-term plankton data which can be used to assess the effects of environmental variability and climatic changes on the marine biota. Table 4.3.2 summarises the plankton surveys of the region (Map 4.3.1).

Table 4.3.2 Details of surveys

Identification in Map 4.3.1	*Frequency*	*Period*	*Reference*
CPR: 'Y' route	Monthly	1955-1961	
PS (■)	Occasional	1988	Jones & Gowen 1990
PS (□)	Monthly	1982-1983	Lewis *et al.* 1985
PS (+)	Occasional	1977	Simpson *et al.* 1979
PS (○)	±Monthly	1970-1976	Tett & Wallis 1978
PS (●)	Occasional	1980	Jones *et al.* 1982
PS (①)	Seasonal	1976-1978	Hannah & Boney 1983
PS (¹)	Monthly	1985	Gowen *et al.* 1988
PS (★)	Occasional	1982 & 1983	Jones *et al.* 1984

Key: CPR: Continuous Plankton Recorder; PS: Plankton Samples

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Warner, A.J., & Hays, G.C. 1994. Sampling by the Continuous Plankton Recorder survey. *Progress in Oceanography, 34:* 237-256.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
CPR survey data	Director, Sir Alister Hardy Foundation for Ocean Science, The Laboratory, Citadel Hill, Plymouth, PL1 2PB, tel: 01752 633100
Plankton research	Director, Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244
Ichthyoplankton	*Director, MAFF Directorate of Fisheries Research, Fisheries Laboratory, Lowestoft, tel: 01502 562244
Information on plankton in Scotland	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Marine research	Director, SOAEFD Marine Laboratory, PO Box 101, Victoria Road, Aberdeen, AB9 8DH, tel: 01224 876544

*Starred contact addresses are given in full in the Appendix.

The nationally scarce thyme broomrape *Orobanche alba* is a root parasite of wild thyme *Thymus polytricus* and occurs only on base-rich rocky outcrops, such as limestone, serpentinite and basalt. In Britain it is found at only a few locations on the South-west Peninsula, in the Pennines and, much more frequently, along the north-west coast of Scotland. Photo: Pat Doody, JNCC.

Chapter 5 Important species

5.1 Terrestrial lower plants

N.G. Hodgetts

5.1.1 Introduction

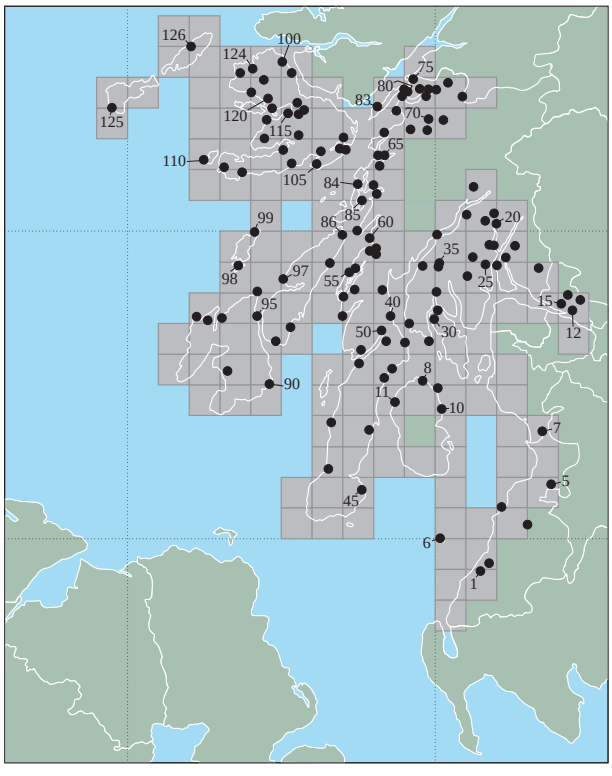
This section covers lichens, bryophytes (mosses and liverworts), stoneworts (a group of freshwater and brackish water algae - the latter are covered in section 5.4) and fungi occurring in the coastal 10 km squares within the boundaries of the region. About 68% of the British bryophyte flora and about 34% of the stonewort flora occur in the region. Similar figures are not available for other groups, but a similarly high percentage of the lichen and fungus floras can be expected because of the oceanic climate.

The position of Region 14 on the west coast of Scotland gives it an extremely oceanic climate and, along with Region 16, the northern part of the region is one of the most important areas for lower plants in Europe, or even the world. Region 14 (along with Region 16) is characterised by the presence of a large number of lower plant species for which Britain has a high proportion of the world population and therefore an international responsibility for their conservation. In particular, many species that are considered threatened in Europe as a whole, but which are not rare enough to qualify for the British Red Data List, have their global strongholds in the region. Indeed, many of these species are near-endemics, the bulk of their populations occurring in western Scotland, with outlying occurrences in such places as Ireland, western Norway, Madeira and the Azores (Schumacker 1988). Furthermore, because of the equable climate, many species that are indicators of habitat continuity elsewhere are much more opportunistic in the west of Scotland, readily colonising and recolonising wherever suitable niches occur.

Another reason for the high lower plant biodiversity of the region is that it supports a relatively large area of little-disturbed semi-natural habitat. Much of the coastal zone is sparsely populated (although more populous than inland areas) and inaccessible and is therefore less vulnerable to anthropogenic pressures than the coast in many other regions.

5.1.2 Important locations and species

Map 5.1.1 shows all the sites in the region that are known to be important for lower plants and that have had at least some degree of survey work: they are listed in Table 5.1.1. Many sites are large, in which case the grid reference refers to a reasonably central point. The large number of sites in Argyll and Bute reflects the supreme international importance of this area for lower plants. Although Arran and most districts south of the Clyde are notably under-recorded, the lower plant flora is certainly less rich in these areas than it is further north. Most of the Sites of Special



Map 5.1.1 Sites in coastal 10 km squares known to be important for lower plants. Site numbers refer to those in Table 5.1.1. Source: JNCC Red Data Book database.

Scientific Interest (SSSIs) in Table 5.1.1 were selected for conservation designation partly on the basis of their bryophyte and lichen interest; many contain rare and scarce species and qualify for SSSI status on the basis of their lower plant flora alone (Hodgetts 1992).

Like higher plants (see section 5.2), lower plants tend to occur in characteristic assemblages that are found in particular habitats. In this region, oceanic woodland is probably the single most important lower plant habitat. Much ancient semi-natural oak-birch woodland remains in the highland parts of the region, often in small patches confined to ravines, but also covering more extensive areas. This is a very rich habitat for lower plants, with an exceptionally high diversity of bryophytes, lichens and fungi, particularly myxomycetes (slime moulds). Many oceanic species (most notably small liverworts such as *Acrobolbus wilsonii*, *Radula* spp. and members of the family Lejeuneaceae) are more-or-less confined to this habitat. Equally, many of these species, such as the liverworts *Acrobolbus wilsonii* and *Radula carringtonii*, the moss *Glyphomitrium daviesii* and lichens in the genera *Leptogium*, *Lobaria*, *Pseudocyphellaria* and *Pannaria*, are near-endemic to

Table 5.1.1 Lower plant sites in coastal 10 km squares

Site no.	Site name	Grid ref.	Protected status
	South Ayrshire		
1	Knockdaw Hill	NX1588	SSSI
2	Aldons Hill	NX1890	SSSI
3	Culzean Park	NS2209	Not protected
4	Kilkerran Park	NS3103	Not protected
5	Martnaham Loch & Wood	NS3917	SSSI
6	Ailsa Craig	NX0199	SSSI
7	Dundonald Wood	NS3634	SSSI
	North Ayrshire		
8	Ossian's Cave Woods, Arran	NR9651	Not protected
9	Leac Gharbh & Sannox Woods, Arran	NS0148	Not protected
10	Corrie Woods, Arran	NS0241	Not protected
11	Pirnmill Woods, Arran	NR8744	Not protected
	Dunbartonshire*		
12	Hawcraig-Glenarbuck	NS4574	SSSI
13	Kilmannan Reservoir	NS4877	Not protected
14	Dumbarton Muir	NS4479	SSSI
15	Lang Craigs	NS4376	SSSI
16	Ross Park	NS3589	SSSI
17	Port an Lochain	NS2189	Not protected
18	Feorlinbreck Ravine	NS2492	Not protected
19	Creag Tharsuinn	NS2796	Not protected
	Argyll & Bute*		
20	Ben Donich	NN2104	Not protected
21	Beinn an Lochain	NN2107	SSSI
22	Hell's Glen	NN1805	SSSI
23	Loch Goil West Woodlands	NS1996	Not protected
24	Loch Goil East Woodlands	NS2096	Part SSSI
25	Craighoyle Woodland (Coille Mheadhonach)	NS1790	SSSI
26	Loch Eck Woodlands	NS1392	Part SSSI
27	Glen Massan Woods	NS1186	Not protected
28	Ruel Estuary Woodlands	NS0180	Part SSSI
29	Glachavoil to Colintraive Woods	NS0275	Not protected
30	North End of Bute	NS0072	SSSI
31	Ardlamont Point	NR9864	Not protected
32	Glenan Bay Woods	NR9270	Not protected
33	Lephinchapel Woods	NR9689	Not protected
34	Conchra, Glendaruel	NS0289	Not protected
35	Glendaruel Woods & Crags	NS0290	SSSI
36	Ardchyline Wood	NN1106	SSSI
37	Glen Shira complex	NN1315	SSSI
38	Barr nan Damh	NS0298	Not protected
39	Inverneil Burn	NR8381	SSSI
40	Artilligan & Abhain Srathain Burns	NR8573	SSSI
41	Tarbert to Skipness Coast	NR9064	SSSI
42	Claonaig Wood	NR8655	SSSI
43	Escairt to Rockfield	NR8452	Part SSSI
44	Torrisdale	NR7835	Not protected
45	Balnabraid Glen	NR7615	SSSI
46	Macrihanish	NR6522	SSSI
47	Glencardoch Point	NR6637	SSSI
48	Dunskeig	NR7557	Not protected
49	Corranbuie Woods	NR8465	Not protected
50	Glen Ralloch to Baravalla Woods	NR8367	SSSI
51	Ardpatrick & Dunmore Woods	NR7661	SSSI
52	Ellary Woods	NR7073	SSSI
53	Ulva, Danna & the McCormaig Isles	NR7079	SSSI
54	Eas Daltot	NR7482	Not protected
55	Tayvallich Juniper & Fen Site	NR7285	SSSI
56	Taynish Woods	NR7486	NNR
	Argyll & Bute* (continued)		
57	Bellanoch Woods, Crinan Canal	NR7992	Not protected
58	Dunardry, Crinan Canal	NR8191	Not protected
59	Moine Mhor	NR8192	SSSI
60	Ardifuir	NR7996	Not protected
61	Craignish Point	NR7599	Part SSSI
62	Kames Woods	NM8111	Not protected
63	Loch Melfort Woods & Degnish Point	NM8013	Not protected
64	Glen Gallain Woods	NM8220	Not protected
65	Loch Feochan Woods	NM8423	Not protected
66	Ardentallen Woods	NM8223	Not protected
67	Kerrera Island North	NM8431	SSSI
68	Clais Dhearg, Connel	NM9332	SSSI
69	Airds Park	NM9832	Not protected
70	Kennacraig & Esragan Burn	NM9935	SSSI
71	Bonawe to Cadderlie	NN0335	SSSI
72	Ard Trilleachan	NN0943	SSSI
73	Glen Ure Woods	NN0547	Not protected
74	Taraphocain Woods	NN0145	Not protected
75	Glasdrum	NM9945	SSSI, part NNR
76	Dallachulish Woods	NM9843	Not protected
77	Gleann na h-Iola	NM9645	Not protected
78	Glenstockdale	NM9448	Not protected
79	Dalnashean Wood	NM9145	Not protected
80	Glaceriska Woods	NM9144	Not protected
81	Eriska	NM9043	Not protected
82	Lochnell House Wood	NM8838	Not protected
83	Lismore	NM8239	Part SSSI
84	Ballachuan Hazel Wood, Seil	NM7514	Not protected
85	Shuna	NM7608	Not protected
86	Kinuachdrach Wood, Jura	NR7097	SSSI
87	Doire Dhonn, Jura	NR6588	SSSI
88	Craighouse Ravine, Jura	NR5266	SSSI
89	Jura House to Brosdale, Jura	NR4863	Not protected
90	Ardmore, Kildalton & Callumkill Woodlands, Islay	NR4650	SSSI
91	Eilean na Muice Dubh, Islay	NR3255	SSSI
92	Glac na Criche, Islay	NR2270	SSSI
93	Feur Lochan-Moine nam Faoleann, Islay	NR2569	SSSI
94	Gruinart Flats, Islay	NR3069	SSSI
95	Port Askaig Woods, Islay	NR4270	Not protected
96	Rubha Bholsa-Bunnahabhain, Islay	NR4279	Not protected
97	West Coast of Jura	NR5083	SSSI
98	Oronsay	NR3587	SSSI
99	Colonsay (including Coille Mhor, North Colonsay)	NR4198	Part SSSI
100	Tobermory & Aros Park, Mull	NM5054	Not protected
101	Sound of Mull Cliffs, Mull	NM5351	SSSI
102	Ardura-Auchnacraig, Mull	NM7029	SSSI
103	Portfield Woods, Mull	NM7125	Not protected
104	Dalnaha Woods, Mull	NM6926	Not protected
105	Laggan Deer Forest, Mull	NM6221	Part SSSI
106	Loch Uisg Woods, Mull	NM6325	Not protected
107	South Mull Coast, Mull	NM5321	SSSI
108	Ardalanish Bay, Mull	NM3618	SSSI
109	Knockvologan Woods, Mull	NM3119	Not protected
110	Iona	NM2422	Not protected
111	Pennycross Woods, Mull	NM5025	Not protected
112	Coladoir Bog, Mull	NM5530	SSSI
113	Ardmeanach, Mull	NM4429	SSSI
114	Gribun Shore & Crags, Mull	NM4535	SSSI
115	Ben More-Scarisdale, Mull	NM5237	SSSI

Table 5.1.1 Lower plant sites in coastal 10 km squares (continued)

Site no.	Site name	Grid ref.	Protected status
	Argyll & Bute* (continued)		
116	Central Mull Complex, Mull	NM5537	SSSI
117	Loch Ba Woodland, Mull	NM5738	SSSI
118	Gruline Woods, Mull	NM5540	Not protected
119	Acharonich to Kellan Mill Woods, Mull	NM4739	Not protected
120	Lagganulva Wood, Mull	NM4542	SSSI
121	Torloisk House & Kilninian Woods, Mull	NM4045	Not protected
122	Coille Chill' a' Mhoraire, Mull	NM4448	Not protected
123	Calgary Dunes, Mull	NM3751	SSSI
124	Penmore Mill Woods, Mull	NM4052	Not protected
125	Tiree	NL9440	Part SSSI
126	Coll (including Totamore Dunes)	NM2059	Part SSSI

Sources: references listed in section 5.1.5 and JNCC's protected sites database. Key: *refers to former district area (data not collated into new local authority boundaries); SSSI = Site of Special Scientific Interest; NNR = National Nature Reserve. Note: site numbers refer to Map 5.1.1.

western Scotland. Many of them are large and spectacular, often forming conspicuous masses hanging off trees. Fungi are important as wood decomposers and as mycorrhizal associates (depending on a close association with the root systems) of higher plants. Many isolated roadside trees in the region also support a good epiphytic lichen flora. Hazel woodland is an important lichen habitat, for instance on the island of Seil. Parks in the region (e.g. Ross Park) are also rich in lichens.

The region contains some important montane areas. North-east-facing corries and late-lying snow patches support bryophyte and lichen assemblages that include species found only in these extreme conditions. Summit ridges, cliffs and rock ledges, high-altitude flushes and other montane habitats all support their own distinctive lower plant communities. Areas of wet heath at medium altitude sometimes support the 'northern Atlantic mixed hepatic mat' community (Ratcliffe 1968). This community is virtually confined to the west coast of Scotland and Ireland and consists of a number of large oceanic liverworts. The Red Data Book (RDB - i.e. nationally rare) species *Adelanthus lindenbergianus* is a member of this community.

The extensive coastal hard rock cliffs of the region support characteristic lichen assemblages, the species composition of which varies according to geology. Limestone exposures, as on Lismore, are particularly rich in lichens. Basalt cliffs are often good lower plant habitat, with mosses such as *Glyphomitrium daviesii* sometimes locally abundant. Species usually encountered as epiphytes, such as *Lobaria* spp., *Ulota phyllantha* etc., often grow on coastal rocks in the favourable oceanic climate. Raised beaches are often good areas for lower plants, as the habitats are many and varied, with dripping cliff vegetation, sea caves, rocks, small wetlands, streams and grassland. Caves on the north coasts of Jura and Islay are notable for the presence of some rare bryophytes.

Machair, occurring in this region principally on the islands of Coll, Tiree and Colonsay, is important for its lower plant communities. Undisturbed calcareous grassland found on the shell sand of these islands can support a distinctive bryophyte community, with a number of scarce mosses present. Characteristic fungus assemblages are also often present. Rocks within the machair can be rich in lichens, and machair lochs are notable for their stonewort communities. Areas of wet grassland and fen also occur and are rich in mosses that are scarce elsewhere. Coastal wetlands, such as small valley mires, raised bogs and areas of wet heathland, occur in abundance on the west coast of Scotland and are usually rich in bryophytes and often in fungi, particularly where there is some base-rich (alkaline) influence.

The region contains a number of threatened species, some of which are given special protection under national and international legislation. Table 5.1.2 lists the Red Data Book species found in the region (out of a total of 137 bryophytes, twelve stoneworts and 179 lichens on the British Red Lists (as at September 1996)), excluding extinct species. For fungi there is insufficient information for a comprehensive count. In addition, the region contains 168 out of 313 nationally scarce bryophytes and four of the nine nationally scarce stoneworts (figures for nationally scarce species are provisional). There is currently not enough information to provide even provisional lists of nationally scarce lichens and fungi.

5.1.3 Human activities

Current issues that may have a bearing on the lower plant flora of the region include road construction programmes, house building, forestry, fish farming, holiday and leisure developments and acid rain. Some machair and woodland areas may be affected by holiday and leisure developments such as caravan sites and golf courses. Over-exploitation of mountain slopes by skiing developments is an important factor influencing fragile alpine lower plant communities, and erosion is a general problem on popular walking routes in the Highlands. Pollution is a general problem but may be aggravated in some areas by oil spillages etc. Nutrient enrichment by spindrift from fish farms can locally affect epiphytic communities.

Some sites in the region are National Nature Reserves (NNRs) and are therefore managed for nature conservation, while many more are SSSIs for which positive management agreements may be entered into. Overgrazing by sheep and deer in the important oceanic woodland sites has an effect on the lower plant communities in the long term, as the average age of the trees increases. The spread of rhododendron *Rhododendron ponticum* has altered the character of many of these sites and should be restricted as far as possible. Any insensitive burning of bog and moorland sites is damaging to the lower plant communities. Undisturbed machair grassland important for bryophytes should be maintained in a damp and open condition, with a close herb and bryophyte-rich sward.

5.1.4 Information sources used

Arran and most districts south of the Clyde are notably under-recorded. Otherwise, data for bryophytes and the larger lichens in the region are generally good, but information is less complete for fungi, algae and the smaller lichens. The computerised database at the Biological Records Centre (BRC), Monks Wood, and the Red Data Book

Table 5.1.2 Red Data Book lower plants

Species	*Locations/habitat*
Liverworts	
*Adelanthus lindenbergianus**	In wet heath at a confidential site, Argyll & Bute
*Jamesoniella undulifolia**	Small coastal minerotrophic bog, Argyll & Bute
Lejeunea holtii	In caves on raised beach on the north coasts of Islay and Jura
Mosses	
Bryum cyclophyllum	On mud at margins of reservoir and canal, Kilmannan Reservoir, Dumbarton, and Crinan Canal, near Dunardry, Argyll & Bute
Bryum marratii	Muddy ground, Danna Causeway, Argyll & Bute
*Cyclodictyon laetevirens**	In caves on raised beach on the north coasts of Islay and Jura
Daltonia splachnoides	On wet peaty ground or rotting wood at several sites, from Loch Eck, Argyll & Bute, to Ardgour
Habrodon perpusillus	On trees, Ross Park, Dumbarton, and Culcharron, Argyll & Bute
Philonotis cernua (Bartramidula wilsonii)	Peaty ground, Glen Coe, Argyll & Bute
Lichens	
Arthothelium macounii (A. reagens)	On hazel, Port Mor, Seil, Argyll & Bute
Biatoridium monasteriense (Biatorella monasteriensis)	Epiphytic, near Doire Dorch, Mull
Caloplaca flavorubescens	On tree bark (usually ash), at several scattered sites in Argyll & Bute
Chromatochlamys larbalestieri	On basalt by stream, Aros Park, Mull
Cladonia peziziformis	Burnt peat, Maol a'Bhaird, Mull
Collema fragile	On limestone, Lismore, Argyll & Bute
*Pseudocyphellaria lacerata**	Mossy rocks and trees, Balnabraid Glen, Kintyre, and near Aros Park, Mull
Sticta canariensis	On rocks and trees at a number of sites in Argyll & Bute, particularly on Mull
Synalissa symphorea	Limestone on coastal cliff, Lismore, Argyll & Bute
Usnea madeirensis	Unlocalised record, Kintyre, Argyll & Bute

Source: JNCC lower plants database. Key: *protected under Schedule 8 of the Wildlife & Countryside Act 1981.

database at JNCC include recent records collected over decades by expert bryologists as well as important historical records. Additional bryophyte information was taken from recent work by Averis (1991). Some important, or potentially important, coastal lichen sites have been identified in recent surveys (Fletcher 1984; James & Wolseley 1991), but as relatively few have been comprehensively surveyed, there may be more than appear in Tables 5.1.1 and 5.1.2. All British Mycological Society foray data are currently being put onto a computer database at the International Mycological Institute under a JNCC contract. Computerised stonewort data are held at BRC and JNCC. More information on freshwater algae may be available from the Freshwater Biological Association.

5.1.5 Further sources of information

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Information on lower plants in Argyll & Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Information on lower plants in of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
Lichens (hard rock coasts)	T. Duke, Sandrock, The Compa, Kinver, Staffs. DY7 6HS, tel: 01384 872798
Lichens (general coastal)	P.W. James, c/o Department of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD, tel: 0171 938 9123
Lichens (woodland and general: British Lichen Society database)	Dr A. Fletcher, Leicestershire Ecology Centre, Holly Hayes, 216 Birstall Road, Birstall, Leicester LE4 4DG, tel: 0116 267 1950
Lichens (general, survey,etc.)	A. Fryday, 4 Broadbent Street, Brotton, Saltburn-by-the-Sea, Cleveland TS12 2TF
Fungi (general and sand dune)	M. Rotheroe, Fern Cottage, Falcondale, Lampeter, Dyfed SA48 7RX, tel: 01570 422041
Fungi (general)	Dr R. Watling, Royal Botanic Garden, Inverleith Row, Edinburgh EH3 5LR, tel: 0131 552 7171
Fungi (British Mycological Society database)	Dr P. Cannon, International Institute of Mycology, Bakeham Lane, Englefield Green, Egham, Surrey TW20 9TY, tel: 01784 470111
Freshwater stoneworts	Director, Institute of Freshwater Ecology - Head Office, Windermere Laboratory, Far Sawrey, Ambleside, Cumbria LA21 0LP, tel: 015394 42468
Bryophytes (BRC database)	*C.D. Preston, Biological Records Centre, ITE Monks Wood, tel: 01487 773381
Bryophytes (British Bryological Society herbarium)	A.R. Perry, Department of Botany, National Museum of Wales, Cardiff CF1 3NP, tel: 01222 397951
Bryophytes (general)	D.G. Long, Royal Botanic Garden, Inverleith Row, Edinburgh EH3 5LR, tel: 0131 552 7171
Bryophytes (lowland)	A.B.G. Averis, 2 Traprain Cottages, Traprain, Haddington, East Lothian EH41 4PY, tel: 01620 860029
Bryophytes (upland)	G.P. Rothero, Stronlonag, Glenmassan, Dunoon, Argyll PA23 8RA, tel: 01369 706281
Lower plants (species status; Red Data Book Database; site register etc.)	*N.G. Hodgetts, JNCC, Peterborough, tel: 01733 62626

*Starred contact addresses are given in full in the Appendix.

5.2 Flowering plants and ferns

V.M. Morgan

5.2.1 Introduction

This section describes the importance of the region for vascular plants (i.e. flowering plants and ferns) occurring in the coastal 10 km squares within the boundaries of the region, particularly species that are rare or scarce in Great Britain. Rare and scarce species grow in a wide range of habitats, but of particular importance in this region are calcareous dunes, lochs and cliffs. In some of the Hebridean islands machair is found alongside the vegetation of beaches, lochs, rocks and heaths. The existence of a suite of semi-natural vegetation types, with little fragmentation of the habitats by human barriers, contributes to the species richness of locations such as Colonsay, Coll and Tiree. The numbers of rare and scarce species in the region are shown in Table 5.2.1.

Table 5.2.1 Numbers of rare and scarce higher plant species in coastal 10 km squares of the region

	Protected species	*Other rare (RDB) species*	*Scarce species*
South Ayrshire	0	0	4
North Ayrshire	1	2	17
Inverclyde	0	0	4
Renfrew	0	2	9
Dunbartonshire*	0	1	15
Argyll & Bute*	5	6	59
Region 14	***5***	***11***	***69***

Source: JNCC Rare Plants database; Stewart *et al.* (1994); BRC database. Key: *refers to former district area (data not collated into new local authority boundaries). Note: species counts exclude known introductions and records from before 1970.

In this region there are two 'classic' British plant localities that are well-known for their internationally significant concentrations of rare and scarce species: the Isle of Arran and the islands of Tiree and Coll. Two other areas, Colonsay and Glen Creran, have been identified as being of particular importance for rare and scarce higher plants. These and other centres of plant biodiversity in the region are shown on Map 5.2.1. The special conditions that support such centres are a combination of climate, geology and location. In this region temperatures are influenced by warm Atlantic currents and, except on the higher peaks, are relatively mild compared with inland areas, with ground frost and snowfall being rare on Colonsay (Clarke & Clarke 1991). Almost all areas are exposed to strong, often salt-laden, winds from most directions; mean windspeeds are 7.5 m/s at Tiree and 4.6 m/s at Prestwick (Smith 1986). Rainfall is very variable and where the coastal zone includes mountains precipitation rates tend to be higher on the higher ground; on Mull it ranges from 125-313 cm per year (Jermy & Crabbe 1978).

A number of different elements, defined by Matthews (1955), are found in the region's flora. A small but significant element consists of species that are widespread in North America but also grow in western Europe. Pipewort *Eriocaulon aquaticum* and Irish lady's-tresses *Spiranthes romanzoffiana* are examples of species that in Europe are

Map 5.2.1 Key localities for rare and scarce higher plants (hatched) and locations mentioned in the text.

confined to western Scotland and Ireland. There are a large number of arctic or arctic-alpine species, including moss campion *Silene acaulis* and purple saxifrage *Saxifraga oppositifolia*, that are typical of uplands but which grow here at sea level (Currie & Murray 1983). The relatively mild temperatures in the region mean that a number of species can grow further north here than on the east coast. Species at the northern limits of their distribution in the region include Portland spurge *Euphorbia portlandica*, yellow bartsia *Parentucellia viscosa*, tree mallow *Lavatera arborea* and blunt-flowered rush *Juncus subnodulosus*. A number of the characteristic species of the region, such as slender naiad *Najas flexilis* and pipewort, rely on unpolluted water, and the position of the region in relation to the prevailing westerly winds has protected their sites from air pollution.

Two higher plant species occurring in the region are protected under international law and four are amongst the 107 listed on Schedule 8 of the Wildife and Countryside Act (1981). Fifteen of the 317 nationally rare species listed for Great Britain in the *British Red Data Book of vascular plants* occur in the region (Perring & Farrell 1983), and of the 254 scarce species (i.e. known from 16 to 100 ten km squares) in Great Britain, 69 occur in the region.

5.2.2 Important locations and species

Rare species in the region are listed in Table 5.2.2. The Arran service-tree *Sorbus pseudofennica* and the whitebeam species *Sorbus arranensis* are known only from the Isle of Arran.

Table 5.2.2 Recorded occurrence of nationally rare (RDB) species and/or protected species

Species	*Recorded occurrence in:*			*Key localities*	*Habitat*
	total no. of 10 km squares in GB	*no. of coastal 10 km² squares in region*	*no. of sites in region (approx.)*		
Arctic sandwort *Arenaria norvegica* subsp. *norvegica**	11	2	2	Glen Creran	Base-rich screes and river shingle
Arran service-tree *Sorbus pseudofennica*	1	1	1	Isle of Arran	Granite bank
Club sedge *Carex buxbaumii*	4	1	1	Near Killinochonoch	Loch margins
Dune gentian *Gentianella uliginosa**	7	2	2	Colonsay	Dunes
Holy-grass *Hierochloë odorata*	14	1	1	Blythswood	Wet places
Iceland-purslane *Koenigia islandica*	5	2	2	Isle of Mull	Bare, stony mountains
Killarney fern *Trichomanes speciosum**† [1]	-	-	-	Isle of Arran; Argyll	Damp, sheltered rock faces
Lapland marsh-orchid *Dactylorhiza lapponica** [2]	9	4	11	Knapdale area	Heaths and bogs
Pipewort *Eriocaulon aquaticum*	9	2	4	Tiree & Coll	Acid lochs
Purple oxytropis *Oxytropis halleri*	10	1	1	Glen Creran	Dry cliff pastures
Scottish dock *Rumex aquaticus*	3	1	2	Loch Lomond	Alder swamps
Shetland pondweed *Potamogeton rutilus*	10	1	1	Tiree & Coll	Lochs
Slender naiad *Najas flexilis**†	15	6	7	Near Port Corbert; near Clachan; Colonsay; Isle of Mull; Tiree & Coll	Lochs of high water quality
Smooth rupturewort *Herniaria glabra*	12	1	1	Near Paisley	Dry sandy places
A whitebeam *Sorbus arranensis*	1	1	2	Isle of Arran	Granite banks
Yellow oxytropis *Oxytropis campestris*	3	1	1	Near Earadale Point	Limestone cliffs

Source: JNCC rare plants database. Key: * = listed for special protection on schedule 8 of the Wildlife & Countryside Act 1981; † = listed on Annexes IIb & IVb of EC Habitats Directive and on Annex I of the Bern Convention; [1]the need to keep sites confidential means that accurate figures are not available; the species is present in both the rare sporophyte (vascular) and the more widespread gametophyte (non-vascular) forms, but only sites of the sporophyte are listed; [2]Lapland marsh orchid was discovered in Britain in 1986 and may be more widespread than the number of confirmed records suggests; its status as a distinct species is not universally accepted. Notes: figures are for numbers of 10 km squares in GB in which species have been recorded since 1970, excluding known extinctions. Eyebrights *Euphrasia* spp. are excluded from this table as up-to-date information about their status is not available.

Other taxa in the region that are endemic (i.e. confined) to the British Isles include purple ramping-fumitory *Fumaria purpurea*, Isle of Man cabbage *Coincya monensis* and the taxonomically difficult Scottish and Atlantic scurvy-grasses, *Cochlearia scotica* and *C. atlantica*. Also of uncertain taxonomic status is the rare endemic eyebright *Euphrasia heslop-harrisonii*, which grows on the island of Coll.

Key localities that support two or more rare and/or many scarce species are listed in Table 5.2.3; their locations are shown on Map 5.2.1. Scarce species may occur near to rather than within some localities. In addition to these key localities, there are a number of moderately rich sites and isolated records of rare species.

5.2.3 Human activities

In the past, some species have been threatened by collecting, particularly in the era of botanical exchange clubs around the end of the last century, when herbarium specimens were swapped amongst botanists. Problems of collecting have now passed, but the precise localities of vulnerable species such as Killarney fern are kept confidential to avoid unwelcome attention.

In the more accessible parts of the region some species have declined or been lost. Oyster plant *Mertensia maritima*, for example, has declined in the Firth of Clyde, perhaps as a result of trampling, recreation and the removal of shingle

Table 5.2.3 Key localities for rare (RDB) and scarce plants (records post 1970)

Locality	*Status*	*Species*
Isle of Arran	Part NNR, part SSSI, part undesignated	RDB species: Arran service-tree, Killarney fern, *Sorbus arranensis* Scarce species: Alpine enchanter's-nightshade *Circaea alpina*, Scottish scurvy-grass *Cochlearia scotica*, plus nine other scarce species
Glen Creran	Part NNR, part undesignated	RDB species: Arctic sandwort, purple oxytropis Scarce species: six scarce species
Colonsay	Part SSSI, part undesignated	RDB species: dune gentian, slender naiad Scarce species: Irish lady's-tresses *Spiranthes romanzoffiana*, small adder's-tongue *Ophioglossum azoricum*, plus four other scarce species
Tiree & Coll	Part SSSI, part undesignated	RDB species: pipewort, Shetland pondweed, slender naiad Scarce species: Irish lady's-tresses, northern knotgrass *Polygonum boreale* plus ten other scarce species

Sources: JNCC Rare Plants Database; Stewart *et al.* (1994); SSSI citation sheets; BRC database. Key: SSSI = Site of Special Scientific Interest; NNR = National Nature Reserve.

(Stewart *et al.* 1994). There is some evidence of soil erosion by visitors to the island of Iona (Millar 1993). Some woodlands, particularly on Islay and Jura, have been invaded by the non-native rhododendron *Rhododendron ponticum* (MacKintosh 1988). This invasion tends to reduce the species diversity of the ground and tree bark flora and may affect such species as the filmy ferns *Hymenophyllum* spp.

Introduced species such as rats and rabbits have reduced populations of some plant species on Ailsa Craig (Zonfrillo 1994). Heavy grazing and uncontrolled burning have altered habitats on many of the islands of the region (Kerr & Boyd 1983; Ogilvie 1995). Most of the Argyll islands are now designated as Environmentally Sensitive Areas (ESAs) in order to conserve or improve the wildlife interest of their agricultural habitats (Ogilvie 1995).

5.2.4 Information sources

Monitoring of the condition and management regimes of Sites of Special Scientific Interest (SSSIs) and National Nature Reserves is conducted by Scottish Natural Heritage (SNH). The Joint Nature Conservation Committee (JNCC) maintains a database of nationally rare plant species that includes site records. Members of the Botanical Society of the British Isles (BSBI) have recently finished collecting up-to-date records of scarce species; these data are held at the Biological Records Centre and have been summarised in *Scarce plants in Britain* (Stewart *et al.* 1994).

5.2.5 Acknowledgements

Thanks are due to J. Barne, D. Mellor, C.D. Preston, J. Sutcliffe, C. Sydes, A. Walker, M. Wigginton and staff at the Biological Records Centre.

5.2.6 Further sources of information

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Species on SSSIs and NNRs, other protected areas, distribution of data on rare and scarce species, rare plant surveys, licensing and protected species in Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Species on SSSIs and NNRs, other protected areas, distribution of data on rare and scarce species, rare plant surveys, licensing and protected species in south of region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
Biological Records Centres and active herbaria	
Ayr	Curatorial Assistant, Centre for Environmental Recording in Ayrshire, The Dick Institute Museum & Art Gallery, Elmbank Avenue, Kilmarnock KA1 3BU, tel: 01563 526401
Isle of Arran	Arran Biological Records Centre, The Ranger Centre, Brodick Country Park, Brodick KA27 8HY, tel: 01770 302462
Isle of Arran	Alastair Clark, Isle of Arran Natural History Society, c/o Arran Outdoor Centre, Shiskine, Isle of Arran KA27 8EW
Renfrewshire	Keeper of Natural History, Renfrewshire Environmental Information Centre, Paisley Museum, High Street, Paisley PA1 2BA, tel: 0141 889 3151
Isle of Islay	Islay Field Centre, Main St., Port Charlotte, Islay, tel: 01496 850218
Local BSBI vice-county recorders' records	c/o Dr P. Macpherson, Hon. Secretary, Scotland Committee, Botanical Society of the British Isles, 15 Lubnaig Road, Glasgow G43 2RY

*Starred contact addresses are given in full in the Appendix.

5.3 Land and freshwater invertebrates

A.P. Foster & M.S. Parsons

5.3.1 Introduction

There are over 28,000 species in the better known invertebrate groups in Great Britain (Kirby 1992). This section deals with most insect orders, though not all families, together with a wide range of non-insect invertebrates, known from sites within the coastal 10 km Ordnance Survey grid squares of the region. Lagoonal species are covered in section 5.4.

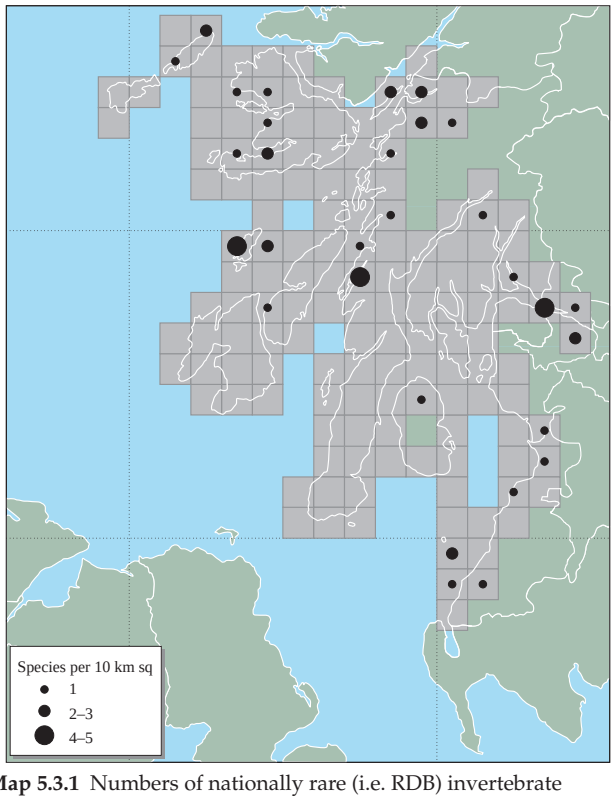
The region is nationally important for the conservation of several species that are not known to occur elsewhere in Great Britain. Moreover, in international terms, some of these are represented by subspecies endemic to the west coast of Scotland: the New Forest burnet moth *Zygaena viciae argyllensis*, known from just a single small colony, is one of Great Britain's most threatened insects; and the slender Scotch burnet moth *Z. loti scotica* is virtually restricted to the coast of Mull. Some species, such as the belted beauty moth *Lycia zonaria*, the Arran carpet moth *Chloroclysta concinnata* and the micro-moth *Scrobipalpa murinella*, have substantial proportions of their known national distributions within this region. Other scarce species occurring here have, or had, their main British populations much further south - a reflection of the prevailing mild conditions in the region. Examples include the forester moth *Adscita statices*, the chequered skipper butterfly *Carterocephalus palaemon*, which is now extinct in England, and the hairy dragonfly *Brachytron pratense*.

Of the 358 Red Data Book (RDB) and 455 nationally scarce species listed as known to be associated with coastal habitats by Kirby (1994a, b), six and 32 respectively are recorded from this region on the JNCC's Invertebrate Sites Register (ISR). Many additional rarities are also represented, in groups not covered by Kirby (1994a, b), or by taxa not strictly coastal in terms their national distribution, but having populations at coastal localities. These include, for example, species associated with woodland habitats, especially oak and birch associated species, and those confined to uplands or wetlands. Map 5.3.1 shows the numbers of all nationally rare (RDB) invertebrate species (including Kirby's 'coastal' species and all others) recorded in coastal 10 km squares in the region. Map 5.3.2 maps the recorded distribution of all nationally scarce invertebrates in the region, including those that are not strictly coastal in terms of their national distribution but which have populations on coastal sites. Note that survey effort has not been equal throughout the region, so actual occurrence may differ from recorded distributions.

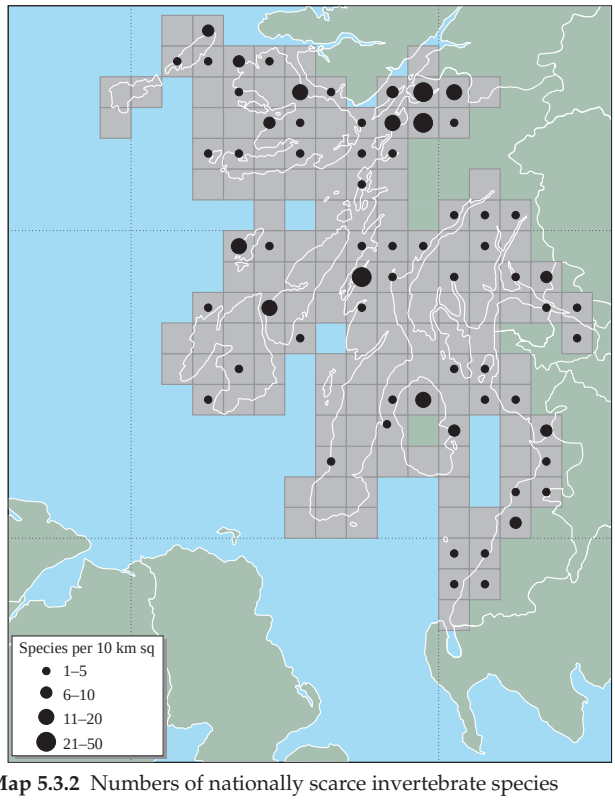
Three invertebrates recorded from the region are listed on international directives, conventions and/or the Wildlife & Countryside Act 1981 (Table 5.3.1). The chequered skipper butterfly, previously listed on Schedule 5 of the Wildlife & Countryside Act, has now been removed.

5.3.2 Important locations and species

Table 5.3.2 lists coastal terrestrial or freshwater RDB species as defined by Kirby (1994a, b) that have been recently recorded from the region.



Map 5.3.1 Numbers of nationally rare (i.e. RDB) invertebrate species recorded in coastal 10 km squares (all dates). Distribution may reflect differences in recording effort. Source: JNCC Invertebrate Site Register.



Map 5.3.2 Numbers of nationally scarce invertebrate species recorded in coastal 10 km squares (all dates). Distribution may reflect differences in recording effort. Source: JNCC Invertebrate Site Register.

Table 5.3.1 Protected invertebrate species in the region

Species	*EC Habitats & Species Directive*	*Berne Convention*	**Wildlife & Countryside Act 1981*	***CITES*
Marsh fritillary butterfly *Eurodryas aurinia*	Annex II	Appendix II	-	-
Medicinal leech *Hirudo medicinalis*	Annex V	Appendix III	Schedule 5 - (Variation of Schedules) Order 1988	Appendix III
New Forest burnet moth *Zygaena viciae*	-	-	Schedule 5	-

Key: *excludes Schedule 5, section 9 (5), sale only; **CITES is the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

The ISR has records from over 160 sites within the region, although a few of these are subsites of much larger statutory nature conservation areas. RDB and nationally scarce species have been recorded at many of the ISR sites. Assemblages of species associated with dune and machair and rocky habitats including undercliffs are well represented in the region. In addition, wetlands such as flushes, boggy moorlands and lochs, with their associated habitats, house many scarce species. Woodlands and upland areas here are also important for their invertebrate assemblages. Table 5.3.3 lists those sites considered to be of major importance for the conservation of invertebrates. Site selection was based on the range and/or scarcity of species present, the species habitat associations and the amount of available habitat. Upland sites are omitted from this table, even though some are near to the coast. Several of the sites listed are of either National Nature Reserve (NNR) or Site of Special Scientific Interest (SSSI) status, although other sites may warrant similar stature on the basis of their invertebrate interest; the current lack of data prohibits their inclusion here.

Ravenscroft (1994) highlights the exceptional importance of certain coastal cliff habitats for the conservation of burnet moths. Three scarce species occur in the region, with the threatened *Z. viciae argyllensis* restricted to a single ungrazed, herb-rich slope where the favoured larval foodplant bird's-foot-trefoil *Lotus corniculatus* grows. *Z. loti scotica* has the same foodplant but prefers grazed areas with bare ground and is virtually restricted to the basalt undercliffs of Mull. The third species, the transparent burnet moth *Z. purpuralis caledonensis*, also prefers grazed areas but has thyme *Thymus praecox* as its larval foodplant. Other scarce species associated with rocky coast sites include the grey *Hadena caesia*, a moth restricted to the Isle of Man and the west coast of Scotland, where the larvae feed on the seeds of sea campion *Silene maritima*.

Dunes and machair systems contain a range of scarce species, some of which, for example the belted beauty moth *L. zonaria*, may be specific to them. The beetles *Hypocaccus rugiceps* and *Anthicus scoticus* also occur, the former associated with carrion and the latter with vegetation litter. Some scarce species, such as the micro-moth *Scrobipalpa clintoni*, inhabit foreshore areas just above the high water mark, where its larvae feed on curled dock *Rumex crispus* on sand or shingle habitats. Others, for example the threatened leaf beetle *Chrysolina crassicornis*, which feeds on plantains, may be associated with grasslands. The micro-moth *Anacampsis temerella* lives on creeping willow *Salix repens* growing either on rocky knolls or in sandhills near the sea.

Table 5.3.2 Coastal Red Data Book (RDB) species in Region 14

Species	*Status*	*Description and notes on recorded occurrence in the region*
New Forest burnet moth *Zygaena viciae argyllensis*	pRDB1	Extremely rare, known from only a single locality in western Scotland, where the larvae are associated with bird's-foot-trefoil *Lotus* spp. The now extinct subspecies *ytensis* used to occur in the New Forest.
Chrysolina crassicornis	pRDB2	Leaf beetle recorded from cliff tops, dry grassland and sandy hills in maritime situations. Plant-eating, associated with plantains *Plantago* spp. and perhaps toadflaxes *Linaria* spp. Egg-laying onto sea plantain *P. maritima* has been observed. Larvae feed externally on the foodplant during summer. Known only from Scotland. Post 1970 records from Argyll mainland & Orkney.
Zygaena loti scotica	RDB3	A burnet moth that inhabits low cliffs and grassy banks near the sea and apparently only where the larval foodplant, common bird's-foot-trefoil *Lotus corniculatus*, grows in association with bell heather *Erica cinerea*, heather *Calluna vulgaris* and bracken *Pteridium aquilinum*. Known only from Argyll. There are doubtful records from other localities in Scotland.
Lycia zonaria	RDB3	A moth found on coastal sandhills where the larvae feed on bird's-foot-trefoils, burnet rose *Rosa pimpinellifolia* and other low-growing plants. The female moth is wingless. The male has brown and white striped wings. Recorded from Caernarvonshire, Cheshire, Lancashire, Argyllshire and the Hebrides. A forthcoming review of macro-moth status re-grades this species as Notable A (see Kirby 1994b).
Anthicus scoticus	pRDB3	2-2.5 mm long reddish ant beetle living in strandline refuse, decaying seaweed etc. in saltmarshes. Until recently known only from the west of Scotland, Cumbria and the Isle of Man. Has recently been discovered in Kent and Devon.
Omalium rugulipenne	pRDBK	Exclusively maritime rove beetle which has been found under seaweed on sandy coasts. Recorded from North Devon, Glamorgan, Flintshire, Cheshire, South Lancashire, Durham, the Dee district and Jura before 1970 and from North Somerset since 1969.

Source: JNCC (after Kirby 1994a, b). Key: Red Data Book categories: RDB1 = endangered; RDB2 = vulnerable; RDB3 = rare; RDB K = insufficiently known; pRDB = proposed species as categorised in e.g. Hyman & Parsons (1992), except pRDB K = proposed species as categorised in e.g. Hyman & Parsons (1994). For further description of RDB categories, see Shirt (1987) and Bratton (1991).

Table 5.3.3 Sites important for invertebrate conservation

Site	*Grid ref.*	*Status*
Ballantrae	NX0882	Undesignated
Ailsa Craig	NX0199	SSSI
Maidens to Doonfoot coast (includes Culzean Castle)	NS2309	SSSI, National Trust for Scotland (part)
Brodick Country Park (Isle of Arran)	NS0138	National Trust for Scotland
Taynish	NR7384	NNR/SSSI
Ardmore Kildalton & Callumkill Woodlands (Isle of Islay)	NR4549	SSSI
Loch Corr (Isle of Islay)	NR2269	Undesignated
Pulpit Hill	NM8529	Undesignated
Lochan dubh Oban	NM8632	Undesignated
Ardconnel/Connel	NM9132	Undesignated
Clais Dhearg/Black Lochs	NM9331	SSSI
Moss of Achnacree	NM9235	Undesignated
Lismore Island (includes Lismore Lochs SSSI)	NM83	SSSI (part)
Port Appin coast	NM9044	Undesignated
Barcaldine Forest	NM9640	Undesignated
Glasdrum	NN0046	NNR
Colonsay and Oronsay	NR3894	Undesignated
Ross of Mull coast	NM5321	SSSI
Kilfinichen Bay	NM4928	Undesignated
Ardmeanach (Isle of Mull)	NM4429	SSSI
Aros	NM5545	Undesignated
Isle of Ulva	NM4238	Undesignated
Lagganunva Woodland	NM4541	SSSI
Kilninian	NM3945	Undesignated
Glen Noe	NM0733	Undesignated
Gunna Island	NM1051	Undesignated
Coll	NM26	Undesignated

Source: JNCC ISR. Key: NNR = National Nature Reserve; SSSI = Site of Special Scientific Interest.

RDB or nationally scarce invertebrates associated with woodland habitats are represented. Many of these are restricted to Scotland, and although occurring mainly inland, significant populations are also known from coastal areas. One example, the click beetle *Harminius undulatus*, is associated with decaying timber.

Wetland habitats such as bogs, small lochs and flushes contain populations of many scarce species, sometimes including boreal or arctic species such as the diving beetle *Dytiscus lapponicus*. Other scarce water beetles found are *Hydroporus longicornis,* from flushes, and the whirligig *Gyrinus distinctus,* in a few lochs. Some coastal lochs also support populations of the legally protected medicinal leech *Hirudo medicinalis*. Flood plain marshes with lush vegetation are the habitat of the threatened snail *Succinea oblonga*.

5.3.3 Human activities

The main threats to invertebrate communities in the region include inappropriate management of sites and direct habitat loss or degradation, such as by construction of stabilising sea defences or the clearing away of organic strandline debris. Appropriate management of sites is vital for maintaining invertebrate interest, since invertebrates occur in the full range of coastal habitats and many require particular microhabitats in a suitable condition, often using subtle features of vegetation structure or areas of bare ground. As invertebrates generally have annual life cycles, the habitat features they utilise must be present in the right condition in each and every year. This is compounded by the fact that many scarce species have poor powers of dispersal and are thus unable to colonise suitable habitat from afar. Site management often overlooks many features that are of importance to invertebrates, many species surviving by default. Grazing has the potential to both create and destroy or damage invertebrate habitat. Appropriate levels of grazing maintain the varied ground conditions and heights of sward that favour a variety of invertebrates. On some sites insufficient or no grazing allows vegetation to become rank and dense, reducing the range of species that it can support and favouring commoner species. However, too heavy grazing reduces the value of, for example, maritime grassland for invertebrates, by increasing nutrient levels in the soil and altering soil structure, thus changing the plant species that occur and restricting the height of the vegetation. Along flushes, where ground water emerges along slopes, heavy poaching can be particularly damaging, as the trampling crushes the soft plants and cuts through the sward, leading to soil erosion and muddying of the water. The differing requirements of the scarce and threatened burnet moths in this region illustrate how critical management of vegetation may be. The fundamentals of managing coastal habitats for invertebrates are covered by Kirby (1992).

5.3.4 Information sources used

The data used here come from the JNCC's Invertebrate Site Register, a computerised GB-wide database based on literature searches of entomological journals and those of local naturalist societies, collation of data from local biological record centres and the Biological Records Centre, Monks Wood, and consultation with invertebrate specialists and non-governmental organisations.

Most of the better known invertebrate groups have been recorded along this section of coast, some much more frequently than others. The Lepidoptera (including both macro- and micro-moths) and aquatic Coleoptera (water beetles) are probably among the best studied taxa in the region. Other groups that are fairly well represented in the ISR data set include Mollusca (slugs and snails), Coleoptera (beetles) and Diptera (flies).

The level of recording around the region varies considerably, although only a few areas have been studied in detail. There is a wealth of published entomological information for certain areas, in particular some of the islands, including historic and modern studies; Smith & Smith (1983) provide a bibliography. Examples of modern reviews or surveys for particular taxonomic groups include Bland *et al.* (1987), Foster & Eyre (1988), Welch (1983) and Wormell (1983). There have also been detailed studies on particular threatened species, for example Barbour & Waring (1991) and Ravenscroft *et al.* (1993). Colvin & Reavey (1993) provides a comprehensive list of addresses for societies, individuals and national and local recording schemes.

5.3.5 Acknowledgements

Thanks are due to D. Procter and Dr S. Ball (JNCC) for providing raw data from the ISR and for assistance in producing maps.

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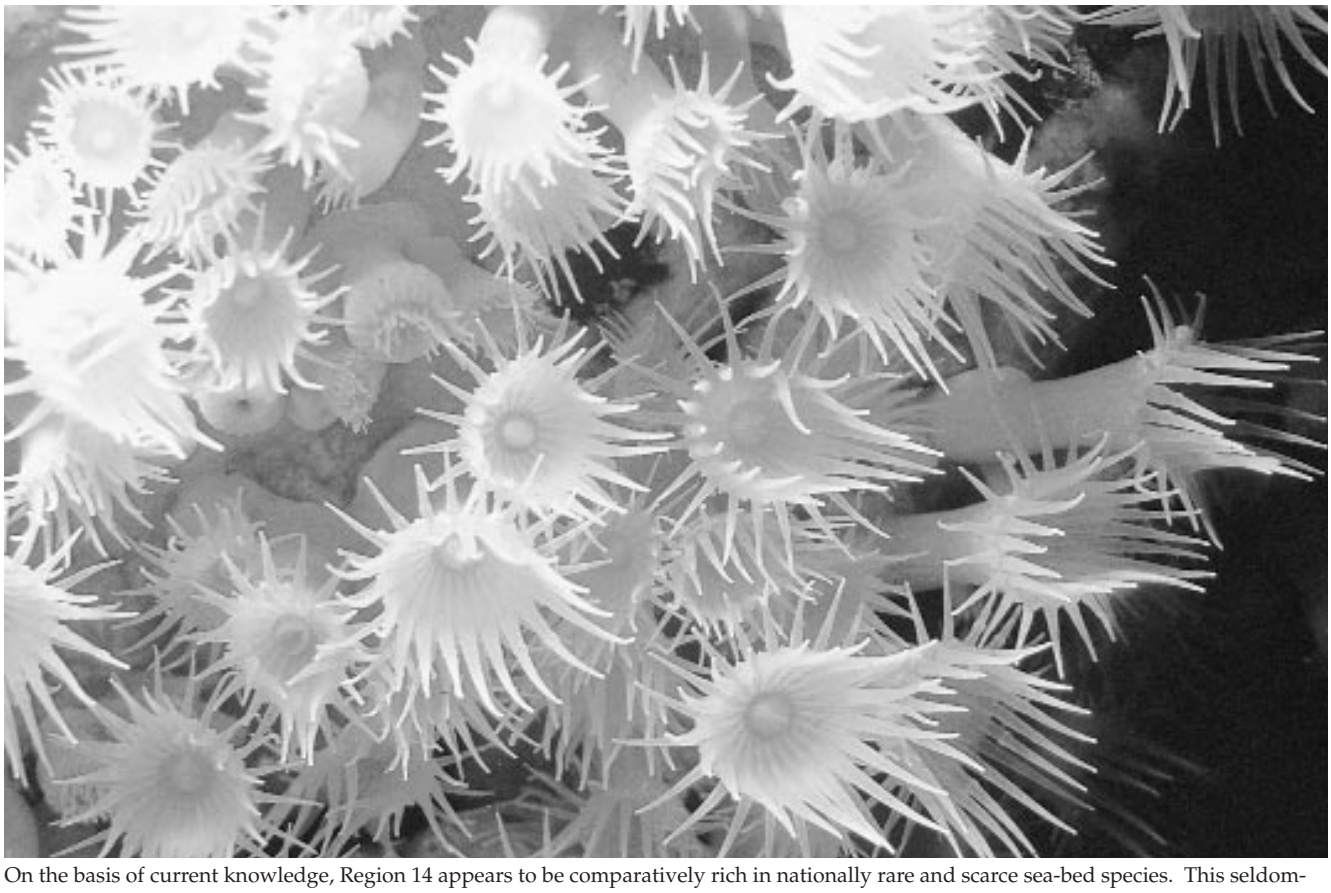
C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Biological records for Arran	Arran Biological Records Centre, The Ranger Centre, Brodick Country Park, Brodick KA27 8HY, tel: 01770 302462
Ayrshire based biological records	Curatorial Assistant, Centre for Environmental Recording in Ayrshire, The Dick Institute Museum & Art Gallery, Elmbank Avenue, Kilmarnock KA1 3BU, tel: 01563 526401
National recording databank for aquatic Coleoptera	Balfour-Browne Club/ Dr G.N. Foster, 3 Eglinton Terrace, Ayr KA7 1JJ, tel: 01292 260064
Occurrence of plants and animals in Britain and Ireland	*Biological Records Centre, ITE Monks Wood, tel: 01487 77338
Conservation of butterflies and moths	British Butterfly Conservation Society, Glasgow Art Gallery & Museum, Kelvingrove, Glasgow G3 8AG, tel: 0141 305 2660
ISR: computerised national inventory of sites of significance to invertebrate conservation; contains localised records of scarce and threatened species of all groups of non-marine invertebrates	*Invertebrate Site Register, JNCC, Peterborough, tel: 01733 62626

Type of information	*Contact address and telephone no.*
Databank of literature-based Scottish insect records	Scottish Insect Records Index, c/o Dr M.R. Shaw, National Museums of Scotland, Chambers Street, Edinburgh EH1 1JF, tel: 0131 225 7534
Invertebrate ecology	*Invertebrate Ecologist, SNH, RASD, Edinburgh, tel: 0131 554 9797
Species on SSSIs and NNRs, other protected areas, distribution of data on rare and scarce species, rare plant surveys, licensing and protected species in Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Species on SSSIs and NNRs, other protected areas, distribution of data on rare and scarce species, rare plant surveys, licensing and protected species in south of region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
Specialist knowledge of Lepidoptera occurring in the region	Dr M. Young, Dept. of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB9 2TN, tel: 01224 272000

*Starred contact addresses are given in full in the Appendix.



On the basis of current knowledge, Region 14 appears to be comparatively rich in nationally rare and scarce sea-bed species. This seldom-found sea anemone, *Parazoanthus anguicomus*, occurs on subtidal rock in the Sound of Mull and perhaps elsewhere in more northerly and deeper waters. Photo: Christine Howson.

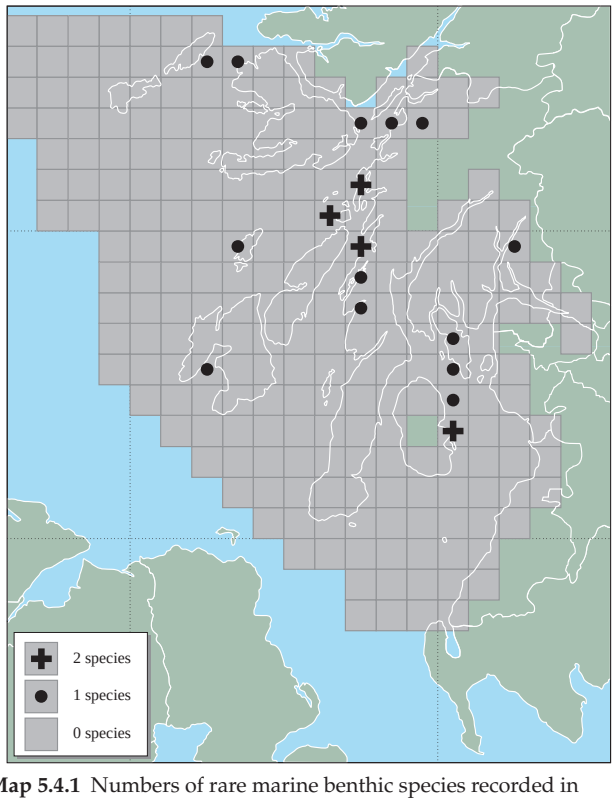
5.4 Rare sea-bed species

J. Plaza & Dr W.G. Sanderson

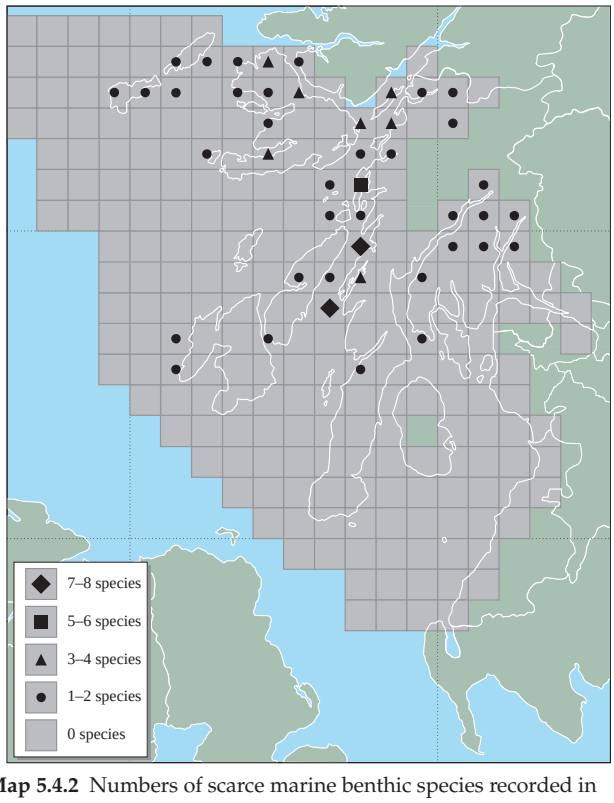
5.4.1 Introduction

This section considers rare and scarce benthic marine (sea-bed) species, excluding fish. The occurrence and distribution of benthic communities is discussed in section 4.2. 'Nationally rare' benthic marine species in this section are those native organisms that occur in eight or fewer of the 10 km squares (of the Ordnance Survey national grid) containing sea within the three-mile territorial limit for Great Britain. 'Nationally scarce' are those that occur in nine to 55 such squares. This methodology and these criteria are analogous to those used for other groups of organisms in British Red Data Books (e.g. Bratton 1991) and by the International Union for Conservation of Nature and Natural Resources (IUCN) (see IUCN Species Survival Commission 1995). The development of the current criteria and the choice of study area for rarity assessment in the marine benthos of Great Britain are discussed in detail by Sanderson (1996). Species considered in this chapter are those conspicuous and readily identifiable in the field by the Marine Nature Conservation Review (MNCR) and similar techniques or for which taxonomic or biogeographic experts consider that sufficient data exist on a national basis to warrant their inclusion. Species at the limit of their global distribution (e.g. 'southern' or 'northern' species) may be rare within Great Britain's territorial seas but common towards the centre of their distribution. Of the 40 species listed from this region, five are southern species near, or at, the northern margins of their range, and five are northern species approaching their southern limits of distribution. A species described here as 'nationally rare' or 'nationally scarce' is not therefore necessarily endangered globally, and although it is without doubt of national interest, its conservation importance needs to be carefully considered. The analysis in this section represents the first attempt to quantify the rarity of marine benthic species and to summarise the known occurrence of rare and scarce species in Great Britain. As either more data become available or populations change, the status of species listed in this chapter will require re-evaluation.

Region 14 appears to be comparatively rich in nationally rare and scarce species: there are thirteen rare and 26 scarce benthic marine species recorded from this region. Maps 5.4.1 and 5.4.2 summarise their current known occurrence. In both maps, species numbers in the 10 km squares that straddle the border between this and other regions include only records from Region 14. Areas around Loch Sween and its approaches and amongst the islands to the east and north-east of Jura apparently contain more rare and scarce benthic marine species than other areas in this region. This appearance may be somewhat misleading, however, since survey effort in this region is not uniform, being concentrated on the coast of Argyll and in the Clyde Sea area. None of the rare and scarce species in Region 14 is currently protected under the Wildlife and Countryside Act 1981 or listed under the EC Habitats and Species Directive.



Map 5.4.1 Numbers of rare marine benthic species recorded in 10 km squares containing sea within the 3 mile limit. Distribution may reflect differences in recording effort.



Map 5.4.2 Numbers of scarce marine benthic species recorded in 10 km squares containing sea within the 3 mile limit. Distribution may reflect differences in recording effort.

5.4.2 Important locations and species

Table 5.4.1 lists the rare and scarce benthic marine species that have been recorded in Region 14, together with their known areas of occurrence and other key information. Species names, and their order of appearance in the table, are after Howson (1987). Species that are likely to be very under-recorded or overlooked on a national scale have not been included. Whereas every effort has been made to obtain biogeographic data for rarity assessment in the present study, data have not been used from reports prior to 1965.

Some nationally rare and scarce species described here are restricted to very specific habitat types in Great Britain that themselves are rare or scarce and in some cases threatened. Such species may therefore be of obvious nature conservation importance. Species confined to saline lagoons, maerl or seagrass beds have been so considered (see e.g. Anon 1995). Within this region of Great Britain species may also be 'nationally rare' or 'scarce' because they are Mediterranean-Atlantic species at the margins of their distribution in Great Britain. It has been argued that populations of many sessile (non-mobile) southern species have a poor capacity for recovery and only replace their numbers slowly near the margins of their distribution and are therefore particularly vulnerable to even the most minor, infrequent impacts. Communities of southern species have therefore been considered important as reference sites for monitoring the marine environment in the UK (Fowler & Laffoley 1993). Northern species in Region 14 at the southernmost extent of their distribution may be similarly considered. Ecological and pragmatic arguments for the conservation of populations of species that are rare because they are at the margins of wider distributions are summarised by Hunter & Hutchinson (1994).

The complex coastline to the east and north-east of Jura contains the highest numbers of both rare and scarce species in the region, particularly at Loch Sween, Loch Crinan, Loch Craignish and in the area around Insh. Here, the combination of a highly dissected coast and a series of inshore islands leads to a very high habitat diversity in which more species are likely to occur, and this would correspondingly increase the likelihood that rarities will also be found in such localities. The diversity of the area has also attracted many marine biological studies; increased survey effort in these areas is thus also a factor in the high numbers of rare species recorded.

None of the species from this region is known to be a common deep-water species, and so it is unlikely that any appear rare simply because their distribution only just includes the generally shallower near-shore sea area that is the focus of this study. Some of the listed species, however, are likely to occur to some extent in the waters of Great Britain beyond the scope of this study.

5.4.3 Information sources used

The sites of intertidal and subtidal benthic survey data utilised in this analysis are mapped in section 4.2. In Region 14 many of the available data come from Marine Nature Conservation Review (MNCR) survey work and earlier Nature Conservancy Council-funded surveys. There is also a history of collecting associated with the University Marine Biological Station, Millport, and the Scottish Marine Biological Association (now the Scottish Association for Marine Science) at Dunstaffnage. Additional records have been considered following personal communications with experts in many taxonomic fields. It has not been possible in this chapter to list all the available literature on which this analysis has been based, but the information reviews and recent papers listed in sections 5.4.5 and 4.2.6 should allow access to the majority of the available information.

Research effort in Region 14 has historically been greatest in the Clyde Sea area, owing primarily to the presence since *c.* 1885 of a marine research laboratory on Millport. Further north, extensive studies of the rocky shore biota were first undertaken by Kitching (1935) and later by Lewis (1957); soft sediment fauna were first surveyed by Elliot *et al.* (1901) and Stephen (1929), among others. In Region 14 old records exist of species not reported since. These include algae found by Batters (1902) at the beginning of the century from around the Firth of Clyde, such as *Symphyocarpus strangulans* and *Derbesia tenuissima.* A mid-18th century record of the Peacock's tail alga *Padina pavonica* also exists from the same area (McNab undated, in Price *et al.* 1979). Other apparently rare/scarce organisms reported only in old records are the amphipods *Epimeria tuberculata, Dulichia tuberculata, Corophium affine, Monoculoides borealis* in the Clyde Sea and Argyll (Moore 1984) and *Metopa solsbergi*, which was found at Keppel Pier, Millport (Moore 1984). It would be valuable to attempt to confirm old records.

MNCR survey work uses a consistent methodology to record conspicuous species (Hiscock 1996). Not all the data available from surveys in this region are as broad in scope as MNCR surveys and they may not include less common species or those less familiar to a specialist worker. Inconsistent recording has, however, not substantially reduced the quantity of available information for rarity assessment in this region. The MNCR of Great Britain is at present incomplete but in future will substantially increase the quality and evenness of distribution of the available data. This combined with other surveys will almost certainly expand our knowledge of the 'nationally rare' and 'scarce' species in Region 14. Consequently the nationally rare and scarce status of the organisms presented here may require re-evaluation and in future further species may be added to the list for this region. Populations of species with short life histories, such as ephemeral algae and sea slugs, may require more regular re-evaluation of their occurrence than others.

5.4.4 Acknowledgements

The author is grateful for the assistance of the JNCC former Marine Conservation Branch and Coastal Conservation Branch, as well as for the advice of Dr. R. Bamber, Dr J.M. Baxter, Dr J. Brodie, P.F. Clark, D.W. Connor, Dr R.L. Fletcher, Dr J.D. Fish, Dr P.R. Garwood, Dr J.M. Hall-Spencer, Dr T. Harris, Dr P.J. Hayward, Dr K. Hiscock, J.M. Light, I.J. Killeen, Dr G. Könnecker, Dr C.A. Maggs, Dr J.D. McKenzie, Prof. P.G. Moore, J.J. Moore, D. Moss, Prof. T.A. Norton, Dr J.D. Nunn, B.E. Picton, D.R. Seaward, Dr. S. Smith, Dr E.C. Southward, I. Tittley and Dr R.B. Williams. Access to the JNCC's MNCR Database and the NIBESRC Database at the Ulster Museum has been invaluable for the overall analysis, as has the general assistance of Dr T.O. Hill.

Table 5.4.1 'Nationally rare' and 'nationally scarce' benthic marine species found in Region 14

Species	*Type of organism*	*Area(s) of occurrence*	*Habitat/associations*	*Comments*	*Useful reference*
Axinella damicornis	Sponge	Loch Crinan	On vertical and horizontal faces at sites of moderate wave action. Sometimes with some silt at depths generally below 20 m.	Mediterranean species at limit of range. This record is the northernmost for the British Isles.	Ackers *et al.* (1992)
Phakellia ventilabrum	Cup sponge	Sound of Mull	Slightly sheltered locations near to deep water	May also occur offshore. May be quite habitat-specific.	Ackers *et al.* (1992)
Mycale lingua	Sponge	Firth of Lorne, Loch Craignish, Loch Sween, Sound of Mull, Loch Linnhe, SW of Insh Island	Generally in deeper water but with a wide depth range	Very conspicuous species	Ackers *et al.* (1992)
Clathria barleei	Sponge	Firth of Lorne	Subtidal on rocks and stones, usually at more than 40 m depth	Possibly an offshore species	Ackers *et al.* (1992)
Plocamilla coriacea	Sponge	SW of Insh Island	Often on vertical or overhanging subtidal bedrock in areas of flowing water. Often has other sponges attached.	Southern species. Distribution includes the Mediterranean.	Ackers *et al.* (1992)
Thecocarpus myriophyllum	Hydroid	Approaches to Loch Sween, Loch Crinan, Sound of Mull, Loch Linnhe, Loch Craignish	Subtidal on sandy substrata	May be associated with deep water and only scarce near shore	Hayward & Ryland (1990)
Diphasia alata	Hydroid	Lower Loch Linnhe	Subtidal rock from around 30-580 m	Scattered records from Shetland, west Scotland, Cornwall, south Devon and SW Ireland	Cornelius (1995)
Tamarisca tamarisca	Hydroid	Loch Sween	Sublittoral rock	Occurs around GB and north to Arctic	Cornelius (1995)
Obelia bidentata *	Hydroid	Loch Etive	On a wide variety of substrata	Temperate to warm water global species	Cornelius (1995)
Parerythropodium coralloides	Soft coral	Loch Scridain, SW of Insh Island, Sound of Mull	Overhangs and crevices out of light, sheltered from strong wave action, 0-25 m	More common in SW Europe and the Mediterranean. Somewhat cryptic but still probably scarce.	Manuel (1988)
Pachycerianthus multiplicatus	Fireworks anemone	Loch Goil, Loch Long, Loch Fyne, Loch Etive, Loch Aline, Sound of Mull	Partly buried in muddy substratum from 10-130 m depth	Elsewhere known only from Scandinavia, Ireland and rest of W Scotland	Manuel (1988)
*Arachnanthus sarsi**	Anemone	Coll, Firth of Lorne, Tiree	Found in a mixture of shell sand amongst bedrock from 15-36 m	Discovered in several localities in W Scotland. Previously known only from Norway (140 m depth).	Picton & Manuel (1985)
Parazoanthus anguicomus	Anemone	Sound of Mull, SW of Insh Island, Loch Crinan, Loch Craignish	Usually on subtidal rock	Possibly a deep-water species	Manuel (1988)
*Amphianthus dohrnii**	Sea fan anemone	Loch Crinan, SW of Insh Island, Firth of Lorne	Found on sea fan *Swiftia pallida*	Sporadic occurrence. Also from Scandinavia to the Mediterranean.	Manuel (1988)
Halcampoides purpurea (= elongatus)	Burrowing anemone	NW coast of Mull	In subtidal gravel	Nocturnal, hence overlooked. Cautiously regarded as rare.	Manuel (1988)
Mesacmaea mitchellii	Burrowing anemone	Loch Etive, Loch Creran	Low shore and subtidal sediments; partly protruding	Southern species. Can be locally frequent in SW England.	Manuel (1988)

Table 5.4.1 'Nationally rare' and 'nationally scarce' benthic marine species found in Region 14 (continued)

Species	*Type of organism*	*Area(s) of occurrence*	*Habitat/associations*	*Comments*	*Useful reference*
Edwardsia timida	Burrowing anemone	Loch Creran, Loch Feochan, Loch Tarbert	Low shore and subtidal gravels; partly protruding	Populations are localised	Manuel (1988)
*Caryophyllia inornata**	Cup coral	Loch Crinan	Typically in sheltered and shaded subtidal rock (0-30 m)	Resembles a more common relative. Edge of range in GB. Common in Mediterranean.	Manuel (1988)
Amalosoma eddystonense	Echiuran worm	Loch Fyne, Loch Sween	Buried quite deep in muddy gravels	Difficult to sample, but still probably scarce	Hayward & Ryland (1990)
Eriopisa elongata	Amphipod	Off Holy Island Arran	Soft mud at 118 m	Only two records before 1965; one since then	Moore (1984)
*Monoculodes gibbosus**	Amphipod	Loch Fyne	Muddy, sandy gravel	Possibly one of the rarest marine amphipods in Great Britain. To date known only from the present site.	Beare & Moore (1994)
*Monoculodes packardi**	Amphipod	Off Glen Sannox, Arran, Holy Island, Arran, Loch Fyne	Deep water mud, from 20-500 m	Northern species also recorded from the Arctic Ocean, the North Sea and from Skagerrak. Present locations are the only recent records in Britain.	Moore (1984)
*Sophrosyne robertsoni**	Amphipod	Clyde Sea area and off Oban	Unknown	Possibly one of the rarest marine amphipods in GB. To date, known only from the Clyde Sea area and Oban.	Moore (1984)
Austrosyrrhoe fimbriatus (#)*	Amphipod	Clyde Sea area and Argyll	Possibly characteristic of maerl substrata in SW Britain	Known only from a few British localities	Moore (1984)
Hydrobia neglecta	Lagoon snail	Luing	In hyposaline lagoons, with salt concentrations usually above 10 g/kg	Seems to favour living on pondweeds *Potamogeton* spp. and eelgrass *Zostera* spp.	Cherril & James (1985)
*Bugula purpurotincta**	Bryozoan	SW Insh Island, Firth of Lorne	Low water to shallow sublittoral on shells, stones and hydroids	A northern species. Occurs north through Norway to Spitzbergen.	Hayward & Ryland (1990)
Ophiopsila annulosa	Brittle star	Garvellachs	Coarse gravel only, buried	Possibly under-recorded, but its habitat is rare	Picton (1993)
Paracentrotus lividus	Purple sea urchin	West coast of Tiree, east coast of Coll, Loch na Keal	Often in rockpools in limestone rocks. Rarely in deeper water to 30 m.	Distribution may have been affected by human predation. Common in W Ireland.	Picton (1993)
Leptoclinides faeroensis	Sea squirt	Loch Sween and approaches	On stones, shells and other hard objects from intertidal zone to 2,000 m	Also recorded from the southern Irish Sea, the western Norwegian coast and more northerly waters	Millar (1970)
*Styela gelatinosa**	Sea squirt	Loch Goil	In muddy sediment to 60 m	Only record for British Isles for this Scandinavian species	Millar (1966)
Molgula oculata	Sea squirt	Sound of Mull, Loch Scridain	Low shore and sublittoral coarse sands, usually partly protruding	Possibly under-recorded	Hayward & Ryland (1990)
Gelidiella calcicola#*	Red seaweed	Jura and Islay, Loch Sween, Coll and Tiree	Normally confined to maerl	Localised in restricted habitat	Maggs & Guiry (1987)

Table 5.4.1 'Nationally rare' and 'nationally scarce' benthic marine species found in Region 14 (continued)

Species	*Type of organism*	*Area(s) of occurrence*	*Habitat/associations*	*Comments*	*Useful reference*
Callophyllis cristata	Red seaweed	Lower Loch Linnhe, Loch Creran, Loch Fyne, Loch Caolisport	Sublittoral to 30 m. Epiphytic on haptera ('roots') of kelp *Laminaria* spp.	Northern species. Can be confused with *Spaerococcus* spp. and *Plocamium* spp., hence may be under-recorded. Its southern limit is reported to be Northumberland.	Irvine (1993)
Schmitzia hiscockiana	Red seaweed	Loch Sween (and around Coll and Tiree and the west coast of Islay)	Sublittoral on tide swept cobbles	Scattered distribution in GB. Restricted habitat. Common at sites of occurrence. Possibly endemic to the British Isles.	Maggs & Guiry (1985)
*Halothrix lumbricalis**	Brown seaweed	Loch Caolisport	Epiphytic on eelgrass *Zostera* spp. leaves	Annual, April to October	Fletcher (1987)
*Battersia mirabilis**	Brown seaweed	Colonsay	Epiphytic on other algae; recorded at 6-9 m depth	-	Norton *et al.* (1969)
Desmarestia dresnayi	Brown seaweed	Dunstaffnage Straits, Rubha an Ridire, Loch Caolisport, Loch Craignish, Loch a'Chumhainn, SE Lunga	Epilithic on small stones and shells. Embedded in gravel in sublittoral areas of moderate to strong water current.	Annual, May to September. Easily overlooked but probably scarce.	Fletcher (1987)
Leblondiella densa	Brown seaweed	Loch Indaal	Epiphytic on decaying stems of eelgrass *Zostera* spp.	Annual; June to August	Fletcher (1987)
Asperococcus scaber	Brown seaweed	Loch Sween	On stones in pools on lower shore	Seasonal, distribution unknown	Fletcher (1987)

In the absence of a specific common name the nearest available group name has been used. Key: *nationally rare; # = maerl or in association with maerl. Note: many of the scarce species listed here are only a little more common than the rare species listed.

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Bryozoans	Dr P.J. Hayward, School of Biological Sciences, University College Swansea, Singleton Park, Swansea, West Glamorgan SA2 8PP, tel: 01792 205678
Brown algae	Dr R.L. Fletcher, University of Portsmouth, Marine Laboratory, Ferry Road, Hayling Island, Hants. PO1 10DG, tel: 01705 876543
Red algae	Dr C.A. Maggs, School of Biology & Biochemistry, Queen's University of Belfast, Belfast BT7 1NN, tel: 01232 245133

*Starred contact addresses are given in full in the Appendix.

5.5 Exploited sea-bed species

C.F. Robson

5.5.1 Introduction

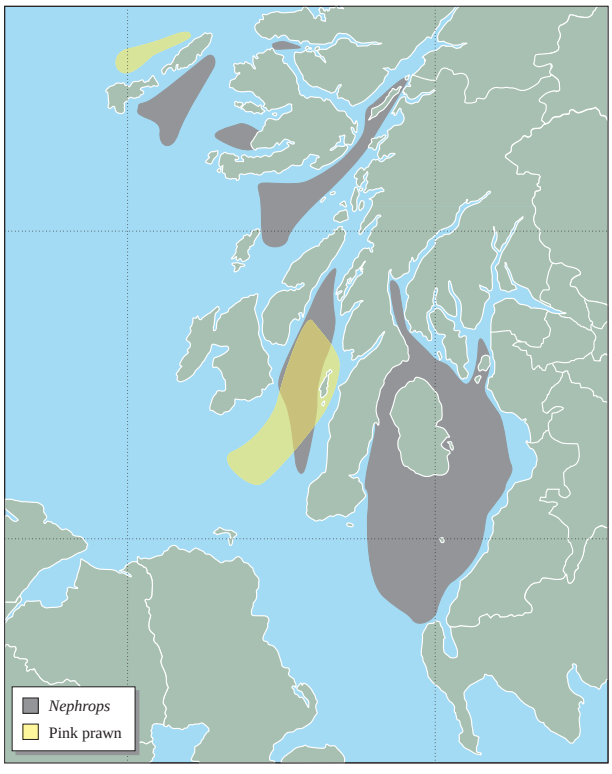
This section describes the distribution of large populations of species that live on, near, or in the bottom sediments of the sea bed (collectively called 'the benthos') and that are routinely exploited, mainly for human food. The exploitation itself is described in sections 9.1 and 9.2. Many of these species also provide an essential food source for other species, such as fish and birds, for example seabirds, waders and wildfowl. Most of the species discussed have planktonic larvae; the dispersal of planktonic larvae and the interrelation between populations of the same species can only be inferred from studies on movements of water masses. Their distributions are determined by factors such as water temperature (see section 2.3) and available habitat/substrate type (see also section 4.2). The species described may also be found elsewhere in the region, but in smaller numbers.

All species apart from *Nephrops* are referred to by their common names in the text. The scientific names of the species are given in Table 5.5.1.

This region is characterised by distributions of exploited species such as lobster, edible crab, velvet crab, crawfish, squat lobster, *Nephrops*, whip prawns, pink prawns, cockles, mussels, scallops and queen scallops. There are no known exploitable quantities of brown shrimp, spider crab, deep water prawn or native oyster in the region.

Table 5.5.1 Species names

Common name	*Scientific name*
Lobster	*Homarus gammarus*
Edible or brown crab	*Cancer pagurus*
Velvet crab	*Necora puber*
Squat lobster	*Munida rugosa*
Dublin Bay prawn, scampi, Norway lobster or langoustine	*Nephrops norvegicus*
Whip prawn (or shrimp - referred to as both)	*Dichelopandalus bonnieri*
Pink prawn (or shrimp - referred to as both)	*Pandalus montagui*
Brown shrimp	*Crangon crangon*
Spider crab	*Maja squinado*
Crawfish, spiny lobster	*Palinurus elephas*
Deep-water prawn (or shrimp - referred to as both)	*Pandalus borealis*
Cockle	*Cerastoderma edule*
Mussel	*Mytilus edulis*
Native oyster	*Ostrea edulis*
Periwinkle	*Littorina littorea*
Scallop	*Pecten maximus*
Queen scallop	*Aequipecten opercularis*
Whelk	*Buccinum undatum* & *Neptunea antiqua*
Razor shell	*Ensis* spp. & *Solen marginatus*
Cephalopods (octopus and squid)	*Eledone cirrhosa* & *Loligo forbesii*
Lugworm	*Arenicola marina*
Ragworm	*Neanthes virens* & *Hediste diversicolor*
Algae, for example knotted wrack & kelp	*Ascophyllum nodosum* & *Laminaria* spp.



Map 5.5.1 Distribution of crustacea: *Nephrops* and pink prawn
Source: SOAEFD; Lee & Ramster (1981). © SOAEFD.

5.5.2 Important locations and species

Crustacea

Lobster, edible crab and velvet crabs are distributed inshore throughout the region wherever there is suitably rocky habitat. Edible crabs are more often found on softer sediments - ranging from sand/gravel to rock - than lobsters. Juveniles tend to be found inshore and adults further offshore (Rees & Dare 1993). Crawfish are a westerly species and are found in the region but are less common than lobster and crab. Squat lobsters have a wide distribution within the region, but are more common on coarser substrates.

The broadscale distributions of *Nephrops* and pink prawns are shown on Map 5.5.1. The distribution of *Nephrops* is determined by its preference for a sea bed of mud and muddy sand, into which it burrows; in this region there are populations in deeper waters such as the Firth of Clyde, Sound of Jura and Firth of Lorn. Pink prawns are found in the deep waters of the Sound of Jura and in an area north of Coll and Tiree. Whip prawns may be found in the same areas as pink prawns, but are generally much less abundant.

Molluscs

Cockles are found in the intertidal mud and sandflats of the estuaries and other sheltered sites in this region. The main known location of significance is in the Firth of Clyde. Mussels are found around most of the coast in the region, from the mid shore to the subtidal zone in water of normal

or variable salinity, and in areas exposed to water currents. On exposed rocky shores mussels are generally small, whereas larger-sized mussels (thus more exploitable) are confined mainly to sheltered inlets such as sea lochs. Mussels attach themselves using 'byssus threads' to sand, gravel or pebble substrata or other mussels and empty shells and have the effect of binding the substratum. In the Clyde Estuary mussels are known to occur widely in the upper reaches, such as at Pillar Bank, and there is also a population in Campbeltown Loch. However, there is relatively little information on the location and size of most mussel populations in the region. Periwinkles are found in abundance on rocky shorelines throughout the region, wherever suitable habitat is present. The native oyster does not occur in exploitable quantities in the region.

Scallops and queen scallops live on sandy/gravelly areas of sea bed. Important populations of scallops and queen scallops are present in many areas of the region; however, queen scallops are not as widely distributed as scallops - especially north of Kintyre. The broad-scale distributions of scallops and queen scallops in the region are shown in Maps 5.5.2 and 5.5.3 respectively. Whelks are widely distributed throughout the region, with *Neptunea* being more common in the deeper waters of Loch Etive and in the more offshore areas of the region. Concentrations of squid occur seasonally in the region and octopus are also present. Razor shells occur in inshore areas where the sea bed is clean sand.

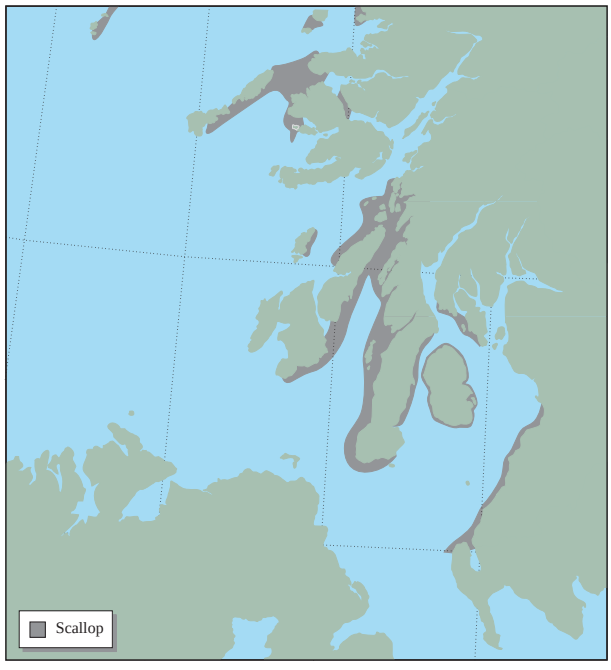
Other potentially exploitable burrowing bivalve molluscs, such as razor shells, are present at various sites within the region (McKay 1992).

Polychaetes

The intertidal and subtidal zones in the region's estuaries support populations of polychaetes, such as the lugworm and ragworm. Lugworms are common in less exposed areas where there is a higher organic content in the substratum. They occur elsewhere in a wide range of sediment types, from almost pure mud to clean sand (Davidson *et al.* 1991).

Others

Seaweeds such as the knotted wrack and kelp are common on the sheltered shores of the regions, especially in sea lochs (Maggs 1986).



Map 5.5.2 Main locations of scallops. © SOAEFD.

Map 5.5.3 Main locations of queen scallops. © SOAEFD.

5.5.3 Human activities

The exploitation by fisheries of the species covered in this section is described in detail in section 9.1, and by mariculture in section 9.2. The major issues relating to the exploited sea-bed species in this region are the state of the stocks in relation to the levels of exploitation, possible effects of harvesting on non-target species and competition between fisheries and other predators such as birds.

Nephrops is considered to be a 'pressure stock', which means that it is perceived to be over-exploited (Anon 1995). It is subject to catch quota management by the setting of an annual Total Allowable Catch (TAC), which limits landings (see section 9.1.3). The TAC for *Nephrops* effective in Region 14 covers ICES Division VIa (West of Scotland).

There are full year and seasonal closures on the use of mobile fishing gear (trawl, seine net, dredge - including suction dredging - etc.) and other prohibitions made under the Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989 (see also section 9.1.3). This was issued under the Inshore Fishing (Scotland) Act 1984 and is applicable in three areas in the region - The Gare Loch, Firth of Clyde and Loch Sween (Map 9.1.3). Lobster, edible and velvet crabs, *Nephrops* and scallops all have a minimum landing size. SOAEFD conducts triennial reviews of inshore fishing legislation under the Inshore Fishing (Scotland) Act 1984. The most recent review was completed in 1996.

Scallop fishing in Scotland is the subject of a consultation by SOAEFD. An assessment of the main scallop stocks at the end of 1994 concluded that there was

concern over the state of the stocks, in particular the sustainable rate of exploiting the fisheries in the east and north-east of Scotland. A weekend ban on fishing for scallops from May until September has been proposed in all Scottish inshore waters, to prevent fishing effort from increasing. The possible effects on the benthos, feeding birds and shellfish stocks of harvesting shellfish species are discussed in some of the publications in section 5.5.6 B.

Bait collection, especially the digging of polychaetes, can have major localised effects on intertidal habitats and communities and can also cause disturbance to birds, particularly when they are concentrated in estuaries and embayments (see sections 5.11.3 and 5.12.3 and publications in section 5.5.6 B). Bait collection in the region is described in section 9.1.2.

The knotted wrack was traditionally harvested from the sheltered shores of sea lochs across the region. It was burned to supply the sodium and potash industry (Howson *et al*. 1994); however, since the collapse of the market for potash this no longer occurs. The processing of knotted wrack for alginates occurs at Girvan, using harvests from the Western Isles. Stranded kelp plants such as *Laminaria hyperborea* are traditionally collected for agricultural use, such as for fertilising crofts and as animal feed. There is currently no harvesting of kelp from the sea. The impact of kelp harvesting is detailed in Wilkinson (1995).

5.5.4 Information sources used

The maps in this section show schematically the known broad-scale distributions of the main species of interest, based on information made available from the SOAEFD Marine Laboratory on the locations of the species and their fisheries. There is supporting information in the form of commercial landings statistics, biological samples and surveys. These data provide some information about the location of spawning and nursery areas. To establish the links between individual areas for spawning, nursery and adults would require specific research vessel investigations on the planktonic stage, the hydrography and the movement (or otherwise) of juveniles and adults. Barring substantial climate change or over-exploitation, these distributions and relationships are likely to remain stable over several decades. The seaward boundaries on the maps are only indicative, and because only large, exploitable populations are described, the species may also be found elsewhere in the region, but in smaller numbers. Some other species of bivalve molluscs, for example *Dosinia exoleta* and *Venerupis* spp., are also widely exploited in the region, although details are currently unavaliable.

Information was also used from Lee & Ramster (1981) and Pawson (1995); the latter contains distribution maps of scallops, lobster, edible crab and spider crab around the British Isles and has a species-specific bibliography. McKay (1992) reports on a survey of potentially exploitable burrowing bivalve molluscs, such as razor shells, and identifies their presence at various sites within the region.

5.5.5 Acknowledgements

The author thanks David McKay (SOAEFD Marine Laboratory), who provided maps and information for this section, and Michael Hayes (City of Glasgow Council), Patrick Stewart (Clyde Fishermen's Association), J. Kinnear (SOAEFD Marine Laboratory), David Donnan (Scottish Natural Heritage) and Martin Sayer and John Gage (Dunstaffnage Marine Laboratory), for comments on the draft.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Marine and estuarine research on exploitable species	*SOAEFD Fisheries Research Services, Marine Laboratory, Aberdeen, tel: 01244 876544
Benthic surveys; Marine Nature Conservation Review (MNCR) database	*MNCR Team, JNCC, Peterborough, tel: 01733 62626
Marine conservation issues	*Aquatic Environments Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797
Marine conservation issues	*Fisheries Officer, JNCC, Peterborough, tel: 01733 62626
Marine conservation issues	*Conservation Officer, RSPB, Sandy, tel: 01767 680551
Marine conservation issues	*Conservation Officer, WWF Scotland, Aberfeldy, tel: 01887 820449, or *Fisheries Officer, WWF-UK, Godalming, tel: 01483 426444
Marine conservation issues	*Conservation Officer, Marine Conservation Society, Ross-on-Wye, tel: 01989 566017

*Starred contact addresses are given in full in the Appendix.

5.6 Amphibians and reptiles

Dr M.J.S. Swan

5.6.1 Introduction

This region is important for the conservation of amphibians and reptiles. It supports seven of the widespread species of amphibian and terrestrial reptiles native to the UK - common frog *Rana temporaria*, common toad *Bufo bufo*, smooth newt *Triturus vulgaris*, palmate newt *T. helveticus*, slow-worm *Anguis fragilis*, common lizard *Lacerta vivipara* and adder *Vipera berus* - as well as the rare and restricted sand lizard *Lacerta agilis*. Sand lizards were introduced onto the island of Coll in 1970 and were confirmed as extant on the island in 1992 (Corbett 1994). The nationally rare great crested newt *Triturus cristatus* has not been recorded along this coast in recent years, although it occurs inland (Herpetofauna Consultants International in prep.; Swan 1994; McCleary pers. comm.; Wiseman pers. comm.); more intensive searching could reveal coastal populations. This region is beyond the northern limit of the UK distribution range of the grass snake *Natrix natrix*.

Marine turtles have been recorded relatively frequently in this region: since 1980, nine leatherback turtles *Dermochelys coriacea* and three loggerhead turtles *Caretta caretta* have been reported (McCarthy pers comm; Langton *et al.* 1996). Most of the reports were from the Loch Fyne area and around the Isle of Bute. The leatherbacks were all sighted alive, as were two of the three loggerheads. The dead loggerhead was found on Colonsay. Three unidentified turtles have also been recorded: one sighted off the Ayrshire coast and two from Argyll & Bute.

The sand lizard, the great crested newt and both the turtle species are totally protected under the Wildlife & Countryside Act 1981, although all the species listed are afforded some degree of protection under national and international legislation (Table 5.6.1).

Table 5.6.2 shows the numbers of amphibian and terrestrial reptile records in the region in relation to survey effort.

Overall the diversity of amphibian species in the region is quite low: only 42% of surveyed 10 km squares in Region 14 support at least three species, compared with 49% for the West Coast as a whole (Map 5.6.1). Reptile diversity is comparatively higher - 52% of squares contain at least three species, compared with 44% for the West Coast (Map 5.6.2). Recorded diversities of both amphibians and reptiles are highest around the Upper Clyde. The reason for the comparatively low figures could simply be low recording effort, although they could also reflect genuinely low diversity on the islands of the region, where fewer species would be expected.

Table 5.6.1 Protected status of amphibians and reptiles occurring in the region

Species	*Protection (see footnote)*
Amphibians	
Common frog *Rana temporaria*	1, 2, 3
Common toad *Bufo bufo*	1, 2
Smooth newt *Triturus vulgaris*	1, 2
Palmate newt *Triturus helveticus*	1, 2
Reptiles	
Slow worm *Anguis fragilis*	1, 2
Common lizard *Lacerta vivipara*	1, 2
Sand lizard *Lacerta agilis*	1, 2, 3
Adder *Vipera berus*	1, 2
Loggerhead turtle *Caretta caretta*	1, 2, 3, 4
Leatherback turtle *Dermochelys coriacea*	1, 2, 3, 4

Key: 1 = Wildlife & Countryside Act (1981); 2 = Bern Convention (1979); 3 = EC Habitats & Species Directive (1992); 4 = CITES Convention.

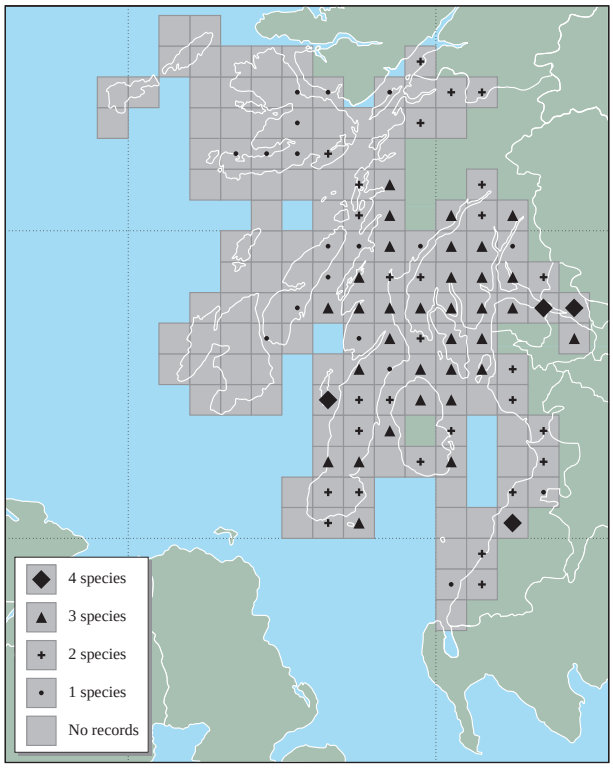
5.6.2 Important locations and species

The sand lizards on Coll are the only terrestrial herpetofaunal species of national and international importance to occur in this region. Otherwise, no individual areas of particularly high amphibian or reptile

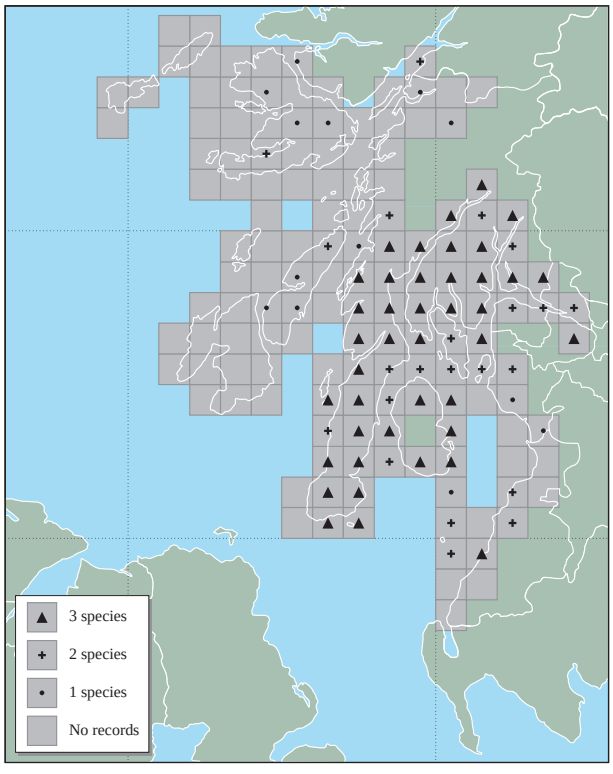
Table 5.6.2 Records of amphibians and terrestrial reptiles related to survey effort

	*Total no. of 10 km squares***	*% 10 km squares surveyed for:*			*Total no. of individual records:*		*Mean no. of individual records per surveyed 10 km square:*	
		any herp. species	*amphibians*	*reptiles*	*amphibians*	*reptiles*	*amphibians*	*reptiles*
South Ayrshire	13	77	62	46	27	16	3.4	2.7
North Ayrshire	17	88	76	82	37	46	2.8	3.3
Inverclyde	4	100	100	100	17	10	4.3	2.5
Renfrew	3	100	100	100	15	7	5.0	2.3
Dumbarton*	6	100	100	100	22	16	3.7	2.7
Argyll & Bute*	117	61	53	47	197	145	3.2	2.6
Region 14	***160***	***68***	***60***	***55***	***315***	***240***	***3.3***	***2.7***
West Coast	620	63	53	49	3,383	1,536	10.2	5.1
GB coast	1,124	69	59	49	7,524	3,138	11.3	5.7
GB (coast and inland)	2,862	84	79	66	27,182	8,803	12.1	4.7

Source: Biological Records Centre, Monks Wood. Key: *former District area referred to; data not collated according to new local authority boundaries; **total includes squares that are partly in the district, but excludes squares that are exclusively marine.



Map 5.6.1 Numbers of amphibian species recorded in coastal 10 km squares. Distribution may reflect difference in recording effort. Source: Biological Records Centre, ITE Monks Wood.



Map 5.6.2 Numbers of reptile species recorded in coastal 10 km squares. Distribution may reflect difference in recording effort. Source: Biological Records Centre, ITE Monks Wood.

species abundance have been identified, either from national records or by individual consultees. Nevertheless, it is likely that the extensive stretches of remote and undisturbed coastline in the west of the region support large numbers of amphibians and reptiles.

Frogs, toads and palmate newts are found throughout the region in a variety of breeding habitats, reflecting variations in human density and land-use. Throughout the whole region the high annual rainfall provides ample temporary standing water in which frogs may breed. The palmate is the dominant small newt species, smooth newts being much less common and with a very localised distribution.

South of Girvan, there are few ponds in the coastal areas and amphibians are restricted to marshes and reed beds. Further north, however, they breed also in lochs, farm ponds, mineral extraction sites, forest fire ponds and ditches. Frogs also spawn in garden ponds, puddles and on wet hillsides. Toads are reported to spawn in rivers and other flowing water-bodies, and in areas of dry substrate, such as around Culzean Castle, they can be more common than frogs. Around the urban and industrial areas of Renfrewshire, West Dumbartonshire and the periphery of Glasgow, amphibian breeding sites include mineral extraction sites, lochs, reservoirs and flowing water. Frogs and newts utilise all of these, but toads are found mainly in the larger water-bodies (Swan 1994, 1995). In the more remote districts of South Ayrshire and Argyll & Bute, amphibians breed in natural wetlands such as marshes. Frogs, toads and palmate newts are reported to breed in splash zone pools above high water mark, which receive salt water and must sometimes be brackish. The three species also breed in lochs, lochans and roadside ditches and frogs also spawn in temporary standing water and shallow forest ditches.

For reptiles, undisturbed areas of coastal grassland and heath, inland cliffs, moorland and scree throughout the region comprise essential habitat. West of the Clyde these semi-natural habitats form extensive landscapes extending right up to the coast; as a result reptiles are not restricted to a narrow coastal strip, as they are in the south-east of the region. In North Ayrshire and Inverclyde common lizards, adders and slow-worms are found along the raised beaches in areas of short turf, scrub, coastal heath, rocks and scree and are also associated with drystone dykes. Adders are particularly abundant on the former sea cliffs that back the raised beaches in places. All three species are recorded in Renfrewshire and West Dumbartonshire, in the heath and moorland inland of the coastal roads and settlements.

Amphibians and reptiles are found on many of the islands of the region. The offshore distributions of the species are described in papers collated in a bibliography of the reptiles and amphibians of the west of Scotland (Gibson 1988).

5.6.3 Human activities

In the agricultural areas of the south-east of the region, the loss of field ponds, the drainage of coastal marshes and the improved drainage and fertility of coastal farmland has led to the loss of suitable habitat for amphibians. Habitat has also been lost through the growth of coastal towns. In the upper Clyde area, water-bodies have been lost to urban and industrial expansion, deliberate drainage of obsolete reservoirs, lack of management and the frequent use of ponds and quarries as landfill sites or for small-scale dumping. Surface-water acidification has been demonstrated to pose a significant threat to amphibians in the UK in areas

of high precipitation, base-poor soils and slowly weathering bedrock, such as occur in the north of the region (e.g. Cummins 1990; Cummins & Ross 1986; Beattie *et al.* 1993). This region receives the highest levels of acid precipitation in Scotland, the problem being particularly acute in the Cowal and the Gare Loch area (Morrison 1994). Widespread planting of conifers may contribute to the acidification.

In the south of the region reptile ranges have contracted through habitat loss and fragmentation. Farming improvements have led to a loss of semi-natural areas, and reptiles in coastal habitats around towns are subject to human disturbance and predation by domestic cats. In the north and west parts of the region the main threat apparent is afforestation: at ground level coniferous plantations are too shaded for reptiles, which need sunshine in which to bask.

Marine turtles are included in Scottish Natural Heritage's (SNH's) Species Action Plans. All sightings should be reported to SNH in Edinburgh.

5.6.4 Information sources

Sixty-eight percent of the 10 km squares comprising this region have received some survey coverage. Amphibians have been searched for in 60% of squares and reptiles in 55%, a slightly more extensive degree of survey coverage than for the British West Coast as a whole, where it is 53% and 49% respectively. In general, the districts south and east of the Firth of Clyde have received better coverage than those in the north and west of the region. The information shortfall in South Ayrshire, Argyll & Bute and associated islands probably reflects the dearth of (potential) recorders in a sparsely populated area. In terms of the thoroughness of the recording effort (i.e. the number of records generated per surveyed 10 km square), coverage is thin. The regional averages of approximately three records per 10 km square for both amphibians and reptiles are lower than the figures for the West Coast as a whole.

National distribution data for the widespread amphibians and terrestrial reptiles were provided by the Biological Records Centre (BRC) at Monk's Wood (Arnold 1983, 1995). These comprise post-1970 species records held by BRC. The NARS formed the focus of national amphibian and reptile recording during the 1980s and early 1990s (Oldham & Nicholson 1986, Swan & Oldham 1989, 1993a, 1993b). Most of these data were collected through a volunteer, mainly amateur, recorder network. Further information on the distribution of the adder and the great crested newt in Scotland is provided in reports to Scottish Natural Heritage by Reading *et al.* (1994) and Herpetofauna Consultants International (in prep.) respectively.

Information on sand lizard distribution was provided by English Nature Lowlands Team (Peterborough) and Corbett (1994). Marine turtle distribution data were supplied by the Natural History Museum, Southampton University and Penhallurick (1990); all sightings at sea and strandings should be reported to the Natural History Museum in London. Concise information on turtle identification, reporting of sightings, UK legislation and instructions on what to do with turtles caught in fishing gear is contained in *The turtle code* (Nature Conservancy Council 1990). Information on local impacts and habitat associations was provided by Scottish Natural Heritage, National Trust for Scotland and other local contacts.

5.6.5 Acknowledgements

Thanks are due to the following people for providing information: Henry Arnold, David Batty, Clive Cummins, Martin Gaywood, Tony Gent, J.A. Gibson, Rosemary Green, Jim McCleery, Richard Sutcliffe, Nicole Wallace and Stephen Wiseman.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Conservation and captive breeding of amphibians and reptiles, nationally	British Herpetological Society, c/o The Zoological Society of London, Regent's Park, London NW1 4RY, tel: 0181 452 9578
Conservation of threatened reptiles and amphibians in Britain; priority species in Europe	Conservation Officer, The Herpetological Conservation Trust, 655A Christchurch Road, Boscombe, Bournemouth, Dorset BH1 4AP, tel: 01202 391319
National secretariat to local amphibian and reptile groups	Common Species Co-ordinator, Herpetofauna Groups of Britain and Ireland, c/o HCIL, Triton House, Bramfield, Halesworth, Suffolk IP19 9AE, tel: 01986 84518
National recording schemes and biological data from throughout UK	*Environmental Information Centre, ITE Monks Wood, Huntingdon, tel: 01487 773381
Turtles	Dr C. McCarthy, Natural History Museum, Cromwell Road, London SW7 5BD, tel: 0171 938 9123
Turtles	Dept. of Oceanography, Southampton University, Highfield, Southampton SO9 5NH, tel: 01703 595000
Amphibians and reptiles in Scotland, including turtles	*Scottish Natural Heritage, RASD, Edinburgh, tel 0131 554 9797
Amphibians and reptiles in Scotland	Institute of Terrestrial Ecology, Banchory Research Station, Glassel, Banchory, Grampian Region AB31 4BY, tel: 01330 823434
Amphibians and reptiles in south of region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
Amphibians and reptiles in Argyll & Bute	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Amphibians and reptiles in region	National Trust for Scotland, Culzean Castle, Maybole, Ayrshire, tel: 01655 760269
Amphibians and reptiles in region	Scottish Natural History Library, Foremount House, Kilbarchan, Renfrewshire PA10 2EZ, tel: 015057 2419
Amphibians and reptiles in region	Kelvingrove Art Gallery and Museum, Dumbarton Road, Glasgow G3 8AG, tel: 0141 357 3929
Amphibians and reptiles in region	Paisley Museum and Art Gallery, High Street, Paisley, Renfrewshire PA1 2BA, tel: 0141 889 3151
Amphibians and reptiles in region	*Scottish Wildlife Trust, Ayr, tel: 01290 52668
Amphibians and reptiles in region	*Scottish Wildlife Trust, Lanark, tel: 01555 666868
Amphibians and reptiles in region	Islay Natural History Centre, Easter Ellister, Port Charlotte, Islay PA48 7UE, tel: 01496 850288

*Starred contact addresses are given in full in the Appendix.

5.7 Fish: exploited sea fish

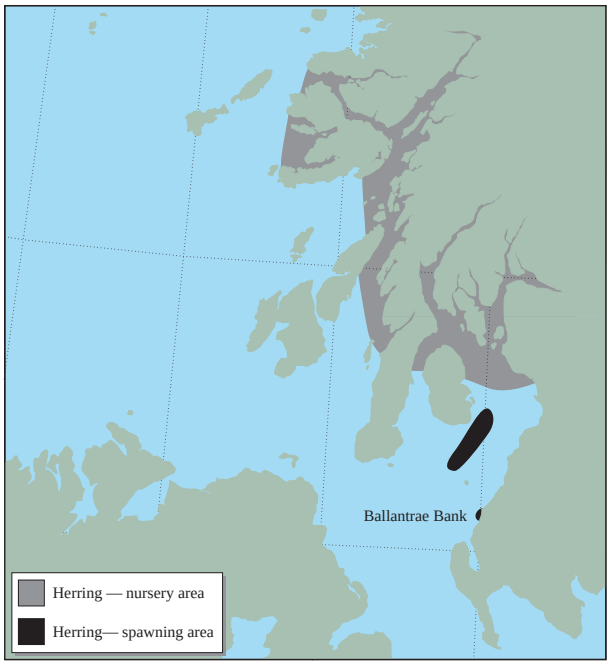
C.F. Robson

5.7.1 Introduction

This section describes the distribution of sea fish that are of interest because they are exploited by people, mainly for food. Their exploitation by fisheries is described in section 9.1. Sea fish described as pelagic are most commonly found in shoals swimming in midwater; they typically make extensive seasonal movements or migrations between sea areas. Demersal fish are those found living at or near the bottom of the sea. For this section, all sea fish that are not 'pelagic' are termed 'demersal'; thus the latter term includes bass and grey mullet. Demersal species are divided here into four groups: elasmobranchs (sharks, skates and rays), gadoids (the cod family), flatfish, and other demersal fish. Most demersal species gather in late winter or spring on persistent and recognisable spawning grounds, to release millions of minute free-floating eggs. From these hatch larvae, which feed on and move with the plankton, often for a hundred miles or more, before metamorphosing into tiny fish, which in some cases may recruit to inshore nursery grounds.

The distribution of exploited sea fish species can be mapped from analysis of catch data. This description of their distribution covers their occurrence at identifiable locations in the region during particular phases of their life history, and Maps 5.7.1 and 5.7.2 show the known spawning and nursery areas of key species. Barring substantial climate change, stock collapse or other factors, these distributions and relationships will remain stable over several decades.

Table 5.7.1 lists the main pelagic and demersal species occurring in the region and give examples of protection measures in this region.



Map 5.7.1 Herring spawning and nursery areas. Source: Lee & Ramster (1981), SNH (pers. comm.). © Crown copyright.

Map 5.7.2 Norway pout and whiting spawning areas. Source: Lee & Ramster (1981). © Crown copyright.

5.7.2 Important locations and species

Of the pelagic species, mackerel are widely distributed around Britain and are present in the seas of the region, more commonly in the summer. Mackerel spawn throughout the shelf waters of the British Isles, but most prolifically along the edge of the continental shelf. Growing juveniles and adults migrate to coastal waters after spawning, where they remain until autumn. Overwintering concentrations of Western stock mackerel are found west of Scotland, west of Ireland and off Cornwall. There have been significant changes in the distribution and migrations of adult mackerel in the last 20 years. In particular, there has been a marked northerly shift in the over-wintering area and the timing of the southerly migration back to the spawning grounds south-west of Ireland (Walsh & Martin 1986).

Herring are locally abundant in the summer and autumn in feeding areas throughout the region. The spawning areas in the Firth of Clyde, including Ballantrae Bank, are shown on Map 5.7.1. The decrease in abundance of herring in the Firth of Clyde can be attributed to reduced recruitment to the local spring-spawning stock. The cause of this may be natural, but the effects of exploitation cannot be ruled out (Bailey *et al.* 1986). Herring larvae drift to shallow nursery areas in the sea lochs of the region (Map 5.7.1); De Silva (1973a) describes the importance of these sea lochs as herring nursery areas. Studies on West Coast herring larvae and juveniles indicate that they may be carried by tidal currents to nursery grounds in the North Sea (Heath & MacLachlan 1986).

Sprat are found only in the shallower areas of the region in winter, especially when they migrate inshore to overwinter between September and March. Although some

Table 5.7.1 Pelagic and demersal species and examples of measures for their protection

Species	*Protection measures*
Pelagic species	
Mackerel *Scomber scombrus*	MLS/QM
Horse mackerel *Trachurus trachurus*	MLS/QM
Herring *Clupea harengus*	MLS/QM
Sprat *Sprattus sprattus*	No limitation
Demersal species	
Elasmobranchs	
Spurdog *Squalus acanthias*	No limitation
Lesser spotted dogfish *Scyliorhinus canicula*	No limitation
Thornback ray *Raja clavata*	No limitation
Cuckoo ray *Raja naevus*	No limitation
Basking shark *Cetorhinus maximus*	No limitation
Gadoids	
Cod *Gadus morhua*	MLS/QM
Whiting *Merlangius merlangus*	MLS/QM
Haddock *Melanogrammus aeglefinus*	MLS/QM
Norway pout *Trisopterus esmarkii*	No limitation
Ling *Molva molva*	No limitation
Pollack *Pollachius pollachius*	MLS/QM
Saithe *Pollachius virens*	MLS/QM
Hake *Merluccius merluccius*	MLS/QM
Flatfish	
Plaice *Pleuronectes platessa*	MLS/QM
Dab *Limanda limanda*	MLS
Long rough dab *Hippoglossoides platessoides*	No limitation
Dover sole *Solea solea*	MLS/QM
Lemon sole *Microstomus kitt*	MLS
Turbot *Psetta maxima*	MLS
Brill *Scophthalmus rhombus*	MLS
Megrim *Lepidorhombus whiffiagonis*	MLS/QM
Witch *Glyptocephalus cynoglossus*	MLS
Flounder *Platichthys flesus*	MLS
Other demersal fish	
Monkfish (angler) *Lophius piscatorius*	QM
Conger eel *Conger conger*	MLS
Gurnards *Triglidae* spp.	No limitation
Sandeels *Ammodytes* spp.	No limitation

Source: European Council (1986, 1995); SOAEFD (pers. comm.).
Key: MLS = minimum landing size; QM = catch quota management.

sprat spawn in coastal waters, they mainly migrate to offshore areas, with spawning peaking between May and July. De Silva (1973b) describes the reproductive biology of sprats in the Firth of Lorne area. Langham (1969) describes the aggregations of sprats in sea lochs around Mull.

Elasmobranch species produce relatively small numbers of live young (10-100 per year, but can be fewer in large shark species) or lay large eggs on the sea bed close to their nursery areas. Several species of elasmobranch occur sporadically, such as the spurdog, lesser-spotted dogfish, thornback ray and cuckoo ray. Other species of ray (such as *Raja batis*) are thought to have undergone a significant reduction in numbers in and around the Irish Sea. The basking shark was once the basis of a fishery and has been recorded in the region since the turn of the century.

Of the gadoids, cod is one of the most important exploited fish species in the North Atlantic and is widely distributed in the region in the summer; spawning peaks during February. Whiting are abundant and widely distributed in the region, especially in inshore waters. The large whiting spawning area in the Northern Irish Sea is within the region's southern area and reaches into the Firth of Clyde (Map 5.7.2). The spawning season is prolonged - from January to July, depending on the latitude - and there are likely to be other spawning areas that have not been identified. The Firth of Lorne is also an important nursery ground for whiting (Gordon 1977b, c; Cooper 1980).

Haddock are widely distributed in the region and are present in large numbers in the summer and autumn. Spawning takes place between February and May, with a peak in March and April; the main spawning areas are outside the region in deeper water (Lee & Ramster 1981). There are no recognised nursery areas, as juvenile haddock are widely distributed. Norway pout is found in deep water offshore in the region and can be a target for the industrial fishery. Most Norway pout spawn for the first time at the age of two years, between January and April far offshore (Map 5.7.2). This spawning area spreads towards the shore and the juveniles are common in sea lochs (Gordon 1977a; Cooper 1980). Ling, pollack and saithe are less abundant than haddock and Norway pout and more locally distributed, particularly around rocky reefs and wrecks. Small hake normally occur in shallow water, whereas larger, commercial sized fish are generally found in deeper water, for example in Kilbrannan Sound and the North Channel.

Plaice, dab and long rough dab are abundant in the region. These species occur on sandy areas of sea bed throughout the region, with juveniles living close to the shore in nursery areas, gradually moving to deeper water as they grow. Much more is known about the life history of the commercially-exploited plaice than the dabs. The knowledge of plaice spawning areas is obtained from the distribution of newly-spawned eggs in spring, determined from plankton surveys (Lee & Ramster 1981). Dab spawn from January to June and are locally abundant. The juveniles move to coastal nurseries in the autumn and migrate to deeper water as they grow. Long rough dab are widespread in the region but are most common in the Firth of Lorne and the Firth of Clyde (Rae 1970). Dover sole have a similar lifestyle to plaice and dab but are more confined to areas with higher sea temperatures and are therefore scarce in the region. Turbot and brill are much less abundant but have a similar lifestyle to plaice, dab and Dover sole. Turbot spawn from May to August (Rae & Devlin 1972). None of the flatfish species exhibits extensive migrations, though the larvae can drift for several weeks from offshore spawning grounds to sandy inshore nursery areas. There may be some interchange, either way, between spawning stocks and nursery grounds in this and adjacent regions. Lemon sole are widespread in the region and favour deeper water than plaice, where rocky or boulder-strewn sea bed is interspersed with rough gravel (Rae 1970). It is assumed that lemon sole spawn wherever they are found, beginning in May and ending in October. Megrim and witches tend to be found only in the deepest water of this region and there are no separate nursery or spawning areas recognised in the region. Flounders migrate in the summer between inshore, estuarine and even riverine nursery areas in the region to spawn up to 20 or 30 miles offshore in late winter, and there appears to be little long-shore coastal movement other than in the egg or larval phase.

Monkfish (angler) spawn in deep water along the

continental shelf edge, mainly between March and June, but juveniles and non-spawning adults can be found throughout the region. Other exploited demersal species of minor importance are conger eel and gurnards. Sandeels are present in the region (Lee & Ramster 1981) and provide an important food source for many exploited fish species. Their distribution is associated with that of the coarse sand they burrow into.

5.7.3 Human activities

A feature of all fish stocks, and the primary reason for their fluctuation, is the variability of recruitment of juvenile fish to the exploited populations. This variability, the causes of which are not fully understood, is determined by environmental conditions at the time of spawning and in the subsequent larval survival. Exploitation of fish stocks may increase the extent of these fluctuations.

In Scottish inshore waters (to 6 nautical miles from baselines) the principal tools of fisheries management are the Inshore Fishing (Scotland) Act 1984 and orders issued under it (see also section 9.1.3). These give the Secretary of State powers to regulate fishing in specified inshore waters and to prohibit the carriage of specified types of net and the use of mobile gear near fixed salmon nets. There are full year and seasonal closures on the use of mobile fishing gear (trawl, seine net, dredge - including suction dredging - etc.), made under the Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989, in areas in the region (Map 9.1.3). SOAEFD conducts triennial reviews of inshore fishing legislation under the Inshore Fishing (Scotland) Act 1984. The most recent review was completed in 1996.

Efforts are made to conserve stocks of pelagic and demersal species by implementing a variety of management measures, including: minimum landing sizes (MLS), minimum mesh size regulations, gear restrictions, bycatch restrictions and quantitative controls on catches of 'pressure stock' species (through catch quota management by the setting of annual Total Allowable Catches (TACs, further explained in section 9.1). Two such protection measures are presented in Table 5.7.1: MLS and catch quota management (QM), which indicates that the UK has been allocated a TAC in the ICES Division that cover Region 14 - Division VIa. Their implementation means that fish caught below MLS or for which the quota is exhausted must be discarded at sea, and this may affect the exploited species fish stocks, as well as other fish, birds and species that live on the sea bed.

Elasmobranch species do not have any protected status in the region. As a result of the relatively long time they take to reach reproductive maturity and the small numbers of young that they produce, they are held to be particularly vulnerable to exploitation.

Spawning and nursery areas may be vulnerable to other activities, such as effluent discharge (Haig 1986), sewage sludge dumping, dredging and dredge spoil dumping and the development of infrastructure such as barrages and pipelines. All dredging activities have short-term, localised effects, such as the removal of material and organisms, but long-term effects on fish stocks or morphology are much more difficult to assess, owing to the difficulty of determining which effects are the result of dredging and which the result of the many other factors operating (Doody *et al*. 1993). Short- or long-term changes in sediment deposition can result, as well as inevitable changes in the topography of the bed. SOAEFD is a statutory consultee for, or licenses, activities such as these, in which the distributions of exploited fish populations and their identifiable spawning and nursery areas have to be taken into account. Other activities, such as seismic activity for oil and gas exploration (Turnpenny & Nedwell 1994), may also have an effect on fish populations.

5.7.4 Information sources used

Whereas the life history of the exploited crustacean and mollusc species can be observed at or near the sites at which they are harvested, the distributions of fish populations can change considerably between juvenile and adult phases and with seasonal migrations. Therefore, the information used in this section is based on the distribution and relative abundance of fish species as revealed by fisheries catch statistics obtained from recorded commercial landing figures. In addition, information is used from research vessel catch data and data from biological sampling during fishing surveys. Data from these surveys on the occurrence of spawning fish and juveniles can be used to identify spawning and nursery areas. However, this information is sometimes limited, and there may be other areas in addition to those described or shown on the maps where the species might also occur. Research surveys involving plankton sampling, hydrographic studies, fishing and tagging are required to establish the links between spawning groups and specific nursery areas, and between growing juveniles there and the adult populations to which they eventually recruit. Lee & Ramster (1981) has been used as a source for the maps. Pawson (1995) shows distribution maps of selected fish and shellfish species around the north-east Atlantic and the British Isles and has a species-specific bibliography. A two-part review of the fish populations of the west of Scotland shelf includes the Clyde and regards Loch Sween and the Firth of Lorne as areas of special interest (Gordon & De Silva 1980; Gordon 1981). Gordon (1990) provides an additional overview of fish populations in the Firth of Lorne area.

European Council Regulations detailing the Total Allowable Catches (TACs) and the national catch quotas for fish and shellfish species for all European countries, and certain conditions under which the species can be fished, are published in Luxembourg in the Official Journal of the European Communities. These regulations are updated annually and the regulations for 1996 are given in European Council (1995).

5.7.5 Acknowledgements

Thanks go to the following for their advice and for commenting on drafts: David McKay, Derek Murison and John Hislop (SOAEFD Marine Laboratory), David Donnan (Scottish Natural Heritage), and John Gordon and Martin Sayer (Dunstaffnage Marine Laboratory).

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C. Contact names and addresses

Type of information	Contact address and telephone no.
Assessment and provision of advice on fish stocks in Scotland; marine conservation issues	*SOAEFD Fisheries Research Services, Marine Laboratory, Aberdeen, tel: 01224 876544
UKDMAP software with maps showing distributions of selected sea fish species and spawning areas	*Project Manager, BODC, Birkenhead, tel: 0151 653 8633
Marine research	Scottish Association for Marine Science (formerly the Scottish Marine Biological Association), Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll, PA34 4AD, tel: 01631 562244
Marine conservation issues	*Aquatic Environments Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797
Marine conservation issues	*Fisheries Officer, Peterborough, tel: 01733 62626
Marine conservation issues	*Conservation Officer, RSPB, Sandy, tel: 01767 680551
Marine conservation issues	*Conservation Officer, WWF Scotland, Aberfeldy, tel: 01887 820449, or *Fisheries Officer, WWF-UK, Godalming, tel: 01483 426444
Marine conservation issues	*Conservation Officer, Marine Conservation Society, Ross-on-Wye, tel: 01989 566017
Marine conservation issues	*Honorary Secretary, The Marine Forum for Environmental Issues, Scarborough, tel: 01723 362392

*Starred contact addresses are given in full in the Appendix.

5.8 Fish: salmon, sea trout and eels

C.F. Robson

5.8.1 Introduction

Diadromous fish spend part of their lives in fresh water and part at sea. The three exploited diadromous fish species covered in this section - the Atlantic salmon *Salmo salar*, sea trout *Salmo trutta* and eel *Anguilla anguilla* - are widespread in British waters and have been recorded in rivers in this region. (Twaite shad *Alosa fallax* are also diadromous but are included in section 5.9, as they are not routinely exploited.) The salmonids (salmon and sea trout) spawn in fresh water and then migrate out to sea to mature, while the eel matures in fresh water and reproduces at sea. Sea trout and brown trout are the same species, but the latter is a freshwater form and is therefore not covered in this section. Information on the life-cycles of these fish can be found in Jones (1959), Mills (1971, 1989), Moriarty (1978), Shearer (1992), Sinha & Jones (1975) and Tesch (1977).

5.8.2 Important locations

Salmon, sea trout and eels have a widespread distribution in the rivers and coastal seas of Britain. The distribution of salmon and sea trout is controlled by natural factors, such as river levels, by man-made barriers that may limit the extent to which they can go upstream, and by pollution levels. Sea trout generally have a westerly distribution in Britain. The rivers shown on Map 5.8.1 are the main ones that are known to contain populations of salmon and sea trout. It is highly likely that smaller rivers and tributaries not shown on the map will also contain populations. Eels are probably found in all river systems in the region, as elsewhere in Britain.

5.8.3 Human activities

The effects of exploitation, especially by different catch methods (rod and line or nets), is an issue for salmon and sea trout stocks (MAFF/SO 1991), especially the effects of commercial net operations during migratory phases. Drift netting has been an illegal salmon fishing method in Scotland since 1962. More specific concern relating to the state of wild salmon and sea trout stocks has focused on a wide range of potential anthropogenic and natural impacts, such as predation by aquatic mammals and birds. The pollution of rivers and inshore waters may affect the ability of fish to return to their natal river to spawn. For example, the River Clyde was once a famous salmon river but has been affected by pollution in the form of effluents from approximately half of Scotland's population and industry (Haig 1986). Water quality in the river is now improving and salmon and sea trout are slowly returning (Mackay 1990). Gilvear *et al.* (1995) discusses the modification of rivers in Scotland and argues that where rivers are permitted to flow in a natural manner, richer habitats, healthier environments and more productive resources will result. Maitland & Campbell (1992) describe the possible effects of various other issues of relevance to freshwater fish.

Map 5.8.1 Principal salmon and sea trout rivers/lochs. Source: SOAEFD.

There is now compelling evidence that salmon may belong to different genetic populations, each associated with its natal river, and that, in larger rivers at least, sub-stocks may be associated with different parts of the river system (Verspoor *et al.* 1991; Scottish Office Agriculture, Fisheries Department 1992). This aspect of salmonid stock definition is significant for the management of salmon fisheries because of concern regarding genetic interactions between wild stocks and escaped farmed fish and fish deliberately introduced for re-stocking purposes (Webb 1991; Webb *et al.* 1991). There is concern that these will impact on natural wild fish stocks and negatively affect salmon-fishing tourism.

5.8.4 Information sources used

The *Map of the distribution in Scottish rivers of the Atlantic salmon* Salmo salar *L.* (Gardiner & Egglishaw 1986) and the list of rivers for which the SOAEFD Montrose Field Station collates salmonid catch data were used as a basis for Map 5.8.1. The papers by Pemberton (1976a, b) describe the population distribution, movements and diet of sea trout in north Argyll sea lochs.

Under the provisions of the Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951, data are collected on catches of salmon and sea trout for each salmon fishery (see also section 9.1). The SOAEFD Montrose Field Station of the Freshwater Fisheries Laboratory collects, collates and publish these data annually as a *Statistical bulletin* (Scottish

Office 1996). The 'returns' are made through an annual questionnaire sent to proprietors and occupiers of salmon fishings. A high percentage of the forms sent out are returned (>95%). Picken (1987) discusses the history of Scottish west coast sea trout catches.

5.8.5 Acknowledgements

Thanks go to Derek Murison (SOAEFD Marine Laboratory), David Dunkley (SOAEFD), Jackie Milne (SOAEFD Montrose Field Station), Michael Hayes (City of Glasgow Council), Andrew Haig (SEPA West Region) and John Gordon and Martin Sayer (Dunstaffnage Marine Laboratory) for information, advice and comments on drafts.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Wild salmon and freshwater fisheries policy; contact details of the Clerks of the District Salmon Fishery Boards	SOAEFD Division K2, Pentland House, 47 Robb's Loan, Edinburgh EH14 1TY, tel: 0131 244 6230
Collation of salmon and sea trout catch statistics in Scotland	SOAEFD, Freshwater Fisheries Laboratory, Montrose Field Station, 16 River Street, Montrose DD10 8DL, tel: 01674 677070
Research into freshwater fish species, habitats, behaviour and exploitation in Scotland	SOAEFD, Freshwater Fisheries Laboratory, Faskally, Pitlochry, Perthshire PH16 5LB, tel: 01796 472060
Additional fisheries data to that published in the Statistical tables. Marine and estuarine fisheries research	*SOAEFD Fisheries Research Services, Marine Laboratory, Aberdeen, tel: 01224 876544
Conservation of wild salmon; salmonid research	Director, The Atlantic Salmon Trust, Moulin, Pitlochry PH16 5JQ, tel: 01796 473439
Conservation issues	*Aquatic Environments Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797
Inter-government convention regulating salmon fishing on the high seas	Secretary, North Atlantic Salmon Conservation Organisation, 11 Rutland Square, Edinburgh EH1 2AS, tel: 0131 228 2551

*Starred contact addresses are given in full in the Appendix.

5.9 Fish: other species

Dr G.W. Potts & S.E. Swaby

5.9.1 Introduction

There are 151 species of exploited and unexploited fish (out of a national total of 336) recorded from off the mainland in this region, comprising three jawless fish (Agnatha), 20 sharks and rays (elasmobranchs) and 128 bony fish (teleosts) (Potts & Swaby 1993b; Bagenal 1965; Halliday 1969). The species regional total is not definitive: some groups, such as skate, have not been identified to species level and the list must be considered incomplete.

This region has published records of all seven British marine and estuarine species protected under national, European and international legislation (Table 5.9.1). However, these have mostly been individual records of allis and twaite shads *Alosa alosa* and *A. fallax*, lampern *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus* and very occasional sturgeon *Acipenser sturio*. These species are considered threatened in UK and European waters (Potts & Swaby 1993a).

Table 5.9.1 Scheduled species and protected status

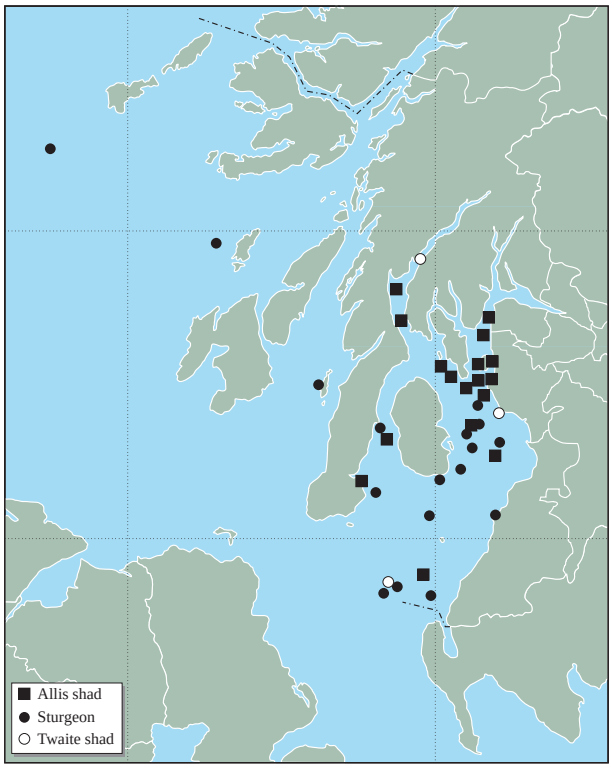
Species	*Wildlife & Countryside Act (Schedule)*	*EC Habitats & Species Directive (Annex)*	*Bern Convention (Appendix)*	*CITES (Appendix)*
Lampern		IIa, Va	III	
Sea lamprey		IIa	III	
Sturgeon	5	IIa, Va	III	I
Allis shad	5	IIa, Va	III	
Twaite shad		IIa, Va	III	
Common goby*			III	
Sand goby*			III	

Source: after Potts & Swaby (1993a). Key: *the sand and common gobies are both very abundant in the UK.

5.9.2 Important locations and species

The associations of fish with habitats are given in Potts & Swaby (1993c). Major marine habitat types have been identified and divided into a series of 'ecotypes', including estuarine, littoral, sublittoral, offshore habitats and specialist habitats (symbiotic and other relationships). These are further refined with reference to substrate type (mud, sand, gravel and particulate substrate, bedrock or boulders (reef) and water column, where appropriate). This classification provides a structure for identifying and classifying fish/habitat associations. However, many fish have complex life-styles and habitat requirements and may occupy several habitats during different phases of their life-cycles.

Table 5.9.2 shows numbers of fish species recorded from lochs, islands and lagoons in Region 14. The fish populations do not differ significantly between lochs, with some species occurring frequently. Fish recorded from the majority of areas included the pollack *Pollachius pollachius*, saithe *P. virens*, ballan wrasse *Labrus bergylta* and goldsinny *Ctenolabrus rupestris*. Inshore fishes such as the bull rout *Myoxocephalus scorpius*, the fifteen-spined stickleback



Map 5.9.1 Distribution records on the British Marine Fishes Database of sturgeon, allis shad and twaite shad. Source: after Potts & Swaby (1993a).

Spinachia spinachia, the three-spined stickleback *Gasterosteus aculeatus* and the butterfish *Pholis gunnellus* are common throughout the area.

The sand goby is a common inhabitant of sandy beaches in Region 14 and its activity patterns have been studied by Gibson & Hesthagen (1981). The common goby appears to be quite common in the Clyde area. The sturgeon and the allis and twaite shads have scattered records, mainly in the Firth of Clyde (Map 5.9.1), with the twaite apparently the rarer of the two shad species (Burkel 1971). Lamperns were found by Scott & Brown (1901) in most streams and lakes in the region, but were described as non-migratory, which suggests that there may have been confusion with the brook lamprey *Lampetra planeri*. A sea lamprey was recorded in the River Clyde in 1993 and in 1995; in the surrounding area they are found mainly in Loch Lomond (where they are non-migratory), the River Endrick and the River Leven. Maitland (1970) reports recent records in the River Girvan. Single records exist from the River Eachaig and from Saltcoats.

Fish species near the northern edge of their distribution in Region 14 are the tompot blenny *Parablennius gattorugine* and the black goby *Gobius niger*. Two other gobies, the leopard-spotted goby *Thorogobius ephippiatus* and Fries' goby *Lesueurigobius friesii*, have been recorded by divers in Region 14. The leopard-spotted goby lives in close association with sub-tidal crevices, where traditional sampling methods are ineffective at catching them. Fries' goby hides by burrowing in soft substrates (Gibson & Ezzi 1978). Fish species typically found on sandy beaches include Nilsson's pipefish

Table 5.9.2 Numbers of fish species recorded from lagoons, lochs and islands in Region 14

Lagoons, lochs and islands	*No. of fish species*	*Reference*
Ballantrae Lagoons	3	Moore (1989)
Loch Ryan	17* (+3)	Howson (1989)
Lochs Riddon, Striven, Goil and Long, Holy Loch and the Gare Loch	37*(+9)	Holt & Davies (1991)
Loch Tarbert	9* (+4)	Connor (1991)
Loch Sween	51* (+10)	Rostron & Hiscock (1985), Lumb (1986), Smith (1986, 1990), Lumb & Hiscock (1990)
Loch Fyne	32* (+4)	Davies (1989)
Loch Feochan, Melfort, Craignish, Crinan, Caolisport, and West Loch Tarbert	31* (+3)	Howson (1990)
Loch Linnhe, Eil, Creran and Aline	30* (+5)	Connor (1990)
Jura & Islay	21*(+7)	Smith (1982), Hiscock (1983)
Luing, Garvellachs & surrounding area	29*(+1)	Buehr (1984), Smith (1984)
Mull	41* (+7)	Smith & Gault (1983), Davies (1990)
Coll & Tiree	18* (+5)	Dipper (1981)

Key: *indicates number of different fish identified to species. Numbers in brackets = additional fish specimens not identified to species level.

Syngnathus rostellatus (R.N. Gibson pers. comm. 1996).

Early records and ancedotal mentions of sharks off the Ayrshire coast include the thresher shark *Alopias vulpinus* and basking shark *Cetorhinus maximus*. About six basking sharks were seen off Arran in 1996. In 1913 a basking shark with an estimated size of >8.5 m was stranded on Little Cumbrae. A basking shark fishery once existed off the Clyde, but is no longer operating. Reports of fishermen seeing 'sailfish' were once common, although it is now believed that these were basking sharks.

Unusual records in Region 14 include a long-finned tunny *Thunnus alalunga* in Loch Fyne in 1968 (Burkel 1971) and an opah *Lampris guttatus* from Ailsa Craig in 1972 (Burkel 1974). Fish populations in the Firth of Lorne are summarised by Gordon (1990). There are many studies on individual species in the Clyde Sea area. Several specimens of red mullet *Mullus surmuletus* were caught in 1995 (Gibson & Robb in press).

The fish species composition in the Clyde Sea area has been studied by Henderson & Hamilton (1986) and has been shown to vary with water quality. Nash & Gibson (1982) studied seasonal fluctuations in demersal fishes in Lynn of Lorne and Irvine Bay, and Gibson *et al.* (1993) looked at seasonal and annual variations in 43 fish species in Tralee Bay and Ardmucknish Bay. The diet and feeding relationships of 24 species in Loch Etive were studied to determine degree of overlap and differences in prey organisms (Kislalioglu & Gibson 1977).

5.9.3 Human activities

Human activities affecting estuaries and adjacent coasts are summarised in Buck (1993); these activities affect the abundance and distribution of fish. There are eight estuaries in Region 14, ranging from the Ruel Estuary, which has relatively few human activities, to the Clyde Estuary and Firth, which receive effluents from about half of Scotland's population and industry (Haig 1986) and were virtually fishless by the mid 19th century (Henderson & Hamilton 1986). Urbanisation and the discharge of untreated sewage to the sea - and particularly into areas such as the Firth of Clyde - result in a reduction in dissolved oxygen, to which fish are particularly sensitive (Mackay *et al.* 1978; Steele *et al.* 1973). The result is that fish leave the area and do not return until treatment plants reduce the amount of sewage and oxygen levels increase (Potts & Swaby 1993b).

Nationally, estuaries are used by up to 180 fish species for migration, spawning, feeding and as nursery grounds (Potts & Swaby 1993b). Dams, weirs, barrages and abstraction intakes can impede the passage of migratory fish. While salmon 'passes' allow some species to migrate up or down rivers and estuaries, they provide obstacles to the majority of fish, which are unable to reach spawning and feeding grounds further upstream.

The possible effects of fisheries on species are discussed in sections 5.7 and 9.1. The cultivation of shellfish and fish species in the region is discussed in Carss (1990) and in section 9.2. Sea angling occurs in many places throughout the region (Orton 1996) (see section 9.1.2).

5.9.4 Information sources used

Rare fish in Scotland are generally reported to SOAEFD; those specific to the Clyde Sea area are mostly recorded in the *Glasgow Naturalist*. Information on non-commercial marine and particularly estuarine fish is patchy, and while some areas are well studied, others have been neglected. The fish in Region 14 have been well studied, particularly in the Clyde Sea. Reviews by Gordon (1981, 1990) and Gordon & De Silva (1980) describe the fish populations of the west of Scotland and list the species that have been caught by various methods in a number of west coast sea lochs. The fish of Loch Sween were examined during a variety of littoral and sublittoral surveys in the 1980s. The Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) hold information on marine and estuarine fish, for commercial reasons.

The British Marine Fishes Database contains data on the marine and estuarine fish of Scotland. The data include published literature, unpublished reports and personal communications from fish biologists, covering aspects of fish biology and ecology, conservation status and fish records.

5.9.5 Acknowledgements

The authors thank Andrew Haig (SEPA West Region) and John Gordon and Martin Sayer (Dunstaffnage Marine Laboratory) for their comments on the draft.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
British Marine Fishes Database	Dr G.W. Potts/S.E. Swaby, Marine Biological Association UK, Citadel Hill, Plymouth PL1 2PB, tel: 01752 633100/600301
Fisheries - Scotland	*SOAEFD Fisheries Research Services, Marine Laboratory, Aberdeen, tel: 01224 876544
Literature/internal reports on fish species in sea lochs	Librarian, Scottish Association for Marine Science (formerly the Scottish Marine Biological Association), Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244
Unpublished biological data on fish species	Dr J.D.M. Gordon, Scottish Association for Marine Science (formerly the Scottish Marine Biological Association), Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244
Fish conservation - UK	*Fisheries Officer, JNCC Peterborough, tel: 01733 62626
Fish conservation - Scotland	*Aquatic Environments Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797

*Starred contact addresses are given in full in the Appendix.

5.10 Seabirds

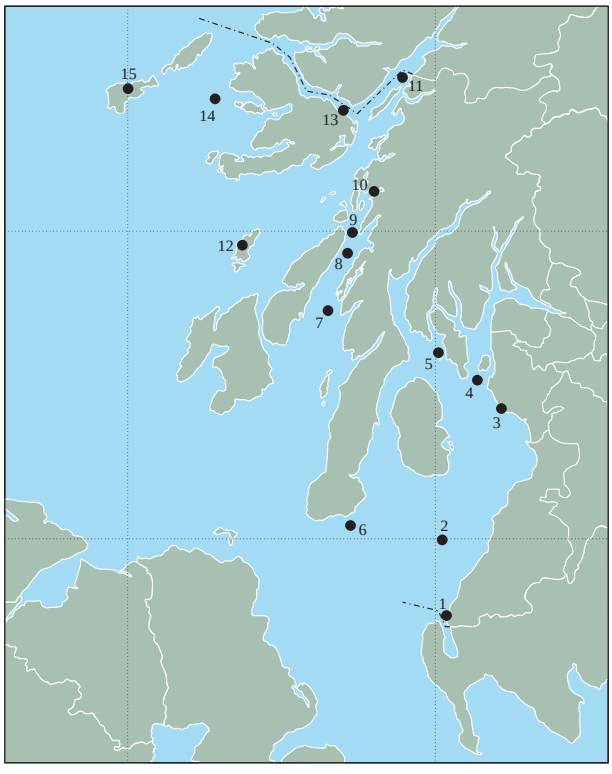
M.L. Tasker

5.10.1 Introduction

This section deals with seabirds both at their colonies on land and while at sea. It covers not only those species usually regarded as seabirds (Table 5.10.1), but also cormorants, divers, grebes and seaduck: in other words, those species reliant for an important part of their life on the marine environment. (Section 5.12.2 includes information on these waterfowl species where they occur close inshore, especially within estuaries.) Scientific names of breeding species are given in the tables.

This region is internationally important for several species of seabirds. Fifteen colonies are of importance in a national context, six of them in the international context. More than 1% of the European population of ten species (gannet, storm petrel, shag, lesser and great black-backed and herring gulls, common tern, guillemot, razorbill and black guillemot) breed in the region, with a further seven present in nationally important numbers (more than 1% of the GB population) (Table 5.10.1). Numbers of birds at sea off the region are moderately high in relation to the rest of the United Kingdom.

The importance of areas at sea off the region varies depending on species. Generally, the areas near colonies are of greatest importance in summer, with the larger inshore sounds and the Firth of Clyde important in autumn. The Clyde remains of importance in winter. The waters off the region are predominantly inshore in character, so species such as fulmar are comparatively uncommon here compared with in more oceanic waters to the north and west.



Map 5.10.1 Colonies holding at least 1% of the GB population of any seabird species. Numbers are those listed in Table 5.10.2. Source: JNCC Seabird Colony Register.

Table 5.10.1 Overall importance of seabirds breeding in the region

Species	*Total*	*% GB*	*% Europe*
Fulmar *Fulmarus glacialis*	7,141	1.4	<1.0
Manx shearwater *Puffinus puffinus*	*c.*1,000	<1.0	<1.0
Gannet *Morus bassanus*	32,456	15.8	12.0
Storm petrel *Hydrobates pelagicus*	2,000+	>1.0	>1.0
Cormorant *Phalacrocorax carbo*	265	3.9	<1.0
Shag *Phalacrocorax aristotelis*	3,300	9.1	2.6
Arctic skua *Stercorarius parasiticus*	105	3.3	<1.0
Black-headed gull *Larus ridibundus*	1,257	<1.0	<1.0
Common gull *Larus canus*	2,455	3.6	<1.0
Lesser black-backed *gull Larus fuscus*	9,835	11.9	5.3
Herring gull *Larus argentatus*	23,994	16.0	2.4
Great black-backed gull *Larus marinus*	1,218	6.6	1.5
Kittiwake *Rissa tridactyla*	13,600	2.8	<1.0
Sandwich tern *Sterna sandvicensis*	3	<1.0	<1.0
Common tern *Sterna hirundo*	2,025	15.9	2.2
Arctic tern *Sterna dougallii*	2,494	5.8	<1.0
Little tern *Sterna albifrons*	100	4.2	<1.0
Guillemot *Uria aalge*	29,089	2.8	1.0
Razorbill *Alca torda*	6,183	4.2	1.0
Black guillemot *Cepphus grylle*	4,287	11.4	4.3
Puffin *Fratercula arctica*	3,500	<1.0	<1.0

Sources: figures for Great Britain from Walsh *et al.* (1995) and for Europe from Lloyd *et al.* (1991). Notes: counts are of pairs, except for guillemot, razorbill, black guillemot and puffin, which are counted individually. Regional totals are compiled from the most recent available good-quality counts up to 1994.

5.10.2 Important locations and species

Breeding seabirds require habitat that is free from predatory mammals, so all colonies in the region are on offshore islands or cliffs. Six colonies are important at the European level (i.e. they hold more than 1% of the EU population of one or more species), with a further nine colonies in the region important at the Great Britain level (Table 5.10.2; Map 5.10.1). Fourteen other colonies hold regionally important numbers of birds and are within SSSIs (see also section 7.3.2).

The feeding areas of birds from colonies are as important as the colonies themselves, as the birds could not survive without food. Natural foods range from zooplankton to small fish and waste from fishing fleets. Habitats that concentrate any of these foods are preferred. Zooplankton can be concentrated in zones where water masses meet or where tides converge around headlands or over some sea-bed features (see also section 4.3). Storm petrels are relatively common in summer over the Islay front, which lies in the seas to the south of Tiree. The region is of moderate importance to divers, with the Sound of Islay/Sound of Jura and the seas between Mull and Tiree being of greatest regional importance. Manx shearwaters

Table 5.10.2 Recent counts of seabird colonies of national or international importance for particular species

Site no. on Map 5.10.1	*Colony*	*Grid ref.*	*Species*	*Count date*	*Count*	*>1% EU/GB population*	*Protected status*
1	Currarie - Portandea	NX050770	Cormorant	1994	154	EU	Not designated
2	Ailsa Craig	NX020995	Gannet	1995	32,456	EU	SPA
			Lesser b.-b. gull	1987	1,800	EU	
			Herring gull	1987	2,350	GB	
3	Horse Isle	NS213428	Lesser b.-b. gull	1990	1,335	EU	AoSP, RSPB
4	Little Cumbrae	NS145515	Lesser b.-b. gull	1986	3,000	EU	Not designated
			Herring gull	1986	3,000	GB	
5	Inchmarnock, Bute	NS020600	Lesser b.-b. gull	1986	825	GB	SSSI
6	Sanda Islands	NR725045	Shag	1994	648	EU	SSSI
7	Dubh Sgeir, Sound of Jura	NR662747	Common tern	1989	200	GB	Not designated
8	Ruadh Sgeir, Sound of Jura	NR722927	Common tern	1987	200	GB	Not designated
9	Reise an t'Struith, Sound of Jura	NR735992	Common tern	1990	203	GB	Not designated
10	Sgeir na Caillich, Loch Melfort	NM808126	Common tern	1994	144	GB	Not designated
11	Sgeir non Tom Islets, Loch Linnhe	NM887478	Common tern	1990	131	GB	Not designated
12	W. Colonsay Cliffs	NR380950	Kittiwake	1986	5,646	GB	SSSI
			Guillemot	1986	13,511	GB	
13	Glas Eileanan, Sound of Mull	NM714399	Common tern	1994	516	GB	SSSI
14	Treshnish Islands	NM295425	Storm petrel	1986	2,000+	EU	SPA
15	Tiree	NL999460	Little tern	1995	22	GB	pSAC

Source: JNCC/Seabird Group Seabird Colony Register. Key: GB = nationally important; EU = internationally important; SPA = Special Protection Area; AoSP = Area of Special Protection for birds; pSAC = possible Special Area of Conservation; RSPB = Royal Society for the Protection of Birds reserve; SSSI = Site of Special Scientific Interest. Notes: counts are of pairs; for most species the most recent available good-quality count is presented; for terns (whose numbers may fluctuate markedly from year to year, reflecting inter-colony movements) the highest count from 1992 is presented.

are common in many inshore waters during the summer and are accompanied by sooty shearwaters *Puffinus griseus* in July and August. Gannets are common near Ailsa Craig, their only colony in the region and the fourth largest gannetry in Britain. Cormorants, eider *Somateria mollissima*, black guillemots, black-headed gulls and terns are predominantly inshore in their distribution and are present for most of the year. Shags do not occur far offshore and are found in areas with relatively high tidal currents, such as off the northern end of Jura and in the Sound of Mull. The Firth of Clyde is important for common, herring and lesser black-backed gulls, particularly in summer. Kittiwakes occur in high densities near their colonies in summer, with the Sound of Jura being important in autumn. Both guillemots and razorbills are at highest density at sea near their colonies in the breeding season, but move to the Clyde/North Channel/Sound of Jura in July, with the Sound of Jura becoming particularly important in August. Most razorbills move southwards out of the region in winter, while the Clyde and areas offshore to the west of the region become more important for guillemots.

Several parts of the Ayrshire coast are of national importance for wintering waterfowl, particularly goldeneye *Bucephala clangula* and eider (Table 5.10.3). It is difficult to be sure that there is no double-counting in this area, with local movements adding to the difficulty in observing some parts. The Inner Clyde is of particular importance to eider, which move to the area from breeding grounds to the north and west. There are no protected sites at sea in the region.

Table 5.10.3 Important locations for marine-wintering waterfowl*

Location	*Peak numbers*	*1% GB*	*1% NW Europe*
Dipple			
Goldeneye	231	170	3,000
Maiden's Harbour - Turnberry			
Goldeneye	575	170	3,000
Greenan Castle - Ayr (Doon Estuary)			
Goldeneye	280	170	3,000
Ayr - Prestwick			
Goldeneye	177	170	3,000
Irvine/Garnock Estuary			
Eider	867	750	20,000
Irvine - Saltcoats			
Eider	2,500	750	20,000
Goldeneye	250	170	3,000
Inner Clyde			
Eider	3,749	750	20,000
Goldeneye	549	170	3,000
Red-breasted merganser *Mergus serrator*	135	100	1,000

Source: peak numbers from Waters & Cranswick (1993), 1% GB from Waters & Cranswick (1993), 1% NW Europe from Rose & Scott (1994). Key: *seaducks, divers, grebes and cormorant.

5.10.3 Human activities

The vulnerability of seabirds at sea to the effects of human activities is calculated from the abundance of birds in the rectangles shown on Map 5.10.2 and a factor derived from the amount of time spent on the water, the overall

population size and the rate at which the species recruits new individuals to the population. For a discussion of vulnerability see Carter *et al*. (1993), Williams *et al*. (1994) or Webb *et al*. (1995).

Seabirds can be particularly affected by marine oil pollution. Spills near the main colonies during the breeding season could be catastrophic. The North Channel and Firth of Clyde are the areas most heavily used by shipping, with the former being a major shipping lane into the Irish Sea. All waters are used to some extent by the fishing industry and some birds may become entangled in fishing nets; although this has caused concern locally, it is not believed to be a major problem. Future changes in fishing practice, particular any increase in the use of monofilament nets, would increase the level of bycatch. Fish farming will have added to the potential for disturbance to seabird colonies in the region, but probably not significantly. Damage to tern and gull colonies has led to particular concern about the spread of feral North American mink *Mustela vison* through the region.

5.10.4 Information sources used

All seabird colonies in the region were counted or reappraised between 1984 and 1987. These counts, and all those made since 1979, are held on the JNCC/Seabird Group Seabird Colony Register. Numbers and breeding performance of several species are evaluated annually (or near annually) at sites on Ailsa Craig, Islay, Colonsay and Treshnish. Surveys of birds at sea off this coast have been carried out by JNCC's Seabirds at Sea Team (SAST). Coverage has in general been good in January, May, July, August and September. The Sound of Jura is inadequately known in February, March, June, October, November and December, and the area to the north-west of Jura is poorly known for some months. The southern Sea of Hebrides has not been surveyed in November or December. Waters at 2 km and 5 km from the shore have been surveyed from the air by SAST in January, May, July, September and December. Land-based coverage of most nearshore waters in the region has been patchy, with SAST making a particular effort systematically to cover a sample of sea lochs on a monthly basis over two years.

5.10.5 Further sources of information

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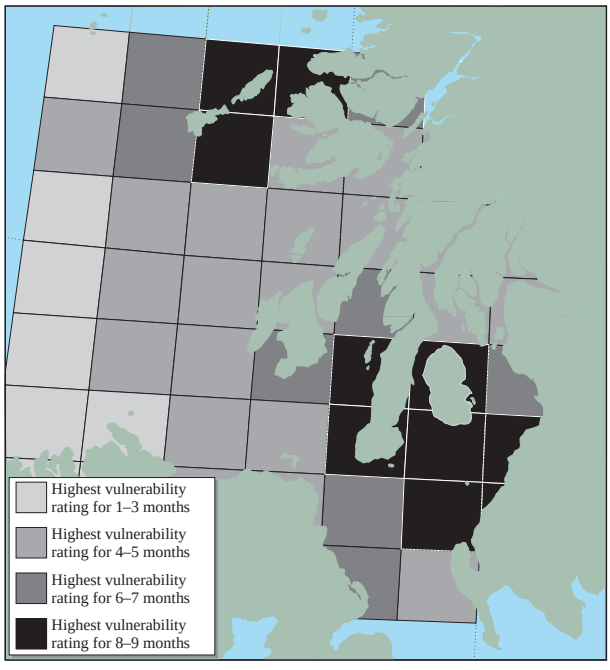

Map 5.10.2 Relative importance of region and adjacent seas for seabirds. The grid is of 15'N x 30'W rectangles; see section 5.10.3 for explanation of vulnerability ratings. Source: JNCC Seabirds at Sea Team.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Seabird colonies	*Coordinator, Seabird Colony Register, JNCC, Aberdeen, tel: 01224 655703
Seabirds at sea	*Seabirds at Sea Team, JNCC, Aberdeen, tel: 01224 655702
Birds database	*Species Data Custodian, JNCC, Peterborough, tel: 01733 62626
Information on seabirds in Scotland	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Information on seabirds in Argyll & Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Information on seabirds in south of region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
Nearshore waterfowl	*Wildfowl and Wetlands Trust, Slimbridge, tel: 01453 890333

*Starred contact addresses are given in full in the Appendix.

5.11 Other breeding birds

D.M. Craddock & D.A. Stroud

5.11.1 Introduction

This section outlines the importance of the region to breeding birds other than seabirds. Because of their distinctive ecology and mixed-species breeding colonies, seabirds are described separately in section 5.10.

The physical nature of the coastline determines the distribution of the different bird assemblages that occur. The region is characterised by extensive rocky and sandy shorelines, sea lochs, islands, sheltered waters and a few large estuaries, and often the distinction between inland and coastal habitats is blurred. The remoteness of much of this region means that for some areas survey coverage is poor, although certain areas, mostly non-estuarine, are known to be very important for breeding birds. Several species have major strongholds in this region, and it has an important role in maintaining the range and breeding distribution of a number of rare breeding species (Pritchard *et al.* 1992). The prevailing low-density agricultural management of much of the region and the undisturbed nature of its coastline contribute to this importance.

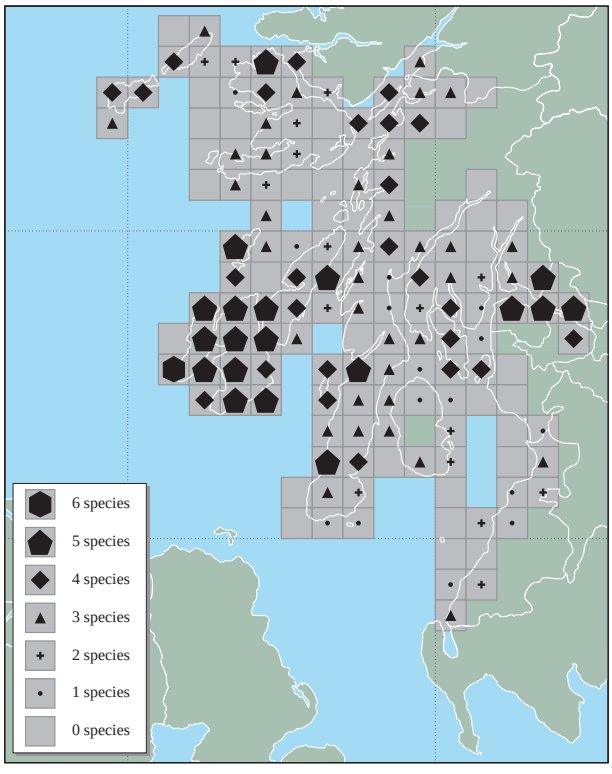
This region, particularly Islay and Mull and other islands in the Inner Hebrides, is extremely important for breeding waders. For example Shepherd *et al.* (1988) found that the machair habitats of Coll and Tiree, including their associated marshes, fens and rough wet pastures, support very high densities of breeding waders (>66 prs/km^2). The machair and wetlands of the region hold internationally important numbers of the British-breeding subspecies of dunlin *Calidris alpina schinzii*. Individual areas support nationally important populations of snipe *Gallinago gallinago*, lapwing *Vanellus vanellus*, redshank *Tringa totanus*, oystercatcher *Haematopus ostralegus*, ringed plover *Charadrius hiaticula*, dunlin and pintail *Anas acuta.*

The entire Scottish breeding population of chough *Pyrrhocorax pyrrhocorax* now occurs in this region, with the islands of Islay and Colonsay being of national importance for this species, which was formerly more widespread. Tiree has internationally important numbers of the globally threatened corncrake *Crex crex*, which, like the chough, relies on low-intensity agricultural habitats. Some of the islands, particularly Arran, Islay, Colonsay, Mull, Coll and Tiree, support some of the greatest densities of breeding raven *Corvus corax* in Britain.

The region supports nationally important numbers of hen harrier *Circus cyaneus* and common scoter *Melanitta fusca*. Both Coll and Tiree are important breeding areas for the north Scottish population of greylag goose *Anser anser.* Red-throated diver *Gavia stellata* breed on the machair and wetlands of the region.

5.11.2 Important locations and species

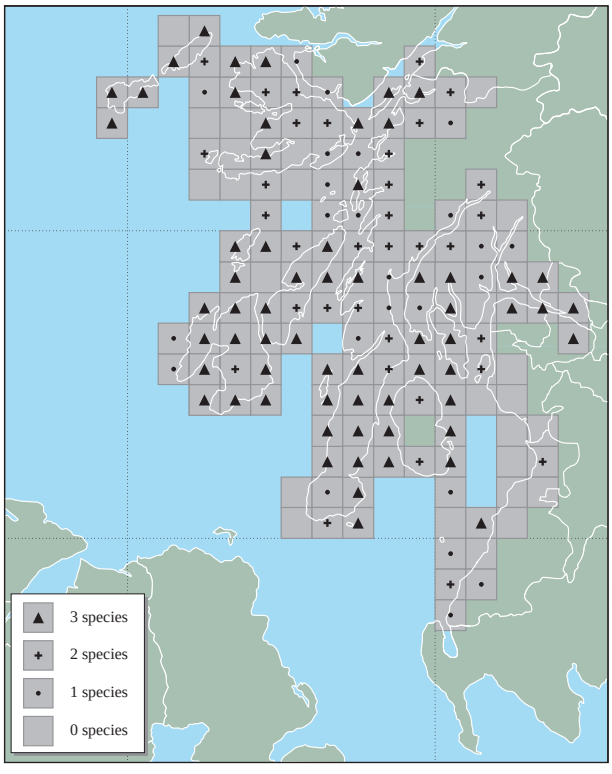
Map 5.11.1 shows the coastal 10 km squares where selected species characteristic of wet grassland (teal *Anas crecca*, lapwing, redshank, mallard *Anas platyrhynchos*, snipe and pintail) were confirmed as breeding (Gibbons *et al.* 1993). Compared with other parts of Britain, wet grasslands of this region have a very diverse breeding bird assemblage. Map 5.11.2 shows the incidence of confirmed breeding in coastal 10 km squares of selected species characteristic of dry coastal grasslands (ringed plover, oystercatcher and shelduck *Tadorna tadorna*).



Map 5.11.1 Number of confirmed breeding species characteristic of wet grassland (redshank, snipe, lapwing, mallard, teal and pintail) in coastal 10 km squares. Source: based on Gibbons *et al.* (1993).

The most important breeding areas for waders in the Inner Hebrides are the machair and other grasslands of Tiree, pasture near Loch Indaal, Loch Gruinart and other farmland on Islay, followed by the low-lying coastal regions of Colonsay and Oronsay (Reed *et al.* 1983; Shepherd *et al.* 1988). One of the most important areas on Tiree is the extensive area of wetland and freshwater marsh, north and east of the Reef, where waders nest in high numbers (Pritchard *et al.* 1992; Shepherd *et al.* 1988).

High densities of breeding lapwings are found on Coll and Tiree, throughout the Loch a' Phuill area and around Loch Bhasapol (Shepherd *et al.* 1988). On Tiree numbers of lapwing (1.7% of the national population), redshank (1.9%), oystercatcher (1.4%), ringed plover (2.9%) and snipe (4.1%) are all nationally important. Although supporting smaller numbers, Coll is also significant for snipe (1.7%). The damp machair on Tiree is one of the few habitats in Britain where breeding redshank densities approach those on saltmarshes (Cadbury *et al.* 1987). Tiree and Coll combined support breeding numbers of over 225 pairs of dunlin (2.5% of the British breeding population). Machair and wetlands are the favoured breeding habitats.



Map 5.11.2 Number of confirmed breeding species characteristic of shingle, sand dunes and other dry grasslands (ringed plover, oystercatcher and shelduck) in coastal 10 km squares. Source: based on Gibbons, Reid & Chapman (1993).

Table 5.11.1 shows the densities of four species of breeding waders (oystercatcher, ringed plover, curlew *Numenius arquata* and redshank) found in a 1985 survey on a sample of saltmarshes in the region.

Table 5.11.1 Densities of breeding waders on a sample of saltmarshes surveyed in 1985*

Site	*Oyster-catcher (pairs/ km²)*	*Ringed plover (pairs/ km²)*	*Curlew (pairs/ km²)*	*Redshank peak (nests**/ km²)*	*Total (pairs/ km²)*
Loch Foechan	28	n/a	n/a	55	83
Loch Don	5	n/a	n/a	7	12
Loch Beg (Mull)	6	3	10	18	35

Source: Allport *et al.* (1986). Key: *other saltmarshes in the region were not surveyed, so this is not a comprehensive listing; **for this table, redshank nest densities are treated as equivalent to pair densities; n/a = not available.

Shelduck breed throughout the region. A national shelduck survey in 1992 by the Wildfowl & Wetlands Trust (WWT) found that several estuaries within the region support at least 45 birds. One of the main concentrations of shelduck in Scotland is found in Kintyre and Islay (Gibbons *et al.* 1993); other breeding sites include the shores of Bute (Gibson 1982), Inchmarnock and Little Cumbrae. Table 5.11.2 shows some of most important sites in the region that support breeding shelduck.

The British stronghold for ringed plover is the islands off the west coast of Scotland. In this region the majority of nesting pairs of ringed plover are found nesting on beaches, and high densities occur on Arran, the Mull of Kintyre, Colonsay, Coll and Tiree (Gibbons *et al.* 1993). Table 5.11.3 shows the numbers of pairs of territorial (presumed breeding) ringed plovers in areas of the region in 1984, compared with numbers nationally.

Table 5.11.2 Sites supporting at least 45 shelduck

Site name	*Total birds*	*Males*	*Pairs*	*Non-breeding birds*
Isle of Gigha & Cara, Kintyre	133	0	47	39
Tayvallich Estate, Keills	105	33	26	20
Loch Gruinart & RSPB Reserve, Islay	77	8	8	61
Inner Clyde	58	2	24	8
Loch Indaal, Islay	49	5	5	34
Clachan, Tiree	47	n/a	n/a	n/a

Source: WWT national shelduck survey, 1992. Key: n/a = not available.

Table 5.11.3 Numbers of pairs of territorial (presumed breeding) ringed plovers in 1984

	Pairs (coastal) counted in survey	*% GB total counted in survey*
Ayr	80*	1.1[e]
Renfrew	22	0.3
Inner Hebrides	500**	6.9[e]
Bute/Arran/Cumbrae	50	0.7
Region 14	***652***[e]	***9.0***[e]
Scotland	5,796	80.4
GB	7,207	100

Source: Prater (1989). Key: *58 counted, others estimated; **418 counted, others estimated; [e]based on estimated total. Note: survey coverage varied between areas, although it was generally good in the region overall.

The majority of the Scottish breeding population of red-breasted merganser *Mergus serrator* are concentrated on the west coast. Eider *Somateria mollissima* breed on Lady Isle (off Troon) and on Horse Isle (off Ardrossan), while on Little Cumbrae there are large numbers of nesting ducks, mainly eider, mallard, shelduck, teal and red-breasted merganser. On the northern end of Great Cumbrae eider, mallard, ringed plover and oystercatcher nest (Gibson 1982). The coastal areas of Bute and the south-west tip of Inchmarnock are also populated by large numbers of breeding eider, with further breeding colonies on the small islands off the north coast of Bute. The islands of Sanda, Sheep Island and Glunimore off the south-east tip of the Kintyre Peninsula are famous for their large colonies of eider duck.

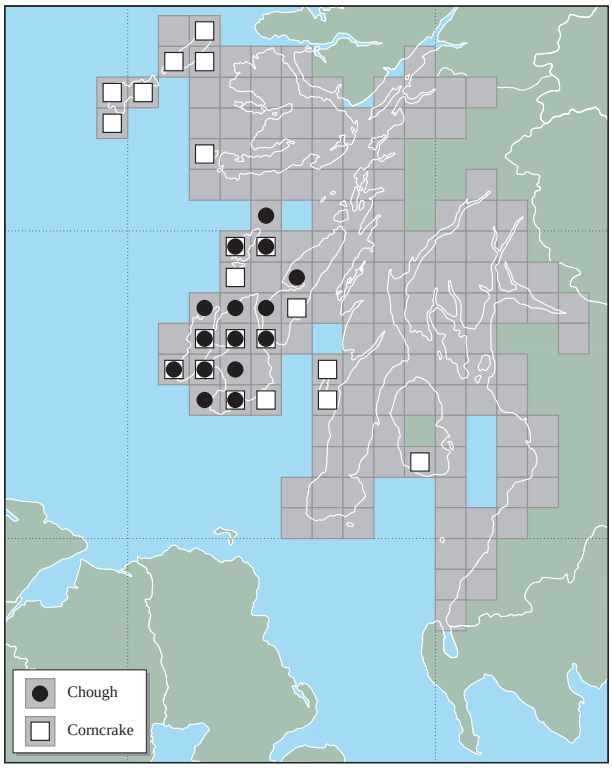
Cliffs within the region are an important habitat, particularly for seabirds (section 5.10) and choughs. The incidence of confirmed breeding in coastal 10 km squares of chough in this region is shown on Map 5.11.3. Islay supports approximately 90% of the Scottish population of choughs and around 40% of the British population (Ogilvie 1992). Colonsay supports at least 3% of the British breeding population, which along with one pair on Mull are the most northerly breeding chough in the world (Pritchard *et al.* 1992). Important sites for chough on Islay include the Rhinns of Islay (21% of the British population), Loch Gruinart (4%) and The Oa (9%).

The incidence of confirmed breeding of corncrake in coastal 10 km squares in Region 14 is shown on Map 5.11.3. In summer Tiree and Coll hold large numbers of breeding corncrakes (about 3% of the rapidly declining western European population and 20% of the British). Numbers on Tiree have been sustained recently, while elsewhere in Scotland numbers have declined markedly (Pritchard *et al.* 1992). Approximately 2% of the British population breed on the Rhinns of Islay.

About 1% of the British and EU breeding population of red-throated divers occur on freshwater lochs on Coll (Pritchard *et al.* 1992). Common scoter are now present throughout the year on Loch Indaal on Islay (Ogilvie 1992). This species is relatively scarce as a breeder on the west coast of Scotland. Other birds using the lochs on Islay for breeding include mallard, tufted duck *Aythya fuligula* (on the north of the island), teal, water rail *Rallus aquaticus*, moorhen *Gallinula chloropus*, sedge warbler *Acrocephalus schoenobaenus* and reed bunting *Emberiza schoeniclus*. Water rail also nest elsewhere in the region, including on Bute (Gibson 1982).

Moorland areas, often close to the coast in this region, are important for several nesting species including hen harrier (Islay and Arran), greylag geese (Coll and Tiree), red-throated diver (Coll), arctic skua *Stercorarius parasiticus* (Coll and Jura) and teal (Jura and Islay).

Rare breeding bird species in the region include pintail (11% of the British population breed on Coll and Tiree), spotted crake *Porzana porzana*, Slavonian grebe *Podiceps auritus*, garganey *Anas querquedula* and whooper swan *Cygnus cygnus*. Other species that breed in the region in notable numbers include shoveler *Anas clypeata*, merlin *Falco columbarius*, peregrine falcon *Falco peregrinus*, barn owl *Tyto alba* and mute swan *Cygnus olor*, for which Tiree is the most important breeding area in the Inner Hebrides.



Map 5.11.3. Confirmed breeding of chough and corncrake in coastal 10 km squares of the region. Source: Gibbons *et al.* (1993).

5.11.3 Human activities

Conservation priorities may be furthered through site designations and agricultural support programmes (e.g. Cadbury & Lambton 1995). Many parts of the important breeding bird habitat in the region lie within designated sites (for example National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Special Protection Areas (SPAs) and Ramsar sites), although the sites were not always chosen principally for their breeding bird interest (see Chapter 7).

On Islay, refuges at Loch Gruinart (Self *et al.* 1994) and Laggan are managed principally for their goose populations, but breeding lapwing, snipe and redshank also benefit. In Ayrshire, Lady Isle is an Area of Special Protection for Birds and Horse Isle is a reserve belonging to the RSPB. Reserves for wildfowl are less numerous than in most other parts of Scotland, but a good deal of protection is afforded by landowners, including water authorities. Outside designated reserves farmers of Sites of Special Scientific Interest (SSSIs) have entered management agreements to manage their land for the geese and not to scare birds away.

In this region incremental land-claim, particularly around the Clyde Estuary, has the potential to affect breeding waterfowl populations through loss of nesting and feeding habitat. At important sites SSSI designation can limit such activity.

Human disturbance during the breeding season may have significant effects on breeding success (Pienkowski 1992), although for the birds discussed in this section there are few assessments of the scale of the problem. On Tiree the lochs supporting rare breeding birds require protection from high levels of disturbance during the breeding season. Gibson (1982) attributes the decline of the breeding bird population on the Burnt Islands in the Kyles of Bute and Eilean Dearg in Loch Riddon to disturbance from oil-related developments. The increasing popularity of marine recreation and boat-based wildlife trips now allows greater access to offshore and remote coastal areas that in the past were relatively undisturbed.

The appropriate agricultural management of wet grassland is of crucial importance for breeding wader populations (see for example Self *et al.* (1994), Coleshaw (1995), Harold (1995), Scholey (1995), Thomas *et al.* (1995) and papers in Hötker (1991)). Different grazing regimes on saltmarshes can significantly alter the density and nesting success of breeding waders through their effects on vegetation composition and structure (Cadbury *et al.* 1987). Careful management of water levels on coastal wet grasslands is important for maintaining breeding wader populations: these areas need low-intensity agricultural management, with a winter flooding regime and a controlled water table in summer to protect nests from flooding during the breeding season (Green *et al.* 1987; Green 1991).

On the west coast of Scotland saltmarshes are mostly grazed, often heavily, by sheep and cattle. To maintain the value of saltmarshes for breeding waterfowl, grazing needs to be carefully managed to maintain the plant communities and vegetation structure favoured by nesting and feeding birds (Cadbury *et al.* 1987). Grazing reduces the overall

height and bulk of the vegetation, which influences the composition of the species assemblage. Cadbury *et al.* (1987) found that there was a marked and highly significant decrease in redshank density on intensively grazed saltings.

On Coll and Tiree the lochs hold much of the breeding waterfowl interest; the attraction of these areas for breeding waterfowl may depend on suitable vegetation cover at the loch edges. Major changes in edge vegetation, as may be caused by changed grazing regimes, can have detrimental effects on the populations of breeding waterfowl.

As a species, the chough is highly sensitive to changes in traditional pastoral farming methods. In Scotland choughs are associated with farming land, with a distinct preference for feeding in grassland grazed by domestic livestock and which has bare ground and short or open vegetation cover. Agricultural management plays an important role in the feeding strategies employed by choughs throughout the year. The loss of traditional livestock farming, and consequently the loss of the pastures that choughs require, has been the overwhelming factor associated with the recent decline of this species. On Islay conservation action includes management agreements with farmers and grants to provide suitable nest sites; the latter initiative has proved very successful (Bignal & Bignal 1987; Ogilvie 1992).

The low intensity of traditional crofting and the evolution of appropriate agricultural systems mean that the islands are of high importance for breeding waders, as well as other birds such as corncrake and corn bunting *Miliaria calandra*. On Coll and Tiree, the conservation of breeding birds can best be achieved through support for traditional crofting and farming practices and through the appropriate management of the wettest areas of machair, fens and the marshes (Shepherd *et al.* 1988). It is hoped that the initiative on Islay by the RSPB, Scottish Natural Heritage and the Scottish Crofters Union, to pay small compensatory sums to crofters and farmers willing to delay cutting selected grass fields until 1st August, will reverse the trend of decline in the corncrake population (Ogilvie 1992).

The Clyde Estuary is particularly vulnerable to threats of recreational disturbance and pollution, owing to its proximity to large urban areas. However, in the Clyde Estuary in the post-war period, huge improvements in water quality in terms of its organic content have led to reductions in invertebrate food supplies and a consequent decline in the numbers of waders (Furness *et al.* 1986). Oil pollution is well known as a serious potential threat to waterfowl in areas where high densities of birds occur. A number of tankers and other ships carrying fuel oil navigate around the west coast of Scotland and there have been a number of small oil spill incidents, affecting birds both at sea and on the coast, when oil is washed up on shore (Bryan 1994).

5.11.4 Information sources used

The most recent and comprehensive overview of the status of breeding birds throughout Britain and Ireland is provided by Gibbons *et al.* (1993). This summarises the results of a national breeding bird census undertaken between 1988 and 1991 and compares distributions at the 10 x 10 km square level with those recorded in the first breeding bird atlas of 1968-1972 (Sharrock 1976). Whilst the data are one of the best sources for comparisons at county, regional or national scales, care should be taken with their use to assess individual sites or 10 km squares. This is because the coverage of each 10 km square was not always equally thorough, and since the atlas survey period (1988-1991) distributions of some breeding species may have changed. Between- and within-region comparisons of precise distributions and densities based on coastal 10 x 10 km should be undertaken with caution as there may be greatly varying amounts of land within each square.

Extensive survey work by volunteers has been undertaken for a number of species. Usually these surveys are organised as part of wider British surveys such as for ringed plover (Prater 1989). It should be noted that, due to the remote nature of Region 14, many surveys find it difficult to achieve full coverage in this area and this should be considered in any comparison of its conservation value of this region.

Extensive survey work by volunteers has also been undertaken for a number of species. Usually these surveys are organised as part of wider British surveys, e.g. that in 1991 by the Wildfowl & Wetlands Trust for shelduck.

5.11.5 Acknowledgements

Thanks are due to Simon Delany and WWT (for the use of unpublished shelduck data); David Cole and George Boobyer (JNCC); and Mark Tasker (JNCC), Roger Board (RSPB) and Nigel Smith (SNH) for their comments.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Breeding atlas data	*Development Unit, British Trust for Ornithology, Thetford, tel: 01842 750050
Coastal breeding wildfowl data	*Wildfowl & Wetlands Trust, Slimbridge, tel: 01453 890333
Site designations and breeding bird information	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Site designations and breeding bird information in Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Site designations and breeding bird information in the south of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
RSPB Strathclyde Office	*Regional Officer, Glasgow, tel: 0141 945 5224

*Starred contact addresses are given in full in the Appendix.

5.12 Migrant and wintering waterfowl

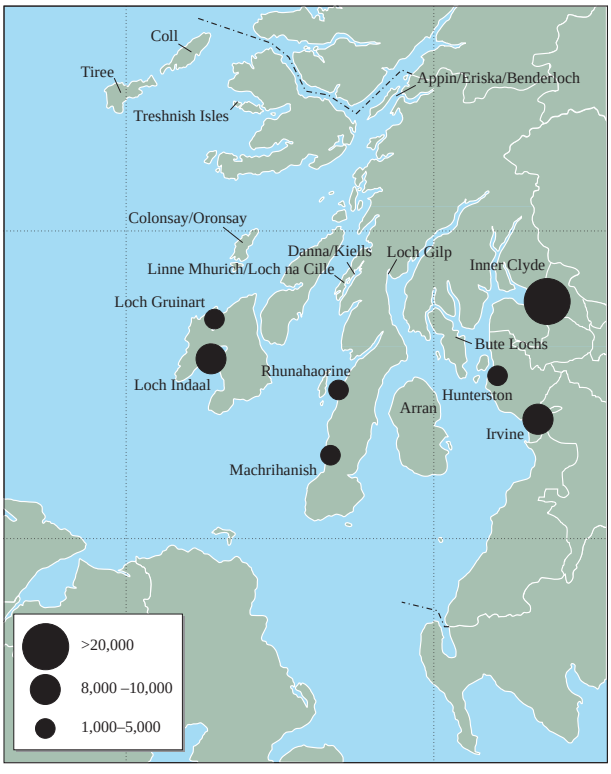
D.M. Craddock & A.B. Law

5.12.1 Introduction

This section describes the importance of the region to waterfowl, defined as waders and wildfowl (divers, grebes, ducks, geese and swans together with coot *Fulica atra*), during their non-breeding period. The section also notes the occurrence of marine-wintering waterfowl and cormorant *Phalacrocorax carbo* where they occur close inshore, especially within estuaries; their overall regional distribution, including the importance of offshore areas, is covered in section 5.10.

This region is characterised by extensive rocky and sandy shorelines, both exposed and sheltered, sea lochs, islands, sheltered waters and one large and a few small estuaries. For some birds, sites within the region are the most important within the UK, either in migratory periods or in winter. Most important in this region are the island lochs, which act as roost sites to internationally important numbers of passage and wintering geese, notably Greenland barnacle geese *Branta leucopsis* and Greenland white-fronted geese *Anser albifrons flavirostris*. In winter, Islay, Coll and Tiree support at least 36% of the world population of Greenland white-fronted geese and approximately 17% of the world population of all races of barnacle goose, as well as being internationally or nationally important for a number of other species. The region lies on a major migratory flyway and many birds pass through as they move between wintering areas on the African and southern European coasts and breeding grounds in the Arctic.

In mid-winter this region holds over 40,000 waterfowl. Table 5.12.1 gives the total January 1993 waterfowl count for this region as a proportion of the coastal totals for Scotland and Great Britain. Regional totals are low compared with other regions because they are based on data from the relatively few sites where counts are undertaken. Such comparisons can give only a rough approximation of relative regional importance, since the data are uncorrected for the level of coverage. Furthermore, ringing studies have shown that many species demonstrate complex patterns of interchange between sites during the course of a winter, which means that individual site totals can be misleading (Davidson *et al.* 1991).



Map 5.12.1. Distribution of main concentrations of wintering intertidal waterfowl. Size of circle proportional to five-year mean of waterfowl numbers, from Waters & Cranswick (1993).

Table 5.12.1 Waterfowl counts in Region 14, Scotland and Great Britain in January 1993

	Total waterfowl count in January 1993	*Number of sites counted*	*% of count in Region 14*
Region 14	40,116	27	-
All counted Scottish coastal sites	299,676	78	13.4
All counted GB coastal sites	***2,060,961***	***214***	***2***

Source: Rose & Taylor (1993). Notes: care should be taken in interpretation as count coverage varies and data have not been corrected. These totals exclude many of the goose populations within the region.

Overall, six species of waterfowl (redshank *Tringa totanus*, Greenland white-fronted goose, Greenland barnacle goose, turnstone *Arenaria interpres*, ringed plover *Charadrius hiaticula* and greylag goose *Anser anser*) occur in the region at levels of international importance on at least one site; with a further seven species occurring at levels of national (i.e. Great Britain) importance. In addition, the west coast of Scotland (Regions 13, 14, 15 and 16), together with Shetland (Region 1), holds some of the most important wintering areas in Britain for great northern divers *Gavia immer* and also has high numbers of black-throated divers *Gavia arctica* (Moser *et al.* 1986).

Although not all sections have been regularly monitored, the rocky shoreline of the region has, in general,

Table 5.12.2 Overall densities of wintering waders on the non-estuarine coast

	Number of wader species recorded	*Total number non-estuarine waders*	*Extent of non-cliff, non-estuarine coast (km)*	*Extent of coast surveyed (km)*	*Overall wader density (birds/km coast)*
Region 14	15	40,207	2,376	2,114	19

Source: Winter Shorebird Count (Moser & Summers 1987)

Table 5.12.3 Wintering waterfowl numbers on sites in the region

Site	*International protected status*	*Five year mean nos. wintering waterfowl*	*1994/95 peak waterfowl numbers*	*1994/95 peak wildfowl numbers*	*1994/95 peak wader numbers*	*Species occurring at levels of national or international* importance*
Irvine	-	9,784	10,688	3,455	7,233	Eider, goldeneye
Hunterston	-	2,045	2,290	1,383	907	-
Inner Clyde Estuary	-	22,242**	20,866	7,051	13,815	Redshank*, cormorant, scaup, goldeneye, curlew, eider, oystercatcher, red-breasted merganseer
Bute Lochs	-	1,984	2,370	2,370	-	Greylag goose*, Greenland white-fronted goose
Loch Gilp	-	1,003	795	290	505	
Machrihanish	-	1,057	1,110	1,110	-	Greenland white-fronted goose*
Rhunahaorine	-	1,010	726	726	-	Greenland white-fronted goose*
Linne Mhurich/ Loch na Cille†	-	542	542	542	-	Greenland white-fronted goose
Danna/Kiells	-	894	381	381	-	Greenland white-fronted goose*, barnacle goose*
Appin/Eriska/Benderloch	-	271	336	336	-	Greenland white-fronted goose
Islay:	7 SPAs, 6 Ramsar sites	-	-	-	-	Greenland white-fronted goose*, barnacle goose*
Loch Indaal	-	6,040	6,182	3,564	2,618	Scaup, red-breasted merganser, barnacle goose*
Loch Gruinart	-	3,081	3,932	1,182	2,750	Greenland white-fronted goose*, barnacle goose*, great northern diver, Slavonian grebe
Colonsay/Oronsay	-	-	-	-	-	Greenland white-fronted goose, barnacle goose*
Treshnish Isles	SPA	-	-	-	-	Barnacle goose*
Coll	SPA & Ramsar site	-	-	-	-	Greenland white-fronted goose*, barnacle goose*, ringed plover*
Tiree	-	-	-	-	-	Greenland white-fronted goose*, barnacle goose*, ringed plover*, turnstone*, sanderling

Sources: WeBS data from Waters *et al.* (1996); Fox *et al.* (1994); Pritchard *et al.* (1992). Key: SPA = Special Protection Area; Ramsar site = internationally important wetland; *species occurring at levels of international importance; **sites holding >20,000 waterfowl are of international importance by virtue of absolute numbers; †probably some overlap in numbers; **-** = no count available. Notes: wildfowl and wader figures include divers, grebes, cormorant and grey heron. Winter season used by WeBS is November to March for waders and September to March for wildfowl. See Waters *et al.* (1996) for further details on interpretation of counts and limitations of data.

a moderate density of waders in a GB context (Table 5.12.2) (Moser & Summers 1987).

5.12.2 Important locations and species

Table 5.12.3 shows numbers of wintering waterfowl on wetland sites in the region, during the winters of 1990/1 to 1994/5 (Map 5.12.1). The species composition of assemblages of estuarine and non-estuarine waders and estuarine wildfowl in the region is shown in Figure 5.12.1.

The Inner Clyde Estuary, Bute Lochs, Machrihanish, Rhunahaorine, Linne Mhurich/Loch na Cille, Danna/Kiells, Islay, Colonsay, Coll and Tiree are of international importance for at least one species of wintering waterfowl. The Inner Clyde Estuary qualifies as being internationally important by virtue of holding over 20,000 waterfowl and in terms of waterfowl species diversity it represents the second most important area on the west coast of Scotland, after the Western Isles (Pritchard *et al.* 1992).

The Clyde Estuary is also internationally important for wintering redshank and supports the largest wintering numbers of greenshank *Tringa nebularia* of any site in Scotland (Pritchard *et al.* 1992). Although it has a relatively small area of tidal flats, the Inner Clyde, with peak count of 1,750 waders per km^2, supports the third highest recorded density of waders in Scotland after the Eden (Region 4) and Ythan (Region 3) Estuaries (Halliday *et al.* 1982). Two areas of outstanding importance are the south shore between Langbank and Longhaugh Bay and the north shore between Milton and Ardoch. A 1976/77 survey of the Clyde showed that shelduck, oystercatcher *Haematopus ostralegus*, lapwing *Vanellus vanellus*, dunlin *Calidris alpina* and redshank were the most numerous species there (Halliday *et al.* 1982). The mussel beds between Woodhall and Finlaystone are exploited around low tide by oystercatcher and curlew *Numenius arquata*, while the flats between Milton and Dumbarton and at Erskine support high concentrations of feeding birds such as redshank on either side of high tide. Pillar Bank supports large numbers of eider *Somateria mollissima* and oystercatcher, which feed on the rich mussel and marine snail *Hydrobia* spp. populations (Halliday *et al.* 1982).

Three species of diving duck - eider, red-breasted merganser *Mergus serrator* and goldeneye *Bucephala clangula* - were found to be abundant in the Firth of Clyde and south Argyll in the Winter Shorebird Survey, with red-breasted

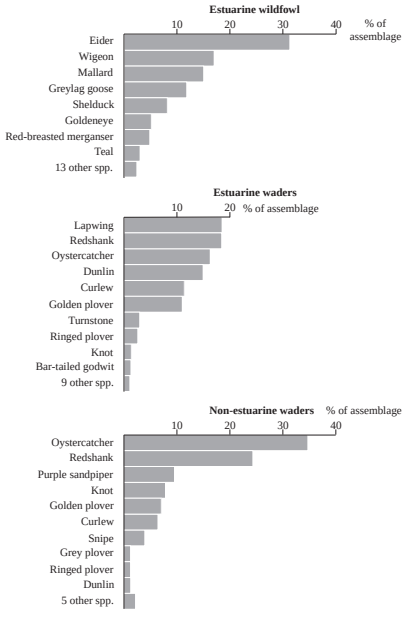


Figure 5.12.1 Relative species composition of non-breeding waterfowl assemblages on coastal areas of the region. Sources: estuarine waterfowl data from Prater (1981), non-estuarine wader data from Moser & Summers (1987).

merganser being the second most abundant diving duck after eider (Moser *et al.* 1986). The Clyde supports nationally important numbers of goldeneye. The Clyde and Garnock Estuaries and the Irvine to Saltcoats coast were all nationally important for eider in the winter of 1992/93 and have among the largest populations found on British sites (Walters & Cranswick 1993). The Inner Clyde sea lochs are also important for eider.

The rocky shorelines of the region hold internationally important numbers of passage and wintering wader species. The Winter Shorebird Survey (Moser *et al.* 1986) found that mallard *Anas platyrhynchos,* wigeon *A. penelope* and teal *A. crecca* were the three most abundant species occurring on the rocky shores of the region; they are normally found at the heads of the larger sea lochs. Shelduck *Tadorna tadorna* are relatively scarce, with the largest concentration occurring on Islay. Those wader species occurring on non-estuarine coasts vary greatly with exposure and type of substrate. Rocky shoreline coastal sites typically show large numbers of waders such as turnstone and purple sandpiper *Calidris maritima* (Moser & Summers 1987).

Arran and Appin/Eriska/Benderloch are nationally important areas for wintering waterfowl. Important moulting sites for red-breasted merganser in the region include Loch Indaal and Claggan Bay on Islay (Ogilvie 1992). The Inner Hebrides are important during winter for other species of waterfowl: Loch Indaal is the second most important British site for scaup *Aythya marila*, and supports small concentrations of great northern diver and Slavonian grebe *Podiceps auritus* (Waters & Cranswick 1993). Numbers of long-tailed duck *Clangula hyemalis* on Loch Indaal, though small in a Scottish context, are important within the region.

In Scotland the Greenland population of barnacle geese is becoming increasingly concentrated on inhabited, cultivated islands, particularly Islay, Coll and Tiree (Delany & Ogilvie 1994). Virtually the whole international population of these birds uses the Loch Gruinart Special Protection Area (SPA) in October before dispersing to other Irish and Scottish wintering sites (Easterbee *et al*. 1987). 60% of them stay at Loch Gruinart over the winter, as do approximately 4% of the world population of Greenland white-fronted geese. Loch Indaal (including the Laggan Peninsula) is the other major roost site on Islay for barnacle geese (Owen *et al.* 1986), and Bridgend is one of the most important sites for lapwing, with a peak count of 3,000 in September 1974 (Boyd & Bowes 1983). The Treshnish Isles support approximately 2% of the wintering population of Greenland barnacle geese (Pritchard *et al. 1992*).

As the region is on the west of the British mainland, it can increase in importance in periods of severe cold weather further east in Scotland and continental Europe. Under these conditions, there may be influxes of waterfowl such as wigeon and teal from other coastal regions or inland areas (Ridgill & Fox 1990). In severe weather in 1981/82 waterfowl populations increased substantially on estuaries throughout Britain (Davidson *et al.* 1991).

Islay, Colonsay, Coll and Tiree are important as staging areas for certain species in autumn, especially for whooper swan *Cygnus cygnus*, golden plover *Pluvialis apricaria*, lapwing, dunlin and snipe *Gallinago gallinago* (Percival *et al.* 1996; Pritchard *et al.* 1992). Important locations include Loch Indaal on Islay, where passage waders also include sanderling *Calidris alba* and ringed plover (Ogilvie 1992). Also on Islay, numbers of knot *Calidris canutus* and sanderling peak during the autumn migration, with only small numbers wintering (Boyd & Bowes 1983). In winter the northern race of the dunlin *Calidris alpina alpina* replaces the southern race *C. a. schinzii,* which breeds in small numbers throughout the region (see section 5.11), with the largest numbers occurring on Islay (Boyd & Bowes 1983).

In autumn and spring Islay holds large flocks of migrating bar-tailed godwit *Limosa lapponica,* and whimbrel *Numenius phaepus* also occur on passage. Curlew are very abundant in winter on Islay, with redshank and greenshank occurring in small numbers on Islay and Mull. Grey plover *Pluvialis squatarola* are regular on passage on Islay and Tiree. On Islay the resident southern race of golden plover is joined by northern race birds on passage in April and May (Booth 1981).

5.12.3 Human activities

Many parts of the region's coast lie within designated sites (for example National Nature Reserves, Sites of Special Scientific Interest, Special Protection Areas and Ramsar sites - see Chapter 7). Many were selected wholly or partly for their migrant and wintering waterfowl interest. International sites include seven Ramsar sites and nine Special Protection Areas important for wintering waterfowl. The RSPB manage much of the pasture around Loch Gruinart (Pritchard *et al.* 1992), parts of both Tiree and Coll, Horse Isle and two areas around the Clyde (Gibson 1982).

Wintering waterfowl may be affected directly or indirectly by a wide range of human activities. For example, the importance of saltmarsh and grazing marsh for wintering waterfowl can be greatly increased by appropriate management. To conserve Islay's internationally important Greenland white-fronted and Greenland barnacle goose populations, a goose management scheme was introduced in 1992/93 by Scottish Natural Heritage, to promote sympathetic management of land where geese regularly occur. The management of this

area is of crucial importance for the well-being of the population (Stroud *et al.* 1990). At both RSPB's Loch Gruinart reserve and elsewhere on Islay, management agreements with SNH have been established, to maintain areas for geese and to prevent the birds from being scared away (Pritchard *et al.* 1992). However, the smaller flocks of Greenland white-fronted geese also need protection, to avoid contraction of their range (Fox *et al.* 1994).

Wildfowling is practised across the UK, especially in estuaries, and is a potential cause of disturbance to waterfowl, although it is generally well regulated. The impacts and regulation of wildfowling on National Nature Reserves have been reviewed by Owen (1992). There is generally close liaison in the regulation of wildfowling between local shooting clubs, the British Association for Shooting and Conservation (BASC) and Scottish Natural Heritage local staff. Owen (1992) made a number of recommendations for improving the operation of existing schemes to regulate shooting on NNRs.

Incremental land claim has the potential to affect waterfowl populations through loss of feeding habitat (Goss-Custard & Yates 1992), although at important sites SSSI designation provides a planning control mechanism which can be used to limit such activity. Coastal windfarm developments in sensitive areas also have the potential to be highly disruptive to wintering waterfowl (Crockford 1992). Islay game bags for snipe have been far lower than in the 1920s (Boyd & Bowes 1983), as have those for woodcock *Scolopax rusticola* on Islay and Mull.

Bait digging and shellfish collection from intertidal sediments, as well as other recreational activities in the more heavily populated parts of the region, are potentially disruptive and may prevent waterfowl using feeding areas. Research is needed on the extent of disturbance caused by these activities and its significance for waterfowl populations in order to ensure that coastal management planning can best minimise negative impacts. The significance of these activities varies not only from site to site but also with the time of year (Davidson & Rothwell 1993). Disturbance may be a particular problem if it occurs in cold periods, when wintering waterfowl need to feed almost continuously in order to survive. The Clyde Estuary is particularly vulnerable to threats of pollution and recreational disturbance, owing to its proximity to large urban areas. However, in the Clyde Estuary in the post-war period, huge improvements in water quality in terms of its organic content have led to reductions in invertebrate food supplies and a consequent decline in the numbers of waders (Furness *et al.* 1986). Oil pollution is well known as a serious potential threat to wintering waterfowl in areas where high densities of birds occur.

5.12.4 Information sources used

Unlike in other areas of the UK, migrant and wintering waterfowl are not especially well surveyed in this region by the Wetland Bird Survey (WeBS - organised by the British Trust for Ornithology, the Wildfowl & Wetlands Trust, the Royal Society for the Protection of Birds and the JNCC), although most of the main sites are covered. This volunteer-based survey collates monthly counts from coastal and inland wetlands through the UK. Coastal coverage is generally good for estuaries, although the open coast is not thoroughly surveyed on an annual basis (Waters & Cranswick 1993). The remote nature of this region means that survey coverage is limited in some areas. The WeBS scheme publishes an extensive annual summary report, the most recent being Waters *et al.* (1996) covering the winter season 1994/95. This report summarises species trends, based on counts at wetlands throughout the UK. It also tabulates counts of total waterfowl numbers at all counted estuaries, as well as inland sites. It is the primary source of information on wintering and migrant waterfowl in the UK. Copies are available from either of the WeBS National Organisers listed in section 5.12.6. The annual report can only summarise what are very detailed data and care should be taken in interpreting the data. Detailed count data for sites can be provided by WeBS, and inspection of these data is recommended for any planning-related activity. The WeBS waterfowl counts are generally undertaken at high tide when waterfowl gather in high densities on roosting areas. To complement this information, at selected estuaries WeBS organises low-tide counts to give information on the feeding distributions of waterfowl during the intertidal period. Sites in the region for which low-tide counts are available include Hunterston and the Clyde Estuary.

The whole British coastline was surveyed for wintering waders during the Winter Shorebird Survey of 1984/85 (Moser & Summers 1987; Moser *et al.* 1986), and there are current WeBS plans for a repeat national non-estuarine waterfowl survey in 1997/98. Such information on the wintering waterfowl of the non-estuarine coast is important for setting annual estuaries' counts in a wider perspective.

There have been a number of more detailed studies of the wintering waterfowl of this region. Sites on Kintyre were the subject of detailed surveys in 1986/87 (Bignal 1987; Batty 1988) and by the RSPB in 1993/94. Regular surveys are also undertaken of pinkfoot, greylag and barnacle geese by the Wildfowl & Wetlands Trust, on behalf of SNH and the Joint Nature Conservation Committee. Information on wildfowl populations on Coll and Tiree is summarised in Stroud (1989).

Although the data are becoming slightly dated, Owen *et al.* (1986) give a thorough and comprehensive account of the wildfowl and wetlands of the region, summarising data available up to the mid-1980s. The volume is an invaluable source of initial information on sites and species, although those data presented should now be supplemented by more recent count information, available as indicated elsewhere in this section.

Prater (1981) gives useful descriptive accounts of the birds of British estuaries, as well as placing these in a wider national and international context, using data from 1969-1975. As in Owen *et al.* (1986), much of the numerical information is dated and the site accounts should be supplemented by the more recent reviews of Davidson *et al.* (1991) and Buck (1993). For sites of international importance (either proposed or designated), *Important bird areas in the UK*, published jointly by RSPB and the country agencies (Pritchard *et al.* 1992), provides further information. Data on the important bird populations of each site are summarised, together with information on locations and habitats.

5.12.5 Acknowledgements

The authors would like to thank Simon Delany at WWT for providing unpublished shelduck data.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
High tide and low tide counts of wintering and migrant wildfowl (WeBS)	*WeBS National Organiser (Wildfowl), The Wildfowl & Wetlands Trust, Slimbridge, tel: 01453 890333
High tide counts of wintering and migrant waders (WeBS)	*WeBS National Organiser (Waders), The British Trust for Ornithology, Thetford, tel: 01842 750050
Low tide counts of wintering and migrant wader (WeBS)	*WeBS National Organiser (Low Tide Counts), The British Trust for Ornithology, Thetford, tel: 01842 750050
Site designations and waterfowl information	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Site designations and waterfowl information in Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Site designations and waterfowl information in south of region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488

*Starred contact addresses are given in full in the Appendix.

5.13 Land mammals

Dr C.E. Turtle & K. Meakin

5.13.1 Introduction

This section covers land mammals that occur in the coastal 10 km squares in the region, concentrating on those that are truly coastal, such as otters, and those that occur on the coast for reasons of shelter and foraging, such as some species of bat. Other mammals - common and widespread throughout Britain, feral or recently introduced - have not been considered.

The mammal fauna of the region is strongly influenced by the distribution of terrestrial habitats. The southern part of the region is more intensively farmed than the northern part and is relatively heavily populated. In the north, much of the coast is dominated by sea lochs with long, sheltered coastlines. Inland the main habitat type is moorland, although large areas of Kintyre and Northern Argyll are heavily forested.

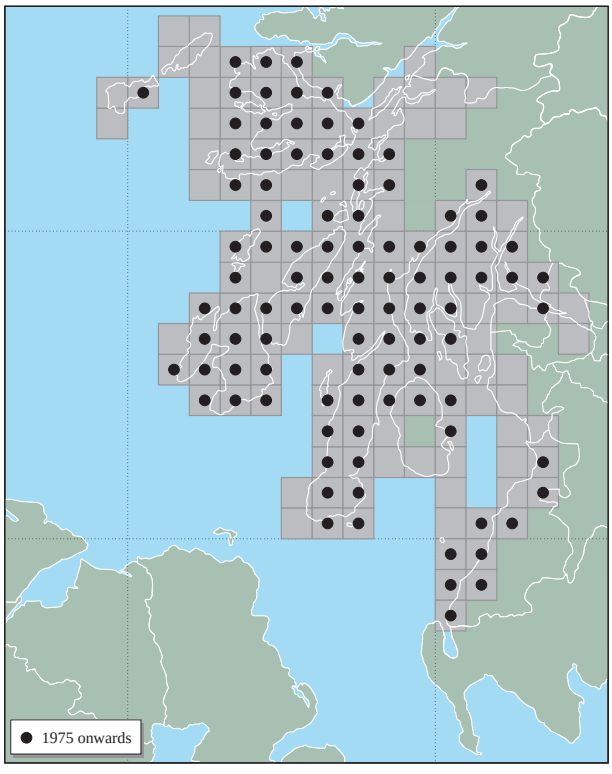
The region is significant for some of the nationally important mammal species that are vulnerable and declining (Morris 1993). The otter *Lutra lutra* is the terrestrial mammal that uses the coast most frequently; it has a stronghold in Scotland. In Britain the wildcat *Felis sylvestris* is restricted to Scotland, where it is on the northern edge of its European range. The European population of the wildcat is diminishing (Easterbee *et al.* 1991), although there is some doubt about the true distribution of this species because of the difficulty of identifying the animal owing to the possibility of hybridisation with feral cats (D. Balharrie pers. comm.). Parts of the region support pine martens *Martes martes* and red squirrels *Sciurus vulgaris*, which are also of national significance. The red squirrel is extinct over much of England and Wales but is still widespread in wooded parts of Scotland (Morris 1993). Pine martens also are extinct over most of England and Wales (Morris 1993).

Only four species of British bat are recorded from this region (Arnold 1993). Three of these, the pipistrelle *Pipistrellus pipistrellus*, brown long-eared bat *Plecotus auritus* and Natterer's bat *Myotis nattereri*, are classed as vulnerable in Europe; the Daubenton's bat *M. daubentonii* is not threatened at present (Stebbings & Griffith 1986). Here, all species are on the edge of their northerly range in Europe.

All these species are protected under Schedule 5 of the Wildlife and Countryside Act. Otters, wild cats and bats are also protected under Schedule 2 of the Conservation (Natural Habitats &c.) Regulations 1994. All British bats are also listed under Appendix III of the Bern Convention. Table 5.13.1 summarises the recorded distribution of protected mammals in the region.

5.13.2 Important locations and species

The 1984-85 otter survey of Scotland (Green & Green 1987) found evidence of otters in all coastal 10 km squares within the region, apart from the mainland coast of the Firth of Clyde between Greenock and Irvine (Map 5.13.1). The highlands and sea lochs of Argyll & Bute support some excellent otter habitat and the long and frequently sheltered stretches of coastline there have a high otter population



Map 5.13.1 Recorded distribution of otters in coastal 10 km squares in the region. Records from 1975 onwards. Source: Arnold (1993).

(Green & Green 1987). In the south of the region, otter signs are present on some coastal burns, suggesting limited exploitation of the coast (Green & Green 1987).

The national bat habitat survey (Walsh & Harris 1996a, b) included coastal habitats and demonstrates that bats use the coast for foraging, where there is suitable habitat with shelter and flightlines to feeding areas.

Red squirrels are dependent on large conifer plantations with good seed crops and relatively low tree densities. They are recorded from the forests of Argyll and from a few scattered locations along the south of the region, reflecting forestry plantation cover (TGUK/FC 1991). In broadleaved woodlands in the UK in general they are mainly found where there are no grey squirrels: there are no records for grey squirrels in this region.

Table 5.13.1 Recorded occurrence of protected mammals in Region 14

Species	*Estimate of importance in region*
Natterer's bat	Rare
Daubenton's bat	Rare
Pipistrelle	Frequent
Brown long-eared bat	Rare
Red squirrel	Rare
Otter	Common
Wildcat	Occasional

Source: Arnold (1993)

Pine martens are dependent on large, mixed conifer plantations and are unable to survive solely in coastal habitats. Pine martens favour young forest plantations with coarse grassland, moorland or grass and scrub rides and borders, as these habitats carry high numbers of field voles (Gurnell *et al.* 1994): mature plantations provide less valuable habitat (D. Balharrie pers. comm.). The pine marten survey of 1980-82 (Velander 1983) records pine martens from the north of Argyll & Bute in coastal conifer plantations, where they are at the southern boundary of their current main distribution; Velander (1983) suggests that pine martens will eventually expand their range southwards to link up with an outlying remnant population at Tarbert.

Wildcats utilise a variety of habitats including woodland, moorland, grassland and marsh. They are also known to use sheltered areas of coast (Easterbee *et al.* 1991), although as with the pine marten their distribution in the region seems to reflect the incidence of forestry plantations. Reduced persecution and forestry plantation have contributed to an expansion in numbers and distribution (Morris 1993).

5.13.3 Human activities

To the south of the Clyde the relatively high human population density, with recreation pressure from beach resorts and sailing, gives rise to considerable potential for disturbance to all terrestrial mammals. Industrial development and relatively poor water quality around the estuary itself coincide with a gap in the coastal range of otters. To the north and west, many sea lochs are now used for fish farming, and although no threat to otter populations has been established (J. Green & R. Green pers. comm.) there is concern that there may be long-term effects to the coastal ecosystem from chemicals used to maintain the health of the fish stocks and organic enrichment by fish food (A. Somerville pers. comm.; Morris 1993).

The use of lobster creels still causes fatalities in otters (Jefferies *et al.* 1984), although eel fyke nets have been successfully modified (J. Green & R. Green pers. comm.).

5.13.4 Information sources used

There are no reliable estimates of the numbers of mammals in the region that could be used to quantify the resource. Using data from Arnold (1993) - although the records are incidental rather than comprehensive - an estimate has been made of their occurrence in the region. As a general observation (Morris 1993), mammals are not recorded with the same intensity as botanical species and the occurrence of mammals within 10 km squares is not enough to establish the status of species.

There have been no comprehensive surveys for bats, although the Biological Records Centre has recent records of all species. English Nature's Bat Sites Register, currently in preparation (Mitchell-Jones 1995), records the region's most important sites for bats as known in 1991. A red squirrel survey was undertaken in 1991 by TGUK/FC using questionnaires sent to their members, the results of which indicated the importance of coastal sites (TGUK/FC 1991).

The otter and wildcat are the only mammals to have been surveyed at coastal sites on a strategic basis (Green & Green 1980). The otter surveys (Green & Green 1980, 1987) have established the importance of coastal areas for the otter population, but it is difficult to establish the significance of the wildcat records owing to the possibility of hybridisation.

The 1980-82 pine marten survey (Velander 1983) did not cover many of the coastal areas of this region, but the records demonstrate the importance of some scattered coastal sites.

5.13.5 Acknowledgements

The authors would like to thank all those people cited in the text for their valuable information and their time. The Biological Records Centre, Monks Wood, provided recent data for the area.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
General mammal information, Biological Records Centre	*Institute of Terrestrial Ecology, Monks Wood, Huntingdon, tel: 01487 773381
Species information; Bat Sites Register	*SNH, Research and Advisory Services Directorate, Edinburgh, tel: 0131 554 9797
Local site and species information in Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Local site and species information in the south of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
Local site and species information	*Dr A. Somerville, Conservation Officer, Scottish Wildlife Trust, Edinburgh, tel: 0131 312 7765
Bats	Prof. P. Racey, Dept. of Zoology, Tilydrone Avenue, Aberdeen AB9 2TN, tel: 01224 272858
Bats	Andrew Collins, The Coach House, Torrance Estate, East Kilbride G75 0QZ, tel: 01355 236644
Otters	Jim and Rosemary Green, The Vincent Wildlife Trust, Otter Rehabilitation Centre, Barjarg, Girvan, Ayrshire KA26 0RB, tel: 01465 821225
General mammal information	The Mammal Society, Unit 15, Cloisters House, Cloisters Business Centre, 8 Battersea Park Road, London SW8 4BG

*Starred contact addresses are given in full in the Appendix.

5.14 Seals

C.D. Duck

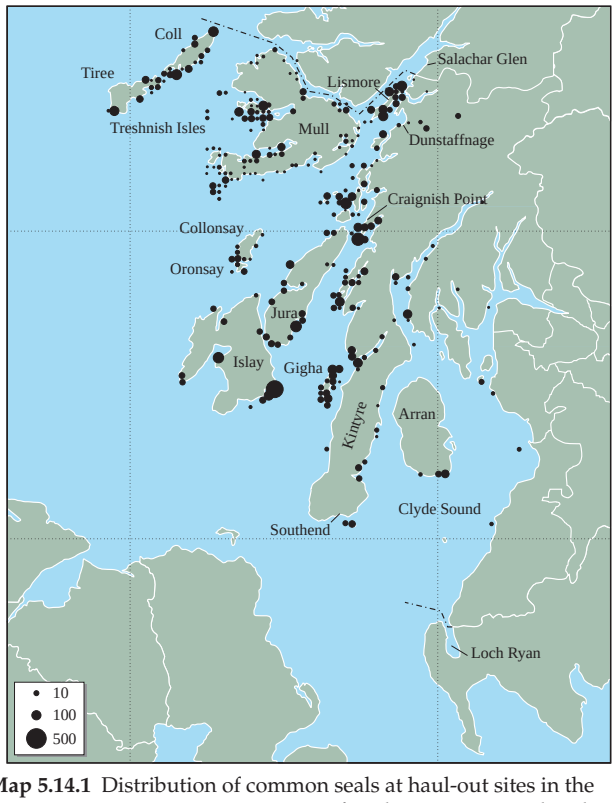
5.14.1 Introduction

Common seals *Phoca vitulina* can be seen throughout the region and are particularly abundant on sheltered coasts from Gigha northwards (Map 5.14.1). Over 18% of the common seals counted in Britain occur in the region. Grey seals *Halichoerus grypus* also occur throughout the region (Map 5.14.2) and breed on a number of islands in the west of the region (Map 5.14.3). In 1993, grey seal pups born in Region 14 amounted to just over 9% of the GB pup production (Sea Mammal Research Unit (SMRU) pers. comm.). Table 5.14.1 gives seal numbers in the region in context.

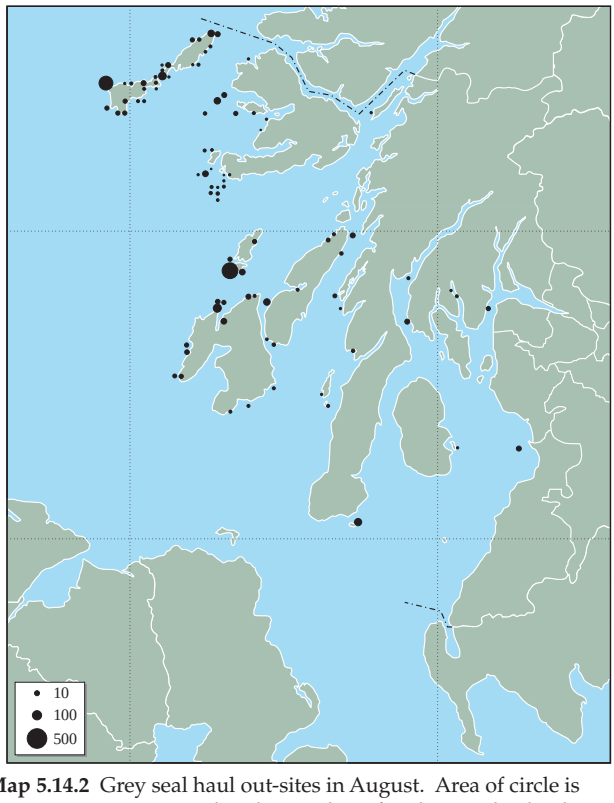
5.14.2 Important locations

The main areas where common seals haul-out in August are: Gigha and the mouth of West Loch Tarbert; Loch Sween; Loch Craignish; islands between the Garvellachs and Luing; the Small Isles off east Jura; south-east Islay; Lismore; the Torran Rocks, Loch Scridain and Ulva on Mull; and the area between Gunna, Tiree and Coll (Map 5.14.1). Although there are numerous haul-out sites around the Clyde Sea, the density of seals is considerably lower there than elsewhere in the region. Numbers of common seals counted at sites in the region are given in Table 5.14.2 (Map 5.14.1).

Grey seal summer haul-out and breeding sites are concentrated in the west of the region (Maps 5.14.2 and 5.14.3). Grey seal numbers at haul-out sites outside the breeding season are unpredictable and can vary greatly from day to day. The main breeding sites are in three groups: the north of Islay and south of Oronsay; the Treshnish Isles; and Gunna (Map 5.14.3). Pup production for each breeding site in 1993 and the associated total population size are given in Table 5.14.3. In addition to the main sites listed, small numbers of pups are born around Loch Tarbert (Jura), on Soa, Staffa and other small islands off the west coast of Mull, and on Coll and Tiree.



Map 5.14.1 Distribution of common seals at haul-out sites in the region in August. Area of circle is proportional to the number of seals in each 2 km by 2 km square. Source: SMRU.

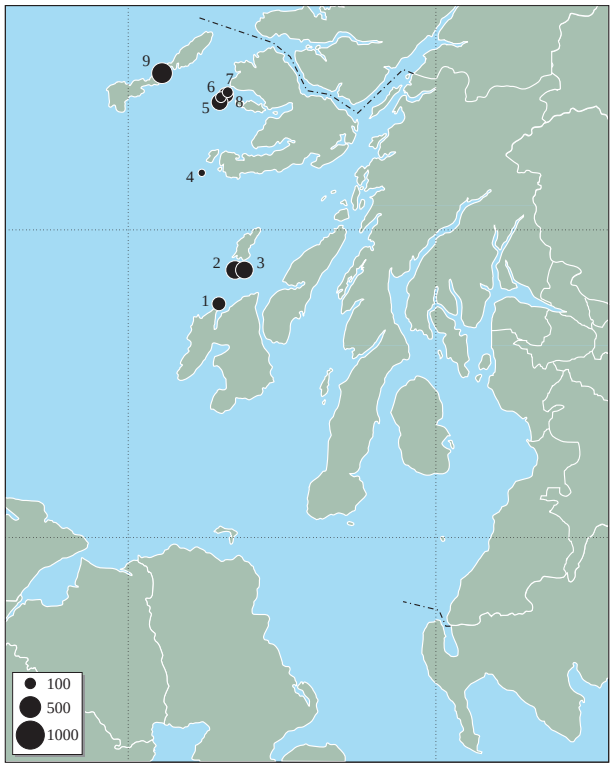


Map 5.14.2 Grey seal haul out-sites in August. Area of circle is proportional to the number of seals in each 2 km by 2 km square. Source: SMRU.

Table 5.14.1 Number of common and grey seals in the region in relation to the rest of GB

Location	*Common seals*		*Grey seals*		
	*Number of seals**	*% of GB total*	*Pup production**	*% of GB total*	*Associated population >=1 year old**
Region 14	***5,150***	***18.2***	***3,175*****	***9.4***	***10,800***
Scotland	26,400	93.1	31,000	91.6	105,300
GB	28,350	100	33,850	100	115,000

Source: SMRU. Key: *to nearest 50; **to nearest 25.



Map 5.14.3 Grey seal pup production. Area of circle is proportional to the number of pups born at each location in 1993. Numbers refer to Table 5.14.3. Source: SMRU.

5.14.3 Human activities

The sheltered inshore waters of the region are popular with small boat owners and sub-aqua divers, particularly during the summer months; these have the potential to disturb seals. Seals are an important tourist attraction and small boat operators from a number of small ports, including Ardfern, Craobh Haven, Oban and Dervaig (Mull), take tourists to see seals. On the west coast of Kintyre, common seals can be observed from the roadside. To encourage seal watching, benches have been positioned by the road at a suitable distance from the haul-out sites.

The region supports an important salmon farming industry, with fish farms being sited in many sheltered coastal locations (see also section 9.2). Seals are discouraged from visiting fish farms and may be shot. There is a thriving inshore fishing industry with small boats operating out of the numerous ports along the coast. The question of seals competing for fish with fishermen remains contentious.

The Firth of Clyde is a major shipping route accessing ports near Glasgow, and there is a naval base in The Gare Loch. However, these appear not to have any direct impact on seals. Seals are always susceptible to contamination from spilled oil, but such occurrences are rare.

5.14.4 Information sources

Data on the numbers and distribution of seals in the region were collected by SMRU as part of the Natural Environment Research Council's statutory obligation under the Conservation of Seals Act (1970) to provide the Scottish and Home Offices with information on the size and status of common and grey seal populations in Britain.

For common seals, information supplied here is summarised from surveys carried out by SMRU between 1989 and 1993. These surveys, using a helicopter equipped with a thermal imaging camera, were conducted during early August when common seals moult and the greatest and most consistent numbers of seals are hauled out. However it is outside the seals' breeding period, so the importance of the region for breeding common seals cannot be assessed. Surveying was restricted to within two hours of low water and to low tides occurring between 1000 hrs and 1800 hrs BST. For areas surveyed more than once (Appin, Mull and Lismore), the mean numbers of seals counted have been used. A second complete survey of these areas will be carried out between 1996 and 1998. Prior to 1988, surveys were conducted from boats during the breeding season, between early June and mid-July 1975 to 1980 (Vaughan 1983).

For grey seals, SMRU undertake annual aerial surveys of the main breeding sites using conventional large-format photography (Hiby *et al.* 1988; Ward *et al.* 1987) and the data used here refer to numbers during the breeding season. Grey seal pup production at the main breeding sites is monitored annually; pup numbers at minor sites are checked every 3-5 years.

Table 5.14.2 Numbers of common seals counted in the region

Location	*Grid ref.*	*No. of seals*	*% of region total*
Clyde Sea: Loch Ryan to Southend (Kintyre)	NW056712-NR687075	381	7.4
Mull of Kintyre, west: Southend to Craignish Point	NR687075-NR754991	1,153	22.4
Firth of Lorn: Craignish Point to Dunstaffnage	NR754991-NM880345	461	9.0
Appin: Dunstaffnage to Salachan Glen	NM880345-NM966533	59	1.1
Lismore	NM834410	461	9.0
Islay	NR340680	724	14.1
Jura	NR520750	375	7.3
Oronsay & Colonsay	NR370930	133	2.6
Mull	NM600370	869	16.9
Treshnish Isles	NM290430	29	0.6
Coll	NM200570	367	7.1
Tiree	NM000460	124	2.4

Source: SMRU aerial survey data 1988-1993

Table 5.14.3 Grey seal pup production at main breeding sites in 1993

Site no. on Map 5.14.3	*Location*	*Grid ref.*	*No. of pups born*	*% of region total*
1	Nave Island	NR287757	312	9.8
2	Eilean nan Ron	NR336866	492	15.5
3	Eilean an Eoin & E. Ghaoideamal	NR367868	474	14.9
4	Soa	NM243192	95	3.0
5	Lunga	NM276415	419	13.2
6	Sgeir a'Chaisteil & Sgeir an Eirionnaich	NM279429 & NM282433	199	6.3
7	Fladda	NM297437	362	11.4
8	Cairn na Burgh Mor & Beg	NM306448	240	7.6
9	Gunna	NM100513	582	18.3

Source: SMRU aerial survey data, 1993.

5.14.6 Acknowledgements

Thanks to Dave Clem and PLM Helicopters for their enthusiasm during the helicopter surveys. Peter Wormell, Robin Tappley and Kenny Taylor (SWT), Andrew Campbell, Patrick Cashman, Doug Gilbert, Dan Hunt and Erica Knott (SNH), Richard Fairbairn (Sea Life Surveys) and Ron Stevenson (Golden Sea Produce) all kindly provided useful information and comments on drafts.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Seal numbers and distribution around GB	Sea Mammal Research Unit, Gatty Marine Laboratory, University of St. Andrews, Fife KY16 8LB, tel: 01334 476161
Seals in the region	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Seals in Argyll and Bute area	*Conservation Officer, SNH, Argyll & Bute Area Office, Lochgilphead, tel: 01546 603611
Seals in the south of the region	*Conservation Officer, SNH, Mid and south Strathclyde Area Office, Clydebank, tel: 0141 951 4488
Seals in Scotland	*Scottish Wildlife Trust, Edinburgh, tel: 0131 312 7765
Seal rehabilitation	Oban Sea Life Centre, Barcaldine, by Oban, Argyll PA37 1SE, tel: 01631 720386
Seal viewing trips around Mull	Sea Life Surveys, Dervaig, Isle of Mull, Argyll PA75 6QL, tel: 01688 400223

*Starred contact addresses are given in full in the Appendix.

5.15 Whales, dolphins and porpoises

Dr P.G.H. Evans

5.15.1 Introduction

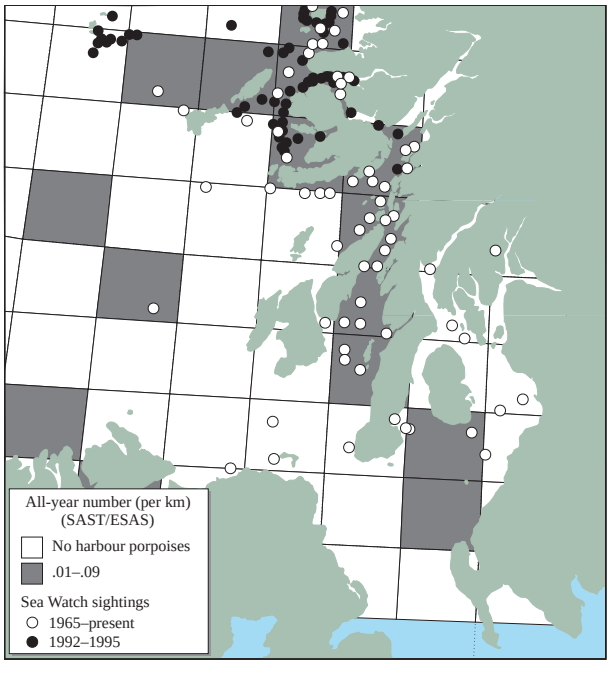
South-west Scotland has a moderately rich cetacean fauna. Headlands and the sounds between islands are the most favoured localities for cetaceans in coastal waters of the region. Fifteen species of cetaceans (whales, dolphins and porpoises) have been recorded since 1980 along the coasts or in nearshore waters (within 60 km of the coast) of the region. Of these, eight species (30% of the 27 UK species) are present throughout the year or are recorded annually as seasonal visitors to the region (Table 5.15.1). The commonest species in nearshore waters are the harbour porpoise *Phocoena phocoena* (Map 5.15.1), common dolphin *Delphinus delphis* (Map 5.15.2), white-beaked dolphin *Lagenorhynchus albirostris* (Map 5.15.3), Risso's dolphin *Grampus griseus* and minke whale *Balaenoptera acutorostrata* (Map 5.15.4), with bottlenose dolphin *Tursiops truncatus*, killer whale *Orcinus orca* and long-finned pilot whale *Globicephala melas* recorded occasionally. The common dolphin is the most abundant species offshore, although the wide-ranging long-finned pilot whale is also recorded regularly.

Other cetacean species recorded in the region include fin whale *Balaenoptera physalus*, humpback whale *Megaptera novaeangliae*, sperm whale *Physeter macrocephalus*, Sowerby's beaked whale *Mesoplodon bidens*, northern bottlenose whale *Hyperoodon ampullatus*, striped dolphin *Stenella coeruleoalba* and white-sided dolphin *Lagenorhynchus acutus*. An immature humpback whale remained in the Firth of Clyde from January to March 1994, where it was observed feeding on sprat and herring. The species was also recorded in the region in August 1985 off the Isle of Luing, Argyll. For geographical comparisons of sightings rates for various cetacean species in UK waters, see Evans (1990, 1992) and Northridge *et al.* (1995).

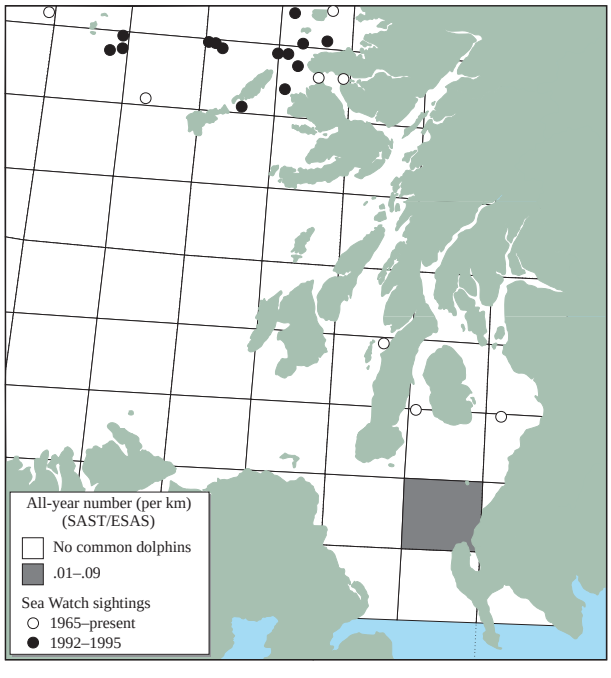
The harbour porpoise and bottlenose dolphin are listed in Annex II of the Habitats & Species Directive as species whose conservation requires the designation of Special Areas of Conservation.

Table 5.15.1 Cetacean species regularly recorded in the region

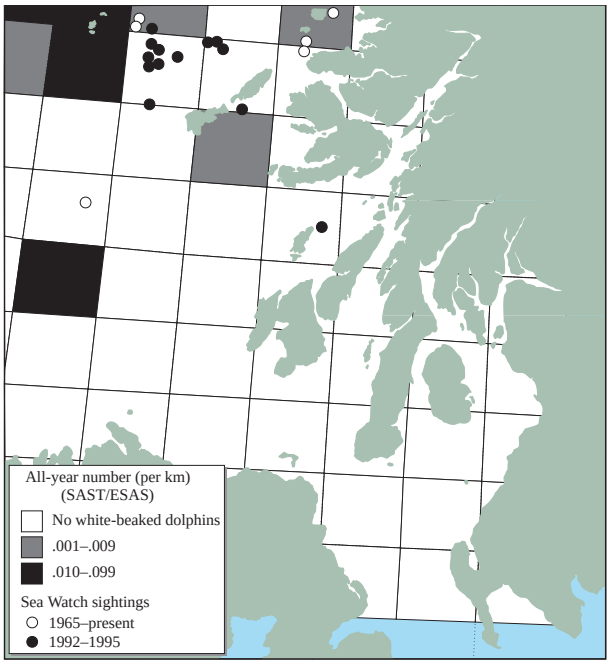
Species	*Status, distribution and seasonal occurrence*
Minke whale *Balaenoptera acutorostrata*	Widely distributed in small numbers, sightings mainly between July and October
Harbour porpoise *Phocoena phocoena*	Common and widely distributed in nearshore waters, sightings mainly between July and October
Bottlenose dolphin *Tursiops truncatus*	Uncommon throughout the year, but with peak numbers and frequency of sightings in April and September
Common dolphin *Delphinus delphis*	Relatively common throughout the region, though mainly offshore; peak numbers and frequency of sightings between May and August
White-beaked dolphin *Lagenorhynchus albirostris*	Uncommon, occurring in nearshore waters; sightings mainly between July and September
Risso's dolphin *Grampus griseus*	Uncommon, occurring mainly between March and September
Long-finned pilot whale *Globicephala melas*	Uncommon and mainly offshore between April and September.
Killer whale *Orcinus orca*	Uncommon, occurring mainly between May and September.



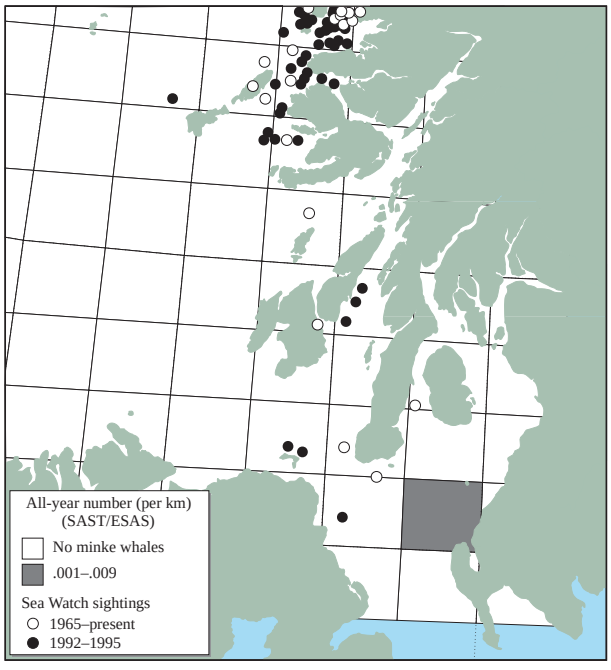
Map 5.15.1 Harbour porpoises: all-year number sighted per kilometre of Seabirds at Sea survey (source: JNCC: SAST/ESAS); and sightings reported to the Sea Watch sighting system (source: Sea Watch pers. comm.).



Map 5.15.2 Common dolphin: all-year number sighted per kilometre of Seabirds at Sea survey (source: JNCC: SAST/ESAS); and sightings reported to the Sea Watch sighting system (source: Sea Watch pers. comm.).



Map 5.15.3 White-beaked dolphins: all-year number sighted per kilometre of Seabirds at Sea survey (source: JNCC: SAST/ESAS); and sightings reported to the Sea Watch sighting system (source: Sea Watch pers. comm.).



Map 5.15.4 Minke whales: all-year number sighted per kilometre of Seabirds at Sea survey (source: JNCC: SAST/ESAS); and sightings reported to the Sea Watch sighting system (source: Sea Watch pers. comm.).

5.15.2 Important locations

Harbour porpoises are widespread in nearshore waters, particularly the Kyles of Bute, Kilbrannan Sound, the Sound of Jura, the Firth of Lorn and the northern part of the Sound of Mull, as well as around various islands, including Arran, Jura, Islay, the Treshnish Isles, Mull, Coll and Tiree. In summer, minke whales occur regularly around the Mull of Kintyre, in the Sound of Jura, around the Treshnish Isles and in the area between Caliach Point in north-west Mull, Ardnamurchan Point, the north-west end of the Sound of Mull and the north-east end of Coll.

Common dolphins are frequently seen between May and July, sometimes in large schools, north of the Cairns of Coll. Risso's dolphins are regularly seen between Mull, Coll and Tiree and killer whales in the vicinity of Iona, Staffa and the Treshnish Isles.

5.15.3 Human activities

Cetaceans in the region face three potential pressures from human activities: conflicts with fisheries (either by competition for a common food resource or accidental capture in fishing gear), habitat degradation (mainly by pollution) and disturbance (e.g. from underwater sound such as ship propellors and seismic survey).

Most of the fishing in this region is for shellfish; small fleets operate out of a number of ports (see also section 9.1). In the Firth of Clyde, there is gill netting and trawling for whitefish (Brady 1991). There are few reports of small cetaceans in the region being killed accidentally in fishing gear, although precise figures are not available (Northridge 1988).

There is no information on contaminant levels in cetaceans from the region. One harbour porpoise from neighbouring Dumfries & Galloway (Region 13) contained a total PCB level of 7.75 ppm (Kuiken *et al*. 1994).

There are few holiday resorts in the region, the major one being Oban. Other ports from which recreational activities (speedboats, jet skis etc.) occur include Stranraer, Ayr, Ardrossan, Greenock, Campbeltown and Tobermory. Such vessels pose threats of direct physical damage from collisions as well as disturbance from the high frequency noise they generate (Evans *et al*. 1992). Heavy shipping may also disturb cetaceans, but most of the sound produced by vessels with large engines is at frequencies below 1 kHz, thus overlapping more with minke whales, and other baleen whale species not resident in or regular visitors to this region, than with dolphins and porpoises (Richardson *et al.* 1995; Evans 1996). However, vessels can also generate high-frequency (>1 kHz) sound overlapping the frequencies used by small cetaceans, and vessel avoidance and increased dive times by bottlenose dolphins and harbour porpoises have been reported by Evans *et al.* (1992, 1994).

Underwater sounds from seismic activities involve low frequencies (20-500 Hz) and are therefore most likely to affect baleen whales. Nevertheless recent studies indicate that other cetaceans may also be disturbed by seismic surveying, as they are sighted less frequently, either acoustically or visually, during seismic surveys (Goold 1996). It is possible that porpoises are affected (Baines 1993), perhaps indirectly by changing the distribution of their fish prey (Evans & Nice 1996).

Codes of conduct for boat users have been produced (for example by the Seawatch Foundation & UK Mammal Society (Sea Watch Foundation & UK Mammal Society 1992)), and Scottish Natural Heritage (SNH) has a dolphin awareness scheme for Scotland, although this currently concentrates on the Moray Firth. Some whale-watching operators in the area (e.g. Sea Life Surveys and Western Isles Sailing Company) observe their own codes of conduct, which are based on those developed by Sea Watch Foundation and SNH.

5.15.4 Information sources used

Information on cetacean status and distribution comes primarily from the national sightings database (1973-present) maintained by the Sea Watch Foundation (Evans 1992) and the strandings scheme organised by the Natural History Museum in London (1913-present) (Sheldrick *et al.* 1994). Systematic land-based watches have been carried out from Calliach Point, Isle of Mull. Sea-based coverage is patchy, being good around the Isle of Mull, Coll and Tiree (as a result of regular cruises between May and October by Sea Life Surveys and Western Isles Sailing Company), but poor elsewhere. Opportunistic sightings effort has been highest between the months of April and September, when sea conditions are also usually best.

Strandings and sightings data, while helpful in providing some indication of the current status of populations, their distribution and migration patterns, do not as yet allow any definite statements to be made about any species.

5.15.5 Acknowledgements

Thanks are due to I. Grant and J. Heimlich-Boran for help in the preparation of the maps, and to all those persons who have contributed valuable sightings data, particularly the systematic observations provided by R. Fairbairns, J. Gordon, C. Swann, M.L. Tasker and A. Webb.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Cetacean strandings	Dr D. George & A. Muir, Natural History Museum, Cromwell Road, London SW7 5BD, tel: 0171 938 8861
Cetacean strandings and pathology	R.J. Reid, SAC Veterinary Investigation Pathology Centre, Stratherrick Road, Inverness IV2 4JZ, tel: 01463 243030
Cetacean sightings, surveys & photo-ID	Dr P.G.H. Evans, Sea Watch Foundation, c/o Dept. of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS, tel: 01865 727984
Cetacean sightings & surveys	*Seabirds & Cetaceans Team, Joint Nature Conservation Committee, Aberdeen, tel: 01224 655702
Cetacean surveys & photo-ID	R. Fairbairns, Sea Life Surveys, Dervaig, Isle of Mull, tel 01688 4223
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Cetacean organochlorine & heavy metal levels	Dr R.J. Law, Directorate of Fisheries Research, MAFF Fisheries Laboratory, Remembrance Avenue, Burnham-on-Crouch, Essex CM0 8HA, tel: 01621 787200
Cetacean pathology	Dr J.R. Baker, Veterinary Field Station, 'Leahurst', Neston, Wirral, Cheshire L64 7TE, tel: 0151 794 6120

*Starred contact addresses are given in full in the Appendix.

Lochranza Castle is an early example of the stone buildings that, during Mediaeval times, came to replace earlier fortified dwellings of timber and earth. Fortifications were important features of inhabited sites on a coast that for centuries was the focus for foreign raids and local territorial struggles. Photo: Pat Doody, JNCC.

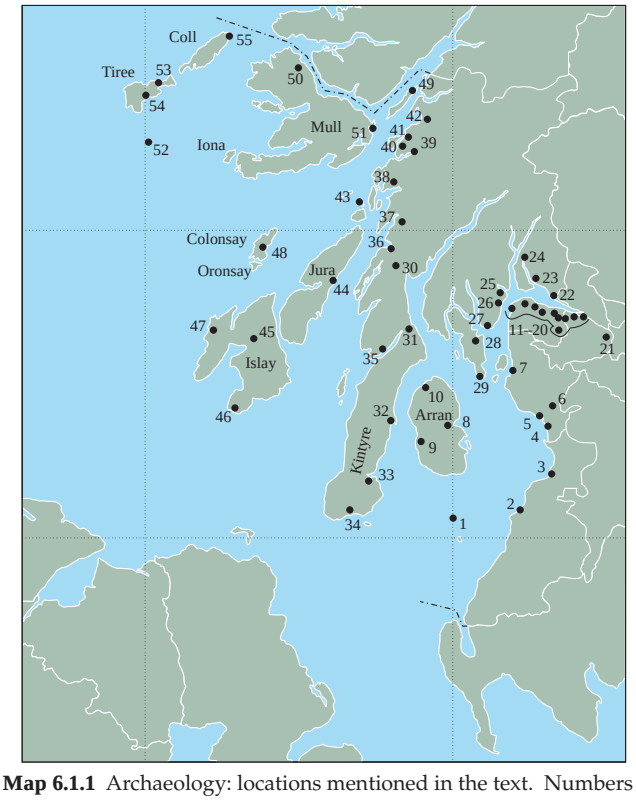
Chapter 6 History and archaeology

A. Gale & V. Fenwick

6.1 Introduction

The physical remains of the human past - archaeological evidence - are an integral and irreplaceable part of the coastal resource. Archaeological sites, whether discrete or part of wider landscapes, are fragile, and those not yet located can be unwittingly destroyed. The distribution of known sites is biased by the uneven spread of survey work, and the discovery and scientific investigation of new sites is vital to developing a full picture of the past. This chapter provides an introduction to the history and archaeology of the region, gives information on the provisions for safeguarding known and unknown sites, and describes the extent of survey work and how to report new finds. Map 6.1.1 shows archaeological locations mentioned in the text, listed in Table 6.1.1.

This region has an impressive array of standing monuments. These range from the burial chambers and standing stones of prehistory to the manufacturing and municipal buildings of New Lanark Industrial Village, the engineering of the Clyde and the awe-inspiring Skerryvore lighthouse. Excavation has revealed the rich cultural contacts of all periods, which place this region at the hub of maritime routes stretching from Africa to Ireland and Norway. The wealth of information derived from prehistoric sites is a reminder of the need for extensive study of the more humble sites of the historic period to elucidate the changes in land-use and culture before the Highland Clearances.



Map 6.1.1 Archaeology: locations mentioned in the text. Numbers refer to Table 6.1.1.

Table 6.1.1 Locations mentioned in text

No. on Map 6.1.1	*Location*	*Grid ref.*
1	Ailsa Craig	NX0299
2	Culzean	NS2510
3	Ayr	NS3321
4	Irvine	NS3238
5	Ardrossan	NS2342
6	Kilwinning	NS3043
7	Largs	NS2059
8	Brodick	NS0135
9	Machrie Moor	NR9032
10	Lochranza	NR9350
11	Cloch Point	NS2075
12	Outerwards	NS2366
13	Greenock	NS2876
14	Lurg Moor	NS2873
15	Port Glasgow	NS3274
16	Barochan	NS4969
17	Walls Hill	NS4158
18	Bishopton	NS4371
19	Renfrew	NS5067
20	Glasgow	NS5865
21	New Lanark	NS8842
22	Dumbarton	NS3975
23	Rhu	NS2684
24	Garelochhead	NS2491
25	Ardnadam	NS1780
26	Dunloskin	NS1678
27	Toward Point	NS1467
28	Rothesay	NS0864
29	Dunagoil	NS0853
30	Dunadd	NR8393
31	Tarbert	NR8668
32	Carradale Point	NR8237
33	Campbeltown	NR7120
34	Dunaverty	NR6807
35	Dun Mor Vaul	NR7961
36	Crinan	NR7894
37	Kilmartin	NR8398
38	Inverary	NN0908
39	Loch Nell	NM8827
40	Oban	NM8629
41	Dunollie	NM8531
42	Bonawe	NN0131
43	Belnahua	NM7112
44	Lussa Wood	NR6487
45	Finlaggan	NR3968
46	Rhinns of Islay	NR1651
47	Ballinaby	NR2167
48	Kiloran	NR3996
49	Lismore	NM8340
50	Tobermory	NM5055
51	Duart Castle	NM7435
52	Skerryvore	NL8426
53	Sorisdale	NM2763
54	Dun Mor	NM0449
55	Hynish	NL9839

Unfortunately, for this maritime region there is little direct evidence of river or sea-going craft. Excavation of boat burials and knowledge of large numbers of logboats found during the construction of Glasgow docks show the potential for recovering information. The scale of potential discoveries is clear from the 30 m long Viking warship found at Roskilde, Denmark, which was built in Dublin (Roesdahl & Wilson 1992). Maritime communities depend on working craft, and a study of the barges and coastal vessels of the region is also vital.

In the sub-tidal zone shipwrecks are expected to be the most numerous site type. Most located shipwrecks around Britain are metal ships that sank in this century. They usually stand proud of the sea bed and can be located by remote sensing equipment. It is difficult to estimate the number of surviving wrecks, but the number of recorded losses of ships suggests that only a very small proportion have been discovered. Records of losses are comprehensive for the 19th century, relatively complete for the 18th, and patchy for the 14th to 17th centuries. For earlier periods it is necessary to examine written evidence for sea-borne trade and extrapolate the opportunities for ship losses by considering hazards to navigation. This process can be extended into the prehistoric period by looking at inland sites for archaeological evidence for trade and seafaring.

The monastery on Iona was founded in the year 563 by St. Columba, an Irish missionary; from here the Picts were converted to Christianity. The monastery was repeatedly sacked by Viking raiders and now stands as an illustration of mediaeval developments in ecclesiastical architecture. Photo: Pat Doody, JNCC.

6.2 History and archaeology of the region

6.2.1 Hunters, gatherers and early farmers (Palaeolithic, Mesolithic and Neolithic)

In southern Britain the presence of man has been traced back to at least 450,000 BC. In Scotland, the absence of comparable evidence for the Palaeolithic era (*c.* 850,000-10,000 BC) has been attributed to the probable absence of occupation during glaciations and to the destruction of earlier remains by ice-sheets. The earliest dated open-air settlement in Scotland is on nearby Rum (Region 16), and Region 14 has, at Druimvargie, Oban, the earliest dated evidence of cave occupation (7,500-7,000 BC). These sites fall within the Mesolithic era (*c.* 10,000 - 4,000 BC), as do shell middens and characteristic flint tools, indicating the use of this region by hunter-gatherers exploiting the coastal resources.

Marine transgressions prior to the uplift of the coastline are likely to have inundated earlier sites on the coastal plain (Woodman 1989). Monitoring of a beach site at Lussa Wood, Jura, has yielded thousands of fine flint tools (Searight 1993). Some of these, and others from Tiree, might be assigned on typological grounds to the Palaeolithic. Islay is also a focus for studies of the Mesolithic and sea-level change, while cave deposits on Ulva have attracted attention as potentially yielding information on these periods (Council for British Archaeology 1994b).

The use of farming technology defines the beginning of the Neolithic (*c.* 4,000 - 2,500 BC), but it is obvious that the practice of hunter-gathering and cultivation co-existed at different levels. The most visible remains of the Neolithic are large communal burial monuments (chambered cairns), which are particularly numerous on Arran and in the Clyde Basin. Chambered tombs, and stone axes, essential for forest clearance, have been the focus for determining population distribution (Hughes 1986). However, Argyll is remarkable in Scotland for the number of house remains dated to this period - at Ardnadam near Dunoon, Dunloskin Wood, and Auchategan on Bute. The last of these is later than 3,000 BC, when farming can be seen to have intensified and chambered cairns appear to have been going out of vogue (Ashmore 1996). This change coincides with the construction of large ritual enclosures, such as the timber ring on Machrie Moor, Arran, and the appearance on ritual and domestic sites of a pottery type called grooved ware, by virtue of its decoration.

6.2.2 Metal-working peoples (Bronze Age and Iron Age)

Change in ritual practice persisted through the 3rd millenium, as individual inhumations and cremations become the norm. Such change was once seen as emanating, directly or indirectly, from incomers, whose presence was identified by beaker pottery. Alternatively, burials later inserted into deliberately filled chambered cairns may reflect the indigenous communities' adopting new funerary rites. The earliest dated Scottish beaker burial comes from Sorisdale on Coll, but in this region grooved ware also appears in single burials and there are some beaker forms that are apparently local. The erection of stone circles at Machrie Moor, one exactly overlying an earlier timber circle, similarly suggests the importance of continuity and tradition (Haggerty 1991). Individual standing stones were set up in this period, for example at Ballinaby, Islay, and on Mull. Kilmartin Valley is now recognised and interpreted for the public as a ritual landscape with Bronze-Age monuments alongside those of earlier and later generations.

The introduction of bronze, though generally associated with this changing society, did not immediately oust other utilitarian materials. Bronze tools and weapons become more prevalent in the following millenium and are interpreted as items of gift-exchange or trade. Rare evidence for farming includes pollen records, a wooden ox yoke from Loch Nell, ard (plough) marks on preserved land surfaces, clearance cairns, and timber and stone field boundaries. Some land surfaces, for example on Arran, have been preserved by peat growth during subsequent deterioration of climate.

The marginalisation of land seemingly caused the shift from open to enclosed settlements with stone buildings or fortifications, which characterised the Iron Age as much as the introduction of the new metal. This region has only a few of the large, complex dry-stone towers (brochs) that are so numerous on the coast to the north and in the Western Isles. Instead there are hillforts: Walls Hill, a single stone-faced rampart enclosing 7.5 ha south-west of Paisley, is one of the largest in Scotland; others, such as Carradale Point and Dunagoil, are vitrified (stone interlaced with timber and subsequently fired). Early excavations sought to differentiate two other site types of which there are numerous examples: duns (stone-walled enclosures) and small fortified hilltops (Peltenburg 1982). For Scotland's west coast the term 'Atlantic Roundhouse' is now applied to the 'confusing typological morass' of stone buildings: these dwellings may be architectural expressions of territoriality for individual families rather than tribal power-centres (Armit 1996).

Dun Mor Vaul, a broch, provides one of the main sources of evidence for the Iron Age economy in Scotland (Cunliffe 1991). In mixed farming, barley was the main crop, with sheep the main grazing stock rather than cattle. Red and roe deer and large quantities of shellfish were caught. On the small fort sites iron-working can be traced. All types of site show considerable continuity, with rebuilding and re-use late into the 1st millenium AD.

6.2.3 The Roman to Medieval periods

Latin texts on the imperial expansion to this region provide the first historical records. However, the Roman presence was one of a campaigning and occupying army, and commentators were concerned with the exploits of military leaders in the context of the Roman Empire (Breeze 1996). Similarly, texts from the few writers describing the 5th to 10th centuries largely focus on the genealogy of kings and

the activities of the church: the region's early saints, namely St. Columba on Iona, St. Moluac on Lismore and St. Kentigern at Glasgow, received attention.

In the 1st century AD the Roman military advance into the Lowlands halted and a chain of forts was constructed, sited to control egress from the Highlands. Barochan, on the Clyde, was the westernmost of this line. However, the frontier was consolidated on the Solway. In the following century for some fifteen years the southern part of this region was taken into the Empire when the Antonine Wall was built on the Clyde-Forth line (Hodgson 1995). A large fort at Whitemoss (Bishopton) controlled the lowest crossing point on the Clyde. Fortlets on the south coast of the Firth, such as Outerwards and Lurg Moor, may be remnants of a coastal watch system.

Two tribes named in Roman sources, the Damnonii and the Epidii, can be placed in this region about the 2nd century AD. Two centuries later the tribes that harried the frontier prior to Roman withdrawal from Britain were referred to generally as Picts or Caledonians. In simple terms, the historical sources for the ensuing six centuries place five peoples in the area of modern Scotland - Picts occupying the greater part of the east and north; in this region the Dal Riata (Gaels) in Argyll and the Britons in Strathclyde; Angles in the south; and latterly Vikings raiding and then occupying coastal areas of the far north and west.

Ultimately the Dal Riata subsumed Pictland in the 9th century. Struggles over the succession and territorial expansion left Duncan I (1034-1040) king of a nominally united Scotland. When, in the following century, the administration, Church, aristocracy and burghs were established on Norman lines, "any possibility that Scotland might be a Celtic country vanished" (Donaldson 1993). Prior to the Treaty of Perth (1266) the islands remained under Norse rather than Scottish control. Powerful individuals, later styled Lords of the Isles, maintained a power base in the region until the Lordship was forfeited to the Scottish Crown in the late 15th century.

Documentary sources have tended to direct archaeological activity to the high status sites (Foster 1996). The scant archaeological clues show that the indigenous peoples of this region cannot have been untouched by the proximity of Imperial Rome. Pieces of glass and pottery from fortified sites such as Dun Mor on Tiree point to maritime trade or exchange with the occupying Romans. At this time a miscellany of artefacts and cultural affinities also 'points to a network of high level communication' from this region acoss the Irish Sea (Laing & Laing 1993). The control of maritime routes is also apparent in the coastally located power centres of the Dal Riata and the Britons, including Dunaverty, Dunadd, Dunollie and Dumbarton.

Excavation at Dunadd and Dunollie has shown that from the later 6th and 7th centuries these sites were the focus for imports of luxury goods from the Mediterranean and Gaul, and benefited from highly skilled craftsmen working in leather, wood and metals. From Dunadd there are crucibles for gold and silver and moulds for the best quality brooches. Analysis of animal bone finds shows that cattle were predominant even where land was not obviously available for cattle rearing. Foster (1996) builds a picture of local potentates extending their territorial control by winning clientship amongst the inhabitants of a well-managed landscape, and as power centres became more distant from the client people, personal, portable symbols of wealth, such as jewelry, became of greater significance.

Monastic sites, especially on Iona, have attracted archaeological investigation. Tiny clues, such as a sherd of African pottery, reinforce the literary image of monasteries providing the impetus for cultural contact. Viking attacks are described, but physical and place-name evidence point to stronger cultural influence by settlement. Grave goods from a ship-burial at Kiloran Bay, Colonsay, include a merchant's weighing scales. Whereas male burials may be interpreted as those of warriors, females were found in the boat burials at Ballinaby, Islay, and Oronsay.

With Medieval archaeology of Scotland seriously underdeveloped, Armit (1996), in discussing the Lordship of the Isles, wrote "it is still too early to present an archaeological narrative of the period from the end of Norse control". The traditional seat of the Lords of the Isles at Finlaggan, Islay, has been excavated. Fortifications enclosed a hall, chapel and domestic accommodation, while an associated settlement supported craftsmen and merchants. However, this political and economic centre did not develop in the manner of the burghs created under the Scottish King (Caldwell & Ewart 1993).

Standing buildings provide evidence of some aspects of the later Medieval changes. Lochranza Castle, for example, is an early example of the stone buildings that came to replace earlier fortified dwellings of timber and earth. The monastery on Iona and cathedral on Lismore are examples of developments in ecclesiastical architecture. New burghs were created on the coast and Clyde Estuary, at Ayr, Irvine, Rothesay, Glasgow, Dumbarton, Renfrew and Tarbert. The potential for such sites to shed light on the Medieval economy is demonstrated elsewhere by excavations in Perth. These revealed the structures of buildings, the nature of imports and the character of industries and raw materials (Yeoman 1995).

6.2.4 Post-Medieval and modern times

Historical sources for this and earlier periods refer to naval expeditions and battles. The remains of a Cromwellian ship wrecked beneath Duart Castle, and the nearby *Dartmouth*, wrecked 1690, testify to the potential for nautical material to be preserved on the sea bed (Martin 1995, 1978). Virtually all castles are strategically related to waterways. For example, Tarbert Castle controls portage over the isthmus of Kintyre, Rothesay Castle commands the anchorage in the Firth of Clyde, and Campbeltown Castle overlooks the harbour.

Documentary evidence has traced the origins of fundamental change in the social and economic structure of the Highlands to the 17th century, with accelerated change after 1760 precipitated by "the irresistible market pressures emanating from Lowland industrialisation and urbanisation" (Devine 1993). Thus the region is characterised both by the monuments of the industrialised western Lowlands around the Clyde and by the estates and rural industries of the Highlands and Islands to the north.

With navigation made difficult by shoals and rocks, the burgh of Glasgow established a downriver port in 1688 (Port Glasgow). The prospect of valuable trade with America prompted neighbouring Greenock to open a new harbour in 1710. Modern redevelopment of the waterfront

at Broomielaw (north Glasgow) revealed a manufactury which had provided the Clyde with tin-glazed earthenware exports for the American market on a level to rival the traditional exporters in Liverpool and Bristol (Denholm 1982). The 19th century dredging of the Clyde, essentially a man-made navigation, enabled the river to develop as a major port and to establish a shipbuilding industry, which rivalled the north-east of England as supplier to the world of fast sailing ships and metal steamers.

The growth of maritime commerce spurred 18th and 19th century investment in engineering works: the Clyde-Forth Canal (1790), the Crinan Canal 1801, and lighthouses. The latter were mostly constructed by the Northern Lighthouse Board, established in 1786, with the Stevenson family as engineers (Muir 1978). Examples include Cloch Point (1797), Toward Point (1812), Rhinns of Islay (1825), Skerryvore (1844) and Ailsa Craig (1866). To build Skerryvore, 12 miles from land, required the construction of a harbour and support facilities at Hynish, Tiree.

Cotton imports enabled the Scottish weaving industry to flourish in Lanarkshire and Renfrewshire. The cotton mills were heavily concentrated around Glasgow. The New Lanark Industrial Village was established as a model for the management of the industry, with public buildings and housing. It is the "outstanding industrial monument in Scotland" (Stevenson 1985). The Clyde's industrial base was underpinned by resources of coal and iron. As early as 1754 charcoal-burning stands in Glen Etive had provided fuel for an iron furnace built at Bonawe. Millstone was quarried in Argyll, and the coast and islands were the centre of the Scottish slate industry. Pink granite was quarried on Mull and marble on Iona.

During the eighteenth century the population of Glasgow increased some eight-fold to exceed 100,000. In this and the following century the urban expansion, with its associated increased demand for foodstuffs, can be credited with increasing the commercialisation of the Highland estates. Landlords sought to increase their productivity to serve the new markets and many of the tenant classes entered into seasonal migration to earn cash-wages in the Lowland industries, such as the bleachfields and the Clyde's herring fisheries. Migration was facilitated by regular steamer services to the islands.

The processes of change were complex, varying between individual landowners and according to the character of the land and the market potential. For the purposes of the archaeological record they are characterised by change in the use of land, with the reduction in importance of the traditional township (baile), the development of large-scale sheep farming, and the creation of crofts. This involved the movement of the population. The development of crofting, a particular feature of the islands of this region, has been interpreted as a deliberate mechanism to provide a large population as a labour force for non-agricultural rural industries (Devine 1994). Kelp-burning to produce fertiliser is typical of such industries, which provided large profits while European wars maintained high prices. Fishing was another industry that employed people once they moved to the coast.

The changes were also affected by Government and philanthropic intervention (particularly after the famines of the mid-nineteenth century). Commissions sought to further agricultural improvements, while the British Fisheries Society created new fishing towns, such as Tobermory (Dunlop 1978). Some intervention also encouraged the large-scale emigration of the nineteenth century.

By 1850 the pattern of land ownership in the Highlands had been revolutionised, as hereditary proprietors sold their estates, including in this region most of Mull and all of Ulva, Islay and Lismore. Most were acquired by Lowland or English interests. While such investment could increase economic activity it also represented a new era for country estates. Railways and steamers enabled visitors to enjoy the hunting, shooting and fishing provided by their hosts. Brodick, Culzean and Inverary Castles, for example, reflect these changes. For the industrial workers of Glasgow, tourism was also facilitated by Clyde steamers, manifested in the development of resorts such as Largs, Rhu, Rothesay and Garelochhead.

6.3 Human activities

6.3.1 Integrated management

The archaeological resource is now being considered within mechanisms for the management of the Scottish coastal zone. The man-made heritage is included in *Scotland's coast: a discussion paper* (Scottish Office 1996). The survey strategies of Historic Scotland and the Royal Commission on the Ancient and Historic Monuments of Scotland (RCAHMS) have been linked with the Focus on Firths initiative led by Scottish Natural Heritage to ensure that archaeological information is gathered within the wider sphere of management activity.

6.3.2 Activities and processes affecting the archaeological resource

It is important to remember that the resource does not consist entirely of discrete sites such as intact wrecks. Many sites are scattered and palaeo-environments can be extensive, stretching across terrestrial, intertidal and subtidal zones. In areas that have not received intensive archaeological survey it is vital to recognise the archaeological potential of environments in which preserved remains might be anticipated.

The archaeological resource, on land, in the intertidal zone and on the sea bed, is vulnerable to natural and man-driven processes. Unfortunately there has been little study of the processes, the impacts or the options for physically protecting intertidal and sea-bed sites. Sea-bed sites can be revealed or destroyed by changes in sediment regimes and marine erosion. Such processes uncovered the Duart Point Wreck, leaving it vulnerable to human interference and to attack by marine fauna and flora. Few sub-tidal sites have been surveyed and so it is difficult to gauge the influence that activities may have on the archaeological resource. Clearly some activities may directly damage or destroy sites, for example salvage diving, dredging for navigation or aggregates, pipe and cable laying, ship wash or the use of fishing gear that is in contact with the sea bed. Chemical or physical changes to the sea bed or water column may also alter the equilibrium of remains that are in a sensitive state of preservation.

Erosion resulting from ongoing, post-glacial sea-level rise has been identified by Historic Scotland as a long-term, serious threat to the Scottish archaeological resource, particularly in the north and west (Ashmore 1994). Protective measures, such as beach engineering and coastal defences, as well as plans for managed retreat, have implications for archaeological sites. Other engineering works in the intertidal zone, such as sewage disposal schemes and land claim, are also of concern.

On land, redevelopment of urban industrial waterfronts requires skilful planning to preserve the fabric and setting of the built heritage. Such works can affect buried remains of earlier waterfronts, for instance former waterfront industrial sites identified by excavation in Glasgow and Greenock (Denholm 1982). Developments for modern industry, such as oil terminals and power stations, though using downriver sites not developed by the Victorian engineers, may encroach on Medieval and prehistoric maritime sites.

Rural land use also has implications for archaeological sites. Effects can be mitigated by cooperation between land-users and archaeologists. The regulation of afforestation has created opportunities to enhance the presentation of the archaeological resource.

6.3.3 Protection of sites, monuments and wrecks

In Scotland three statutes provide for protection of *in situ* remains of archaeological or historic importance. The Ancient Monuments & Archaeological Areas Act 1979 (AMAA) provides for Scheduled Ancient Monuments (SAMs), the Planning (Listed Buildings and Conservation Areas) Act 1990 provides for Listed Buildings and Conservation Areas, and the Protection of Wrecks Act 1973 allows designation of shipwrecks of archaeological, historic or artistic importance.

The legislative arrangements, controls on works and criminal offences related to SAMs are described in Planning Advice Note 42, which also includes the non-statutory list of criteria for determining the national importance of sites prior to scheduling (Scottish Office 1994b). The AMAA definition of a monument includes sites both on land and in UK territorial waters, including remains of vehicles, vessels and aircraft. Prior written consent is necessary from Historic Scotland for any works that will destroy, damage, repair or remove such a monument. Scotland has precedents for scheduling underwater remains and there is no bar to using this designation for wreck sites in order to cater for visitor access while providing protection (N. Fojut pers. comm.). In practice, however, in this region scheduling has only been applied above low water mark.

The numbers of coastal Scheduled Ancient Monuments in the region and nationally are given in Table 6.3.1. Current review programmes are increasing the numbers of Scheduled Monuments in Britain; in Scotland the increase is around 300 monuments per year. Scheduled Monuments represent only a small number of the total known archaeological sites. Sites and Monuments Records - archaeological databases maintained at regional level - are a key source of information on sites of local and regional significance.

Buildings considered of special architectural or historic importance may be Listed, under the provisions of the Town & Country Planning (Scotland) Act 1972. There is now a presumption against the destruction of Listed Buildings, and consent is required prior to any demolition, alteration or extension. Listed Buildings in the region include maritime structures such as warehouses and lighthouses. Conservation Area designation is usually applied to urban areas to protect the historic environment. Historic Scotland (1993) has published detailed guidance on the treatment of Listed Buildings, for which controls are generally exercised by the local authority.

Table 6.3.1 Numbers of coastal Scheduled Ancient Monuments (SAMs) in the region

District	*No. of SAMs in region*
Wigtown	3
Kyle & Carrick	72
Renfrew	12
Cunninghame	101
Clydebank	3
Argyll & Bute	372
Lochaber	6
Region 14	***569***
Scotland (whole country)*	5,300
GB (whole country)*	21,000

Sources: Breeze (1993); Historic Scotland (1995). Note: except where marked*, totals are of all sites occurring in 10 km x 10 km squares of the national grid that include sea, as shown on Ordnance Survey 1:50,000 series maps.

Shipwrecks of archaeological, historical or artistic importance may be designated under the Protection of Wrecks Act 1973 (Archaeological Diving Unit 1994). There are no standard criteria for designation but Historic Scotland receives guidance from the Advisory Committe on Historic Wreck. There are two designated wrecks in this region, and one where the Designation Order has been revoked (Table 6.3.2). Fewer than 45 wrecks have been designated for the whole of Britain, and their distribution cannot be accepted as a reasonable guide to the total sea-bed resource. Information on shipwrecks in the region is contained in the Sites and Monuments Record (SMR) maintained by the West of Scotland Archaeology Service and in the National Monuments Record (Maritime Section) for Scotland, maintained by the Royal Commission on the Ancient and Historical Monuments of Scotland. Sites may be visited on behalf of Historic Scotland by the Archaeological Diving Unit, which is contracted by the Department of National Heritage to provide field inspection throughout the UK. Except under licence from Historic Scotland it is illegal to tamper with or remove material, to use diving or salvage equipment, or to deposit anything which may damage or obliterate the wreck (ADU 1994).

6.3.4 Key organisations and their responsibilities

Historic Scotland executes the responsibility of the Secretary of State in respect of the protection, management and interpretation of the 'built heritage' (i.e. ancient monuments, archaeological sites and landscapes, historic buildings, parks and gardens, and designed landscapes). Historic Scotland compiles and amends the Schedule of Ancient Monuments and the statutory lists of buildings of special architectural or historic interest. Historic Scotland also has responsibility for wreck sites designated under the Protection of Wrecks Act 1973.

The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) has responsibility for the survey and inventory of archaeological sites. It maintains an index of terrestrial sites as part of its National Monuments Records Scotland (NMRS). In 1992 new Royal Warrants extended their remit to the territorial seas, and the RCAHMS has now established NMR Maritime Sections. Local Authorities have 'far reaching powers, both statutory and discretionary . . . to deliver a conservation service' (Historic Scotland 1996a). The cornerstone of their work under the development control system is the Sites and Monuments Record (SMR) - an inventory of all known archaeological features in their area and the main source of information at a local level; the RCAHMS is the lead agency for SMRs. Historic Scotland's guidance asks all authorities to ensure that they have day-to-day access to an SMR. A professionally qualified curator is a specified element of the SMR provision (Scottish Office 1994b). Since the reorganisation of local government in this region the twelve unitary authorities have access to an SMR maintained by the West of Scotland Archaeology Service.

The Scottish Institute for Maritime Studies at the University of St. Andrews is the only formally constituted academic department in Scotland concentrating on the maritime heritage. It undertakes and supervises research and is involved in fieldwork. The Scottish Trust for Underwater Archaeology is a charitable body that aims to further the study of sunken settlements and drowned landscapes. It is involved in education, research and survey.

6.3.5 Development control

The White Paper *This common inheritance* (DoE *et al.* 1990) expressed the government commitment to preserving and enhancing the heritage. To landward of low water mark, archaeology is considered within the unified system of development control provided by the planning system. National Planning Policy Guidance Note 5 (Scottish Office 1994a) explains the regard that should be accorded to archaeological remains: "the preservation of ancient monuments and their settings is a material consideration in determining planning applications and appeals, whether a monument is scheduled or not" (Scottish Office 1994a). Stress is placed on recognising that the value of the archaeological resource is much wider than the small proportion of sites that have so far received designation as

Table 6.3.2 Historic wrecks designated in the region

Site Name	*Location*	*Grid ref.*	*Description*	*Designation Order*
Dartmouth	Eilean Rudha an Ridire, Sound of Mull	NM724407	5th rate frigate built 1655, lost 1690	(1992 No. 2; 1992/1229 [S.123])
Duart Point Wreck	Duart Point, Sound of Mull	NM748354	Probably the *Speedwell*, a Cromwellian vessel	(1992 No. 3; 1992/115 [S 104])
Rhinns of Islay Wreck	Frenchman's Rock, Islay	NR153540	Probably remains of more than one wreck	(1976 No. 2; 1976/720 (revoked))

Source: DNH

Scheduled Ancient Monuments. Account must be taken of sites with regional or local significance and of other sites and finds recorded in the SMR. Specific guidance is also available on the treatment of SAMs within the planning system (Scottish Office 1994b).

The "development planning system provides the policy framework for meeting the needs of development along with the need for preserving archaeological resources, and for minimising the potential conflict between these two objectives" (Scottish Office 1994a). This framework is largely provided by Structure and Local Plans, which should carry general policies for the protection of archaeological sites. Government guidance (Scottish Office 1994a, b; Historic Scotland 1996a) places emphasis on early consultation between developers and the planning authority and on the importance of drawing on the information and expertise available from the SMR, in order to reconcile the needs of archaeology and development. In essence there is a presumption in favour of preservation *in situ* because "the primary policy objectives are that [archaeological sites] should be preserved wherever possible" (Scottish Office 1994a). Where preservation *in situ* is not justified, planning "procedures should be in place to ensure proper recording before destruction, and subsequent analysis and publication". Archaeology is also one of the considerations for significant developments when Environmental Assessment is required under the Town & Country Planning (Environmental Assessment) (Scotland) Regulations 1988.

To seaward of low water mark there is a sectoral approach to development control, although many functions fall within the remit of the Scottish Office. Regulation, including the need for Environmental Assessment, is divided between a range of government departments and agencies. Until recently consideration of archaeology was precluded by the dearth of information on the extent of the resource and the absence of a management structure in the subtidal zone. However, growing awareness of marine archaeology and the development of the NMRS Maritime Section should encourage closer consideration of the marine resource. Sea-bed developers can now obtain guidance from a *Code of practice for seabed developers* (Joint Nautical Archaeology Policy Committee 1995).

6.3.6 Reporting archaeological information

The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) and the Sites and Monuments Records (SMRs) are the accepted reporting points for new archaeological information. Information and enquiries concerning Scheduled Monuments and Historic Wrecks should be directed to Historic Scotland. Enquiries concerning Listed Buildings should be directed to the building control department of the local authority.

In Scotland the combination of laws on Treasure Trove and *Bona Vacantia* ('lost property') means that, in effect, all antiquities found on land can be claimed by the Crown (Longworth 1993). "It is important to report anything that might be claimed. Some things should always be reported: objects and coins of gold and silver, and other hoards of coins and things, in pots or loose" (National Museums of Scotland undated). Reports should be made to a museum, the police or the Procurator Fiscal. The Treasure Trove Panel advises the Crown as to which items should be claimed as Treasure Trove. Finds from excavations funded by Historic Scotland, made casually on monuments in care or during excavation undertaken with Scheduled Monument Consent, if not claimed by the Crown, go before the Finds Disposal Panel (Historic Scotland 1994). It advises to which institution they should go and the reward to be made to the finder. Further advice is available from the National Museums of Scotland.

The Merchant Shipping Act 1894 requires any recovered wreck to be reported to the Receiver of Wreck. Wreck is now defined as any ship, aircraft, hovercraft or parts of these, their cargo, or equipment, found in or on the shores of the sea or any tidal water. The Receiver provides advice and supplies forms for reporting recovered wreck. These include a form which finders may use to volunteer information to the RCAHMS on the identity and condition of wreck sites. The Receiver advertises reported wreck, regardless of age, in order that owners may claim their property. After one year, unclaimed wreck becomes the property of the Crown and is disposed of in order to pay the expenses of the Receiver and any salvage awards. Finders are often allowed to keep unclaimed wreck in lieu of a salvage award. There is a policy of offering unclaimed wreck of historic, archaeological or artistic interest to registered museums. During the statutory year, such items may be lodged with a museum or conservation facility with suitable storage conditions. The responsibility of the Receiver to the finder, with regard to salvage awards, remains regardless of the historic character of the wreck.

6.4 Information sources

6.4.1 Information gathering and collation

A review of coastal survey in the terrestrial and intertidal zones was produced by Historic Scotland in advance of preparing policy (Ashmore 1993). This showed that no survey work had been geographically targeted on the identification and problems of the coastal archaeological resource of this region. Historic Scotland have now produced a specification for coastal zone assessment surveys, which sets out a standard level for future survey (Historic Scotland 1996b).

Archaeological work on the sea bed has traditionally been site-specific, for example investigating the historic wrecks designated under the Protection of Wreck Act. RCHAMS is now taking a wider approach. An initial database, linked to a Geographic Information System (GIS), has been compiled using data from the Hydrographic Department Wreck Index, which is maintained as an aid to publishing Admiralty Charts for navigation. The index contains mainly metal wrecks that stand proud of the sea bed and which have been identified by remote sensing, as well as 'last position' reports of 20th century shipping casualties (Table 6.4.1). Further sources are being used to extend this initial record, using documentary accounts of ship losses and reports from field observations. It is also intended to collate environmental data on sea-bed deposits in order that the GIS may be used to indicate areas of likely preservation.

Table 6.4.1 Preliminary records compiled from the Hydrographic Department Wreck Index

	No. of wrecks
Region 14	427
Scotland	***1,530***

Source: RCAHMS NMR-Maritime Record

6.4.2 Acknowledgements

Thanks are due to all the organisations mentioned in the text who provided information and advice, and particularly to staff at Historic Scotland for their amendments to early drafts.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Scotland: Scheduled Ancient Monuments; Listed Buildings; designated wreck sites; rescue archaeology; management of monuments in care	Principal Inspector of Monuments, Historic Scotland, Longmore House, Salisbury Place, Edinburgh EH9 1SH, tel: 0131 668 8650
Reporting of recovered wreck in Britain	Receiver of Wreck, Coastguard Agency, Spring Place, 105 Commercial Road, Southampton SO15 1EG, tel: 01703 329474
Research and education	The Secretary, Scottish Institute for Maritime Studies, University of St. Andrews, St. Andrews, Fife KY16 9AL, tel: 01334 462916
Research and education	The Scottish Trust for Underwater Archaeology, Department of Archaeology, 16-20 George Square, University of Edinburgh EH8 9JZ, tel: 0131 650 1000
Code of practice for seabed developers	Joint Nautical Archaeology Policy Committee, Head of Recording (Maritime), National Monuments Record, Royal Commission on the Historical Monuments of England, National Monuments Record Centre, Kemble Drive, Swindon SN2 2GZ, tel: 01793 414600
RCAHMS NMRS - information and location of sites	Royal Commission on the Ancient & Historical Monuments of Scotland, National Monuments Record of Scotland, John Sinclair House, 16 Bernard Terrace, Edinburgh EH8 9NX, tel: 0131 662 1456
Regional SMR	SMR Officer, West of Scotland Archaeology Service, House 3, Charringcross Complex, 20 India Street, Glasgow G2 4PF, tel: 0141 287 8333
Information on, and reporting of, Treasure Trove	Archaeology Department, National Museums of Scotland, Queen Street, Edinburgh EH2 1JD, tel: 0131 225 7534

Chapter 7 Coastal protected sites

R.G. Keddie

7.1 Introduction

7.1.1 Chapter structure

This chapter incorporates statutory and non-statutory site protection mechanisms operating at international, national and local level, including those administered by voluntary bodies and other organisations who own land. It covers only the various types of site protection mechanisms currently found within this region, giving a brief explanation for each category. For the purposes of this chapter, any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal. Where a site straddles the boundaries of two Coastal Directories Project regions and there is no easy way of calculating the percentage of the site lying in each, the site area has been halved, one half being included in each region. National data included in this section have been collated since 1994 and are as up to date as practicable; regional data are correct as at September 1996, unless otherwise stated.

Statutory protected sites are those notified, designated or authorised under European Directives and/or implemented through British legislation (most notably the Wildlife & Countryside Act 1981) by a statutory body, thereby having recognised legal protection. 'Non-statutory sites' include a wide variety of sites that are not directly protected by legislation but which are recognised by statutory bodies or owned, managed or both by non-statutory organisations for their nature conservation or aesthetic value. Note that the categories of conservation protection (e.g. National Nature Reserve, RSPB Reserve) are not mutually exclusive. In many localities several different types of protected site overlap, since they have been identified for different wildlife and landscape conservation purposes. Patterns of overlap are often complex, since site boundaries for different categories of site are not always the same.

Further explanation of the various site protection mechanisms can be found in Davidson *et al.* (1991). Planning Policy Guidance Note (PPG) 9 - Nature Conservation (DoE 1994a), although dealing specifically with planning policy in England, gives useful summaries of some of the existing site protection mechanisms also found in Scotland. It sets out the Government's objectives for nature conservation and provides a framework for safeguarding the natural heritage under domestic/international law, emphasises the importance of both designated sites and undesignated areas for nature conservation, advises that potential Special Protection Areas (SPAs) and candidate Special Areas of Conservation (SACs) should be treated similarly to classified SPAs and designated SACs and deals with the treatment of nature conservation issues in development plans. It also includes copies of the Ramsar Convention, the Birds Directive and the EC Habitats & Species Directive (including lists of important species and habitat types). The statutory framework for site protection is set out in the Scottish Office Circular 6/90/95 (Scottish Office 1995). The Scottish Office is preparing two National Planning Policy Guidance (NPPG) notes: one on natural heritage and one on coastal matters. They are currently in draft format and may be ready by 1997.

The following types of protected site have not been included in this chapter:

- archaeological designations and protected sites (covered in Chapter 6);
- 'Sites of Importance for Nature Conservation' (SINCs): a general term for the variously-named non-statutory sites identified by local authorities and wildlife trusts as having special local value for nature conservation but not currently managed for nature conservation; the most common are Sites of Nature Conservation Importance. For more information, see Collis & Tyldesley (1993);
- sites designated for fisheries purposes, e.g. areas covered by Several Orders and Regulating Orders (discussed in sections 5.7, 9.1 and 9.2).

Non-site based measures contained in conventions and directives aimed at broad species and habitat protection, such as the Bonn Convention, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), parts of the EC Birds Directive and parts of the EC Habitats & Species Directive, are also not covered.

This chapter is divided into five sections. A regional summary of all categories of site is given in Table 7.1.1. Section 7.2 covers those site-based protection measures falling under international conventions or European directives. Sites identified under national statute are discussed in section 7.3, whereas section 7.4 covers sites without statutory protection but which are identified, owned or managed by statutory bodies; and finally, other types of sites (i.e. those identified, owned or managed by charities, trusts etc.) are described in section 7.5. For each category of protected site, a list of coastal sites is given (clockwise around the coast), showing their type, area/length and location, with an accompanying map. Each section concludes with further information sources and contact points relevant to the region.

7.1.2 Importance of the region

The region contains a large proportion by area of Britain's coastal Environmentally Sensitive Areas (24.3%), National Scenic Areas (18.8%), Regional Landscape Designations (72.5%) and Marine Consultation Areas (50.1%). Except for Environmentally Sensitive Areas, these designations are restricted to Scotland. There are also substantial areas of Sites of Special Scientific Interest. Table 7.1.1 summarises site protection in the region, showing the numbers and areas of each type of site and comparing these with West Coast and British (whole country coast) totals.

Table 7.1.1 Summary of site protection in Region 14

	Number of protected sites					*Area* covered by site protection*				
	Region	*West Coast*	*% of West Coast total in region*	*GB coast*	*% of GB coastal total in region*	*Region (ha)*	*West Coast (ha)*	*% of West Coast total in region*	*GB coast (ha)*	*% of GB coast total in region*
Biosphere Reserves	1	7	14.3	8	12.5	362	21,746	1.7	27,243	1.3
Ramsar sites	7	23	33.3	58	12.1	9,828	114,618	8.6	287,329	3.4
Special Protection Areas	10	39	25.6	93	10.8	11,524	123,243	9.4	306,711	3.8
Possible Special Areas of Conservation (SACs)	10.5**	63	36.9	112	23.8	n/av	n/av	n/av	n/av	n/av
Environmentally Sensitive Areas	1.5**	10	15.0	17	8.8	339,857	1,118,067	30.4	1,397,545	24.3
National Nature Reserves	5	37	13.2	80	6.2	1,589	51,548	3.0	86,617	1.8
Sites of Special Scientific Interest	112	646	17.1	1,198	9.2	63,243	373,454	16.6	703,844	8.8
Areas of Special Protection	2	9	22.2	23	8.6	n/av	n/av	n/av	n/av	n/av
National Scenic Areas	7.5**	23	32.6	27	27.8	140,000	693,400	20.2	745,800	18.8
Country Parks	2	14	14.3	34	5.9	301	1,498	20.1	4,441	6.8
Geological Conservation Review sites	91	545	16.7	1,098	8.3	n/ap	n/ap	n/ap	n/ap	n/ap
Marine Consultation Areas	8.5+	23	37.0	29	29.3	56,016	103,287	54.2	111,896	50.1
Regional Landscape Designations	10	24	41.7	58	17.2	367,866	434,341	84.7	507,182	72.5
The National Trust & The National Trust for Scotland	7	262	2.7	452	1.6	4,419	45,517	9.7	62,974	7.1
Royal Society for the Protection of Birds	4	29	14.3	82	4.9	3,114	14,125	22.0	38,680	8.1
The Wildlife Trusts reserves	6	95	5.3	217	2.3	1,946	13,108	16.7	23,419	8.2
Ministry of Defence sites	12	45	26.7	110	10.9	4,277	18,961	22.6	53,410	8.0
Woodland Trust reserves	1	35	3.4	72	1.6	40	480	8.3	1,590	2.5

Source: JNCC. Key: n/ap = not applicable; n/av = not available; *to nearest hectare; **site lying partly within Region 16; half the relevant site area has been included in the total; +site lying partly within Region 13; half the relevant site area has been included in the total.
Notes: site types not currently found in the region: World Heritage (Natural) Sites, Biogenetic Reserves, Marine Nature Reserve, Local Nature Reserves, Wildfowl and Wetland Trust sites, John Muir Trust sites. In this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

7.1.3 Further sources of information

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7.2 Sites designated under international conventions and directives

This section describes those types of site designated under international conventions to which the UK is a contracting party and sites designated under UK statute to implement EC Directives concerning wildlife and landscape conservation. Sites protected by domestic legislation only are covered in section 7.3.

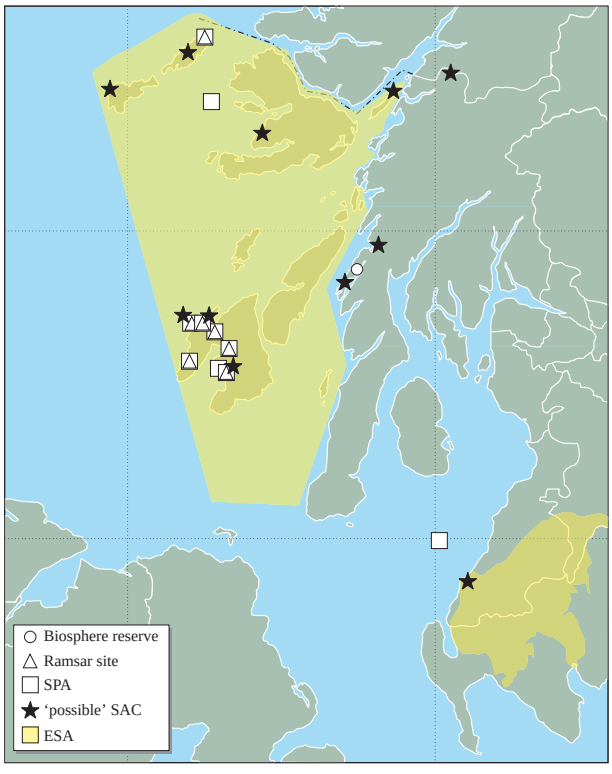
7.2.1 Biosphere Reserves

Biosphere Reserves are non-statutory protected areas representing significant examples of biomes - terrestrial and coastal environments, throughout the world - protected for conservation purposes. They have particular value as benchmarks or standards for the measurement of long-term changes in the biosphere as a whole. They were devised by UNESCO as Project No. 8 of their Man and the Biosphere (MAB) ecological programme, and were launched in 1970.

Table 7.2.1 Biosphere Reserves

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date designated*
Argyll & Bute	**1**			
Taynish		NR735850	362	1977
Region 14	***1***		*362*	
West Coast	7		21,746	
GB coast	8		27,243	
GB whole country	13		44,258	

Sources: JNCC, Scottish Natural Heritage. Key: *to nearest hectare. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.



Map 7.2.1 Sites designated under international conventions and directives. Sources: JNCC, SNH.

Criteria and guidelines for selection of sites were produced by a UNESCO task force in 1974. All British sites are also National Nature Reserves (section 7.3.1). There is one coastal Biosphere Reserve (362 ha) in Region 14, at Taynish (Table 7.2.1; Map 7.2.1).

Table 7.2.2 Ramsar sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date designated*	*Selection criteria used*
Islay (Argyll & Bute)	**6**				
Duich Moss (Eilean na Muice Duibhe)		NR320550	574	1988	Representative wetland; 1% of a waterfowl species population
Bridgend Flats		NR330620	331	1988	1% of a waterfowl species population
Rinns of Islay		NR235620	2,926	1995	Representative wetland; 1% of a waterfowl species population
Glac-na-Criche		NR2270	265	1990	Representative wetland; 1% of a waterfowl species population
Feur Lochain		NR2569	384	1990	Representative wetland; 1% of a waterfowl species population
Gruinart Flats		NR285665	3,170	1988	1% of a waterfowl species population
Coll (Argyll & Bute)	**1**				
Coll		NM240610	2,177	1995	Genetic and ecological diversity; 1% of a waterfowl species population
Region 14	***7***		***9,828***		
West Coast	23		114,618		
GB coast	58		287,329		
GB whole country	99		304,527		

Sources: JNCC, SNH. Key: *to nearest hectare. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

7.2.2 Wetlands of international importance (Ramsar sites)

Ramsar sites are statutory areas 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'. Ramsar sites are designated for their waterfowl populations, their important plant and animal assemblages, their wetland interest or a combination of these: all Ramsar sites have first to be designated as Sites of Special Scientific Interest. There are seven coastal Ramsar sites (9,828 ha) in Region 14 (Table 7.2.2; Map 7.2.1). Table 7.2.2 summarises the interest for which the sites have been designated, and sections 5.10, 5.11 and 5.12 describe the importance of these sites for the region's birds.

7.2.3 Special Protection Areas

The 1979 EC Directive on the Conservation of Wild Birds (the Birds Directive) 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 statutory Special Protection Areas (SPAs) by the UK government on the advice of the statutory conservation agencies. This designation is implemented through the Wildlife & Countryside Act 1981; all SPAs have first to be notified as SSSIs. There are ten coastal SPAs (11,524 ha) in Region 14 (Table 7.2.3; Map 7.2.1). Table 7.2.3 summarises the interest of these sites, and sections 5.10, 5.11 and 5.12 describe the importance of these sites for the region's birds.

Table 7.2.3 Special Protection Areas (SPAs)

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date designated*	*Qualifying interest*
South Ayrshire	**1**				
Ailsa Craig		NX020998	104	1990	Internationally important numbers of gannets *Sula bassana*; nationally important numbers of lesser black-backed gulls *Larus fuscus* and herring gulls *L. argentatus*
Islay (Argyll & Bute)	**7**				
Duich Moss		NR320550	574	1988	Internationally important numbers of two roosting and feeding species of geese; wintering raptors; breeding seabirds, raptors and waterfowl
Laggan Peninsula		NR297555	1,270	1988	Internationally important numbers of two wintering species of geese; breeding and wintering choughs *Pyrrhocorax pyrrhocorax*; breeding colonies of arctic and little terns *Sterna paradisaea* and *S. albifrons*
Bridgend Flats		NR330620	331	1988	Internationally important numbers of wintering and roosting barnacle geese *Branta leucopsis*; nationally important numbers of wintering scaup *Aythya marila* and red-breasted merganser *Merganser serrator*; wintering waterfowl and raptors
The Rinns of Islay		NR235620	2,926	1995	Internationally important numbers of two species of wintering geese; nationally important breeding populations of four bird species and passage whooper swan *Cygnus cygnus*
Glac-na-Criche		NR2270	265	1990	Internationally important numbers of two wintering species of geese; nationally important numbers of four breeding bird species, and of passage whooper swans
Feur Lochain		NR2569	384	1990	Internationally important numbers of two wintering species of geese; nationally important numbers of four breeding bird species, and of passage whooper swans
Gruinart Flats		NR285665	3,170	1988	Internationally important numbers of two wintering species of geese; nationally important numbers of breeding and wintering chough and breeding hen harrier *Circus cyaneus*; wintering raptors and passage waterfowl
Argyll & Bute	**2**				
Treshnish Isles		NM2741	208	1994	Internationally important for wintering barnacle geese; nationally important for breeding storm petrels *Hydrobates pelagicus;* nine species of breeding seabirds
Coll		NM240610, NM103514	2,292	1995	Internationally important numbers of four breeding bird species, three species of wintering geese and two wader species
Region 14	***10***		***11,524***		
West Coast	39		123,243**		
GB coast	93		306,711**		
GB whole country	125		439,663**		

Sources: JNCC, SNH, Pritchard *et al.* (1992). Key: *to nearest hectare; **includes areas of all SPA designations, whether or not they relate to discrete areas. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

7.2.4 Special Areas of Conservation

The designation of Special Areas of Conservation (SACs) is one of the main mechanisms by which the EC Habitats & Species Directive 1992 will be implemented. SACs are areas identified as outstanding examples of selected habitat types or areas important for the continued well-being or survival of selected non-bird species. The protection measures are based around a series of six annexes: Annexes I and II list the habitats and species respectively whose conservation requires the designation of SACs. The other annexes and the directive cover the selection of SACs and various species protection measures. In the UK the Directive will be implemented through the Conservation (Natural Habitats &c.) Regulations (DoE 1994). A list of 'possible' SACs was announced by the Government on 31 March 1995. There are ten whole and part of one other possible SACs proposed in Region 14 (Map 7.2.1; Table 7.2.4) (see JNCC (1995) for more information).

7.2.5 Environmentally Sensitive Areas

European Community authorisation for Environmentally Sensitive Areas (ESAs) is derived from Article 19 of Council Regulation (EEC) No. 797/85 - National Aid in Environmentally Sensitive Areas. ESAs are statutory areas in which the Government seeks to encourage environmentally sensitive farming practices, prevent damage that might result from certain types of agricultural intensification, and restore traditional landscapes, for which member states are allowed to make payments to farmers. There is one whole and part of one other ESA (339,857 ha) that includes land in Region 14 (Table 7.2.5; Map 7.2.1).

7.2.6 Acknowledgements

Thanks are due to Alan Law (JNCC), Siaron Hooper (English Nature), SOAEFD and the Ministry of Agriculture, Fisheries and Food (MAFF).

7.2.7 Further sources of information

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Table 7.2.4 Possible Special Areas of Conservation (SACs) in Region 14

Site name	*No. of sites*	*Qualifying interest*
South Ayrshire	**1**	
Lendalfoot Hills Complex		Species-rich mat-grass *Nardus stricta* grassland, on siliceous substrates in mountain areas (and submountain areas in continental Europe)
Argyll & Bute	**5**	
Taynish Woods		Marsh fritillary butterfly *Eurodryas aurinia*; old oak woods with holly *Ilex europaeus* and hard fern *Blechnum spicant* in the British Isles
Moine Mhor		Degraded raised bogs (still capable of natural regeneration)
Eilean na Muice Duibhe, Islay		Blanket bog (active only)
Glac na Criche, Islay		Blanket bog (active only)
Feur Lochain, Islay		Blanket bog (active only)
Argyll & Bute/Lochaber	**0.5***	
Loch Etive Woods*		Old oak woods with holly and hard fern in the British Isles
Argyll & Bute	**4**	
Lismore Lochs, Lismore Island		Hard oligo-mesotrophic waters with benthic vegetation of stoneworts *Chara* spp. formations.
Ardmeanach, Mull		Species-rich mat-grass grassland, on siliceous substrates in mountain areas (and submountain areas in continental Europe).
Coll Machair, Coll		Slender naiad *Najas flexilis*, machair
Tiree Machair, Tiree		Machair
Region 14	***10.5****	
West Coast	63	
GB	112	

Sources: JNCC, SNH. Key: *part of the Loch Etive Woods SAC is in Region 16, half the total has been included. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

Table 7.2.5 Environmentally Sensitive Areas

Site name	*No. of sites*	*Area (ha)**	*Date designated*	*Interest*
Western Southern Uplands**	0.5**	128,188	1993	Heather moorland, heather as habitat for bird species, especially grouse, raptors and waders; native woodland, archaeological interests on rough grazing
Argyll Islands	1	211,669	1993	Machair, coastal and herb rich grasslands (including hay meadows), heather moorland, native woodland, scrub, wetlands, dunes, saltmarsh, peatlands and rushy mires; many breeding birds including corncrake *Crex crex* and waders. Well-preserved archaeological features including prehistoric remains, 17-19th century settlements and field systems.
Region 14	***1.5****	***339,857***		
West Coast	10	1,118,067		
GB coast	17	1,397,545		

Sources: MAFF, SOAEFD, SNH. Key: *to nearest hectare; **part of Western Southern Uplands is in Dumfries and Galloway (Region 13); half of the area has been included in the total for Region 14. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

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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*. Peterborough, Nature Conservancy Council.

Von Droste, B., & Gregg, W.P. 1985. Biosphere Reserves: demonstrating the value of conservation in sustaining society. *Parks, 10:* 2-5.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Biosphere Reserve, Ramsar sites, SPAs, Special Areas of Conservation, ESA (Argyll & Bute)	*SNH, Lochgilphead, tel: 01546 603611
SPAs, Special Areas of Conservation, ESA (South Ayrshire)	*SNH, Clydebank, tel: 0141 951 4488
Ramsar sites, SPAs	*Regional Officer, RSPB South and West Scotland Regional Office, Glasgow, tel: 0141 945 5224
ESAs	*Scottish Office Agriculture, Environment and Fisheries Department, Edinburgh, tel: 0131 556 8400
Special Areas of Conservation	Environment Department (Scottish Office Agriculture, Environment and Fisheries Department) Pentland House, 47 Robbs Loan, Edinburgh, tel: 0131 244 4072
Special Areas of Conservation	Department of the Environment (DoE), European Wildlife Division, Tollgate House, Houlton Street, Bristol BS2 9DJ, tel: 0117 987 8000

*Starred contact addresses are given in full in the Appendix.

7.3 Sites established under national statute

Included in this section are those five of the eight types of site identification made under national legislation relating to wildlife, landscape and amenity value that occur in this region. Identifications are made by the statutory conservation agencies (in this region Scottish Natural Heritage), local authorities or the government acting on advice from these bodies.

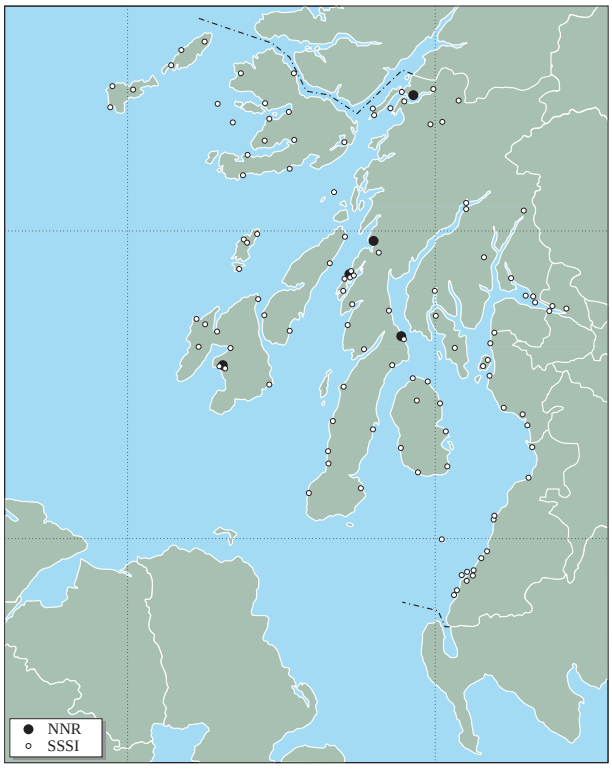
7.3.1 National Nature Reserves

National Nature Reserves (NNRs) contain examples of some of the most important natural and semi-natural ecosystems in Great Britain. They are managed to conserve their habitats, providing special opportunities for scientific study of the habitats, communities and species represented within them. They are declared by the country agencies under section 19 of the National Parks and Access to the Countryside Act 1949, or section 35 of the Wildlife and Countryside Act 1981. All NNRs are also Sites of Special Scientific Interest (SSSIs). There are five coastal NNRs (1,589 ha) in Region 14 (Table 7.3.1; Map 7.3.1).

7.3.2 Sites of Special Scientific Interest

Sites of Special Scientific Interest (SSSIs) are notified under the Wildlife & Countryside Act 1981. They are intended to form a national network of areas, representing in total the parts of Britain in which the natural features, especially those of greatest value to wildlife conservation, are most highly concentrated or of highest quality. Each SSSI represents a significant fragment of the much-depleted resource of wild nature remaining in Britain. Within the area of an SSSI the provisions of the Wildlife & Countryside Act 1981 and its 1985 amendments aim to limit or prevent operations that are potentially damaging to the wildlife interest of the area. There are 112 coastal SSSIs (63,243 ha) in Region 14 (Table 7.3.2; Map 7.3.1). 8.2% of the total land area of Britain is SSSI, as at March 1995.

Of the 112 coastal SSSIs in the region, nearly three quarters (69%) include intertidal land to Mean Low Water of Spring Tides Mark, while one third (32%) are purely terrestrial. Almost 75% were selected at least partly for their biological interest and nearly two-fifths at least partly for their earth science (geological or geomorphological) interest. Of the total, nearly one tenth have both biological and earth science interest. Examples of a very wide range of habitats and species occur within the SSSIs in this region, the most frequently occurring habitats being dry grassland, maritime heath, woodland and peat bog, these habitats occurring in



Map 7.3.1 Coastal National Nature Reserves and Sites of Special Scientific Interest. Note: a single symbol may represent more than one site in close proximity. Sources: SNH, JNCC.

Table 7.3.1 National Nature Reserves

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date last declared*	*Habitats*
Argyll & Bute	**5**				
Mealdarroch		NR890670, NR914625	205	1987	Scattered woodland on steep slopes, gorges, Atlantic bryophytes and fern species
Taynish		NR735850	362	1977	Native deciduous woodland, foreshore and sea lochs
Moine Mhor		NR822985	493	1987	Raised mire, wetlands (acid peat to saltmarsh)
Eilean Na Muice Duibhe, Islay		NR323558	360	1993	Blanket mire with peaty pools and lochans
Glasdrum Wood		NN000460	169	1967	Deciduous woodland
Region 14	***5***		***1,589***		
West Coast	37		51,548		
GB coast	80		86,617		
GB whole country	287		194,927		

Sources: SNH, JNCC. Key: *to nearest hectare. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

Table 7.3.2 SSSIs in Region 14

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date last notified*
South Ayrshire	**14**			
Sgavoch		NX073808	6	1985
Ballantrae Shingle Beach		NX080818	34	1985
Knockdolian Hill		NX113848	68	1992
Girvan - Ballantrae		NX095874	89	1985
Littleton & Balhamie Hills		NX130867, NX135882	243	1990
Bennane Head Grasslands		NX110880, NX099863, NX094864	74	1985
Knockormal Hill		NX134885, NX137889, NX138890, NX143891	6	1990
Pinbain Burn - Cairn Hill		NX165925	524	1984
Byne Hill		NX180945	9	1986
Ailsa Craig		NX020998	104	1990
Turnberry Dunes		NS199062	78	1986
Turnberry Lighthouse - Port Murray		NS196072-NS207081	24	1993
Maidens to Doonfoot		NS316194	225	1983
Troon Golf Links & Foreshore		NS335287	150	1986
North Ayrshire	**8**			
Western Gailes		NS320358	94	1984
Bogside Flats		NS305394	254	1987
Ardrossan - Saltcoats		NS240415	54	1984
Portencross Coast		NS190521	478	1984
Kames Bay		NS171550	5	1990
Ballochmartin Bay		NS182570	19	1987
Largs Coast Section		NS192627	8	1984
Skelmorlie Glen		NS207662	37	1984
Isle of Arran (North Ayrshire)	**8**			
Laggan		NR986504	7	1985
Corrie Foreshore		NS026432	13	1986
Clauchlands Point - Corrygills		NS048338	47	1993
Dippin Head		NS052224	18	1985
South Coast of Arran		NR951208, NS042213	218	1990
Drumadoon - Tormore		NR894287	78	1986
Arran Northern Mountains		NR945439	12,037	1989
North Newton Shore		NR933517	9	1984
Inverclyde & Renfrewshire	**1**			
Erskine to Langbank		NS395734	545	1986
West Dunbartonshire	**2**			
Hawcraig - Glenarbuck		NS453742	18	1986
Dumbarton Rock		NS400745	4	1990
Argyll & Bute	**32**			
Dumbuck Foreshore - Pillar Bank		NS350760	820	1989
Geilston Burn		NS341777	3	1985
Ardmore Point		NS314785	135	1990
Rhu Point		NS264840	0.1	1986
Craighoyle Woodland		NS175905	79	1990
Central Lochs Bute		NS075615	187	1983
North End of Bute		NS009719	934	1983
Ruel Estuary		NS010800	342	1990
Beinnan Lochain		NN204080	1,369	1995
Glen Loin		NN307062	68	1986
Ardchyline Wood		NN112064, NN126075	179	1989
Argyll & Bute (continued)				
Strone Point, North Loch Fyne		NN116087	4	1984
Artilligan & Abhain Srathain Burns		NR857736	63	1985
Tarbert - Skipness Coast		NR901640	592	1986
Claonaig Wood		NR864555	55	1983
Torrisdale Cliff		NR798348	28	1986
Balnabraid Glen		NR760154	109	1987
Dun Ban		NR595141	248	1986
Machrihanish Dunes		NR653238	299	1983
Bellochantuy & Tangy Gorges		NR657278, NR670329, NR669337	21	1971**
Sanda Islands		NR725037	83	1995
Glenacardoch Point		NR660379	82	1990
Ardpatrick & Dunmore Woods		NR765610	751	1990
Rhunahaorine Point		NR695493	326	1987
Kilberry Coast		NR716690	214	1992
Ellary Woods		NR730750	800	1990
Taynish Woods		NR735850	390	1988
Linne Mhuirich		NR726847	108	1985
Ulva, Danna & The McCormaig Isles		NR700799	743	1986
West Tayvallich Pennisula		NR706834	662	1985
Tayvallich Juniper & Fen		NR725858	420	1990
Moine Mhor		NR815925	1,195	1987
Jura (Argyll & Bute)	**4**			
Kinuachdrach		NR707979	143	1992
Doire Dhonn, Jura		NR655890	41	1990
Craighouse Ravine, Jura		NR526666	3	1986
West Coast of Jura		NR441726, NR441752, NR660986, NM689003	1,876	1985
Islay (Argyll & Bute)	**9**			
Rubha A 'Mhail to Uamhannan Donna Coast		NR425774, NR363766	418	1990
Ardmore, Kildalton & Callumkill Woodlands		NR450495	1,589	1991
Eilean na Muice Duibhe		NR320550	574	1992
Laggan Peninsula		NR297555	1,270	1989
Bridgend Flats		NR330620	331	1983
Rinns of Islay		NR235620	8,312	1986
Glac na Criche		NR225708	265	1985
Feur Lochain		NR252695	384	1989
Gruinart Flats		NR285665	3,170	1985
Colonsay and Oronsay (Argyll & Bute)	**4**			
North Colonsay		NR415985	800	1983
Loch Fada		NR383956	87	1985
West Colonsay Seabird Cliffs		NR370970	49	1984
Oronsay		NR350875	329	1983
Argyll & Bute	**11**			
Garvellachs		NM670120	265	1985
South Kerrera & Gallanach		NM794279-NM803256, NM826271	83	1986
Ard Trilleachan		NN095425	605	1983
Bonawe - Cadderlie		NN035355	892	1984
Kennacraig & Esragan Burn		NM997347	168	1984
Lynn of Lorne Small Islands		NM860400	98	1984

Table 7.3.2 SSSIs in Region 14 (continued)

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date last notified*
Argyll & Bute (continued)				
South Shian & Balure		NM909422, NM896420	9	1988
Glasdrum		NN005460	448	1986
Clach Tholl		NM899448	8	1984
Lismore Lochs		NM808376, NM829394, NM859424	111	1992
Bernera Island		NM795395	44	1990
Mull (Argyll & Bute)	**11**			
Sound of Mull Cliffs		NM535517	39	1986
Ardura-Auchnacraig		NM705290	846	1991
Ardlanish Bay		NM365180	71	1991
South Mull Coast		NM523204	599	1986
Ardtun Leaf Beds		NM379248	18	1985
Coladoir Bog		NM537301, NM550297, NM549289	51	1984
Ardmeanach		NM440290	3,257	1992
Gribun Shore & Crags		NM456355	231	1986
Ben More & Scarisdale		NM523378	4,123	1985
Lagganulva Wood		NM450420	214	1986
Calgary Dunes		NM372512	24	1983
Argyll & Bute	**2**			
Staffa		NM325355	45	1986
Treshnish Isles		NM274412	208	1988
Tiree (Argyll & Bute)	**3**			
An Fhaodhail & The Reef		NM014454	319	1986
Ceann a'Mhara		NL934405	34	1984
Hough Bay & Balevullin Machair		NL943463	508	1989
Coll (Argyll & Bute)	**3**			
North East Coll Lochs and Moors		NM243608	2,301	1984
Totamore Dunes		NM173574	128	1986
Crossapol & Gunna		NM124530	973	1989
Region 14	***112***		***63,243***	
West Coast	646		373,454	
GB coast	1,198		703,844	
GB whole country	6,097		1,941,936	

Sources: SNH, JNCC. Key:*to nearest hectare; **sites notified before the 1981 Wildlife & Countryside Act and not yet renotified are not afforded protection under this Act: these sites may later be renotified. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

9-18% of sites. SSSIs in the region include many sites of interest for their lower plants, terrestrial invertebrates, mammals, breeding seabirds or internationally important migrating/wintering bird populations. Further details of SSSIs may be found in the coastal and marine UKDMAP datasets module disseminated by JNCC Coastal Conservation Branch (BODC 1992; Barne *et al.* 1994), or SNH offices.

7.3.3 Areas of Special Protection

'Area of Special Protection' (AoSP) is a designation replacing Bird Sanctuary Orders under the 1954 to 1967 Protection of Birds Acts, which were repealed and amended under the Wildlife & Countryside Act 1981. Designation aims to prevent the disturbance and destruction of the birds for which the area is identified, by making it unlawful to damage or destroy either the birds or their nests and in some cases by prohibiting or restricting access to the site. There are two AoSPs in Region 14, Lady Isle and Horse Isle (Table 7.3.3; Map 7.3.2).

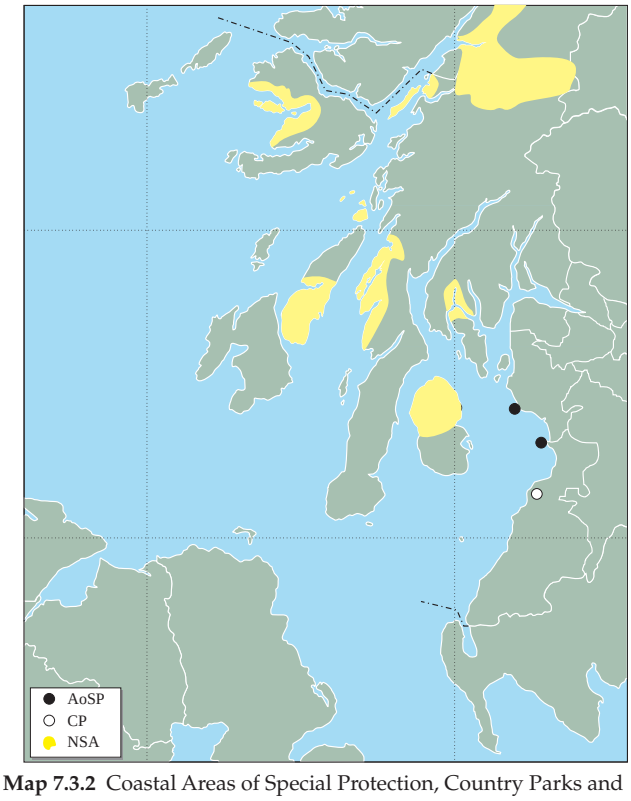
Table 7.3.3 Areas of Special Protection (AoSPs)

Site name	*No. of sites*	*Date designated*
Lady Isle, Firth of Clyde (No. 1854 (S.145))		1955
Horse Isle (No. 120 (S.4))		1963
Region 14	***2***	
West Coast	9	
GB coast	23	
GB whole country	38	

Source: DoE European Wildlife Division. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

7.3.4 National Scenic Areas

National Scenic Areas are designated by Scottish Natural Heritage as the best of Scotland's landscapes, deserving special protection in the nation's interest. Special development control measures for the 40 National Scenic Areas in Scotland were introduced by the Scottish Development Department in 1980. This designation replaces two earlier categories of importance for scenic interest, which



Map 7.3.2 Coastal Areas of Special Protection, Country Parks and National Scenic Areas. Sources: SNH, Countryside Commission for Scotland (1985, 1978).

served to fulfil some of the approaches embodied in the National Park and AONB designations in England and Wales. The seaward boundary of National Scenic Areas is the same as that for planning purposes in Scotland, i.e. mean low water of spring tides. There are seven whole and part of one other National Scenic Areas (140,000 ha) that include areas within the coastal zone in Region 14 (Table 7.3.4; Map 7.3.2).

Table 7.3.4 National Scenic Areas

Site name	*No. of sites*	*Area (ha)**	*Date designated*
North Arran	1	23,800	1980
Kyles of Bute	1	4,400	1980
Knapdale	1	19,800	1980
Jura	1	21,800	1980
Scarba, Lunga & the Garvellachs	1	1,900	1980
Ben Nevis & Glen Coe**	0.5**	50,800**	1980
Lynn of Lorn	1	4,800	1980
Loch Na Keal, Isle of Mull	1	12,700	1980
Region 14	***7.5****	***140,000****	
West Coast	23	693,400	
GB coast	27	745,800	

Sources: Countryside Commission for Scotland (1978), SNH. Key: *to nearest hectare; **part of the Ben Nevis & Glen Coe NSA is in Region 16; half of the area has been included in the total for Region 14. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

7.3.5 Country Parks

Country Parks are primarily intended for recreation and leisure opportunities close to population centres and do not necessarily have any nature conservation interest. Nevertheless, many are in areas of semi-natural habitat and so form a valuable network of locations at which informal recreation and the natural environment co-exist. They are statutorily declared and managed by local authorities under section 7 of the Countryside Act 1968. There are two coastal Country Parks (301 ha) in Region 14 (Table 7.3.5; Map 7.3.2).

Table 7.3.5 Country Parks

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date designated/ opened*
South Ayrshire	**1**			
Culzean		NS235094	229	1969
North Ayrshire	**1**			
Brodick Castle, Isle of Arran		NS015382	72	1980
Region 14	***2***		***301***	
West Coast	14		1,498	
GB coast	34		4,441	
GB whole country	281		35,150	

Source: Countryside Commission for Scotland (1985). Key: *to nearest hectare. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

7.3.6 Acknowledgements

Thanks are due in particular to Kathy Duncan, Donald Balsillie and Natasha O'Connell (Scottish Natural Heritage), Ray Woolmore (Countryside Commission) and to Roger Bolt (JNCC).

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Nature Conservancy Council. 1989. *Guidelines for selection of biological SSSIs.* Peterborough, Nature Conservancy Council.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Site designations	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
NNRs, SSSIs, NSA (Argyll & Bute)	*Advisory Officer, SNH, Lochgilphead, tel: 01546 603611
SSSIs, AoSP, NSA, Country Park (Inverclyde, Renfrew, West Dunbartonshire)	*Advisory Officer, SNH, Clydebank, tel: 0141 951 4488
SSSIs, AoSP, NSA, Country Park (North Ayrshire, South Ayrshire)	*Advisory Officer, SNH, Ayr, tel: 01292 261392
Areas of Special Protection	Department of the Environment (DoE), European Wildlife Division, Tollgate House, Houlton Street, Bristol BS2 9DJ, tel: 0117 987 8000
Coastal and marine UKDMAP datasets	*Coastal Directories Team, JNCC, Peterborough, tel: 01733 62626

*Starred contact addresses are given in full in the Appendix.

7.4 Sites identified by statutory agencies

This section covers sites which, although not protected by statute, have been identified by statutory agencies as being of nature conservation or landscape importance.

7.4.1 Nature Conservation Review sites

Nature Conservation Review (NCR) sites are non-statutory sites that are the best representative examples of wildlife habitat; for some coastal sites, for example estuaries, all sites that were above a critical standard of nature conservation importance were selected. Ratcliffe (1977) related this particularly to migrant and wintering waterfowl populations and breeding bird assemblages. The NCR helps to identify sites that may qualify for declaration as National Nature Reserves. There are 953 NCR sites (approximately 1,500,000 ha) in Britain. 149 of them (approximately 360,000 ha) are coastal as defined by Ratcliffe (1977), but his definition of 'coastal' differed from that adopted in this chapter.

7.4.2 Geological Conservation Review sites

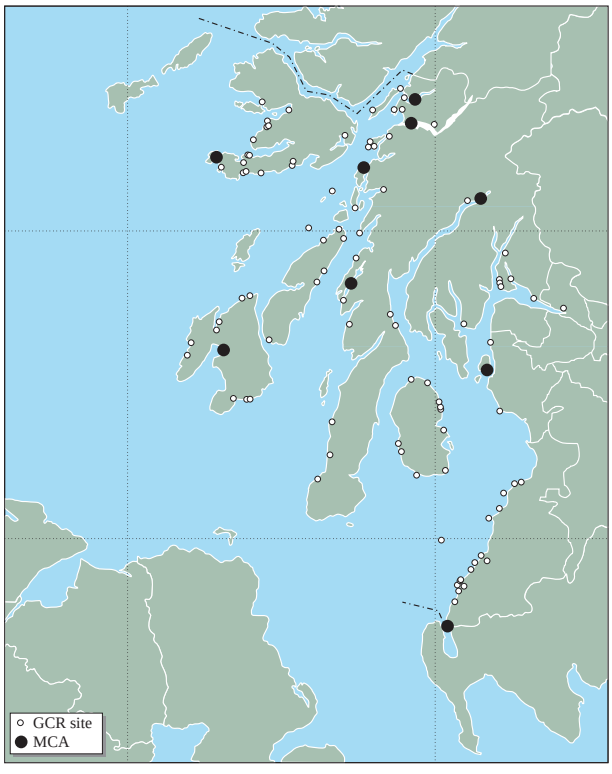
Geological Conservation Review (GCR) sites are non-statutory sites identified as having national or international importance for earth science. The GCR selection process describes and assesses key sites in the context of their geology, palaeontology, mineralogy or geomorphology; GCR sites are the earth science equivalent of NCRs (see section 7.4.1). There are 91 coastal GCR sites within Region 14 (Map 7.4.1), listed in Table 7.4.1 with an indication of whether they were selected for their geological or their coastal geomorphological interest. Detailed scientific accounts of coastal and inland GCR sites have been published or are in preparation in 22 volumes of a planned 42-volume *Geological Conservation Review* series (Ellis *et al.* 1996).

7.4.3 Marine Consultation Areas

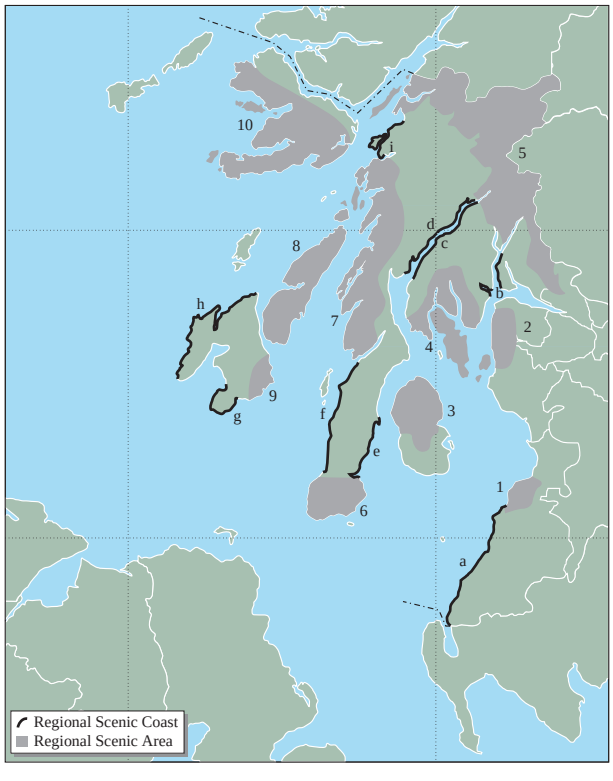
The non-statutory Marine Consultation Area designation identifies areas considered by Scottish Natural Heritage to deserve particular distinction in respect of the quality and sensitivity of the marine environment within them. Their selection encourages coastal communities and management bodies to be aware of marine conservation issues in the area. There are eight whole and part of one other Marine Consultation Area (56,016 ha) in Region 14 (Table 7.4.2; Map 7.4.1).

7.4.4 Regional Landscape Designations

Regional Landscape Designations (RLDs), identified in 1974, provide a mechanism whereby Scottish planning authorities can identify sites where there should be a strong presumption against development (Cobham Resource Consultants 1988). The designation recognises that these



Map 7.4.1 Coastal Geological Conservation Review sites and Marine Consultation Areas. Note: a single symbol may represent more than one site in close proximity. Sources: JNCC, SNH, NCC (1990).



Map 7.4.2 Regional Landscape Designations: Regional Scenic Coasts and Regional Scenic Areas. Sources: Cobham Resource Consultants (1988), SNH.

Table 7.4.1 GCR sites

Location	*No. of sites*
South Ayrshire	**15**
Sgavoch	
Bennane Lea	
Balcreuchan Port - Bennane	
Balcreuchan Port - Port Vad	
Games Loup	
Ailsa Craig	
Slockenray Coast	
Girvan Foreshore	
Woodland Point	
Byne Hill	
Turnberry Lighthouse to Port Murray	
Culzean Harbour	
Port Schuchan to Dunure Castle	
Heads of Ayr	
Bracken Bay - Longhill Point	
North Ayrshire	**2**
Ardrossan to Saltcoats Coast	
Largs	
Arran, (North Ayrshire)	**10**
Laggan	
Corrie Shore (2 sites)	
Corrie Foreshore	
Corrygills Shore	
Dippin Head	
South Coast of Arran	
Drumadoon to Tormore	
Kings Cave - Drumadoon	
North Newton Shore	
Dunbartonshire	**1**
Dumbarton Rock	
Argyll & Bute	**30**
Geilston	
Rhu Point	
Kilcreggan Coast	
Baron's Point	
Glen Dhualt	
Portincaple	
Toward Quay, South Dunoon	
Strone Point, North Loch Fyne	
South Bay, Barmore Island	
Mealdarroch Point, Tarbert	
Machrihanish Coast and South Kintyre	
Tangy Burn, Drumone Burn & Allt a'Ghlaoidh Glens	
Glenacardoch Point	
Port Cill Maluaig	
Kilmory Bay	
West Tayvallich Peninsula	
Craignish Point	
Fearnach Bay	

Location	*No. of sites*
Argyll & Bute (continued)	
Black Mill Bay, Luing	
Pulpit Hill	
South Kerrera	
Garvellach Isles	
Ardmore to Gallanach	
South Kerrera	
Bonawe - Cadderlie Burn	
Port Selma, Ardmucknish	
Camas Nathais	
South Shian and Balure	
Clach Tholl	
South Coast, Lismore Island	
Jura (Argyll & Bute)	**5**
West Coast of Jura*	
Kinuachdrach, Jura	
Lussa Bay	
Tarbert, Jura	
Ardfin, Jura	
Islay (Argyll & Bute)	**11**
West Coast of Jura	
(Bàgh Gleann Speireig-Carragh an t-Sruith)	
Rubha a'Mhail to Rubha Bholsa coast	
Lagavulin Bay, Dunyveg Castle	
Surnaig Farm, Islay	
Kilnaughton Bay, Islay	
Kilchiaran to Ardnave Point, Islay	
Machir Bay*	
Loch Gruinart, Islay*	
Bun-an-uillt, Islay	
Rubha a'Mhail, Islay	
Dubh Loch	
Mull (Argyll & Bute)	**17**
Loch Spelve to Auchnacraig	
Carsaig Bay	
Nuns Pass	
Port Bheathain	
Ardalanish Bay (2 sites)	
Cnoc Mor to Rubh' Ardalanish	
Knockvologan to Eilean A'Chalmain	
Loch an t-Suidhe	
Ardtun (3 sites)	
Aird na h-lolaire	
Gribun (2 sites)	
Scarisdale	
Laggan Bay	
Region 14	***91***
West Coast	545
GB coast	1,098
GB whole country	3,025

Sources: JNCC, SNH. Key: *sites selected wholly or partly for their coastal geomorphological interest. Note: site names that occur more than once refer to sites at different grid reference points but with the same name. In this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

scenic areas have considerable unexploited potential for tourism and therefore for benefiting local economies. Local circumstances and the absence of central guidance since 1962 means that Regional Landscape Designations vary in title, scale and objectives from one planning authority to another (Cobham Resource Consultants 1988), such that there are at least five types of RLD.

In Region 14 there are nineteen coastal areas covered by RLDs (in this region they are either Regional Scenic Areas (RSAs) or Regional Scenic Coasts (RSCs), covering approximately 367,866 ha and 391km respectively) that include areas somewhere within the coastal zone (Tables 7.4.3 and 7.4.4; Map 7.4.2). There has been no monitoring or further comprehensive study of the number of RLDs since Cobham Resource Consultants (1988).

Table 7.4.2 Marine Consultation Areas

Site name	*No. of sites*	*Area (ha)**	*Date established*
Loch Ryan**	0.5**	2,080**	1990
Cumbraes	1	2,823	1990
Upper Loch Fyne	1	1,705	1990
Loch Sween	1	6,328	1986
Loch Indaal, Islay	1	3,075	1986
Firth of Lorn	1	33,900	1986
Loch Etive	1	3,070	1986
Loch Creran	1	1,510	1990
Sound of Iona, Mull	1	1,525	1986
Region 14	***8.5****	***56,016****	
West Coast	23	103,287	
Scotland	29	111,896	

Source: NCC (1990). Key: *to nearest hectare; **part of Loch Ryan MCA is in Dumfries and Galloway (Region 13); half the area of the MCA has been included in Region 14.

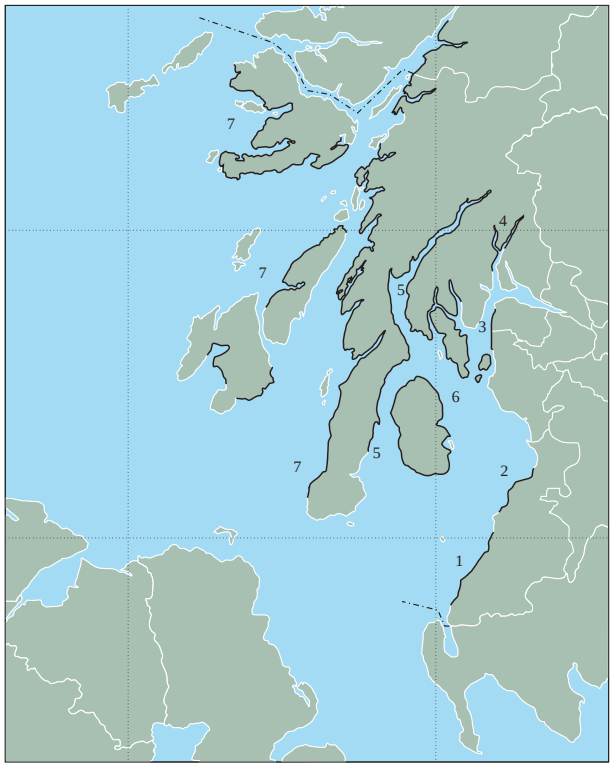
Table 7.4.3 Regional Scenic Areas

Site no. on Map 7.4.2	*Site name*	*No. of sites*	*Area (ha)**
1	Heads of Ayr		5,443
2	Renfrew Hills (West) and the Cumbraes		12,352
3	North and Central Arran		24,759
4	Bute and South Cowal		30,984
5	North and West Argyll		130,030
6	Mull of Kintyre		17,674
7	Knapdale/Melfort		45,195
8	Jura		35,131
9	South East Islay		7,061
10	Central, South and West Mull		59,257
	Region 14	***10***	***367,866***
	West Coast	24	434,341
	Scotland coast	58	507,182
	Scotland whole country	178	1,468,000

Sources: Cobham Resource Consultants (1988), SNH. Key: *to nearest hectare. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

7.4.5 Preferred Conservation Zones (PCZ)

Preferred Conservation Zones (PCZs) are non-statutory coastal areas in Scotland, of particular national, scenic, environmental or ecological importance, in which major new oil- and gas-related developments would in general be inappropriate or would have a socio-economic impact on a small community, and would only be justified in exceptional circumstances (see also section 9.5). They are areas with a distinctive aesthetic appeal, heritage and character, where tourism and recreation take priority over major industrial processes. PCZs are the opposite of Preferred Development Zones. In Region 14 there are six whole and part of one other PCZs (Table 7.4.5; Map 7.4.3). This compares with 22 PCZs on the Scottish mainland and numerous potential PCZs around the islands (only the larger islands have defined Preferred Conservation Zones), of which eight whole defined PCZs and the majority of the 1,771 km Dounreay to Machrihanish PCZ are on the West Coast.



Map 7.4.3 Preferred Conservation Zones. Numbers refer to Table 7.4.4. Sources: Cobham Resource Consultants (1988), Scottish Development Department (1974).

Table 7.4.4 Regional Scenic Coasts

Site letter on Map 7.4.2	*Site name*	*No. of sites*	*Length (km)**
a	Carrick		41
b	Loch Long and Loch Goil		22
c	East Loch Fyne		36
d	West Loch Fyne		39
e	East Kintyre		18
f	West Kintyre		40
g	South West Islay		21
h	North and West Islay		66
i	North West Argyll		108
	Region 14	***9***	***391***
	West Coast	9	391
	Scottish coast	9	391

Sources: Cobham Resource Consultants (1988), SNH. Key: *to the nearest km.

7.4.6 Acknowledgements

Thanks are due to Donald Balsillie, Alan McKirdy, Kathy Duncan and Natasha O'Connel (Scottish Natural Heritage), and Roger Bolt (JNCC).

Table 7.4.5 Preferred Conservation Zones (PCZs)

Site no. (*Map 7.4.3*)	*Location*
1	Woodland Bay - Finnart's Bay
2	South of Ayr - Dipple
3	Cloch Point - North of Largs
4	Loch Goil and Loch Long
5	The Clyde: North of Campbeltown - Port Lamont
6	Arran, Bute and the Cumbraes
7	The West Coast: Dounreay - Machrihanish*

Source: Scottish Development Department (1974). Key: *the West Coast: Dounreay - Machrihanish PCZ extends from Region 14, through Region 16 to Region 3. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
NCR sites, GCR sites, MCAs (Inverclyde, Renfrew, West Dunbartonshire)	*Advisory Officer, SNH, Clydebank, tel: 0141 951 4488
NCR sites, GCR sites, MCAs (North Ayrshire, South Ayrshire)	*Advisory Officer, SNH, Ayr, tel: 01292 261392
NCR sites, GCR sites, MCAs (Argyll & Bute)	*Advisory Officer, SNH, Lochgilphead, tel: 01546 603611
RSAs, RSCs and PCZs: Argyll & Bute	*Argyll & Bute Council, tel: 01546 604263
RSAs, RSCs and PCZs: North Ayrshire	*North Ayrshire Council, tel: 01294 324110
RSAs, RSCs and PCZs: South Ayrshire	*South Ayrshire Council, tel: 01292 612000

*Starred contact addresses are given in full in the Appendix.

Designated as a Ramsar site and a Special Protection Area, Loch Gruinart, Islay, is one of the most important sites for birds in a region that is of outstanding international ornithological importance. Part of the site is managed by the RSPB for its birds, amongst them barnacle geese *Branta leucopsis*. The entire Greenland population of the species flies in to Gruinart Flats in the autumn before dispersing to overwinter at sites throughout the north and west of the British Isles, more than a third remaining here. 17% of the world population of the species overwinter in the region. Photo: Lorne Gill, Scottish Natural Heritage.

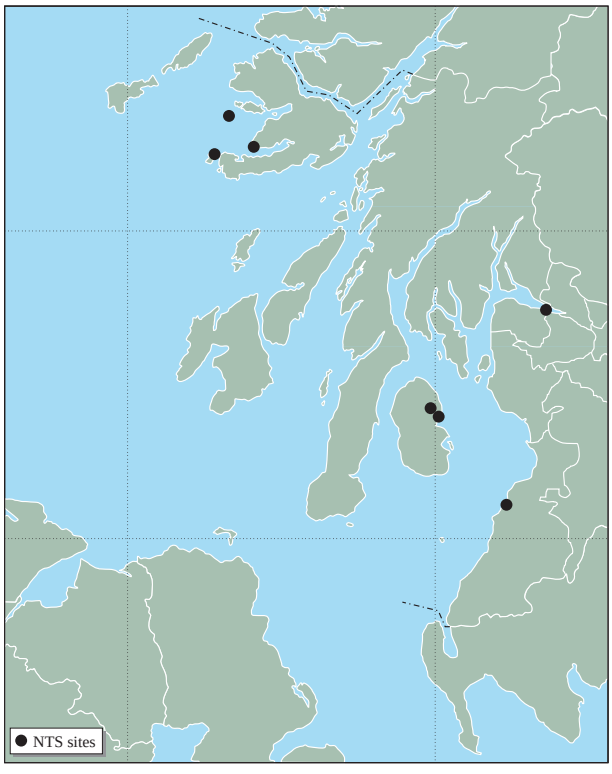
7.5 Other types of protected site

7.5.1 The National Trust for Scotland

The National Trust for Scotland is a charitable organisation, established in 1931 (National Trust for Scotland Order Confirmation Act 1935) for the purpose of promoting the permanent preservation of Scotland's heritage of fine buildings, beautiful landscape and historic places, and to encourage public enjoyment of them. The Trust now has over 100 properties in its care, including over 40,500 ha of countryside, from forest, mountains and moorland to the coast (National Trust for Scotland 1993). The National Trust for Scotland practises active conservation and management of its land. Land that is not owned by the Trust can be protected by a Conservation Agreement under powers given to the National Trust for Scotland by a 1938 Act of Parliament. Conservation agreements are entered into voluntarily by landowners who wish their land to come under a form of protection short of full Trust ownership. There are seven National Trust for Scotland sites (4,419 ha) of potential nature conservation interest in Region 14 (Table 7.5.1; Map 7.5.1).

7.5.2 The Royal Society for the Protection of Birds

The Royal Society for the Protection of Birds (RSPB) has substantial non-statutory reserve holdings and currently manages over 130 reserves (84,000 ha) in Britain (RSPB 1993). Wherever possible, reserves are purchased, so that the level of safeguard for the wildlife and their habitats is high. Where reserves are leased, the RSPB aims to acquire long leases (longer than 21 years) with appropriate management rights. There are four RSPB sites (3,114 ha) in Region 14 (Table 7.5.2; Map 7.5.2).



Map 7.5.1 National Trust for Scotland sites. Sources: National Trust for Scotland.

7.5.3 The Wildlife Trusts

The Wildlife Trusts were established to promote non-statutory nature conservation at a local level. They own, lease and manage (by agreement with owners) over 1,800 nature reserves (more than 52,000 ha). There is usually one trust covering a whole county or group of counties, although

Table 7.5.1 National Trust for Scotland sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date acquired*	*Landform*
South Ayrshire	**1**				
Culzean Castle & Country Park		NS233100	235	1945	Country park
Inverclyde	**1**				
Parklea Farm		NS361741	28	1950	Recreation ground
Isle of Arran (North Ayrshire)	**2**				
Goatfell		NR992415	2,671	1958	Coastal mountains
Brodick Castle & Country Park		NS017380	72	1958	Country park
Argyll	**3**				
Iona		NM275240	768	1980-91	Island
Burg		NM417275	617	1961	Headland, cliffs and beach
Staffa		NM325355	28	1986	Island
Region 14	***7***		***4,419***		
West Coast**	262		45,517		
GB coast**	446		64,127		

Sources: NTS, JNCC. Key: *to nearest hectare; **includes National Trust sites in England and Wales. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

Table 7.5.2 Royal Society for the Protection of Birds sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date acquired*	*Interest*
Horse Isle		NS212427	8	1961	Low-lying exposed island, shingle beaches; breeding seabirds including gulls and terns
Inner Clyde		NS380745	231	1981	Tidal mudflats and saltmarsh-wintering and roosting waterfowl
Loch Gruinart, Islay		NR275672	1,654	1984	Improved and rough pasture, saltmarsh, tidal loch, moorland and woodland; extensive numbers of overwintering geese, breeding and overwintering raptors, nesting waders
Coll		NM1554	1,221	1986	Beaches, sand dunes, machair, fen meadows, hay meadows and moorland-nesting corncrakes, breeding waders, overwintering geese
Region 14	***4***		***3,114***		
West Coast	29		14,125		
GB coast	82		38,680		

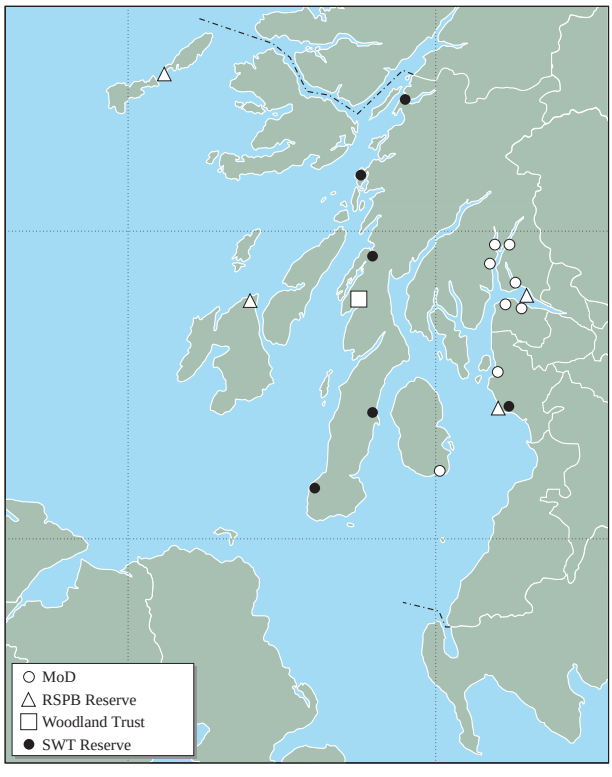
Sources: RSPB (1994; *in litt.*). Key: *to nearest hectare. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

both Scotland and the Isle of Man each have a single Trust. The Scottish Wildlife Trust owns, leases and manages, by agreement with owners, over 80 nature reserves (more than 15,000 ha). There are six coastal Scottish Wildlife Trust sites (1,784 ha) in Region 14 (Table 7.5.3; Map 7.5.2). Scottish data were extracted from the Scottish Wildlife Trust (1996).

Table 7.5.3 Wildlife Trust sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**	*Date acquired*
Parkhouse Community Nature Reserve		NS236427	4	1993
Carradale Point		NR817372	68	1973
Largybaan		NR614143	1,620	1993
Fairy Isles		NR766884	21	1982
Ballachuan Hazel Wood		NM763146	49	1984
Shian Wood		NM907418	22	1995
Region 14#	***6***		***1,784***	
Scotland#	26		13,785	
West Coast	95		13,108	
GB coast	217		23,420	

Sources: Scottish Wildlife Trust; JNCC. Key: #all Scottish Wildlife Trust; *to nearest hectare. Notes: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.



Map 7.5.2 Other coastal voluntary and private sites. Note: a single MoD site symbol may represent more than one site in close proximity. Sources: Ministry of Defence (MoD), RSPB, Woodland Trust, Scottish Wildlife Trust (SWT).

7.5.4 The Ministry of Defence

As at August 1994, the Ministry of Defence (MoD) owned, leased or used under licence landholdings covering some 320 km of coastline around the UK, not all of it significant for its nature conservation value. The MoD gives high priority to nature conservation on the Defence Estate, subject to the overriding importance of military training. The restrictions to public access on some sites mean that they can be amongst the most pristine areas of wildlife habitat in the region. There are twelve coastal MoD sites (4,277 ha) in Region 14 (Table 7.5.4; Map 7.5.2).

7.5.5 The Woodland Trust

The Woodland Trust was established in 1972 with the aim of conserving, restoring and re-establishing trees (particularly broad-leaved) and woodland plants and wildlife in the United Kingdom. There is one Woodland Trust site (40 ha) in Region 14 (Table 7.5.5; Map 7.5.2).

Table 7.5.4 MoD sites

Site name	*No. of sites*	*Area (ha)**	*Habitats*	*Protected status*
Fairlie		6	Rock/shingle	No designation
Greenock (2 sites)		12	Shingle and harbour	No designation
Faslane		136	Docking berths	No designation
Garelochhead		3,350	Rock/shingle	No designation
Rhu		3	Rock/shingle	No designation
Rosneath		6	Sand/shingle	No designation
Coulport		743	Rock	No designation
Arrochar		1	Shingle	Forest Park
Loch Goil		3	Shingle	Forest Park
Loch Long		1	Rock	Forest Park
Arran Island		17	Rock/shingle	No designation
Region 14	***12***	***4,277***		
West Coast	45	18,961		
GB coast	110	53,410		

Source: Ministry of Defence. Key: *all areas are approximate and include land leased or used under licence. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

Table 7.5.5 The Woodland Trust sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha)**
Crinan Wood		NR790940	40
Region 14	***1***		***40***
West coast	35		480
GB coast	72		1,590

Source: Woodland Trust (1993). Key: *to nearest hectare. Note: in this table any site that is wholly or partly intertidal, and any terrestrial site at least partly within 1 km of the Mean High Water Mark, or any tidal channel as depicted on 1:50,000 Ordnance Survey maps, is included as coastal.

7.5.6 Acknowledgements

The author wishes to thank Andrew Brown (MoD), Dr J. Fenton (National Trust for Scotland), Dr A. Somerville (Scottish Wildlife Trust), Bob Scott (RSPB) and the Woodland Trust.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
National Trust for Scotland sites in region	*The National Trust for Scotland, Edinburgh, tel: 0131 226 5922
RSPB sites	Regional Officer, RSPB South and West Scotland Regional Office, Unit 3.1, West of Scotland Science Park, Kelvin Campus, Glasgow G20 0SP, tel: 0141 945 5224
Scottish Wildlife Trust sites	*Conservation Officer, Scottish Wildlife Trust HQ, Edinburgh, tel: 0131 312 7765
The Woodland Trust sites	The Woodland Trust, Autumn Park, Dysart Road, Grantham, Lincolnshire NG31 6LL, tel: 01476 74297
MOD sites	Conservation Officer, MoD Conservation Office, B2/3, Government Buildings, Leatherhead Road, Chessington, Surrey KT9 2LU, tel: 0181 391 3028/9

*Starred contact addresses are given in full in the Appendix.

Lismore Island, Loch Linnhe. The predominant system of agriculture in the north of the region is crofting, a low-intensity form of land management that is traditional in the Highlands and Islands. Photo: P.A. Macdonald, Scottish Natural Heritage.

Chapter 8 Land use, infrastructure and coastal defence

S.L. Fowler, S.J. Everett & J.A. Norton

8.1 Introduction

This chapter is divided into three sections: rural land use, covering agriculture (especially as it affects important coastal wildlife habitats) and woodland; infrastructure, covering population distribution, industry, ports, harbours and power generation; and coastal defence, including sea defence and coast protection.

In the south of the region the coast is dominated by agriculture - mainly grazing in the Southern Uplands south of Girvan and arable with some pasture in the Midland Valley between Girvan and Glasgow. Coastal towns include Ayr, Irvine, Largs and Greenock, with the major industrial and residential conurbation of Glasgow situated in the sheltered Clyde Estuary. To the north and west, an area that includes Arran and part of the Inner Hebrides as well as the mainland, the land is only sparsely populated, with the primary land use being non-intensive agriculture - mainly grazing and, locally, crofting. There are large areas of semi-natural vegetation, and forestry is also very important in certain localitites.

Arran and Argyll & Bute (including the islands of the Inner Hebrides) have been designated as an Objective 1 area by the European Union and form part of the Highlands and Islands Enterprise Area. Objective 1 promotes the structural adjustment of regions within the EU that are considered to be in need of development. These areas qualify for special support from the European Union's structural funds and regional aid programmes. The remainder of this region is designated an Objective 2 Industrial Area. This qualifies the region for economic aid to regenerate localities in industrial decline.

Most of the region is rural in character; the shores of the Clyde, however, have been extensively developed over several centuries and the area is one of the most densely populated in Britain. Dumbarton Rock presides over the heavily industrialised banks of the River Leven where it flows into the Clyde. Photo: Lorne Gill, Scottish Natural Heritage.

8.2 Land use

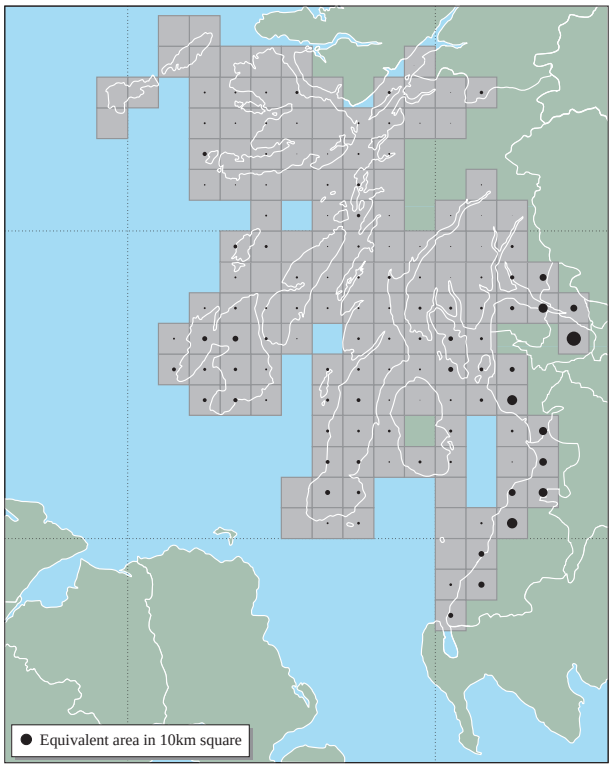
S.L. Fowler, S.J. Everett & J.A. Norton

8.2.1 Introduction

The region is divided into two parts by the Clyde Estuary. To the south of the Clyde dairy farming occurs, as in other coastal areas of western Britain. To the north and west land use is transitional between the more intensive agriculture in the south and the pastoral upland areas further north in Regions 15 and 16.

Only 440,900 ha (5.7%) of Scotland's land surface is covered by prime quality land (Classes 1, 2 and 3.1). Practically all the coastal land in this region is of the poorest agricultural quality (Classes 5, 6 and 7), although the southern part of the region (south of Turnberry) is classed as 3.2 or 4 (Macaulay Land Use Research Institute pers. comm.). Over half of the coastal land on the islands and in the north of the region is of limited agricultural value, useful only as rough grazing. Prime quality land (mainly Class 2) is restricted to very small pockets immediately to the north and south of Ayr.

Overall, 10% of the land area in Scotland is devoted to forestry, with about 60% of this managed by Forest Enterprise. Much of this occurs inland from the coast and especially on the uplands. Within this region Argyll & Bute have large areas of recent afforestation, many of which abut the coast.

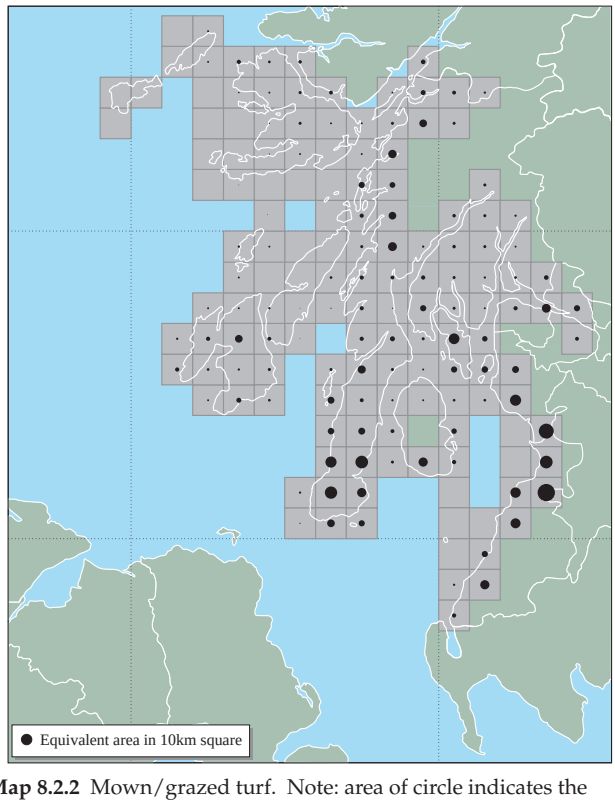


Map 8.2.1 Tilled land. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE (1993).

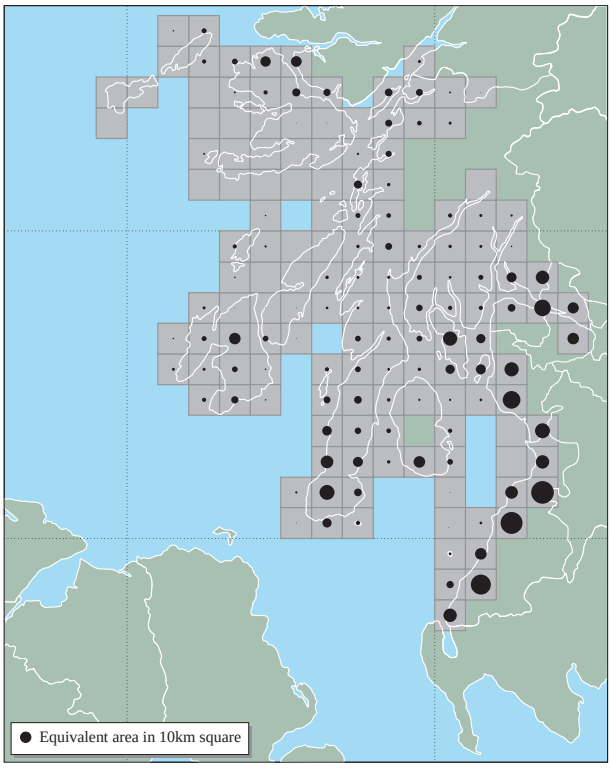
8.2.2 Locations and land uses

Maps 8.2.1, 8.2.2 and 8.2.3 show the distributions in the region of, respectively, tilled land, intensively managed mown/grazed turf and lightly managed meadow/semi-natural grassland. Coastal agricultural land to the south and east of the Firth of Clyde is mainly used for dairy cattle, with areas of more intensive arable farming on land in the Clyde valley. In the north and west, low-lying sheltered coastal areas are generally used for mixed farming, with sheep on the uplands. Crofting is practised in some of the more remote areas of the mainland and islands. However, traditional patterns of agriculture in the region have undergone major changes, with a decline in crofting over the last 150 years. Crofters in remote areas now often supplement their income from other sources, including fishing (see also section 9.1), fish farming (see section 9.2), forestry and tourism (see also section 9.7). The isles of Argyll, including Jura, Islay, Colonsay, Lismore, Mull, Coll and Tiree, form an Environmentally Sensitive Area, where farmers may be given financial incentives to avoid certain types of agricultural intensification, and restore traditional landscapes.

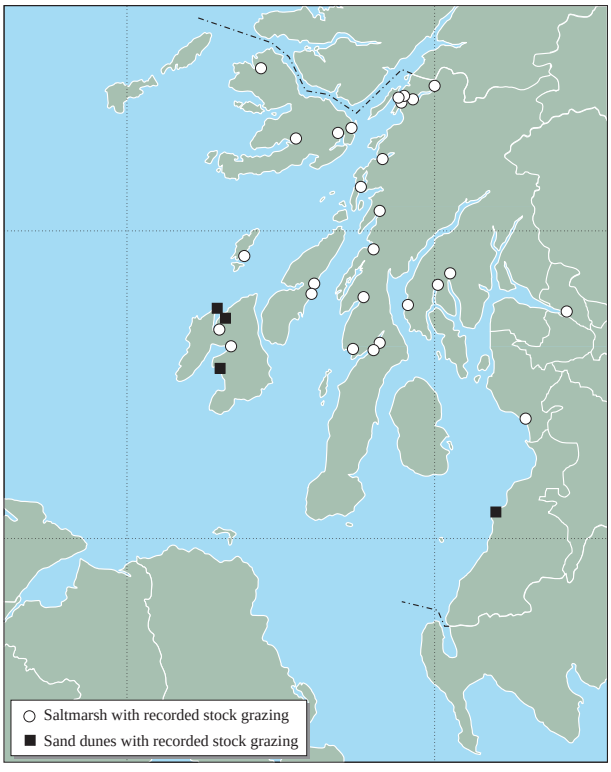
The quantity and quality of semi-natural vegetation is influenced by its management for agriculture. The characteristic semi-natural vegetation of most stable dunes is grasslands or heathlands, which have developed as a result of grazing of the indigenous vegetation by sheep, rabbits and cattle. Map 8.2.4 shows sand dune sites in the region at which stock grazing has been recorded. Doody (undated) notes that restricted sediment supply and strong winds, combined with overgrazing, have caused serious erosion on dunes at Ardnave on Islay and at other Scottish west coast sites. Grazing on saltmarshes is common in this



Map 8.2.2 Mown/grazed turf. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE (1993).



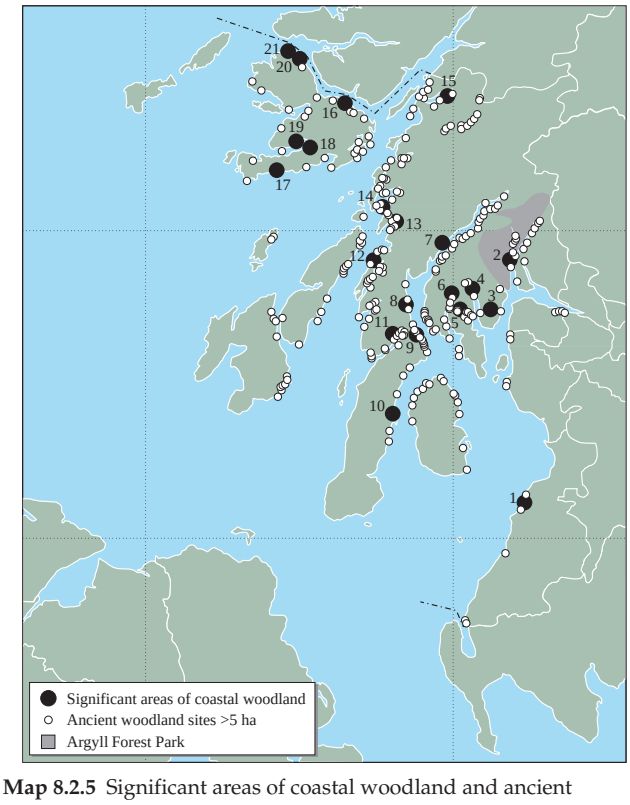
Map 8.2.3 Area of meadow or semi-natural grassland in coastal 10 km grid squares. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE (1993).



Map 8.2.4 Saltmarshes and sand dunes with recorded grazing. See Maps 3.6.1 and 3.2.1 for distribution of saltmarsh and sand dune sites. Source: JNCC Coastal Database.

region, although the areas involved are small, as most saltmarshes are of limited extent, typically situated at the heads of lochs (Map 8.2.4) (see also section 3.6). Up to 200 ha of semi-natural shingle vegetation has been lost to agricultural improvement at Rhunahaorine Point on the Kintyre Peninsula.

This region has some of the most densely forested coastline in Britain. The extensive Argyll Forest Park is made up of a number of areas of commercial forest owned by Forest Enterprise, interspersed with unafforested areas of higher land, located between Loch Long and Loch Fyne. There are also important areas of broadleaved woodland in the region. Because of the humid climate and the region's general inaccessibility, in particular in Argyll & Bute, the coastline has a very high number of ancient (including 'ancient semi-natural' and 'long-established semi-natural') woodland sites. The Scottish Natural Heritage (SNH) Ancient Woodland Inventory lists 928 sites with more than one hectare of semi-natural woodland whose central grid references lie within 500 m of the coast in this region. Most have only small areas of semi-natural woodland. Map 8.2.5 shows all coastal woodland sites >5 ha listed on the inventory; inventory sites in the region >50 ha and major areas of coastal afforestation are numbered on the map and listed in Table 8.2.1. Indicative Forestry Strategies have been produced for regions throughout Scotland and are published within Structure Plan documents produced by the former Regional Councils. These strategies, which are intended to control new afforestation, classify land into three categories for afforestation: preferred, potential and sensitive. They identify significant existing areas of productive woodland, as well as land unsuitable for tree crops on account of physical or climatic limitations.



Map 8.2.5 Significant areas of coastal woodland and ancient woodland sites. Numbers refer to Table 8.2.1. Shaded area shows the approximate extent of Argyll Forest Park. Sources: ITE (1993), Ordnance Survey Landranger maps. © Crown copyright.

Table 8.2.1 Significant areas of coastal woodland

Site no. on Map 8.2.5	*Location*	*Grid ref.*	*Notes*
1	Culzean	NS2413	70 ha long-established semi-natural woodland (AWI)
2	Loch Long	NS2090	>2,000 ha coniferous (Argyll Forest Park)
3	Dunoon	NS1373	>5,000 ha, small area of mixed in south, otherwise coniferous
4	Loch Striven	NS0877	>1,000 ha coniferous
5	Loch Riddon and Kyles of Bute	NS0275	>500 ha deciduous on lower slopes; coniferous inland
6	Craig Lodge	NS001782	76 ha long-established semi-natural woodland (AWI)
7	Loch Fyne (including Kilmichael and Strathlachan forests)	NR9594	>10,000 ha coniferous
8	Erines	NR860750	79 ha ancient woodland (AWI)
9	Mealdarroch	NR897653	61 ha long-established semi-natural woodland (AWI)
10	Kilbrannan Sound	NR8040	>2,000 ha coniferous
11	West Loch Tarbert (Kintyre)	NR8064	>1,000 ha mainly coniferous, some mixed
12	Knapdale Forest	NR7590	>5,000 ha coniferous
13	Loch Craignish	NM8101	>500 ha mixed on lower slopes; coniferous inland
14	Shuna	NM7708	*c.* 200 ha deciduous woodland round much of coast
15	Barcaldine	NM970430	62 ha ancient woodland (AWI)
16	Salen Forest, Mull	NM6642	>200 ha coniferous
17	West Mull	NM4520	>500 ha coniferous
18	West Mull	NM5326	>500 ha coniferous
19	West Mull	NM4828	>500 ha coniferous
20	Tobermory, Mull	NM5354	>1,000 ha mixed on lower slopes; coniferous inland
21	Ardmore Point Mull	NM4859	>1,000 ha coniferous

Source: OS Landranger maps; SNH Ancient Woodland Inventory. Key: AWI = Ancient Woodland Inventory site.

8.2.3 Information sources used

The main source of information for agricultural land use was the Countryside Survey 1990 (ITE 1993), which is based primarily on high resolution satellite images. These images show the dominant land cover for each 25 m x 25 m area (pixel) of Great Britain. Land cover is classified into seventeen key types (including tilled land and managed grassland), and field surveys of randomly selected areas were used to check the results. Maps 8.2.1, 8.2.2 and 8.2.3 are derived from these data, which are held in the DoE Countryside Information System. The main limitations of these data are derived from errors in classifying areas covered by a mixture of land types. The Countryside Information System can provide data on a 1 km square framework, but this level of detail was not considered appropriate here. More detailed information on agricultural land use and grades is available from SOAEFD and local authority documents.

Sand dune and saltmarsh data come from the JNCC Coastal Database, which holds the results of national surveys of these habitats. Information on woodland and forestry was obtained from the 1:50,000 scale Ordnance Survey Landranger maps, which differentiate between coniferous, mixed and broad-leaved woodland. The former Nature Conservancy Council's Inventory of Ancient Woodlands provides comparative data for the region and Great Britain; District inventories are available from Scottish Natural Heritage HQ and Area Offices. A Geographic Information System (GIS) containing the Scottish Ancient Woodland Inventory data is held at SNH HQ Edinburgh.

8.2.4 Acknowledgements

Thanks go to John Kupiec (SNH) for providing ancient woodland data and to Robin Fuller (ITE) for Land Cover data.

8.2.5 Further sources of information

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Macaulay Land Use Research Institute. 1988. *Land cover of Scotland. The measurement and analysis of land cover changes in part of the Central Valley of Scotland.* Craigiebuckler, Aberdeen.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Agriculture in the region	*SOAEFD, Edinburgh, tel: 0131 556 8400
Crofting	Crofters Commission, 4/6 Castle Wynd, Inverness IV2 3EQ, tel: 01463 663450
Crown agricultural and forestry estates	The Crown Estate, 10 Charlotte Square, Edinburgh EH2 4DR, tel: 0131 226 7241
Land use information in Scotland	Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen AB15 8QH, tel: 01224 318611
ITE Countryside Survey 1990	Department of Rural Affairs, DoE, Tollgate House, Houlton Street, Bristol BS2 9DJ, tel: 0117 987 8000
Distribution, ownership, management of woodlands - Strathclyde	Forestry Authority, Strathclyde Conservancy, Portcullis House, 21 India Street, Glasgow G2 4PL, tel: 0141 248 3931
Distribution, ownership, management of woodlands - Scotland	Forestry Commission, 231 Corstorphine Road, Edinburgh EH12 7AT, tel: 0131 334 0303
Coastal woodlands of nature conservation significance	*Agriculture and Woodlands Environment Branch, SNH, RASD, Edinburgh, tel: 0131 554 9797

*Starred contact addresses are given in full in the Appendix.

8.3 Infrastructure

S.L. Fowler & M. Dunbar

8.3.1 Introduction

This section summarises the infrastructure of the region, including population distribution, industry, ports, harbours and power generation. Oil and gas exploration and development are covered in section 9.5.

Major residential development is confined to the south of the region. Industry in the region is centred around the Clyde, which dates as an industrial centre from the growth in trade across the Atlantic in the 19th century. The inner Clyde is one of the most heavily industrialised stretches of coast in Britain; the City of Glasgow and other industrial towns such as Greenock, Port Glasgow, Dumbarton and Helensburgh expanded rapidly in the 19th century as a result of their easy access both to the sea and to the iron ore and coal deposits inland. Changes in local industries have subsequently affected population distribution, and some of the small coastal settlements in the north of the region have declined. More recently, traditional inner Clyde industries, including shipbuilding and heavy engineering, have been replaced by new industries, such as electronics, for example at Prestwick and Irvine. Tourism, knitwear and whisky production are important sources of income outside the urban centres.

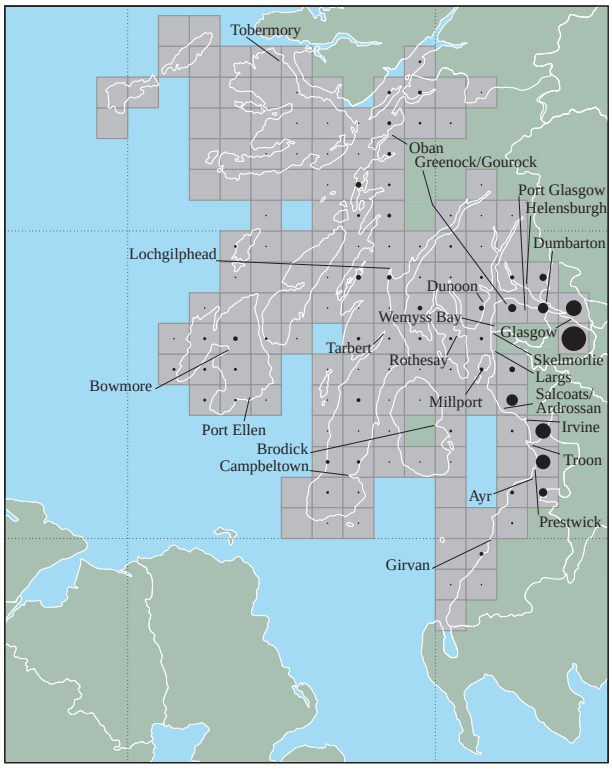
In Scotland most electricity is produced by three companies - Scottish Power, Scottish Hydro-Electric and Scottish Nuclear. Diversification into renewable sources of energy has been stimulated by the diminishing reserves of fossil fuel (and the government's Non Fossil Fuel Obligation) and stricter legislation on the environmental impact of power stations, for example emission reductions required under the 1988 EC Directive on large combustion plant. The current total output capacity of the region's coastal power stations (approximately 1,184 MW) represents 11.3% of Scotland's total power production capacity of 10,456 MW (Scottish Power, Scottish Hydro-Electric and Scottish Nuclear, pers. comm.).

8.3.2 Important locations

Residential development

The main centres of population are listed in Table 8.3.1 and shown on Map 8.3.1. The area around Glasgow and the Clyde Estuary is one of the most densely populated in Britain, while the whole of Argyll & Bute has a population of only 90,550. There is a continuing demand for new housing in the Glasgow area and some derelict waterfront land on the inner Clyde is being developed as housing. At Irvine the harbour area has recently been redeveloped, with the derelict waterside converted into housing, a museum, a promenade and a beach park.

The 1991 census results show that the populations of Lorn (centred on Oban), Mull and some of the other islands including Coll and Lismore all increased between 1981 and 1991, that of Mull by almost 15%. However, the southern parts of Argyll & Bute, including Kintyre, Islay and Jura, all



Map 8.3.1 Distribution of areas of industrial and residential development, and major towns and cities. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE (1993).

Table 8.3.1 Major population centres

Location	*Population*
South Ayrshire	**113,960**
Ayr	50,000
Prestwick	14,300
Troon	14,000
North Ayrshire	**139,020**
Irvine	32,000
Stevenston/Saltcoats/Ardrossan	33,090
Largs	9,800
Inverclyde	**89,390**
Greenock	57,000
Port Glasgow	21,554
Renfrewshire	**176,970**
City of Glasgow	**623,850**
West Dunbartonshire	**97,790**
Dumbarton	22,600
Argyll & Bute	**90,550**
Helensburgh	16,400
Dunoon	9,300
Rothesay	5,400
Campbeltown	6,100
Oban	8,100

Sources: Cook (1993); local goverment area figures (coastal and inland) from Scottish Local Government Information Unit (1996).

have declining populations. Nearly all (95%) of the population of Argyll & Bute is coastal. Coastal activities provide the livelihoods for a significant number of residents and many more make use of coastal land and waters for leisure activities. Several of the islands, particularly Arran and Bute, receive many holiday visitors in the summer months.

Industry

Table 8.3.2 provides details of the main industries present along the region's coastline: locations are shown on Map 8.3.2. The distribution of industrial infrastructure is strongly skewed to the south-west of the region, with the Ayrshire coast and the Clyde being by far the most developed parts of the region. Many traditional industries such as ship-building have declined during this century, as has - recently - the construction of oil rigs. The two oil rig construction yards at Ardyne Point and Portavadie in Cowal have been mothballed but could be reactivated if commercial quantities of oil and gas are discovered off Scotland's west coast. One approach to dealing with the problem of the declining industries of Clydeside has been the designation of the Inverclyde Enterprise Zone in Port Glasgow in 1989. This designation lasts for ten years and aims to restore private-sector activity by providing automatic planning permission for a range of industrial uses, removing tax burdens, relaxing various administrative controls, waiving rates, and providing special capital allowances for the construction of buildings. In the north and west of the region the main industries are boat-building and whisky distilling.

Map 8.3.2 also shows the locations of existing power stations in the region (listed in Table 8.3.2) and proposed renewable energy power generation schemes (Table 8.3.3). Hunterston A nuclear power station was closed down in 1990. Hunterston B Advanced Gas-cooled Reactor power station, commissioned in 1976, and Torness nuclear power station on the Firth of Forth (Region 4) now provide approximately half of Scotland's electricity (Scottish Nuclear pers. comm).

An assessment of the potential for renewable energy in Scotland has been produced by a group of bodies including Scottish Hydro-Electric, Scottish Power, the Scottish Office, Scottish Enterprise and the DTI. The DTI carried out a *Review of wave energy* in 1992 (DTI 1992) and established that there was potential to generate electricity from wave power along the north and west coast of the British Isles (from the South West Approaches to Shetland) corresponding to 11-15% of current UK electricity capacity. Following the release in December 1994 of the Scottish Renewables Order, several new power generating schemes are planned for the region,

Table 8.3.2 Major areas of coastal industrial development

Site no. on Map 8.3.2	*Location*	*Grid ref.*	*Details*
1	Girvan	NX1998	Shipyard and ship repair specialising in fishing boats. Also whisky, fabrics.
2	Ayr	NS3322	Electronics, heavy engineering, knitwear/fabrics
3	Prestwick	NS3524	BAE aircraft factory and airport
4	Troon	NS3232	Shipbuilding, hosiery, seawater distillation research centre
5	Irvine	NS3039	Chemical plants, paper mill, electronics, hosiery, light engineering, bottle works
6	Stevenston	NS2741	ICI chemical works
7	Hunterston	NS1953	Large ore terminal, oil rig construction, sheet metal stripping yard, boat repair yard, nuclear power station (1,170 MW). Total area of industrial land: 250 ha.
8	Arran	NS0135	Small hydro-electric power station
9	Greenock	NS2974	Shipyards and docks (100 ha)
10	Port Glasgow	NS2974	110 ha of land designated an Enterprise Zone in 1989
11	Inner Clyde Estuary west of Glasgow	NS3675	Metalworking, ship building, printing at Glasgow, Mountblow and Finnart, woollens, chemicals, electronics
11	Glasgow (Erskine Bridge to Dalmarnock)	NS5865	More than 700 ha of industry over 36 km of tidal river. Shipbuilding and docks still a major industry, but substantial areas of dockland no longer used. 60% of the central Glasgow waterfront area is included in development schemes.
12	Bowling	NS4373	Oil terminal (50 ha)
13	Dumbarton	NS3975	Shipbuilding, iron and brassware. Industrial units close to coast. Major centre for distilling. 200 ha of infrastructure.
14	Helensburgh & the Gare Loch	NS3083	Naval installations
15	Ardyne Point	NS0968	Oil rig construction yard (mothballed)
16	Portavadie	NR9369	Oil rig construction yard (mothballed)
17	Lochgair	NR9391	Hydro-electric power station (6 MW)
18	Lochgilphead	NS8687	Local boat building and repair
19	Campbeltown	NR7320	Distilling, local boat builders, small hydro-electric power station
20	Crinan	NR7993	Boat building and repair (<5 ha)
21	Kilmelford	NM8413	Hydro-electric power station (2 MW)
22	Oban	NM8630	Boat building and repair, woollens
23	Jura	NR5367	Distillery
24	Islay	NR4369	Distillery
25	Islay	NR3845	Distillery, small oil-fired power station
26	Tobermory	NM5055	Small hydro-electric power station
27	Tiree	NM04	Small oil-fired power station, airfield

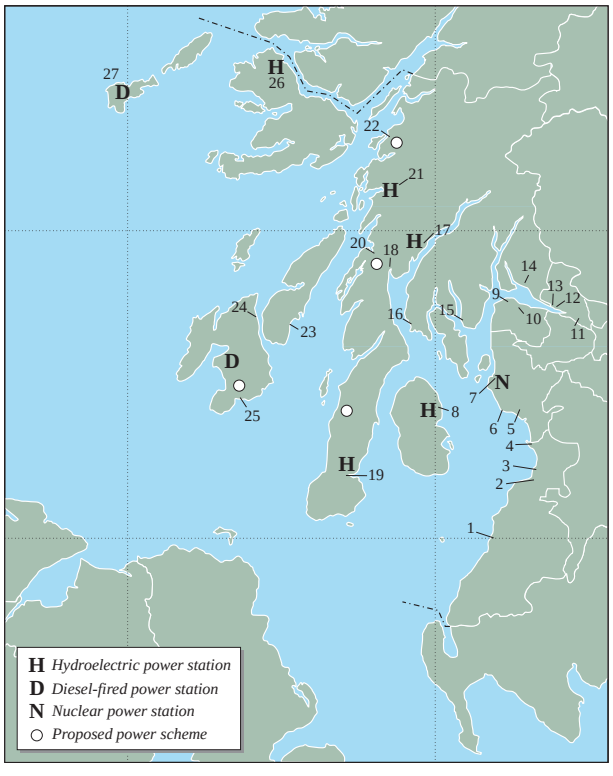
Sources: OS Landranger maps, local councils, Scottish Hydro-Electric (pers. comm.)

including wind, hydro, biomass and waste-to-energy generating methods; those so far awarded contracts are listed in Table 8.3.3. The potential for wind farming on the coast in this region is greater than on the east coast, owing to the more favourable prevailing wind direction, but no wind farms are as yet operating in the region (British Wind Energy Association pers. comm).

Ports and harbours

The region contains some of the most significant ports in the UK. These include the Clydeports Group (Hunterston, Greenock and Port Glasgow) and the Faslane Naval Base. The sheltered waters of the Firth of Clyde are the most heavily used shipping lanes in the north-west of the UK. There is a significant naval presence on the Clyde and the area is often used for submarine exercises. In terms of shipping activity, much of the coastline is subject to considerable supertanker traffic moving oil down from the North Sea oil terminals at Sullom Voe and on Orkney. In the north-west, this region has numerous small ports, most of them traditional fishing ports, some of which double as ferry terminals for the many passenger and supply ferries between the mainland and the islands. Ports and harbours are listed in Table 8.3.4 and shown on Map 8.3.3.

Lord Donaldson (1994) recorded that there was virtually no clear information available on where ships go within UK waters. The Department of Transport, UK Offshore Operators Association and the Health and Safety Executive have addressed this issue by jointly funding a project to produce a ship traffic database (COAST), which provides details of 3,500 shipping routes across the UK continental shelf, giving the numbers of vessels and their distribution by ship type, age and flag. Information from this database, showing shipping lanes and traffic separation schemes in the region, is given on Map 8.3.4. Lord Donaldson also notes that no records are kept of how many ships use UK port facilities. Under MARPOL (the United Nations' International Convention on the Prevention of Pollution from Ships), the UK must provide port facilities that are "adequate to meet the needs of ships using them and do not cause undue delay to ships". These facilities should prevent ships from discharging oil and other wastes into the sea. However, Lord Donaldson (1994) describes UK facilities as "inadequate". A survey of the quality of UK port reception facilities for the disposal of ship's wastes was carried out by WRC (1995). The Marine Safety Agency also carry out a regular assessment of port reception facilities for the International Maritime Organisation.



Map 8.3.2 Industrial infrastructure, coastal power stations and proposed power schemes. Numbers refer to Table 8.3.2.

Map 8.3.3 Ports and harbours. Sources: Walker (1996) and others.

Table 8.3.3 Proposed* renewable energy power generation schemes in the region

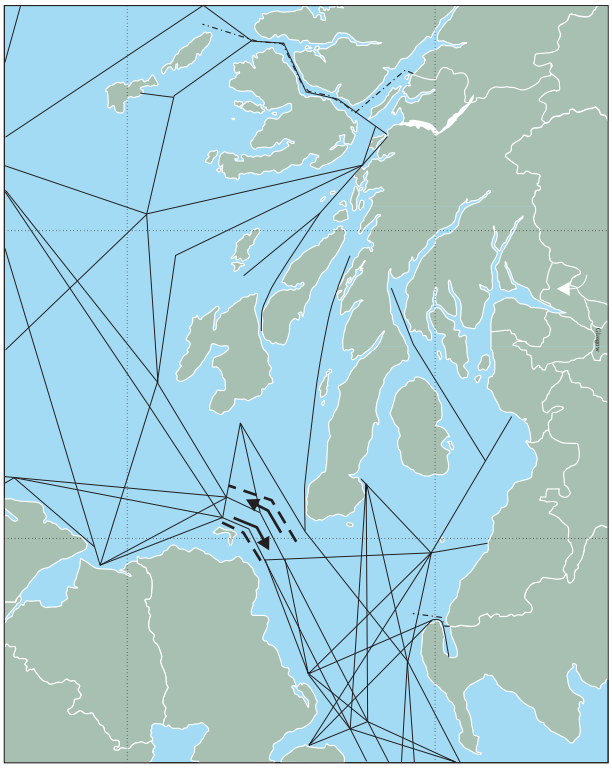
Site name	*Location*	*Proposer*	*Technology*	*Power output (MW)*
Largie	Kintyre	TriGen Ltd	Wind	6.39
Laggan Windcluster	Islay	Windcluster Ltd	Wind	1.28
Duror	Lochgilphead	Edinburgh Hydro Systems Ltd	Hydro	0.69
Ardtornish	Oban	Ardtornish Estate Company Ltd	Hydro	0.66

Source: Scottish Office pers. comm. Key: *awarded contracts under the Scottish Renewables Obligation First Renewables Order (SRO-1).

Table 8.3.4 Ports and harbours

Port	*Notes*
Ballantrae	Small fishing port
Port of Girvan	Municipal port (South Ayrshire Council). 153 m of berths. Open storage of 1,000 sq m. Dry bulks, fish, moorings for leisure craft, ship repair/graving docks.
Maidens	Small fishing fleet
Dunure	Small fishing fleet
Port of Ayr	Authority/operator: Associated British Ports. Exports of coal to Northern Ireland (served by rail terminal), scrap metal, fertiliser imports and general cargo, bulk whisky to USA. Also an important fishing port.
Prestwick Freeport	No information available
Port of Troon	Associated British Ports. General cargo. Yacht marina (345 + 40 visitor berths). Two dry docks.
Port of Irvine	Owned and operated by Irvine Harbour Co. Pleasure craft use, base for Scottish Maritime Museum. 7 berths, 100 m length.
Saltcoats	Harbour redevelopment
Ardrossan	Port authority/operator: Clydeport Operations Ltd. Enclosed docks. Ro-ro (roll-on, roll-off), vehicles/wheeled cargoes, passengers, dry bulks, refrigerated cargoes, hazardous cargoes, fish, scrap metal export. Ferry port to Isle of Arran and Douglas, Isle of Man.
Hunterston	Authority: Clydeport plc; operator: Clydeport Operations Ltd. 2 berths, 733 m total length. 56 ha open storage. Dry bulks, aggregate/ore/coal/coke. Major iron-ore terminal, possible redevelopment to handle general bulk cargoes.
Millport	Small harbour
Inverkip	Marina (700 + 40 visitor berths)
Largs	Ferry and fishing port owned and operated by Caledonian MacBrayne. One 60 m berth used by the ferries, fishing boats and other small craft (Largs Yacht Haven).
Gourock	Ferry port owned and operated by Caledonian MacBrayne. One 100 m berth.
Greenock	Authority: Clydeport plc, operator: Clydeport Operations Ltd. One 364 m berth. 16 ha of open storage. 1.6 ha covered storage. Lo-lo (crane-load on and off), vehicles/wheeled cargoes, passengers, dry bulks, forest products, general cargo, project cargo (heavy lift).
Clydeport (Port Glasgow)	Authority: Clydeport plc. Operator: Clydeport Operations Ltd. 11 berths: 1,462 m length. 997,528 tonnes p.a. 56,350 sq m covered storage. Dry bulks, grain/feedstuffs, general cargo, project cargo (heavy lift).
Bowling, Old Kirkpatrick	Clydeport terminals.
Faslane	Naval base and Clydeport terminal. Restricted area for military exercises.
The Gare Loch	Piers and jetties at SW corner. Rhu Marina (150 berths) on north bank. Pier (north bank).
Coulport	Jetty (restricted area)
Finnart	BP oil terminal
Dunoon Pier	Municipal port (Argyll & Bute Council). 150 m of berths. Vehicles/wheeled cargoes, passengers. Small stone jetty capable of handling bulk cargoes of up to 600 tonnes by barge (dries out at low water).
Rothesay, Isle of Bute	4 berths, 280 m total length. Passengers, ro-ro, vehicles/wheeled cargoes, fish. Moorings for leisure craft; lay-up berths & yacht marina.
Brodick, Isle of Arran	Major harbour for Arran, owned and operated by Caledonian MacBrayne. One 80 m berth. 28 sq m open storage. Vehicles/wheeled cargoes, passengers, dry bulks, oil/petroleum. Moorings for leisure craft.
Tighnabruaich Pier, Kyles of Bute	Owned and operated by Argyll & Bute Council. 25 m berth.
Ardrishaig	Authority/operator: British Waterways. One 80 m berth. 30,000 tonnes p. a. 780 sq m open storage. Dry bulks, hazardous cargoes, forest products. Yacht marina and leisure craft moorings. Fishing harbour.
East Loch Tarbert	Fishing harbour. Berthing for 100 visiting yachts.
Carradale	Small municipal fishing harbour (Argyll & Bute Council). 50 m length of berths.
Campbeltown	Municipal harbour (Argyll & Bute Council). 400 m length of berths. Hazardous cargoes, fishing port. Moorings for leisure craft, shiprepair/graving docks, yacht marina.
Gigha Island	Municipal port (Argyll & Bute Council) with passenger ferry to Tainloan (mainland) taking 12 cars. One berth: 30 m long. Moorings for leisure craft.
Kennacraig, West Loch Tarbert	Owned and operated by Caledonian MacBrayne. 2 berths (180 m). 200,000 tonnes p.a. ro-ro. Vehicles/wheeled cargoes, passengers (summer ferry to Islay and Jura).
Craighouse, Jura	Small harbour with small jetty
Port Askaig, Islay	Harbour
Port Ellen, Islay	Operated and owned by Caledonian MacBrayne. 2 berths (160 m length). Vehicles/wheeled cargoes, passengers, grain/feedstuffs. Moorings for leisure craft.
Scalsaig, Colonsay	Small harbour
Crinan	Harbour, fishing fleet
Ardfern	Small harbour
Craobh Haven (Loch Shuna)	Yacht harbour with marina (200 + 50 visitors)
Loch Melfort	Pier; Kilmelford Yacht Haven
Oban	Ferry port for Castlebay, Colonsay, Lochboisdale and Islay
Craignure, Mull	Municipal harbour (Argyll & Bute Council)
Tobermory, Mull	Small harbour

Source: Walker (1996), D'Oliveira & Featherstone (1993) and Ordnance Survey Landranger 1:50,000 maps. Note: refer to section 9.7.2 for further details of recreational harbours and associated facilities



Map 8.3.4 Shipping routes and Traffic Separation Scheme. Source: COAST database, held by Dovre Safetec Ltd.

8.3.3 Information sources used

Sources of residential and industrial information for this section included Cook (1993), Buck (1993), River Clyde Project Group (1989) and Ordnance Survey Landranger 1:50,000 maps. The Office of Population Censuses and Surveys has published 1991 census data on a district basis and population estimates for subsequent years based on those data (e.g. Registrar General Scotland 1995). Cook (1993) presents town and city data from population censuses from a number of dates, including the 1981 census, and is therefore somewhat out of date.

Map 8.3.1 is adapted from the ITE (1993) Countryside Survey database, which is derived from 1990 satellite imagery. Areas represent land cover types 'urban' and 'suburban/rural development' (see also section 8.2.3).

Most of the information on power generation was provided by the major Scottish power producing companies, who should be contacted for further information. The figure for Scotland's total power output capacity includes the outputs of Scottish Power, Scottish Hydro-Electric and Scottish Nuclear. When other smaller producers are taken into account, the total may be higher. However, the difference is likely to be minimal and will only increase in future by around 0.7% (76 MW) once the SRO-1 proposed schemes come on-stream.

Information for ports and harbours was derived primarily from Walker (1996) but also from British Ports Association (1994) and D'Oliveira & Featherstone (1993). Brady (1995) lists details of all fishing vessels and their base ports (see also section 9.1).

8.3.4 Acknowledgements

Thanks are due to Anthony Payne (Argyll & Bute Council) for his helpful comments and additional information.

Shipping routes on Map 8.3.3 are reproduced from the COAST Database, developed and held by Dovre Safetec Ltd.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Industry	
Planning developments	*Local planning authorities
The European Social Fund and Regional Aid programmes - Highlands and Islands	Programme Director, Highlands & Islands Partnership Programme, Bridge House, 20 Bridge Street, Inverness IV1 1QY, tel: 01463 244292
The European Social Fund and Regional Aid programmes - Strathclyde	Programme Director, Strathclyde European Partnership, 20 India Street, Glasgow G2 4BF, tel: 0141 248 9900
Economic and urban development policy including European Funds (Scotland)	*The Scottish Office Development Department, Edinburgh, tel: 0131 556 8400
Industrial and economic development	Highland and Islands Enterprise, Bridge House, 20 Bridge Street, Inverness IV1 1QR, tel: 01463 234171
Economic development: Highlands and Islands Objective 1 area	Highlands and Islands Partnership Programme, Bridge House, 20 Bridge Street, Inverness IV1 1QY, tel: 01463 244292
Enterprise Zones	Department of Environment, 2 Marsham Street, London SW1P 3EB, tel: 0171 276 6166
Energy production	
Energy production - general	Education and Industry Department, Energy Division, Scottish Office, Victoria Quay, Edinburgh EH6 6QQ, tel: 0131 244 7140
Energy production - general	Secretary, Institute of Energy, 18 Devonshire Street, London W1N 2AU, tel: 0171 580 7124
General information on renewable energy. Non Fossil Fuel Obligation Renewables Orders.	Energy Technology Support Unit (ETSU), Renewable Energy Enquiries Bureau, ETSU, Harwell, Oxfordshire OX11 0RA, tel: 0235 432450
General information on wind farms	British Wind Energy Association - Scottish Branch, National Wind Turbine Centre, National Engineering Laboratory, East Kilbride, Glasgow G75 0QU, tel: 013552 72068

Type of information	*Contact address and telephone no.*
Energy production (continued)	
Wave and hydro power	Project Director, Energy Systems Group, Coventry Polytechnic, Dept of Electrical, Electronic and Systems Engineering, Priory Street, Coventry CV1 5FB, tel: 01203 838861
Nuclear issues- general	Secretary-General, British Nuclear Forum, 22 Buckingham Gate, London SW1E 6LB, tel: 0171 828 0166
Radioactive discharges	Information Officer, National Radiological Protection Board (NRPB), Chilton, Didcot, Oxfordshire OX11 0RQ, tel: 01235 831600
Radioactive waste disposal (statistical bulletin on radioactive waste disposal)	Scottish Office Agriculture, Environment and Fisheries Department, New St. Andrews House, Edinburgh EH1 3TG, tel: 0131 244 4042
Nuclear power generation	Scottish Nuclear Limited, 3 Redwood Crescent, Peel Park, East Kilbride G74 5PR, tel: 01352 62000
Hydro-electric power generation	Scottish Hydro-Electric plc., 10 Dunkeld Road, Perth PH1 5WA, tel: 01738 455040
Conventional power generation	Scottish Power plc., Cathcart House, Spean Street, Glasgow G44 4BE, tel: 041 637 7177
Ports and shipping	
British Ports Association	Africa House, 64-78 Kingsway, London WC2B 6AH, tel: 0171 242 1200
The UK Major Ports Group Ltd	150 Holborn, London EC1N 2LR, tel: 0171 404 2008
Port reception facilities	Marine Safety Agency, Spring Place, 105 Commercial Road, Southampton SO15 1EG, tel: 01703 329100
Ports of Ayr and Troon	*Port Office, Ayr, tel: 01292 281687
Ardrossan Harbour	*Ardrossan Harbour Company Limited, Ardrossan, tel: 01294 63972/4
Ports of Glasgow, Greenock, Hunterston, Ardrossan	*Clyde Port Authority, 16 Robertson Street, Glasgow G2 8DS, tel: 0141 221 8733

*Starred contact addresses are given in full in the Appendix.

8.4 Coastal defence

S.L. Fowler & M.J. Dunbar

8.4.1 Introduction

Coastal defence covers two types of works: coast protection and sea (or flood) defence. Coast protection works prevent or slow the erosion of land and encroachment by the sea. Sea (or flood) defences protect against the flooding of low-lying land, especially to protect human life and property in coastal settlements and industrial areas. Many sea defences were built in the past to protect agricultural land from flooding and to enable agricultural improvement and drainage. It is sometimes difficult to differentiate between the two categories of coastal works, particularly where they protect against both erosion and flooding, or where they are owned and maintained by bodies not usually responsible for coastal defeneces, such as the Ministry of Defence. For this reason this section describes coastal defence works in general, irrespective of the purpose for which they were constructed. The works range from simple wooden groynes installed on beaches to control sediment movement, to major concrete engineering works (berms and sea walls). Some of these forms of coastal defence can provide vital 'toe' support to the base of coastal cliffs.

Coastal defence works in Britain are most widely distributed along urban and industrial coastlines, and along subsiding or eroding coasts. They are therefore particularly common along the heavily-developed coasts of south-east and north-west England. The risk of coastal erosion or flooding in the region is very localised, owing to the absence of extensive areas of low-lying land and because of the upward isostatic movement of land in the region (see section 2.5). There are occasional episodes of flooding in coastal towns in Scotland as a result of storm surges, but they are generally small in scale, and consequently the construction of flood defences tends to be a less important issue than it is in the south of Britain.

8.4.2 Important locations

Map 8.4.1 shows the location of coastal defence works mentioned in the text.

Much of the coast of this region is exposed, rocky and undeveloped, with coastal erosion and flooding not a significant problem in most areas. However, sea walls front most of the developed areas in the south of the region. Gabions have been installed to prevent erosion of the golf links at Troon, and various *ad hoc* coastal defence works have been built at Western Gailes golf course to the north of Barassie. A damaged sea wall protects the industrial plant to the north of Irvine. Sea walls front most of the main towns in the Firth of Clyde, and between Gourock and Port Glasgow the coastline is entirely artificial, fronting extensive land-claim. Most of the larger fishing villages in the north of the region have sea walls and harbour protection works (HR Wallingford 1995).

Buck (1993) reports linear coastal defences at Garnock, Hunterston Sands, Inner Clyde, Loch Gilp, Loch Gruinart and Loch Crinan, and groynes on the Inner Clyde, which has been extensively canalised.

Map 8.4.1 Locations of coastal defence works mentioned in the text.

8.4.3 Management

Under the Coast Protection Act (1949) local authorities in Scotland have powers as coast protection authorities to protect land from erosion and encroachment and to prevent flooding of non-agricultural land. Legislation relating to the construction of flood or sea defence works is included in the Water Resources Act (1991) and the Land Drainage Act (1994). Departmental responsibility for flood defence and coast protection lies with the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD). The Scottish Environmental Protection Agency (SEPA) advises authorities on flood risk.

There are no formal regional coastal (engineering) groups in Scotland. Hydraulics Research have recently conducted a study on coastal process cells in Scotland, co-sponsored by Scottish Natural Heritage, SOAEFD and Historic Scotland. Phase one, a broad delineation and description of cells, is now complete (HR Wallingford 1995) and is to be followed by a further two years' work to provide a comprehensive description of the cells. This study will set out a framework for the management of coastal areas in Scotland and could be used to set up coastal engineering groups of the type established in England and Wales.

8.4.4 Information sources used

HR Wallingford (1995) is the only collated source for coastal defence information in this region. ASH Consulting Group

(1994) provides an incomplete list of sites where coastal defence techniques are known to have been used, or where a perceived coastal erosion problem exists, derived from information provided by Scottish Natural Heritage Regional Offices and some local authorities. The list includes ten sites in the region, with case studies provided for three of these: Troon, Irvine and Lunderston Bay. Coastal defence works in Scotland are also dealt with in the *Review of Scottish coastal issues* (Burbridge & Burbridge 1994).

8.4.5 Acknowledgements

Thanks are due to George Lees (SNH) for additional information and helpful comments. The assistance of the Regional Councils and Harbour Authorities is gratefully acknowledged.

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Scottish Office Agriculture, Environment & Fisheries Department. 1996. *Scotland's coast: a discussion paper.* Edinburgh, HMSO.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Flood defence and coast protection policy, grants towards capital expenditure	*SOAEFD, Edinburgh, tel: 0131 244 4042
Coast protection	*Unitary Authorities' Highways Departments
Storm Tide Warning Service	Meteorological Office, Johnstone House, London Road, Bracknell, Berkshire RG12 2SZ, tel: 01344 420242
Coastal defence, sediment cells, erosion and deposition	*SNH, Earth Science Branch, RASD, Edinburgh, tel: 0131 554 9797
Coastal Engineering Research Advisory Committee	International Council for the Exploration of the Sea, Palægade 2-4, DK-1261, Copenhagen K, Denmark
Coastal Engineering Advisory Panel	Anne-Marie Ferguson, Institute of Civil Engineers, Great George Street, London SW1P 3AA, tel: 0171 222 7722

*Starred contact addresses are given in full in the Appendix.

Fishing boats at Fionnphort, Ross of Mull, overlooking the Sound of Iona. Shellfish, such as *Nephrops* ('scampi'), lobsters, edible and velvet crabs and scallops, are now the most important resource for the region's inshore fleet, most of which is dependent on *Nephrops:* landings here represent more than a fifth of the British total. Photo: Lorne Gill, Scottish Natural Heritage.

Chapter 9 Human activities

9.1 Fisheries

D. Murison & C.F. Robson

9.1.1 Introduction

This section gives an overview of the main fishing activities in the coastal waters and rivers of the region. There are fisheries for pelagic and demersal fish and several marine shellfish species (demersal fish live on or near the sea bed; pelagic fish tend to be found in midwater) and diadromous fish (which spend part of their lives in fresh water and part at sea) - in this section salmon and sea trout. The section also covers sea angling and bait collection. For more information about the species concerned, including their scientific names, see sections 5.5, 5.7 and 5.8.

The locations of the main fishing ports in the region where landings are recorded by SOAEFD, and the Scottish Sea Fisheries Districts in the region, are shown on Map 9.1.1. In addition to the main fishing ports there are many island and coastal fishing communities, often situated in the sheltered areas around lochs. The larger islands (e.g. Islay and Mull) support fishing fleets, and shellfish buyers and processors are now establishing themselves in many of the islands, as markets and transport links improve.

In 1992, 2.8% of all recorded landings of fish and shellfish species in Britain and the Isle of Man were made in this region, which is below the average of all regions of 5.9%. The total tonnages of pelagic and demersal species landed in the region represent 0.5% and 2.2% respectively of the British and Isle of Man totals. Total landings of shellfish species in the region, at 10,927 tonnes, account for 9.8% of the British and Isle of Man and 22.3% of the Scottish totals. The tonnage of periwinkles landed in the region represents 46.7% of the British and Isle of Man total and there are also significant landings of *Nephrops* (20.7%), crabs (18.5%) and scallops (15.0%). A summary of the totals for pelagic, demersal and shellfish species is given in Table 9.1.1.

Table 9.1.2 summarises landings to the ports of Ayr, Campbeltown, Oban and Loch Scridain in the four years from 1991 to 1994, showing trends in landings in relation to 1992, the year on which the more detailed landings data analysis in Table 9.1.1 was based.

Map 9.1.1 Fishing ports and Scottish Sea Fisheries Districts. Source: SOAFD (1995a).

In the Scottish Salmon Fishery Statistical Districts in the region (Map 9.1.2), salmon (including grilse, which are salmon that have spent not more than one winter at sea before maturing) and sea trout support rod-and-line fisheries from rivers and netting stations along the coast.

Table 9.1.3 shows that the average total recorded catch of salmon and grilse made by all methods between 1989 and

Table 9.1.1 Species group landings in 1992 (tonnes)

Species group	*Region 14*	*West Coast**	*Scotland*	*Britain and Isle of Man*	*% of West Coast* total landed in region*	*% of combined British and Isle of Man total landed in region*
Pelagic	1,330	68,026	227,669	252,335	2.0	0.5
Demersal	6,084	47,404	193,914	275,460	12.8	2.2
Shellfish	10,297	42,984	46,112	104,917	24.0	9.8
All groups	***17,711***	***158,414***	***467,695***	***632,712***	***11.2***	***2.8***

Source: Ministry of Agriculture, Fisheries and Food (1994); Scottish Office Agriculture and Fisheries Department (1993); Isle of Man Department of Agriculture, Fisheries & Forestry (pers. comm.). Key: *west coast of Britain; see section 9.1.4 for further explanation. Notes: amounts landed are rounded up to the next whole tonne. Figures are given in 'nominal live weight' i.e. weight of the whole fish. Calculating the figures in this table was a complex process: refer to section 9.1.4.

Table 9.1.2 Landings[a] of all fish species to selected Region 14 ports 1991-1994 (thousands of tonnes)

	1991	*1992*	*1993*	*1994*
Ayr	3.5	2.5	3.9	2.6
Campbeltown	1.3	1.7	1.8	1.3
Oban	2.4	2.6	3.6	3.7
Loch Scridain (Mull)	0.8	1.0	0.7	0.9
Region 14 selected ports	***8.0***	***7.8***	***10.0***	***8.5***
Scotland	458.4	467.7	491.8	487.8
% of Scottish total landed in above ports	1.7	1.7	2.0	1.7

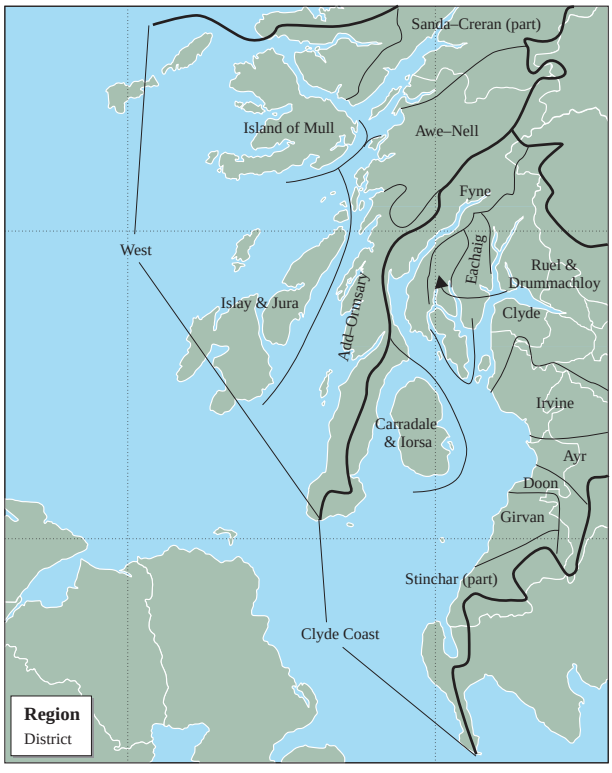
Sources: Ministry of Agriculture, Fisheries and Food (1995b). Key: [a]landings totals relate to 'nominal live weight', i.e. weight of the whole fish. Note: calculating the figures in this table was a complex process: refer to section 9.1.4.

1993 in the region represents 4.2% of the British total and 18.3% of the total for the 'West Coast'. The average total recorded catch of sea trout made by all methods between 1989 and 1993 in the region represents 2.8% of the British total and 10.7% of the total for the 'West Coast'.

Table 9.1.3 Average catch (numbers of fish) of salmon and grilse and sea trout 1989-1993

Totals	*Salmon and grilse*	*Sea trout*
Region 14	10,727	3,964
West Coast*	58,582	37,024
Scotland	187,481	65,468
GB	***254,829***	***141,813***
% of West Coast* total in region	18.3	10.7
% of GB total in region	4.2	2.8

Source: Scottish Office Department of Agriculture and Fisheries (1990); National Rivers Authority (1991, 1992, 1993, 1994a, b) and Scottish Office (1991, 1992, 1993, 1994). Key: *west coast of Britain, here including the Isle of Man; see section 9.1.4 for further explanation. Note: calculating the figures in this table was a complex process: refer to section 9.1.4.



Map 9.1.2 Scottish salmon fishery statistical districts. Source: Scottish Office (1994).

9.1.2 The fisheries

Pelagic species

Table 9.1.4 gives the quantities of various pelagic species landed in 1992 in the region, compared with landings nationally. Handlines are used to catch mackerel and drift net for herring. Following the almost complete demise of the Clyde herring fishery in the 1980s, local fishermen shifted most of their efforts to catching more demersal and shellfish species. The decrease in abundance of herring in the Clyde can be attributed to reduced recruitment to the local spring-spawning stock. The cause of this may be natural, but the effects of exploitation cannot be ruled out

Table 9.1.4 Pelagic species landings in 1992 (tonnes)

Species group	*Region 14*	*West Coast**	*Scotland*	*Britain and Isle of Man*	*% of West Coast* total landed in region*	*% of combined British and Isle of Man total landed in region*
Argentines	1	43	180	180	2.3	0.6
Herring	830	10,944	83,879	85,650	7.6	1.0
Horse mackerel	4	125	473	1,499	3.2	0.3
Mackerel	57	55,360	141,583	150,726	0.1	<0.1
Pilchard	0	P	0	4,244	-	-
Sprat	438	1,554	1,554	10,032	28.2	4.4
Whitebait	0	0	0	1	0	0
Others	0	0	0	3	0	0
Total	***1,330***	***68,026***	***227,669***	***252,335***	***2.0***	***0.5***

Source: Ministry of Agriculture, Fisheries and Food (1994); Scottish Office Agriculture and Fisheries Department (1993); Isle of Man Department of Agriculture, Fisheries & Forestry (pers. comm.). Key: *west coast of Britain, here including the Isle of Man; see section 9.1.4 for further explanation. P = species landed in the region in small quantities (here <0.5 tonnes); - = % not calculated. Notes: amounts landed are rounded up to the next whole tonne. Figures are given in 'nominal live weight' i.e. weight of the whole fish. Calculating the figures in this table was a complex process: refer to section 9.1.4.

(Bailey *et al.* 1986). Herring and sprat are exploited in the Firth of Clyde by a small number of local trawlers and refridgerated sea-water-tank trawlers from Northern Ireland working pair trawls, from summer through to the end of the year. The sprat fishery is targeted on overwintering concentrations of adults, but the fishery in the region is not significant.

Demersal species

Table 9.1.5 gives the quantities of various demersal species landed in 1992 in the region, compared with landings nationally. Otter trawls, seine nets, pair trawls, fixed nets and long lines are used to catch cod, haddock, whiting, saithe, plaice, rays, conger eel and dogfish. Landings of cod, haddock and whiting are greatest from the Firth of Clyde in winter. The deep waters of the Firth of Clyde provide excellent fishing grounds for hake, which is targeted in the summer months. The tonnage of hake landed in the region represents 28.5% of the British total and large amounts of whiting and cod are also landed in the region. A small number of boats set lines for dogfish, the landings of which represent 4.1% of the British total.

Shellfish species

Table 9.1.6 gives the quantities of various shellfish species landed in 1992 in the region, compared with landings nationally.

Shellfish, such as *Nephrops*, lobsters, edible and velvet crabs and scallops, are now the most important resource to the inshore fleet of the region. The majority of the inshore trawling fleet are dependent on *Nephrops*, which are landed all year in the region, representing 20.7% of the British total. Pink and whip prawns are also taken in *Nephrops* trawls. *Nephrops* are also caught in creels placed in the deeper water lochs and, to a much lesser extent, in the Firth of Clyde. Squat lobsters are also taken in *Nephrops* creels. *Nephrops* are generally exploited by the Clyde fleet to the west of the Kintyre peninsula during the summer and in the more

Table 9.1.5 Demersal species landings in 1992 (tonnes)

Species group	*Region 14*	*West Coast**	*Scotland*	*Britain and Isle of Man*	*% of West Coast* total landed in region*	*% of combined British and Isle of Man total landed in region*
Elasmobranchs						
Dogfish	549	5,899	9,657	13,348	9.3	4.1
Skates and rays	370	4,011	3,670	7,827	9.2	4.7
Gadoids						
Cod	1,292	6,084	35,898	59,524	21.2	2.2
Haddock	591	4,365	49,867	53,586	13.5	1.1
Hake	1,032	3,031	1,993	3,620	34.0	28.5
Ling	118	1,433	4,318	6,027	8.2	2.0
Pollack (lythe)	12	1,102	1,285	3,023	1.1	0.4
Saithe	317	1,570	10,310	12,602	20.2	2.5
Whiting	860	4,322	35,923	41,055	19.9	2.1
Whiting, blue	0	0	6,531	6,531	0	0
Flatfish						
Brill	14	126	50	443	11.1	3.2
Dab	57	198	759	1,215	28.8	4.7
Dover sole	12	855	57	2,876	1.4	0.4
Flounders	4	106	4	273	3.8	1.5
Halibut	12	28	114	194	42.9	6.2
Halibut, Greenland	18	18	20	137	100	13.1
Lemon sole	21	569	2,566	5,573	3.7	0.4
Megrim	88	2,658	2,566	4,037	3.3	2.2
Plaice	156	3,138	7,902	23,887	5.0	0.7
Turbot	7	181	196	742	3.9	0.9
Other species						
Catfish	8	39	1,378	1,935	20.5	0.4
Conger eel	26	411	107	510	6.3	5.1
Gurnard	4	259	32	627	1.5	0.6
Monkfish/angler	211	4,865	11,557	14,678	4.3	1.4
Redfish	33	56	193	774	58.9	4.3
Sand eel	0	0	4,152	4,152	0	0
Torsk (tusk)	4	42	194	207	9.5	1.9
Witch	166	576	1,789	1,981	28.8	8.4
Others	91	1,414	682	3,833	6.4	2.4
Fish roes	11	48	144	243	22.9	4.5
Total	***6,084***	***47,404***	***193,914***	***275,460***	***12.8***	***2.2***

Source: Ministry of Agriculture, Fisheries and Food (1994); Scottish Office Agriculture and Fisheries Department (1993); Isle of Man Department of Agriculture, Fisheries & Forestry (pers. comm.). Key: *west coast of Britain, here including the Isle of Man; see section 9.1.4 for further explanation. Notes: amounts landed are rounded up to the next whole tonne. Calculating the figures in this table was a complex process: refer to section 9.1.4.

Table 9.1.6 Shellfish landings** in 1992 (tonnes)

Species group	*Region 14*	*West Coast**	*Scotland*	*Britain and Isle of Man*	*% of West Coast* total landed in region*	*% of combined British and Isle of Man total landed in region*
Cockles	16	5,848	2,546	32,047	0.3	<0.1
Crabs	3,142	7,853	7,501	16,970	40.0	18.5
Lobsters	102	447	564	1,069	22.8	9.5
Mussels	97	1,690	3,067	6,555	5.7	1.5
Nephrops	4,060	11,271	17,707	19,639	36.0	20.7
Periwinkles	891	1,592	1,837	1,907	56.0	46.7
Queen scallops	494	9,066	5,518	11,273	5.4	4.4
Scallops	1,243	3,771	5,068	8,290	33.0	15.0
Shrimps	1	128	180	743	0.8	0.1
Squids	191	623	1,071	2,005	30.7	9.5
Whelks	51	488	858	2,393	10.5	2.1
Others	9	207	195	2,026	4.3	0.4
Total*	***10,297***	***42,984***	***46,112***	***104,917***	***24.0***	***9.8***

Source: Ministry of Agriculture, Fisheries and Food (1994); Scottish Office Agriculture and Fisheries Department (1993); Isle of Man Department of Agriculture, Fisheries & Forestry (pers. comm.). Key: *west coast of Britain, here including the Isle of Man; see section 9.1.4 for further explanation; **excluding landings of farmed shellfish - see section 9.2. Notes: amounts landed are rounded up to the next whole tonne. Calculating the figures in this table was a complex process: refer to section 9.1.4.

sheltered and accessible waters of the Firth of Clyde in winter. A statutory weekend ban on trawling for *Nephrops* in the Firth of Clyde may reduce effort. Trawlers from the east coast of Scotland also work the region's coast for *Nephrops*, and early in the year their numbers in Oban can exceed those of the local fleet.

Creels are used to catch edible crab, velvet crab, lobster and crawfish. Crawfish are also taken in tangle nets. The lobster and crab fishery is important for many communities in the region, particular around the islands to the west of Kintyre and along the rocky mainland coast. Lobster and crabs are the most important species targeted in areas of hard ground. Additional effort is being directed towards catching edible crabs further offshore: creeling boats capable of setting 2,000 creels and equipped with vivier tanks (which keep the shellfish alive) are now being used. Edible crab and lobster are landed during the summer and early autumn, with velvet crabs being landed towards the end of the year and into spring.

Scallops are exploited in the region by a fleet of dredging boats. Scallop dredging developed in this area in the early 1960s and initially worked beds in the Firth of Lorne and around the Islands of Colonsay, Islay and Jura. Scallop dredging has now extended into other areas in the region. Some fishermen on the islands of Jura and Islay periodically switch from fishing for scallops to using creels for edible crabs, which can be more economical. Scallops from some beds inaccessible to dredging are hand collected by SCUBA divers.

Otter trawls are used to catch squid. Periwinkles and mussels are collected by hand.

Diadromous species

The distribution of diadromous fish species in rivers in the region is discussed in section 5.8 and shown on Map 5.8.1. In this region, two diadromous species - salmon (including grilse) and sea trout - support rod-and-line fisheries from rivers, as well as netting stations. Net-and-coble and rod-and-line fishing is permitted on the coast, in estuaries and in rivers. Fixed engines (stake nets and bag nets) can be used only outside estuary limits. In practice, most diadromous fisheries in the region operate in estuaries or in rivers, rather than on the open coast. There are a small number of fixed netting stations situated along the Clyde coast. Table 9.1.7 shows the average numbers of salmon and grilse and sea trout caught in the region's Statistical Districts in the five years between 1989 and 1993. In order to protect commercial confidentiality, the reported catches for each Scottish Statistical District are published without an indication of catch method. The salmon fishery in this region is not as prolific as that on the east coast of Scotland, because historically the rivers support smaller stocks of salmonids.

Table 9.1.7 Salmon and grilse and sea trout five-year (1989-1993) average catch (as numbers of fish reported to SOAEFD)

Scottish Salmon Fishery Statistical District[b]	*Salmon & grilse*	*Sea trout*
Stinchar[c]	717	121
Girvan	473	185
Doon	1,583	88
Ayr	570	162
Irvine	380	321
Clyde	688	1,634
Echaig	119	393
Ruel & Drummachloy[a]	38	10
Fyne	520	80
Carradale & Iorsa[a]	586	159
Islay & Jura[a]	425	531
Island of Mull	2,530	160
Add & Ormsary[a]	638	82
Awe & Nell[a]	1,460	38
Region 14	***10,727***	***3,964***

Sources: Scottish Office Department of Agriculture and Fisheries (1990) and Scottish Office (1991, 1992, 1993, 1994). Key: [a]Statistical District covers the two named Salmon Fishery Districts; [b]see Map 9.1.2; [c]partly in Region 13. Notes: Sanda to Creran District, part of which is in this region, is covered in Region 16. 'Sea trout' here includes all migratory trout.

Sea angling

Sea angling is a popular sport practised by over two million people in Great Britain (Fowler 1992). The governing body is the Scottish Federation of Sea Anglers, which has approximately 64 affiliated clubs and approximately 200 additional personal members, not necessarily members of affiliated clubs. Sea angling is distinguished from two other types of sport fishing: game fishing for salmon, sea trout, brown and rainbow trout (the first two are covered here) and coarse fishing, which is for freshwater fish species and so is not covered here. Sea angling has three main forms: angling from the shore, inshore fishing within about 5 km of the shore and deep sea fishing. Sea angling occurs in many places in the region, for example, at Girvan, and in the Estuaries of the Ayr and Doon. Fishing from the shore takes place in South Bay and in Saltcoats and Ardrossan Harbours. Lamlash Bay is the main centre for sea angling on Arran, and boats trips leave from Lamlash to fish in Whiting Bay, further south. On Arran sea angling also takes place in Brodick Bay between Merkland Point and Clauchlands Point. Off Campbeltown sea angling is popular off the causeway between Davaar Island and the mainland. Sea angling around Oban is best off the south and west sides of Kerrara Island. Orton (1996) also gives further information on places where sea angling takes place in the region, the facilities available and potential catch species.

Bait collection

Bait collection for sea angling occurs in many areas in the region, although some areas are more prolific than others and may attract commercial collectors. Anglers often collect their own bait locally, while commercial collectors travel in teams to suitable shores. Many species are collected, including ragworm, lugworm, peeler crabs (moulting shore crabs), mussels, cockles, limpets and razor shells. Different bait species are targeted according to the species of fish being caught as well as the location and time of year. The main collecting techniques on the shore are digging and boulder turning. Bait digging, especially for lugworms, is carried out over the lower part of muddy and sandy shores around the time of low water. Fowler (1992) identified that the exploitation of bait species was taking place at the following locations in the region: Stevenson, Fairlie, the north shore of the Inner Clyde Estuary, and Inveraray (at the head of Loch Fyne). At the time of the survey (1985) this was mainly occasional non-commercial exploitation. There have been recent problems on some beaches in Ayrshire, where large gangs of bait diggers from north-east England have been digging for bait.

9.1.3 Management and issues

Responsibility for the management of fisheries in coastal waters rests with the Commission for the European Union (EU), who delegate it to member states under the Common Fisheries Policy (CFP). European Council regulations are implemented through UK law, usually by means of statutory instruments, which define limits and restrictions and set down powers of enforcement and penalties. All national regulation measures, including local sea fisheries bylaws, must conform with the requirements of the CFP.

The CFP seeks to manage stocks of fish in EU waters on a biological basis, principally by implementing catch quota management measures, by setting agreed annual Total Allowable Catches (TACs) for particular stocks. The policy came into effect in 1983 and was subject to a mid-term review in 1993, with a full review planned for 2002. The CFP is described in Coffey (1995), which sets out the basic elements of the policy and contributes to the debate on fisheries and the environment. A central principle of the policy is the rule of 'equal access' - that all member states of the EU have equal access to all community waters and all fishing resources. However, this rule is subject to the principle of 'relative stability', which takes account of established practice, and consequently a number of exceptions have been adopted, based on various precedents and historic fishing patterns. Between 6 and 12 nautical miles from baseline (low water mark) other member states with historic rights also have access and beyond 12 nautical miles (the limit of British Territorial Seas) access to vessels from the other member states is limited based on historic fishing rights and to vessels from non-member countries by reciprocal agreements with the European Union.

For the purpose of stock assessment, the UK coastal waters have been designated by the International Council for the Exploration of the Sea (ICES) into statistical areas. The coastal seas around this region are part of Division VIa (West of Scotland). ICES provides scientific advice on the management of all the important commercial species of fin fish and some shellfish stocks in all areas of the north-east Atlantic. This work is summarised in the annual report of the Advisory Committee for Fisheries Management, which is responsible for providing scientific advice on TACs and other conservation measures to the international fisheries commissions, including the EU. The TAC is a fishery management tool which may, amongst other management needs, take account of the maximum level of exploitation that a given stock can sustain. Precautionary TACs are applied to important stocks where there are not enough scientific data to make an analytical assessment. Once the TACs are set for each stock they are divided between member states in the form of catch quotas. European Council Regulation No. 3074/95 (European Council 1995) fixes, for 1996, details of the catch quotas for fish and shellfish species for all European countries and certain conditions under which the species may be fished. The TACs, UK quotas and 'uptake' for 1995 for each species in the ICES statistical division in the region are given in SOAEFD (1996a), which is published annually. European Council Regulation No. 3760/92 (European Council 1992) summarises the CFP, including the proportions by which TACs are allocated as national quotas. Information on minimum landing sizes and whether an annual quota applies in the region for the important pelagic and demersal species is given in Table 5.7.1.

In Scotland the administration and management of sea fisheries is carried out by the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) in accordance with the CFP of the European Union. Research relating to the CFP and other fisheries management requirements is carried out by the SOAEFD Marine Laboratory, Aberdeen. The District Office in each of the three Sea Fisheries Districts partly or wholly within the region (Map 9.1.1) collects data on landings at all ports in that district. Administration and enforcement of sea fisheries legislation within Sea Fisheries Districts is the responsibility

of the Sea Fisheries Inspectorate branch of the Scottish Fisheries Protection Agency, which operates the Fisheries Protection Fleet and aircraft. In Scottish inshore waters (to 6 nautical miles from baselines), the principle instrument of fisheries management is the Inshore Fishing (Scotland) Act 1984. This gives the Secretary of State powers to regulate fishing in specified inshore waters and to prohibit the carriage of specified types of net and the use of mobile gear near fixed salmon nets. Table 9.1.8 lists the full year and seasonal closures on the use of fishing gear (trawl, seine net, dredge (including suction dredging) etc.) in three areas in the region, made under the Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989, issued under the Inshore Fishing (Scotland) Act 1984 (Map 9.1.3).

The Sea Fisheries (Wildlife Conservation) Act 1992 gives SOAEFD limited scope to have due regard for wider environmental interests when managing fisheries. Fisheries managers have been given environmental responsibilities under the Environment Act 1995 and the Conservation (Natural Habitats etc.) Regulations 1994. There are a total of nine Regulating Orders in Britain covering approximately 215,889 ha (as at July 1995) (MAFF 1995a). While Regulating Orders do not presently apply in Scotland, the Scottish Office issued a consultation paper in December 1994 reviewing its policy on Several and Regulating Orders. Regulating Orders can be granted under the Sea Fisheries (Shellfish) Act 1967 by SOAEFD to a responsible body to enable it to regulate the natural fishery via regulations and restrictions and to levy tolls or royalties. Several Orders are discussed in more detail in section 9.2.3.

Fishermen's Organisations, such as the Scottish Fishermen's Federation and the Clyde Fishermen's Association, represent fishermen's and boat owners' interests in the fishing industry and are consulted on fisheries management issues and other fisheries-related issues. The Unitary Authorities have a role in providing infrastructure and support to the fishing industry. Highlands and Islands Enterprise helps to develop and supports the fishing industry (Highlands and Islands Enterprise 1993).

The Salmon Fishery Statistical Districts (composed of one or more Fishery Administrative Districts) in the region are shown on Map 9.1.2 and listed in Table 9.1.7. In Scotland there is no public right to fish for salmon, and exclusive rights for each stretch of river are privately owned. Coastal and estuarine fisheries are similarly governed by heritable titles. Within District Salmon Fishery Board areas there may be associations of those concerned with a fishery, such as the proprietors, tenants, gillies and anglers.

Map 9.1.3 Sea areas in which fishing restrictions apply. Note: this map is for illustrative purposes only; see associated text and Table 9.1.8. Source: The Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989.

Issues relating to the fisheries for pelagic, demersal and shellfish species and sea angling and bait collection are closely linked to wildlife conservation in several ways. Issues include the effects of fisheries on target species as major components in marine ecosystems, the changed availability of food for predators, the effects on non-target species, and effects on species and habitats of nature conservation interest.

Table 9.1.8 Full year and seasonal closures on the use of fishing gear

Sea area within which prohibition applies	*Full year/ seasonal closure*	*Type of prohibition and, for seasonal closure, the period of prohibition (inclusive dates)*	*Method of fishing for species of sea fish excepted from prohibition and period of exception*
The Gare Loch	Full year	Mobile gear	-
Firth of Clyde	Full year	General prohibition of fishing	(a) Any method of fishing for herring, mackerel or sprats during full year; (b) fishing for any species of sea fish (except above species) from a fishing boat with an overall length not greater than 70 feet (21.3 m) during full year
Firth of Clyde	Seasonal	Mobile gear at weekends (midnight on Fridays until midnight on Sundays) and (Ballantrae Bank only) from 15 February to 30 April	-
Loch Sween	Full year	Suction dredging only	-

Source: the Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989. Notes: mobile fishing gear includes gear such as a trawl, Danish seine or similar net, purse seine, ring net or dredge, including suction dredge. A suction dredge is designed to raise fish, shellfish or other material from the sea bed using a solids pump or air lift, or water jets to dig into the sea bed.

Further information on issues concerning fisheries can be found in references such as Commission of the European Communities (1995), and concerning the species targeted in references given in sections 5.5, 5.7 and 5.8.

9.1.4 Information sources used

Inshore fisheries review of England, Scotland and Wales, 1992/1993 (Gray 1994) has been used in compiling this section. Gray (1994) describes the different types of fishing gear used inshore and any related restrictions. It also gives details of the numbers of boats operating from ports in the region, the amount of fishing effort involved by various methods and which species or species groups are targeted during the different seasons. Brady (1995) lists details of all fishing vessels, their base ports and main fishing methods. The key GB statutes relating to fisheries are described in Eno & Hiscock (1995) and specifically for Scotland in Cleator & Irvine (1994). Figures given in Tables 9.1.1 - 9.1.7 come from various sources: MAFF, NRA (now the Environment Agency), SOAEFD and Isle of Man Department of Agriculture, Fisheries and Forestry (IoM DAFF); their interpretation is described below.

Information on the number and size of fishing vessels (i.e. under 10 m length; 10 m and over) based in the region may be obtained from the *The Scottish fishing fleet at December 1995* (SOAEFD 1996b). Numbers of full-time and part-time fishermen resident in Sea Fisheries Districts within the region are also given in this annual publication. Trends in fish landings (tonnage and value) at Scottish ports are decribed in detail in MacKay & Adam (1995).

Pelagic, demersal and shellfish species

Statistics given in this section are for landings recorded in the region, as distinct from fish catches taken. Choice of landing port reflects a combination of operational factors such as market prices, distance from the fishing grounds and the location of fishermen's weekend bases. Consequently, locally-based vessels may land catches at ports in other regions. Some fish caught may have been discarded before landing. The data presented give an indication of the economic importance of the species that were landed in the region in 1992 (used as a reference year), compared with the rest of Britain and the Isle of Man. Data for Scotland are published annually and for 1993, 1994 and 1995 are available in SOAFD (1994, 1995) and SOAEFD (1996a).

Statistics for the Scottish Sea Fisheries Districts are based on *Scottish sea fisheries statistical tables*, published annually by the Scottish Office Agriculture, Environment and Fisheries Department (formerly the Scottish Office Agriculture and Fisheries Department) (SOAFD 1993). The contributions to fish and shellfish landings by Scottish vessels landed in the part of the Ayr Sea Fisheries District within Region 14 were provided by SOAEFD.

The landings for the Sea Fisheries Districts have been combined to give the figures in the 'Region 14' column for Tables 9.1.1 and 9.1.4 - 9.1.6. The figures in the 'West Coast' column were calculated by adding together all the landings data for the six Coastal Directories regions on the west coast of Great Britain, as defined in section 1.1. The figures in the 'Scotland' column of these tables was calculated by adding together all of the SOAEFD data for Scotland, and those in the 'Britain and Isle of Man' column by combining MAFF, SOAEFD and IoM DAFF data. Because these organisations do not use the same categories, landings in some of their categories have been added to the 'others' rows in the tables in this section. Also, SOAEFD publish the weight of fish as 'standard landed weight' (gutted fish with head on), whereas MAFF and IoM DAFF publish them as 'nominal live weight' (whole fish). These two are the same for pelagic and shellfish species, but converted data from SOAEFD were used for all demersal species, apart from sandeels (which are not gutted), so that all the data presented are as 'nominal live weight'.

Diadromous species

The data for the Scottish Salmon Fishery Statistical Districts are based on returns made in response to an annual questionnaire sent to proprietors and occupiers of salmon fishings under the provisions of section 15 of the Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951, as amended by the Salmon Act 1986. Over 95% of the forms sent out in 1992 were returned. The figures presented are the reported catch and no allowance is made for inaccuracies, non-returns or gaps in the roll of proprietors and occupiers. Therefore the figures given in Table 9.1.7 should be used only as an indication of the pattern of the catch in the region. In order to protect commercial confidentiality, the reported catches for each district are published without an indication of catch method. The *Statistical Bulletin* of Scottish salmon and sea trout lists catch returns for each individual Salmon Fishery Statistical District (Map 9.1.2) and is published annually (SODAF 1990; SO 1991-1996).

Sea angling

In the 85th edition of *Where to fish*, Orton (1996) lists much useful information relating to angling, including the locations from which various species of fish can be caught.

Bait collection

Bait collection is discussed by Fowler (1992), who presents results from a survey around the coast of Britain in 1985.

9.1.5 Acknowledgements

The authors thank the following members of the 'Fisheries Working Group' for their contributions and comments, which enabled the production of this section: Stephen Lockwood (MAFF DFR), Mike Pawson (MAFF DFR), Miran Aprahamian (Environment Agency North-West Region), Bill Cook (North Wales and North Western Sea Fisheries Committee (SFC)), Phil Coates (South Wales SFC), Russell Bradley (Association of SFCs), Neil Downes (Devon SFC), Paul Knapman (English Nature), Blaise Bullimore (Countryside Council for Wales), Indrani Lutchman (WWF-UK), Clare Eno (JNCC) and Mark Tasker (JNCC).

Thanks also go to David Dunkely (SOAEFD Montrose Field Station), David Donnan (Scottish Natural Heritage), Patrick Stewart (Clyde Fishermen's Association), Andrew Haig (SEPA West Region) and John Gordon and Martin Sayer (Dunstaffnage Marine Laboratory) for providing a great deal of information specific to this region and for checking drafts and maps.

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Wildlife & Countryside Link Seals Group. 1995. *Seals and fisheries: the facts.* East Grinstead, Wildlife & Countryside Link Seals Group.

C. Contact names and addresses

Type of information	Contact address and telephone no.
Scientific aspects of managing important fish and shellfish stocks	General Secretary, International Council for the Exploration of the Sea, Palaegade 2 -4, DK-1261 Copenhagen K, Denmark, tel: 00 45 331 57092
Inter-government convention regulating salmon fishing on the high seas	Secretary, North Atlantic Salmon Conservation Organisation, 11 Rutland Square, Edinburgh EH1 2AS, tel: 0131 228 2551
Statistics on sea fish landings in Scotland. Analysis and dissemination of data and statistics on vessels in the Scottish fishing fleet.	*SOAEFD Division J4, Pentland House, Edinburgh, tel: 0131 556 8400 or 0131 244 6441
International fisheries policy for Scotland. Fisheries conservation including quota policy.	*SOAEFD Division J1, Pentland House, Edinburgh, tel: 0131 556 8400 or 0131 244 6440
Domestic fisheries policy for Scotland. Inshore and shell fisheries management - including Regulating Orders, enforcement and environmental aspects.	*SOAEFD Division J2, Pentland House, Edinburgh, tel: 0131 556 8400 or 0131 244 6440
Marine and estuarine fisheries research in Scottish waters; interaction between fisheries and non-fisheries conservation issues in Scotland; seals and fisheries	*SOAEFD Fisheries Research Services, Marine Laboratory, Aberdeen, tel: 01224 876544
Diadromous fish and fisheries information	SOAEFD Freshwater Fisheries Laboratory, Montrose Field Station, 16 River Street, Montrose, Angus DD10 8DL, tel: 01674 677070
Wild salmon and freshwater fisheries policy; contact details of the Clerks of the District Salmon Fishery Boards	*SOAEFD Division K2, Pentland House, Edinburgh, tel: 0131 556 8400 or 0131 244 6231
Scottish Office publications sales	HMSO, 731 Lothian Road, Edinburgh EH3 AA2, tel: 0131 228 4181
Research and development, marketing and training for the fishing industry	Sea Fish Industry Authority, 18 Logie Mill, Logie Green Road, Edinburgh EH7 4HG, tel: 0131 5583331
Representation of fishermen's and boat owners' interests in the Scottish fishing industry	Scottish Fishermen's Federation, 16 Bon Accord Crescent, Aberdeen AB1 2DE, tel: 01224 582583
Representation of fishermen's and boat owners' interests in the Clyde area	Clyde Fishermen's Association, 2 Castlehill, Campbeltown, Argyll PA28 6AW, tel: 01586 552871
UKDMAP software; mapped fishing areas of selected species, ICES Statistical Division boundaries etc.	*Project Manager, BODC, Birkenhead, tel: 0151 653 8633
Shellfish production (commercial)	Director, Shellfish Association of the UK, Clerk, Fishmongers Hall, London Bridge, London EC4R 9EL, tel: 0171 6263531
Affiliated sea angling clubs	Secretary, Scottish Federation of Sea Anglers, Administrator, Caledonia House, South Gyle, Edinburgh EH12 9DQ, tel: 0131 317 7192
Game fishing	Director, Salmon and Trout Association (Scottish Branch), Administrator, 10 Great Stuart Street, Edinburgh EH3 7TN, tel: 0131 225 2417
Interaction between fisheries and non-fisheries conservation issues	*Fisheries Officer, JNCC, Peterborough, tel: 01733 62626
Interaction between fisheries and non-fisheries conservation issues	*Aquatic Environments Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797
Interaction between fisheries and non-fisheries conservation issues	*Marine Policy Officer, RSPB HQ, Sandy, tel: 01767 680551
Interaction between fisheries and non-fisheries conservation issues	*Conservation Officer, WWF Scotland, Aberfeldy, tel: 01887 820449, and *Fisheries Officer, WWF-UK, Godalming, tel: 01483 426444
Interaction between fisheries and non-fisheries conservation issues	*Conservation Officer, Marine Conservation Society, Ross-on-Wye, tel: 01989 566017
Interaction between fisheries and non-fisheries conservation issues	*Honorary Secretary, The Marine Forum for Environmental Issues, Scarborough, tel: 01723 362392
Seals and fisheries	Co-ordinator, Wildlife & Countryside Link Seals Group, 105 Halsford Park Road, East Grinstead, West Sussex RH19 1PR, tel: 01342 315440
Seals and fisheries	Sea Mammal Research Unit, Gatty Marine Laboratory, University of St Andrews, Fife KY16 8LB, tel: 01334 476161

*Starred contact addresses are given in full in the Appendix.

9.2 Mariculture

C.F. Robson

9.2.1 Introduction

Mariculture is the cultivation of marine species. In this region the coastline provides good shelter and adequate water exchange for salmon farms, which have become an important addition to the local economy. Shellfish, such as the Pacific oyster, native oyster, mussel, scallop and queen scallop, are also cultivated in areas around the region's coast.

9.2.2 Locations and species

Maps 9.2.1 and 9.2.2 show the locations of areas where salmon and non-salmonids and shellfish are cultivated in the region. Table 9.2.1 lists the main species that are under commercial cultivation in the region and in Great Britain and the Isle of Man. There is currently no cultivation of polychaetes in the region.

Table 9.2.1 Main species that are cultivated in the region and in Great Britain

Species	*Species status*	*Cultivated in region?*
Salmonids		
Atlantic salmon *Salmo salar*	Native	✓
Sea trout *Salmo trutta*	Native	✓
Non-salmonids		
Turbot *Psetta maxima*	Native	
Halibut *Hippoglossus hippoglossus*	Native	✓
Shellfish: bivalve molluscs		
Common mussel *Mytilus edulis*	Native	✓
Native oyster *Ostrea edulis*	Native	✓
Pacific oyster *Crassostrea gigas*	Un-established introduction	✓
Hard shelled clams *Mercenaria mercenaria*	Non-native	
Manila clams *Tapes philippinarum*	Un-established introduction	
Palourde *Tapes decussatus*	Native	
Scallop *Pecten maximus*	Native	✓
Queen scallop *Aequipecten opercularis*	Native	✓
Polychaetes		
King ragworm *Neanthes virens*	Native	

Sources: The Crown Estate & Scottish Office Agriculture, Environment and Fisheries Department (pers. comms.), La Tene Maps (1995a, b). Note: for the JNCC's Marine Nature Conservation Review (MNCR), non-native species are those introduced species that are established in the wild; other introduced species are described as un-established introductions.

Salmonids and non-salmonids

The areas where marine fish farm sites are located within the region are shown on Map 9.2.1. Salmon is cultivated at all except one of these sites; halibut is cultivated in farms and hatcheries at three sites. There may also be other sites

Map 9.2.1 General location of marine fish farm sites and species in culture. Sources: The Crown Estate (pers. comm.), SOAEFD (pers. comm.), La Tene Maps (1995a).

Map 9.2.2 General location of shellfish farm sites and species in culture. Sources: The Crown Estate (pers. comm.), SOAEFD (pers. comm.), La Tene Maps (1995b).

that are leased for fish farming but not currently used for cultivation. The majority of the separate smolt units, hatcheries and freshwater sites are not shown on the map. Rainbow trout *Onchorynchus mykiss* and brown/sea trout are sometimes cultivated in sea cages alongside salmon. Table 9.2.2 shows the production of salmon in Region 14 in 1995, compared with the whole of Scotland. Both Region 14 and Scotland as a whole have shown large increases in production since 1992.

Table 9.2.2 Employees and annual production (tonnes) in 1995 of salmon at sea sites

	No. of staff	*Annual production*
Region 14	298	15,777
Scotland	1,355	70,060

Source: Scottish Office Agriculture, Environment and Fisheries Department (1996a). Note: number of staff includes full time and part time staff.

Shellfish

Shellfish farming in Scotland has developed significantly in the last ten years, but the number of active shellfish companies has now decreased slightly since its peak in 1990. The distribution of the shellfish farm sites and the species farmed in the region are shown on Map 9.2.2. There may also be other sites that are leased for shellfish farming but not currently used for cultivation. Separate hatchery unit sites are not shown on the map. Hatchery-reared 'spat' of Pacific and native oysters are grown to market size in bags made from net located on trestles on the lower shore. Mussels are commonly cultivated from 'spat' collected from the sea using ropes. Scallops and queen scallops are grown on the lower shore from natural spat suspended either in bag nets or individually from holes drilled in the shells. Table 9.2.3 shows the results of the 1995 SOAEFD survey of shellfish companies for Region 14 compared with the whole of Scotland.

9.2.3 Management and issues

The Food Safety (Live Bivalve Molluscs) Regulations (which implement European Council Directives) require that all waters from which bivalve molluscs are taken for human consumption are classified by the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD), following sampling carried out by the Port Health Authority or Local Authority. Samples of live shellfish are submitted to SOAEFD Marine Laboratory for bacteriological examination and, depending on the resulting category (A - D), restrictions and further treatment may apply before human consumption is permitted. Samples are taken regularly and the classification can change. Shellfish must also meet the 'End Product Standard', to which all live bivalves intended for immediate human consumption must comply.

The consent of the owners or managers of the sea bed is required and a lease may be needed, applications for which must go through an extensive consultation process, before structures for mariculture can be erected on the sea bed. In many areas a lease must be sought from the Crown Estate, since it owns or manages 55% of the foreshore and the same proportion of the beds of tidal rivers between mean high and low water in Great Britain, together with virtually the entire territorial sea bed. These leases are controlled through a formal consultation procedure involving a range of interested bodies including local authorities, the Scottish Environment Protection Agency (SEPA), SOAEFD and Scottish Natural Heritage (Crown Estate 1987, 1989a, 1989b). Details of all salmonid and shellfish cultivation leases in this region are held by the Crown Estate in Edinburgh. If the intended structures are potentially hazardous to navigation the Department of Transport must also issue a consent. If they are to be above mean low water mark planning permission must be sought from the local authority, who will take nature conservation and landscape considerations into account. SEPA and local authorities are responsible for processing consents to discharge from fish and shellfish farms; they hold details of the consents issued to operational sites and site monitoring records. The development of a control policy for fish farming in the region is discussed in Smith & Haig (1991).

Several Orders are granted under section 1 of the Sea Fisheries (Shellfish Act) 1967 and are administered in Scotland by SOAEFD. Several Orders take precedence over the public right to fish and are granted to an individual, a co-operative or a responsible body to cultivate the sea bed within a designated area of water and to protect, conserve and enhance a fishery for named molluscan shellfish species. There is one Several Order in this region (Table 9.2.2), out of 22 in Britain covering a total of approximately 3,299 ha (as at July 1995). The existence of a Several Order does not necessarily mean that mariculture is actively occurring at the location covered. There are consultations proceeding to extend the Act to cover Crustacea as well as molluscs.

The Scottish Salmon Growers Association and the Association of Scottish Shellfish Growers are trade associations which act as information sources for the mariculture industry in Scotland, encourage research and act as consultees on relevant issues.

The introduction of non-native shellfish species for cultivation has caused concern over their potential to establish self-sustaining populations, which may affect marine ecosystems. Since January 1993 there have been new requirements for the control of shellfish disease in Great

Table 9.2.3. Scottish shellfish companies 1995 production* (weight of shellfish in tonnes)

	No. of companies	*No. of staff*	*Pacific oysters*	*Native oysters*	*Mussels*	*Queen scallops*	*Scallops*
Region 14	69	142	141	14	509	40	20
Scotland	190	327	273	15	882	46	36

Source: Scottish Office Agriculture, Environment and Fisheries Department (1996b). Key: *'production' is that for sale for the table only. Note: except for mussels, which are recorded in tonnes, the following average weights of individuals have been used to convert numbers of individuals to (next whole) tonnes: Pacific and native oyster - 80 g, queen scallop - 40 g, scallop - 120 g. Number of staff includes full time, part time and casual staff.

Table 9.2.4 Several Orders in the region

Title	*Species covered*	*Grid ref.*	*Location*	*Grantee*	*Approx. area (ha)*	*Year of expiry*
Loch Crinan Scallops Fishery Order	Scallops	NR784950	Loch Crinan	Scallop King plc	97	2005

Source: Ministry of Agriculture, Fisheries and Food (1995). Note: Regulating Orders are discussed in section 9.1.3.

Britain and for the importation and 'deposit' of molluscan shellfish and lobsters, under the EC Fish Health Directive (Directive 91/67). The regulations list diseases on which national authorities will take action and those animals that are susceptible to notifiable diseases. The lists may be amended with changing circumstances. In Great Britain two shellfish diseases are now notifiable: *Bonamia* and *Marteilia*, both of which are of serious economic importance and are present in one or more EU member states. The agents of the diseases, *Bonamia ostreae* and *Marteilia refringens*, are parasites that cause high mortalities in susceptible species, notably the native oyster. Movements of species susceptible to these diseases can only be made from areas of equal or better health status, and imports of Pacific oysters are subject to screening for species contamination. Imports from non-EU countries can only be made under licence, and enter through designated border inspection posts. Fish farming and shellfish farming businesses in Scotland should register with SOAEFD within two months of starting operations. This is a requirement under the Registration of Fish Farming and Shellfish Farming Businesses Order 1985, with a view to preventing the spread of disease. A former turbot farm on Gigha Island (off the Kintyre Peninsula) was closed following the first outbreak of viral haemorrhagic septicaemia (VHS) in Scotland. Diagnosis, collation of information and research on fish- and shellfish-related diseases in Scotland is carried out by SOAEFD Marine Laboratory.

Issues relating to the cultivation of marine species are closely linked to marine nature conservation interests, particularly the possible effects on species and habitats of nature conservation interest. For instance, the intensification of mussel farming has enhanced the potential for eider ducks, which feed on mussels, increasingly to predate the farmed shellfish, causing a conflict between interests in the area. Advice on precautions against eider duck predation of mussel farms is outlined in Galbraith (1992). Bird-scaring devices and human presence on the farms may be effective deterrents.

As in agriculture, efficient mariculture operations depend on intensive production methods (i.e. at greater than natural population densities), requiring high water quality. The maintenance of the coastal marine environment in an uncontaminated and fully functional state is recognised as an important objective shared by mariculturists and other users of the coastal zone. The presence of fish farming operations in the sea may lead to some interactions between husbandry procedures and the environment. This subject is an active research and monitoring area in Scotland and other northern European countries where salmon farming has developed as the primary form of mariculture. Interactions that give rise to expressions of concern are associated with: the siting and appearance of fish farms, effects on water quality, the sea bed, benthic communities and wildlife (fish predators), opportunities for exchange of pathogens and parasites between wild and farmed fish, the use of chemicals to treat sea lice, the use of antibiotics and their persistence in sediments and the potential for genetic interactions between wild fish and escaped farmed fish. All shellfish species cultivated in Scotland depend on natural food supplies and receive no therapeutic (chemical) treatments for disease or parasites. The high water quality requirement for shellfish farming has, occasionally, led to some concern regarding the impact of certain pollutants in the marine environment.

9.2.4 Acknowledgement

Thanks go to Dr P.D. McGovern (Crown Estate), Colin Wishart (Highland Council), Derek Murison (SOAEFD), David Donnan (Scottish Natural Heritage), Alan Haig (SEPA West Region) and Martin Sayer (Dunstaffnage Marine Laboratory) for commenting on the text.

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Fish and shellfish farming policy, disease control, Several Orders in Scotland.	*SOAEFD, Division K4, Pentland House, Edinburgh, tel: 0131 244 6224 or 0131 556 8400
Research into fish and shellfish cultivation in Scotland, interaction between mariculture activities and marine nature conservation issues	*SOAEFD Fisheries Research Services, Marine Laboratory, Aberdeen, tel: 01224 876544
Leases	The Crown Estate, 10 Charlotte Square, Edinburgh EH2 4DR, tel: 0131 226 7241
Discharge consents and water quality	*Scottish Environment Protection Agency (SEPA), West Region HQ, East Kilbride, tel: 01355 238181
Market research and technical advice on shellfish purification	Sea Fish Industry Authority, 18 Logie Mill, Logie Green Road, Edinburgh EH7 4HG, tel: 0131 558 3331
Salmon farming	Director, Scottish Salmon Growers Association, Drummond House, Scott Street, Perth PH1 5EJ, tel: 01738 635420
Shellfish farming	Association of Scottish Shellfish Growers, The Old Parsonage, 2 Manse Road, Roslin, Midlothian EH25 9LS, tel: Jim Buchanan, 0131 440 2116

Type of information	*Contact address and telephone no.*
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Interaction between mariculture activities and marine nature conservation issues	*Aquatic Environments Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797
Interaction between mariculture activities and marine nature conservation issues	*Fisheries Officer, JNCC, Peterborough, tel: 01733 62626
Mariculture and marine nature conservation issues	*Coastal Policy Officer, RSPB HQ, Sandy, Beds., tel: 01767 680551
Mariculture and marine nature conservation issues	*Conservation Officer, WWF Scotland, Aberfeldy, tel: 01887 820449, and *Fisheries Officer, WWF-UK, Godalming, tel: 01483 426444
Mariculture and marine	*Conservation Officer, Marine Conservation Society, Ross-on-Wye, tel: 01989 566017
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Seals and mariculture	Sea Mammal Research Unit, Gatty Marine Laboratory, University of St Andrews, Fife KY16 8LB, tel: 01334 476161

*Starred contact addresses are given in full in the Appendix.

9.3 Quarrying and landfilling

C.A. Crumpton & M.J.Goodwin

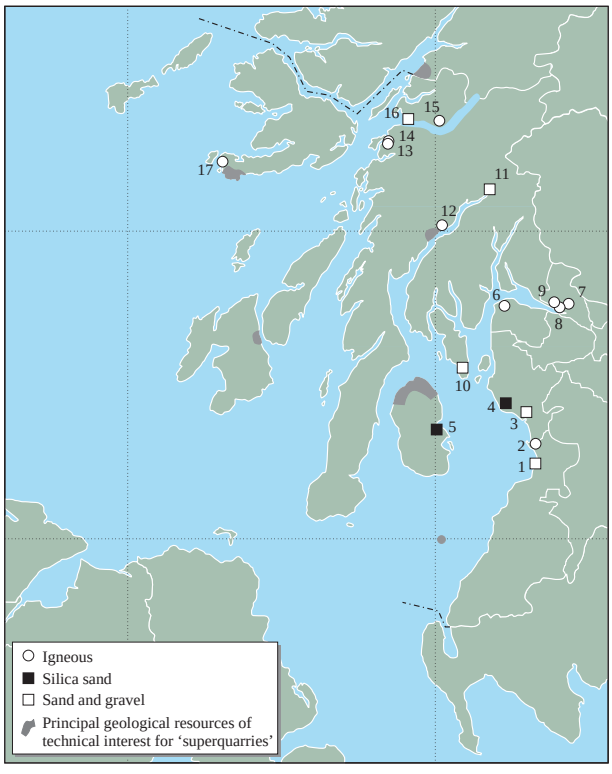
9.3.1 Introduction

In this section, quarries are included as coastal if they are less than 2 km inland and landfill sites if they are in a coastal 10 km square. The minerals quarried in the region include sand and gravel, igneous rock and silica sand. These are put to a variety of uses including for roadstone and construction (igneous rock), concrete aggregate (igneous rock and sand and gravel), coating and fill (sand and gravel) and railway ballast (igneous rock). The quartz-rich silica sand quarried in the region is used for glassmaking, foundry moulding, glass fibre, water filtration, oil reservoir engineering and the manufacture of sodium silicate and carborundum. Large areas of sandstone exist around the Clyde coast, central Ayrshire and within the Glasgow conurbation, and there has been a recent increase in demand for such building stone (Strathclyde Regional Council 1995), although none is currently extracted in the region.

Table 9.3.1 shows the whole-county production levels of the minerals extracted in the region's coastal quarries, compared with national and British levels. The region's most important mineral product is igneous rock, which in 1993 contributed nearly 15% of the national total production.

Table 9.3.2 shows the numbers of mineral workings on the region's coast by type of mineral, compared with British totals.

The 39 coastal landfill sites in this region represent approximately 0.3% of the British whole country total of approximately 15,000.



Map 9.3.1 Currently-operating coastal quarries and potential superquarry sites. Numbers refer to Table 9.3.3. Source: BGS (1994). © Crown copyright.

9.3.2 Important locations

Coastal quarries in the region are listed in Table 9.3.3 and shown on Map 9.3.1. The principal geological resources of technical interest for potential superquarries in Region 14 are shown on Map 9.3.1.

The region's currently-used landfill sites are shown on Map 9.3.2; the status codes are defined in Table 9.3.4. On the mainland coast sites are closely linked to the concentrations of industry around the Firth of Clyde and deal with difficult as well as household and non-hazardous waste. Landfills located on the islands deal mainly with household waste.

9.3.3 Management

In April 1996 the Scottish Environment Protection Agency (SEPA) came into force, under the terms of the 1995 Environment Act. The region falls entirely within SEPA West Region; in general terms the Agency's boundaries follow political boundaries in order to facilitate local accountability. The new agency integrates the functions of several pre-existing authorities: Her Majesty's Industrial Pollution Inspectorate (HMIPI), the local Waste Regulation

Table 9.3.2 Numbers of coastal workings in the region compared with British totals (including inland workings) by mineral type

Type of working	*No. on region's coast*	*No. in Britain (including inland)*
Igneous	10	236
Silica sand	2	46
Sand and gravel	5	896
Totals	***17***	***2,012***

Source: British Geological Survey (1994)

Table 9.3.1 Minerals production* in Region 14 (1993)

	Igneous rock		*Sand & gravel*		*Silica sand*	
	Tonnes	*% of GB total*	*Tonnes*	*% of GB total*	*Tonnes*	*% of GB total*
Region 14	***7,065,000***	***14.4***	***3,263,000***	***3.6***	***n/a***	***n/a***
Scotland	20,806,000	42.3	11,359,000	12.7	n/a	n/a
Great Britain	49,209,000	100	89,470,000	100	4,201,000	100

Source: Central Statistical Office (1994). Key: *amounts rounded up to the next whole thousand tonnes; n/a = not available.

Table 9.3.3 Coastal quarries in Region 14

Site no. on Map 9.3.1	*Location*	*Grid ref.*	*Operator*	*Mineral*
1	Prestwick	NS342280	Gavin Lawrie	Sand & gravel
2	Troon	NS346343	Hillhouse Quarry Co.	Igneous
3	Irvine	NS332367	Kenneth Building Services Ltd.	Sand & gravel
4	Stevenston	NS281415	Hugh King Ltd.	Silica sand
5	Brodick	NS008373	Scotsand Ltd.	Silica sand
6	Gourock	NS203751	Alfred McAlpine Quarry Products (Scotland)	Igneous
7	Rigangower	NS438754	Wm Thompson & Son Ltd	Igneous
8	Milton Hill	NS435745	Wm Thompson & Son Ltd	Igneous
9	Dumbuckhill	NS419746	Tilcon - Scotland	Igneous
10	Rothesay	NS097561	Bute Estates	Sand & gravel
11	Clachan	NN192130	Bonnar Sand & Gravel Co.	Sand & gravel
12	Furnace	NN028001	Tilcon - Scotland	Igneous
13	Oban	NM866281	John Maclachlan Ltd.	Igneous
14	Oban	NM868299	C.J. Mackinnon	Igneous
15	Bonawe, Loch Etive	NN015335	J. & A. Gardener & Co. Ltd.	Igneous
16	North Connel	NM908363	J. & A. Gardener & Co. Ltd.	Sand and gravel
17	Fionnphort	NM305239	Scottish Natural Stones Ltd.	Igneous

Sources: British Geological Survey (1994); Argyll & Bute Council (A. Payne pers. comm.).

Table 9.3.4 Status of the region's landfill sites

Status code	*Definition*	*No. in region*
1 Inert only	Uncontaminated excavated natural earth materials, and uncontaminated brick rubble and concrete with similar properties to natural earth materials.	5
2 Non-hazardous	Mainly uncontaminated and industrial wastes such as packaging materials, wood and plastic. Some of these wastes are biodegradable but not rapidly so.	2
3 Household/ putrescible	Typical contents of a household dustbin and similar wastes of industrial origin e.g. food processing wastes.	24
4 Difficult wastes	Any wastes which require particular handling techniques at the disposal site, e.g. vehicle tyres, dry feathers, animal carcasses. They are not the same as Special Wastes, which are toxic and require pre-notification of disposal to the Waste Regulation Authority.	8
Total		*39*

Source: Aspinwall & Co. (1994). See Map 9.3.2.

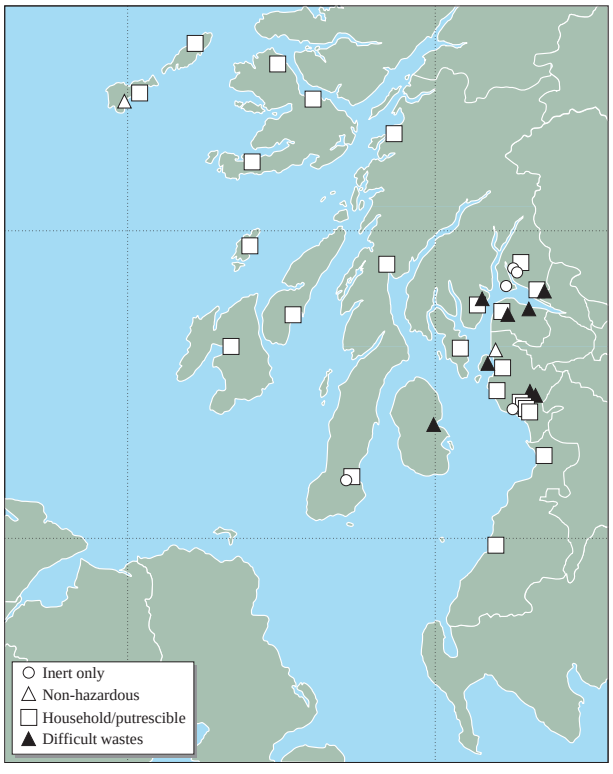
Authorities (WRAs) and the River Purification Authorities. Landfill site licensing is now the responsibility SEPA, which is required to maintain public registers of waste management licences and resolutions. Waste management licences were introduced by the 1990 Environmental Protection Act to replace the disposal site licences previously required by the 1974 Control of Pollution Act. Provisions relating to producer responsibility for waste will provide a mechanism to ensure that business initiatives on re-using, recovering and recycling waste are not undermined. Also within the Environment Act 1995 is the requirement for mine operators to give SEPA at least six months' notice of their intention to abandon a mine, in order that steps can be taken to avoid pollution from minewater.

According to a Scottish Office survey of aggregate production, 90% of the aggregate (including igneous rock) produced in the region is retained for use within the region itself, with a further approximately 1 million tonnes per annum being imported into the region from Stirling (Scottish Office 1995). However, proportions of aggregate produced in the region that are retained there may in future be affected by increased demand from England (BGS 1995).

In a 1992 report (Whitbread & Marsay 1992) the Department of the Environment found no reasonable prospects for superquarry development along the coastlines of England and Wales, and speculated that there may be scope for five superquarries in Scotland, with the greatest potential being found on the north and west coasts. Regions considered suitable for the development of superquarries are listed in Scottish Office (1994). These are the north coast of Highland region, the Shetland Islands and the Western Isles. However, Scottish Office (1994) notes that no more than four sites should be identified by 2009.

The region's geological resources of interest for potential superquarries are unlikely to be developed to their full potential, owing to the sensitive environmental settings of the favoured locations. The main environmental objection to development is likely to be the potential release of contaminated ballast water from transport ships, as has been the case with the proposed superquarry on the Isle of Harris (Region 15). It is thought that this could result in damage to the aquatic environment, including impacts on local fish farms. Landscape issues are also potentially important. A number of criteria have been devised to guide the selection of sites for superquarry development; these include minimising impacts to local interest and the natural heritage and assessing the potential benefits to the community (Scottish Office 1994).

It is envisaged that the demand for high quality silica sand from the North Sea oil and gas industry will increase, although whether sand from areas such as Arran in the region would be of the appropriate quality has yet to be



Map 9.3.2 Coastal landfill sites. Source: Aspinwall & Co. (1994)

confirmed. At present, silica sand is imported from the USA for this purpose.

In 1995 Strathclyde Regional Council investigated the suitability of the area west of Glasgow for hard rock extraction. A potential area for extraction extends to the coast and any proposed workings would face considerable environmental constraints (Strathclyde Regional Council 1995).

9.3.4 Information sources used

Data on quarrying were obtained from the British Geological Survey's 1994 *Directory of mines and quarries* and the Central Statistical Office's *Business monitor (minerals)* publication. Data for quarrying in BGS (1994) may be up to three years old and may therefore include information on some operations that have now ceased. In a small number of cases, exact locations of quarries were not listed and therefore it was not known if they were coastal. Local plans dealing with mineral issues are available from local authorities.

The data for landfilling were provided by Aspinwall & Co. from their Sitefile Digest on waste treatment and disposal (Aspinwall & Co. 1994). This contains regularly updated information from the 152 (former) Waste Regulation Authorities (WRAs) and represented the most up-to-date collection of public information on British waste management available at the time of writing.

9.3.5 Acknowledgements

Thanks go to Dr Ron Moore and Susan Morley (Aspinwall & Co.) for providing information from the Sitefile Digest and to Anthony Payne (Argyll & Bute Council) for his helpful comments and additional information.

9.3.6 Further sources of information

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B. Further reading

Department of the Environment. 1994. *Minerals Planning Guidance Note 6: guidelines for aggregate provision in England.* London, HMSO.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
General information on Scottish mining	British Geological Survey - Scottish Office, Murchison House, West Mains Road, Edinburgh EH9 3LA, tel: 0131 667 1000
British Directory of Mines and Quarries	Director, British Geological Survey, Keyworth, Nottingham NG12 5GG, tel: 0115 936 3100
Landfill sites (Sitefile Digest)	Senior Consultants, Aspinwall & Co., Walford Manor, Baschurch, Shrewsbury SY4 2HH, tel: 01939 261144
Waste regulation	*SEPA West Region HQ, East Kilbride, tel: 01355 238181
Information on quarries and landfill sites	*SNH, RASD, Edinburgh, tel: 0131 554 9797
Local plans (including minerals planning)	*Unitary authorities

*Starred contact addresses are given in full in the Appendix.

9.4 Marine aggregate extraction, dredging and solid waste disposal at sea

C.A. Crumpton & M.J. Goodwin

9.4.1 Introduction

Sand and gravel on the sea bed are important sources of industrial aggregate for concrete production, road construction, building and, increasingly, for beach replenishment and soft coastal defences. The national demand for aggregate from all sources increased steadily during the 1980s, and marine aggregates satisfy an increasing proportion of the national requirement - 15% in 1992 (Crown Estate 1995). 26.1 million tonnes were dredged in Britain in 1995 under licence from the Crown Estate (Crown Estate 1996). The main market is in the south-east of England. Approximately 6.8 million tonnes of aggregate were dredged in Great Britain but exported to landing ports abroad.

There is currently no commercial extraction of aggregate in this region. No aggregate was extracted under licence from the Crown Estate in Scottish waters or landed in Scottish ports in 1993 (Crown Estate 1995). Generally, prospecting for sand and gravel deposits in Scotland's waters has been unpromising, with only limited expoitable reserves being located, although some good quality gravels in shallow waters have been reported from reconnaissance surveys. Also, there is a lack of local demand for marine-based resources, local requirements being adequately met from land-based supplies (see also section 9.3). British Geological Survey sea-bed sediment sheets give an overview of potential resources, but in the absence of detailed company prospecting, these have not been verified (see also section 2.2).

Navigational dredging is of two types: capital dredging and maintenance dredging. Capital dredging refers to the one-off removal of sediment, chiefly when deepening shipping channels and during the construction of new dock facilities. Thereafter, maintenance dredging is the regular dredging of existing ports and their approaches to maintain safe navigation.

Most dredged material, which can range in composition from silts to boulder clay and rock, is deposited at sea, although it is also used for land-claim and increasingly for beach recharge. Since 1988 there have been fluctuations in the wet tonnage of dredged material deposited in the seas off Scotland, from 2,109,114 tonnes in 1990 to 4,026,861 tonnes in 1992 and back down to 2,025,525 tonnes in 1993 (MAFF 1995). The total quantity of dredged material deposited in the region in 1994 (250,525 tonnes) constituted 0.6 % of the total dredged material deposited at offshore sites in the UK in 1994 (35,962,835 tonnes) (Table 9.4.1).

No sites are licensed for the disposal of solid industrial waste in Scottish waters. Other material deposited at sea under licence from the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) includes sewage sludge. The UK produces some 1.1 million tonnes dry solids (tds) of sewage sludge annually and disposes of approximately 300,000 tds in the sea. Sewage sludge has been disposed of at sea since the early 1900s and in 1994 some 1,603,000 tonnes were deposited at one site in this region: off Garroch Head in the Firth of Clyde. Disposal from ships in the Firths of Forth and Clyde currently accounts for 75% of Scotland's sewage sludge disposal, but this will be phased out by the end of 1998 under the Urban Waste Water Treatment Directive (91/271/EEC). UK sewage sludge production is set to increase dramatically over the next decade, with predicted increases to 3.3 million tds by 2006: this will have to be disposed of on land, by incineration or landfilling.

9.4.2 Important locations

Table 9.4.2 lists the marine sites in the region licensed for the disposal of dredged material and sewage sludge in 1994 (Map 9.4.1) and the quantities of material disposed of at

Table 9.4.1 Dredged material licensed and disposed of at sea in 1994

	Licences issued	*Sites under licence*	*Sites used*	*Tonnes licensed*	*Wet tonnage deposited*
Region 14	6	4	3	690,000	250,525
Scotland	23	28	22	3,643,250	1,822,053
N. Ireland	5	8	5	113,200	91,314
England and Wales	106	84	71	53,087,009	34,049,468
UK	***134***	***120***	***98***	***56,843,459***	***35,962,835***

Source: MAFF (pers. comm.). Note: licences may commence at any time and generally last for one year.

Table 9.4.2 Dredged material and sewage sludge disposed of at licensed sites in the region in 1994

Site name	*MAFF code**	*Dredging waste type*	*Depth (m)*	*Distance from coast (km)*	*Source of dredgings*	*Wet tonnage deposited*
Ayr Bay	MA050	Maintenance	30	4.6	Ayr and Troon	26,210
Cloch Point	MA021	Maintenance	50	1.5	Upper Clyde	222,116
Garroch Head	MA018	Sewage sludge	80	6.0	n/a	1,603,000
Birch Point	MA019	Maintenance	150	6.6	Firth of Clyde	2,199
Region 14						***1,853,525***

Source: MAFF, SOAEFD. Key: *shown on Map 9.4.1; n/a = not applicable.

each site. A number of additional sites have been used in previous years for dredge spoil, adjacent to ports such as Girvan and Hunterston.

Sites at which significant maintenance dredgiong occurs are listed in Table 9.4.3. The major sites of navigational dredging in the region are at Ayr and in the Clyde Estuary, which must be regularly dredged to allow deep ships to navigate. Activity on the Clyde has declined, but it is still one of the major UK ports.

Table 9.4.3 Locations in the region where significant maintenance dredging occurs (1994)

Location	*Volume dredged (m^3)*
Ayr	16,679
Clyde Ports	127,242
Scotstoun Yard, River Clyde	21,771

Source: SOAEFD

9.4.3 Management and issues

Marine sand and gravel are extracted by commercial mineral companies under licence from the Crown Estate. Aggregates from terrestrial sources are insufficient to meet UK demand (Doody *et al.* 1993), and dredging for marine aggregates tends to arouse less controversy than terrestrial extraction. So Government policy for the provision of aggregates, formulated in 1982 and 1989, has encouraged marine extraction of sand and gravel. The government promotes environmentally sustainable coastal defences, and, as a result, the use of sand and gravel for beach recharge is predicted to grow substantially (NERC undated). The Scottish Office is currently considering changing the system whereby approval is given for the issuing of licences for aggregate extraction. The current system involves obtaining a favourable 'Government View', through a non-statutory analysis and consultation process co-ordinated by the Scottish Office (Crown Estate 1994). A statutory system of licensing based on procedures set out in the Town and Country Planning Act 1990 is proposed for the future.

The primary legislation in force to control the disposal of solid waste, including dredged material, at sea in the UK is the Food and Environmental Protection Act (1985) (Deposition at Sea and in Intertidal Areas). In this region, licences to deposit solid wastes, including sewage sludge and dredged material, at sea are issued by the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) under that Act. Each licence is subject to certain conditions, which have become more stringent in the last few years. The Oslo Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft and the London Convention on the Dumping of Wastes at Sea also include within their scope disposal of solid wastes and dredged material at sea.

The main effect of the disposal of dredged material is blanketing of the sea bed, burying benthic flora and fauna and preventing respiration and feeding. Other impacts may include the elevation of metal concentrations originating from the deposited sediment. Localised increases in the turbidity of the water column may temporarily interfere with fish migration. Changes in sediment particle size can result in changes in benthic flora and fauna which, while not damaging in themselves, may affect the distribution of higher animals by altering the food chain. Shallows over banks of sediment can also be created, which could be a navigation hazard (Irish Sea Study Group 1990).

Map 9.4.1 Main licensed marine sites for disposal of dredged material and sewage sludge. Numbers refer to Table 9.4.2. Source: SOAEFD.

Navigational dredging is the responsibility of individual harbour authorities and is carried out as required, although (as already discussed) a licence from SOAEFD is required for the disposal of dredged material offshore. Because of the perceived negative environmental impacts of disposing of material at sea, dredged sediment is increasingly being used for landfill or beach recharge.

9.4.4 Information sources used

The statistics on marine aggregate extraction relate to royalty returns to the Crown Estate (as owners of the foreshore and sea bed) for 1994. Information on navigational dredging was obtained from the Nature Conservancy Council's 1991 Estuaries Review (Davidson *et al.* 1991) and from individual harbour commissions. Data on the disposal of dredged material and sewage sludge were provided by SOAEFD and MAFF. MAFF's (1995) report on the aquatic environment gives details of the effects of the disposal of dredged material and other kinds of waste off the region's shores.

9.4.5 Acknowledgements

Thanks to Derek Saward and Laura Goodwin (SOAEFD Marine Laboratory), Martyn Cox (The Crown Estate) and G. Singleton (British Marine Aggregate Producers Association) for comments on the draft. Dr C. Vivian (MAFF Fisheries Laboratory, Burnham-on-Crouch) provided information on waste disposal at sea.

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Pullen, S. Undated. *Dumping of dredged spoils from ports: contamination, pollution control*. Godalming, World Wide Fund for Nature.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Offshore geoscience data including 1:250,000 maps of geology of coastline	Director, British Geological Survey, Keyworth, Nottingham NG12 5GG, tel: 01602 363100
Marine aggregate extraction	The Crown Estate, 10 Charlotte Square, Edinburgh EH2 4DR, tel: 0131 226 7241
Licensing of disposal at sea	*SOAEFD, Edinburgh, tel: 0131 556 8400
Marine dredging and disposal of sewage and dredged material; scientific assessments of dredging and waste disposal	*SOAEFD Marine Laboratory, Aberdeen, tel: 01224 876544
Marine aggregate extraction: conservation issues	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Marine aggregate extraction	Secretary, British Marine Aggregate Producers Association (BMAPA), 156 Buckingham Palace Road, London SW1 9TR, tel: 0171 730 8194
Marine resource management (Managing Agents Offshore for The Crown Estate)	Technical Manager, Posford Duvivier, Eastchester House, Harlands Road, Haywards Heath, West Sussex RH16 1PG, tel: 01444 458551
Database of licensed disposal operations at sea	Head of Laboratory, MAFF Directorate of Fisheries Research, Fisheries Laboratory, Remembrance Avenue, Burnham-on-Crouch, Essex CM0 8HA, tel: 01621 782658
Sand and gravel extraction	Director, Sand and Gravel Association (SAGA), 1 Bramber Court, 2 Bramber Road, London W14 9PB, tel: 0171 381 8778
Disposal of dredged material at sea - international	The Oslo and Paris Commissions, New Court, 48 Carey Street, London WC2A 2JE, tel: 0171 242 9927
Disposal of dredged material at sea - international	London Convention Secretariat, International Maritime Organisation (IMO), 4 Albert Embankment, London SE1 7SR, tel: 0171 735 7611

*Starred contact addresses are given in full in the Appendix.

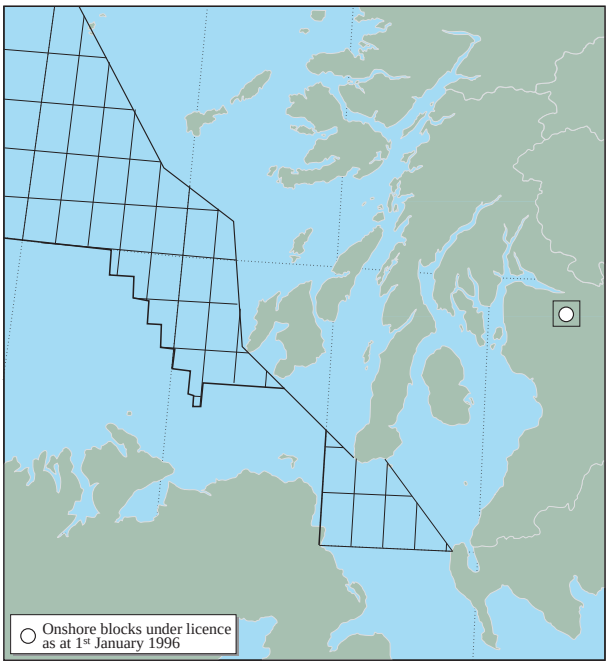
9.5 Oil and gas developments

C.A. Crumpton & M.J. Goodwin

9.5.1 Introduction

There is little oil and gas related activity in this region, despite the current interest from oil companies in areas off the north and west coasts of Scotland. Currently the only oil-related activity in the region is associated with the onshore licence near the Clyde Estuary, held by Law Holdings (Map 9.5.1). Blocks in the region were considered in the 16th Offshore Round of oil and gas licensing, and in the 7th Landward Round, but none was licensed. The 17th Offshore Round has recently been completed: again no blocks were licensed in this region.

Total UK Continental Shelf (UKCS) oil and gas production in 1995 was a record of some 220 million tonnes of oil equivalent and accounted for about 2% of Gross Domestic Product (DTI 1996). A total of 98 exploration and appraisal wells were drilled in the UK continental shelf in 1995 and seven significant discoveries were announced, none of them in this region.



Map 9.5.1 Oil and gas offshore licensing blocks and onshore field under licence. Source: DTI. © Crown copyright.

9.5.2 Important locations

There was no drilling of exploration or appraisal wells in this region in 1995 and no offshore blocks were under licence for production. Map 9.5.2 shows the sedimentary basins around the UK Continental Shelf regarded as being suitable areas for oil and gas exploration.

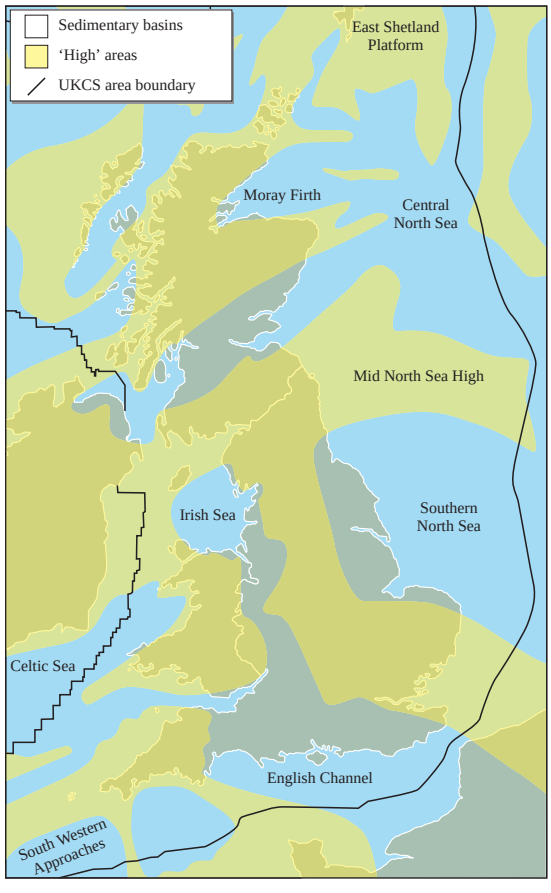
BP has an oil terminal at Finnart, Loch Long. Former oil rig construction yards at Ardyne Point and Portavadie in Cowal could be reactivated if oil or gas is found off the west coast of Scotland in commercial quantities.

9.5.3 Management and issues

Licences are awarded by the Department of Trade and Industry, in consultation with a wide range of organisations, including government departments, environmental agencies, local groups, local authorities, fishermen's federations and other non-governmental organisations. A range of conditions may be applied, linked to the environmental sensitivity of the block. Davies & Wilson (1995) describe the conditions applied to the 16th Round.

In July 1995 the 7th Landward Round for oil and gas exploration was announced, under which applications were invited for licences covering both land and certain inshore 'watery areas', which include most of the coastal waters of this region. Results were announced in March 1996, when 74 blocks were awarded, but none in this region.

The range of potential issues for nature conservation is wide. The potential for oil spills to harm birds and marine and coastal wildlife is well known, especially in sheltered embayments and estuaries (see also sections 5.10, 5.11 and 5.12). Spills may result from exploration and production procedures or from oil transportation. Concern has also been expressed about the potential risk to seals and dolphins from oil-related developments. There is a small risk of injury to seals in the immediate vicinity of a vessel conducting



Map 9.5.2 UK Continental Shelf (UKCS) sedimentary basins and structural 'highs'. Source: DTI. © Crown copyright.

seismic surveys (see also sections 5.14.3 and 5.15.3). In the case of cetaceans, results obtained during seismic surveys by Marathon Oil UK Ltd and BHP Petroleum Ltd in the Irish Sea were inconclusive, and experimental evidence for disturbance arising from seismic activities remains lacking (Evans *et al*. 1993). Nevertheless recent studies indicate that cetaceans may be disturbed by seismic surveying, as they are sighted less frequently, either acoustically or visually, during seismic surveys (Goold 1996). Best practice environmental management guidance for carrying out seismic surveys in areas where marine mammals occur, without compromising safety or operational viability, is among environmental issues considered in UKOOA's *Environmental guidelines for exploration operations in near-shore and sensitive areas* (UKOOA 1994).

9.5.4 Information sources used

Data included in this section come from the DTI's 'Brown Book' (DTI 1996), which should be referred to for further explanation. It is updated annually.

9.5.5 Acknowledgements

Thanks go to Mark Tasker (JNCC) for comments on an early draft of the text.

9.5.6 Further sources of information

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C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Oil and gas developments	Public Relations Officer, Department of Trade and Industry, 1 Palace Street, London SW1E 5HE, tel: 0171 215 5000
Oil and gas industry issues	Public Relations Officer, UK Offshore Operators Association, 3 Hans Crescent, London SW1X 0LN, tel: 0171 589 5255
Oil transportation and terminals	Technical Adviser, Oil Companies International Marine Forum (OCIMF), 15th Floor, 96 Victoria Street, London SW1E 5JW, tel: 0171 828 7966
General information on the oil industry	Librarian, Institute of Petroleum Library and Information Service, 61 New Cavendish Street, London W1M 8AR, tel: 0171 467 7100
Gas industry	Director and Secretary, Society of British Gas Industries, 36 Holly Walk, Leamington Spa, Warwickshire CV32 4LY, tel: 01926 334357
Oil spillages: government body carrying out pollution control at sea	Marine Pollution Control Unit, Spring Place, 105 Commercial Road, Southampton SO15 1EG, tel: 01703 329484
Response (privately-funded) to oil spills worldwide	Oil Spill Response, Oil Spill Service Centre, Lower William St., Northam, Southampton SO14 5QE, tel: 01703 331551
Research into oil pollution	Oil Pollution Research Unit, Fort Popton, Angle, Pembroke, Dyfed SA71 5AD, tel: 01646 641404
Advice on oil pollution strategies worldwide	International Tanker Owner's Pollution Federation Ltd, Staple Hall, Stonehouse Court, 87-90 Houndsditch, London EC3A 7AX, tel: 0171 621 1255
Guidelines on the environmental protection of offshore waters	*SOAEFD Marine Laboratory, Aberdeen, tel: 01224 876544
Advice on oil spill control equipment	British Oil Spill Control Association (BOSCA), 4th Floor, 30 Great Guildford Street, London SE1 0HS, tel: 0171 928 9199
Information on the environmental effects of exploration and production	*WWF - UK, Godalming, tel: 01483 426444

*Starred contact addresses are given in full in the Appendix.

9.6 Water quality and effluent discharges

C.A. Crumpton & M.J. Goodwin

9.6.1 Introduction

This section summarises information about water quality and effluent discharge from a number of sources. Sewage sludge disposal is covered in section 9.4. Full interpretation of the information base on water quality and pollutants is complex and beyond the scope of this book.

Waste products and effluents containing contaminants reach the marine environment in this region in a number of ways: sewage, agricultural run-off and trade effluents are discharged from outfalls into rivers or directly into the sea, and contaminants can reach the sea by airborne means, for example aerosols and rain. Industrial pollutants can enter the marine environment through licensed discharge or by accidental release. Discharges occurring outside the region may also have a detrimental effect on coastal water quality.

In this region the area with historically the worst record of pollution is the Clyde Estuary, which receives effluents from about half of Scotland's population and industry and was for a long period one of the most polluted tidal waters in Britain (Haig 1986). Discharges of effluent to extensive stretches of the Clyde Sea coast remained completely uncontrolled until 1984, but since then improvements, particularly in sewage treatment, have led to a marked improvement in water quality in the Clyde Estuary. Similar improvements have been achieved in the region of Irvine Bay and the Garnock Estuary. Water quality in the rest of the region is generally good. The Scottish Environment Protection Agency (SEPA) carries out a five-yearly water quality survey (Scottish Office 1992). The 1990-1995 survey showed that 88% of coastal and 55% of estuarine waters in the region were of 'excellent' or 'good' quality. Only 4% of coastal waters and 16% of estuarine waters were classed as 'unsatisfactory' or 'polluted' (SEPA pers. comm.).

There are 464 EC-identified Bathing Waters around the UK coast (those that are tested for certain standards of quality under the EC Bathing Water Directive (76/160/EEC)). Despite results having improved between 1994 and 1995, the quality of bathing waters in the region is well below the Scottish and UK average (Table 9.6.1). The four identified bathing waters in the region that failed to reach the mandatory standards in 1995 were the only failures in Scotland that year. Overall, 1995 was the best year on record for UK bathing water quality, with 89% complying with EU standards, compared with 82% in 1994 and 80% in 1993.

Table 9.6.1 Bathing waters survey, 1994 & 1995

	Pass		*Fail*		*Total*	
	1994	*1995*	*1994*	*1995*	*1994*	*1995*
Region 14	***1***	***3***	***6***	***4***	***7***	***7***
England & Wales	347	380	72	45	419	425
Scotland	16	19	7	4	23	23
N. Ireland	15	15	1	1	16	16
UK	376	413	81	51	457	464

Source: DoE (pers. comm.); Scottish Office (pers. comm.); SEPA (pers. comm.). Note: pass denotes compliance with Bathing Water Directive (76/160/EEC): Coliform standards.

In 1994, overall beach quality in the region showed a marked deterioration compared with previous years, according to Coastwatch UK (1994) (Table 9.6.2). Sewage-related debris is a persistent problem in the region, with an average of 149 sanitary items per kilometre found on the region's beaches during the survey (Coastwatch 1994).

Table 9.6.2 Beach quality in the region* compared with national standards in 1993/1994

Area	*% of beaches rates as:*					
	excellent		*moderate*		*polluted*	
	1993	**1994**	**1993**	**1994**	**1993**	**1994**
Region 14*	***14***	***5***	***36***	***22***	***50***	***73***
Scotland	7	7	37	37	56	56
Great Britain	8	8	42	42	50	50

Source: Coastwatch UK (1994). Key: *figures relate to the former Strathclyde Region; figures for Region 14 alone were not available.

There are 162 Tidy Britain Group Seaside Award beaches in Britain, twelve of which are in Scotland, including one in this region (Tidy Britain Group 1995). There are fifteen Blue Flag beaches in Britain, although none in Scotland.

9.6.2 Important locations

All sewage outfalls serving significant populations in this region are listed in Table 9.6.3 and shown on Map 9.6.1.

Map 9.6.1 Consented sewage outfalls listed in Table 9.6.3. Note: a single symbol may represent more than one outfall in close proximity. Source: SEPA.

Most sewage effluent in the region enters Clyde tidal waters within the 15 km stretch between Glasgow and Erskine Bridge, although substantial amounts are also discharged to Irvine and Ayr Bays. Only the sewage discharged at Butlins Wonderwest World (Ayr), Erskine, Shieldhall and Paisley has had secondary treatment. Much of the rest has had no treatment or only preliminary treatment.

Table 9.6.4 lists the larger trade effluent outfalls in the region, i.e. those with a consented daily effluent flow in excess of 1,000 m^3 per day. These are shown on Map 9.6.2. In Region 14, more than 97% of trade effluent from these larger outfalls is of cooling water from the nuclear power station at Hunterston. Most of the remainder comes from distilleries and is untreated.

The seven identified EC Bathing Waters in the region are located at Girvan, Turnberry, Ayr South Beach, Prestwick, Troon South Beach, Irvine Gailes New Town and Saltcoats/Ardrossan South Beach (Map 9.6.3). Of these, only Prestwick, Troon South Beach and Irvine Gailes New Town passed mandatory standards in 1995 (only Troon South passed in 1994). Troon South is also a Tidy Britain Group Seaside Award beach.

Table 9.6.3 Sewage outfalls to tidal waters in the region serving a population equivalent to >1,000

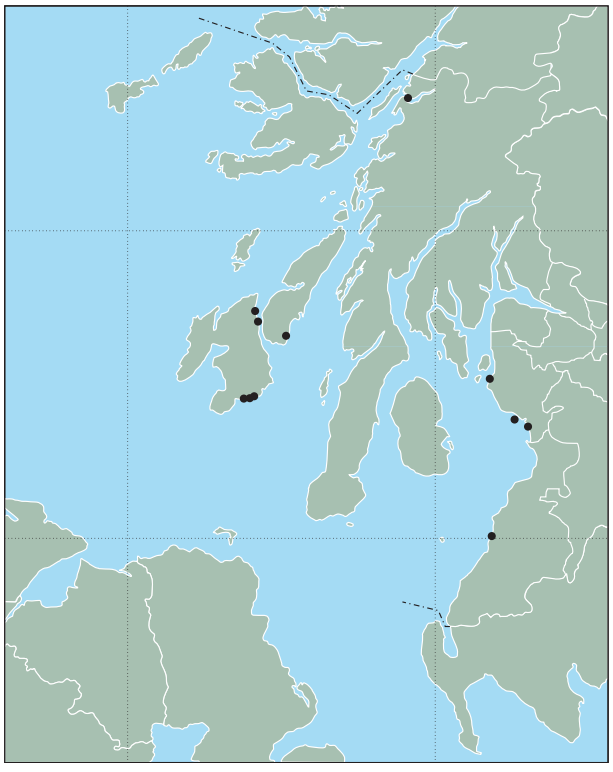
Location of outfall	*Grid ref.*	*Population equivalent*	*Type of treatment*	*Maximum daily dry weather flow (m^3)*
Girvan (Grangestone)	NX180982	8,000	Screening	4,560
Butlins Wonderwest World (Ayr)	NS295189	n/a	Secondary	1,152
Ayr (Greenan)	NS314198	12,700	Comminution	3,715
Ayr (South Beach)	NS331221	16,200	Barminutes	4,834
Ayr (Euchar Rock)	NS335231	10,700	None	3,629
Ayr (Newton)	NS341239	13,300	None	5,961
Irvine Valley sewer	NS303352	217,000	Preliminary	69,120
Garnock Valley sewer	NS267392	210,000	Preliminary	35,000
Largs	NS200605	12,000	Maceration & screening	2,246
Ardgowan	NS203725	50,942	Comminution	4,560
Greenock Long Sea Outfall	NS253782	20,000	Preliminary	n/a
Greenock (Brynner Street)	NS283762	1,920	None	n/a
Greenock Road	NS289758	6,200	None	n/a
Greenock (Inchgreen Street)	NS311753	6,830	None	n/a
Port Glasgow (Anderson Street)	NS322748	4,060	None	n/a
Port Glasgow (Caledonia St.)	NS331744	1,050	None	n/a
Port Glasgow (Fyfe Park Road)	NS334732	28,638	None	n/a
Port Glasgow (Woodhall))	NS347740	1,610	Primary	n/a
Erskine	NS493695	22,509	Secondary	2,093
Paisley	NS485661	285,753	Secondary	220,000
Shieldhall	NS537660	787,216	Secondary	220,000
Dalmuir	NS477708	1,146,600	Primary	214,000
Old Kilpatrick	NS459730	2,379	Primary	n/a
Bowling	NS444735	8,000	Primary	n/a
Dumbarton East	NS407745	26,334	Primary	9,940
Ardoch	NS370747	36,330	Primary	20,050
Cardross	NS345774	1,849	Primary	n/a
Helensburgh (Ardmore)	NS317805	14,463	Preliminary	6,590
Garelochhead No. 1	NS238909	1,325	Primary	n/a
Rothesay	NS107652	10,800	None	6,825
Campbeltown	NR748214	14,000	None	1,800
Oban	NM849306	13,278	Screening	2,140
Bowmore	NR308603	12,000	None	n/a

Source: Scottish Office (pers. comm.), SEPA (pers. comm.). Key: n/a = not available.

Table 9.6.4 Trade effluent outfalls with maximum daily flow >1,000 m^3

Location of outfall	*Grid ref.*	*Type of treatment*	*Maximum daily flow (m^3)*
Kelco, Girvan	NS198025	None	25,000
Smithkline Beecham, Irvine	NS304357	Biological plant	5,600
ICI Explosives, Ardeer	NS270369	Individual process treatment	22,737
Hunterston B Power Station	NS174517	None (cooling water)	2,500,000
Kelco, Barcaldine	NM962422	None	5,350
Isle of Jura distillery	NR527671	None	2,300
Ardbeg distillery	NR416461	None	1,060
Lagavulin distillery	NR404457	None	1,843
Laphroaig distillery	NR388452	None	1,910
Bunnahabhain distillery	NR420732	None	1,533
Caol Ila distillery	NR429701	None	2,693

Source: SEPA (pers. comm.)



Map 9.6.2 Consented trade effluent outfalls listed in Table 9.6.4. Source: SEPA.

Map 9.6.3 EC identified bathing waters in the region. Source: Scottish Office.

9.6.3 Management and issues

Levels of pollution in the Clyde have dropped substantially since the 1970s (Haig 1986), but problems remain with the production of increasingly complex contaminants from sources such as the carpet, chemicals and pharmaceuticals industries.

Tides, the prevailing wind and the physical characteristics of the sea lochs means that many act as accumulation points for flotsam and jetsam, litter and other waste. The problem has become so severe in Loch Long that the local authorities and enterprise companies are spending £1.1 million on an environmental enhancement scheme, a key element of which is to enable such waste and litter to be collected more efficiently. Eutrophication leading to plankton and algal blooms is another persistent problem, particularly in Loch Long and Loch Goil.

A range of legislation is in force to control discharges to the aquatic environment. The primary statute in Scotland is the Control of Pollution Act 1974. Discharge consents from 'prescribed processes', including trade effluent and discharges from nuclear installations, are authorised by SEPA under the Environmental Protection Act 1990. Environmental Quality Standards (EQSs) for many of these prescribed substances are specified in the Environmental Protection (Prescribed Processes etc.) Regulation 1991. The EQSs may be set by the EU (under the Dangerous Substances Directive 76/464/EEC and Framework Directive 86/280/EEC) or nationally (DoE Circular 7/89, March 1989). The reports of the former regional River Purification Boards (RPBs) should be referred to for further details on the regional and national situation.

From early 1993, all authorised disposal of liquid industrial waste directly into the sea around the UK ceased, in accordance with the Ministerial Declarations of the 2nd and 3rd North Sea Conferences. Under the Urban Waste Water Treatment Directive (91/271/EEC), except in 'high natural dispersion areas', all significant sewage discharges to coastal waters, where the outfalls serve populations >10,000 (roughly equivalent to 1,800 m^3 per day), and to estuaries, where they serve populations >2,000 (roughly 360 m^3 per day), will require at least secondary treatment, to be phased in by 2005. However, some outfalls will be permitted to discharge sewage with a minimum of primary treatment, provided that comprehensive studies, currently being carried out by the relevant water companies, show that there will be no adverse effects on the environment. In this region 'high natural dispersion areas' are at Dunoon, Ardgowan, Rothesay, Campbeltown and Oban, with provisional 'high natural dispersion areas' at Ayr Bay and Irvine Bay.

The whole of this region is covered by the spillage action scheme 'Strathspill', which deals with beach or offshore pollution caused by oil or other hazardous substances (SEPA pers. comm.).

SEPA became operational in April 1996. Its activities are grouped under two broad headings: pollution prevention and control (including waste regulation and water quality); and water management. However, there will be a strong link between the two in order to ensure continuing integrity of estuarine and coastal management.

There are currently several schemes used for assessing the quality of beaches and their waters in relation to waste disposal. First there is the EC Bathing Water Directive (76/160/EEC), with its associated monitoring of identified bathing waters for levels of coliforms (bacteria that indicate sewage presence). Monitoring is now carried out by SEPA and beaches are tested regularly to assess whether they have

met the 'mandatory' or more stringent 'guideline' standards. Any measures required to improve the quality of the waters are a matter for the dischargers of industrial effluent or the local councils as sewerage authorities. Under the terms of the Environmental Protection Act 1990, the quality of bathing beaches is also the responsibility of local councils.

The European Blue Flag Award and the Tidy Britain Group Seaside Award schemes are for beaches that meet minimum standards of beach and water quality, as well as certain land based criteria. The latter scheme is designed to complement the former, but with less stringent standards. Finally there are the annual litter surveys of Coastwatch UK and Beachwatch, both of which employ volunteers to survey lengths of coastline for litter and other signs of pollution. Coastwatch UK is organised by Farnborough College of Technology and Beachwatch by Reader's Digest and the Marine Conservation Society.

9.6.4 Information sources used

Monitoring of water quality in the region is carried out by SEPA and SOAEFD, with SEPA concerned mainly with point sources of contamination from outfalls in the nearshore environment. The interests of SOAEFD lie in the disposal of sewage sludge and dredge spoil further offshore, and their possible effects on fisheries, and they carry out a wide range of sampling work associated with this. SEPA and SOAEFD contribute to the National Marine Monitoring Plan, which monitors a wide range of listed chemicals in water, biota and sediments, at a range of frequencies which decreases from the estuarine to the offshore environment.

SEPA carry out sampling cruises whose frequency depends on the scale of the perceived problem: parameters such as dissolved oxygen temperature, salinity and nutrient levels are measured up to once per month in the Clyde Estuary and six times per year in the 'northern sea lochs', such as Loch Long and the Gare Loch, and also to the south around Ayr and Irvine, but less frequently around Bute and other parts of the Firth of Clyde. In the north of the region water is sampled around fish farms (which must also carry out their own monitoring) and in locations with a perceived water quality problem, such as Oban Bay, or where there are trade outfalls. SEPA also samples sea-bed sediments and sea-bed fauna and flora (SEPA pers. comm.).

The Department of the Environment (DoE) Environmental Protection Statistics Division publishes an annual *Digest of environmental protection and water statistics* (DoE 1995), which provides detailed national statistics on aspects of environmental protection, including coastal and marine waters, radioactivity, waste and recycling, and wildlife. MAFF (Directorate of Fisheries Research, Lowestoft) publishes two annual Aquatic Environment Monitoring Reports (e.g. MAFF 1994; MAFF 1995). One reports on radioactivity in the marine environment, the other deals with non-radioactive pollution and waste disposal operations at sea.

Schemes such as the Tidy Britain Group Seaside Award and the European Blue Flag monitor beaches during the year previous to the publication of their results. Monitoring of the EC Bathing Waters and other beaches under schemes such as Coastwatch UK and Beachwatch take place over one or two days. The results may therefore be skewed by heavy rain or localised effects at the time of survey. Coastwatch UK and Beachwatch do not sample the whole coastline in their region, owing to a shortage of volunteers. The results may therefore sometimes be unrepresentative because of the small sample size. In the 1994 Coastwatch survey 73 km of the coast of this region were sampled.

9.6.5 Acknowledgements

Thanks are due to Andrew Haig and Dr Kevin Milner (SEPA West Region) and Anthony Payne (Argyll & Bute Council) for additional information and helpful comments.

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Scottish Office. 1992. *Water quality survey of Scotland*. Edinburgh, Scottish Office Environment Department.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Discharge consents and database, coastal water quality and sewage treatment	*SEPA West Region HQ, East Kilbride, tel: 01355 238181
Environmental research and scientific assessment of water quality in Scotland	*SOAEFD Marine Laboratory, Aberdeen, tel: 01224 876544
Information on water quality in Scotland	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Seaside Award and European Blue Flag beaches	Tidy Britain Group, Lion House, 26 Muspole St, Norwich NR3 1DJ, tel: 01603 762888
Beachwatch	*Marine Conservation Society, Ross-on-Wye, tel: 01989 66017
Coastwatch UK	Project Officer, Coastwatch UK, Farnborough College of Technology, Boundary Road, Farnborough, Hampshire GU14 6SB, tel: 01252 377503
Aquatic environmental research and monitoring related to water quality and waste disposal at sea: national issues	Head of Laboratory, MAFF Directorate of Fisheries Research, Fisheries Laboratory, Remembrance Avenue, Burnham-on-Crouch, Essex CM0 8HA, tel: 01621 782658

*Starred contact addresses are given in full in the Appendix.

The Firth of Clyde is one of the most intensively used areas for coastal recreation in Scotland and is very popular with yachtsmen. Facilities include marinas, yacht moorings, dinghy parks, launching slips and water sports centres. Photo: Andi Robertson, Scottish Natural Heritage.

9.7 Leisure and tourism

M.J. Dunbar & S.L. Fowler

9.7.1 Introduction

Most of the region's tourism and leisure infrastructure is concentrated to the south and east of the Firth of Clyde, one of the most intensively-used areas for coastal recreation in Scotland. On the outer reaches of the firth there are numerous sandy beaches, where resorts, many of which still retain their traditional character, developed rapidly in the 19th century to serve the growing population of Glasgow. Infrastructure for tourism in the northern part of the region is confined to a small number of locations such as Inveraray, Oban, Mull and Iona, leaving the rest of the coast largely undeveloped. Many areas here have no tourist infrastructure, or just one camp site or a picnic site: the major attractions are the scenery, wildlife and historical and archaeological features.

Many kinds of land-based leisure activities take place along the coast, including walking, camping, golf, beach recreation, bird watching, horse riding, angling and, in a few locations, the use of motorised vehicles on beaches and dunes. Wildfowling - a traditional coastal activity in the region - is now recreational, although formerly it was commercially practised for food. The most important examples of land-based leisure infrastructure on the coast are golf courses, caravan parks and campsites, rural car parks (which provide the access points necessary for most land and water-based leisure activities) and leisure centres or amusement parks. These tend to be concentrated near centres of population and the main seaside towns.

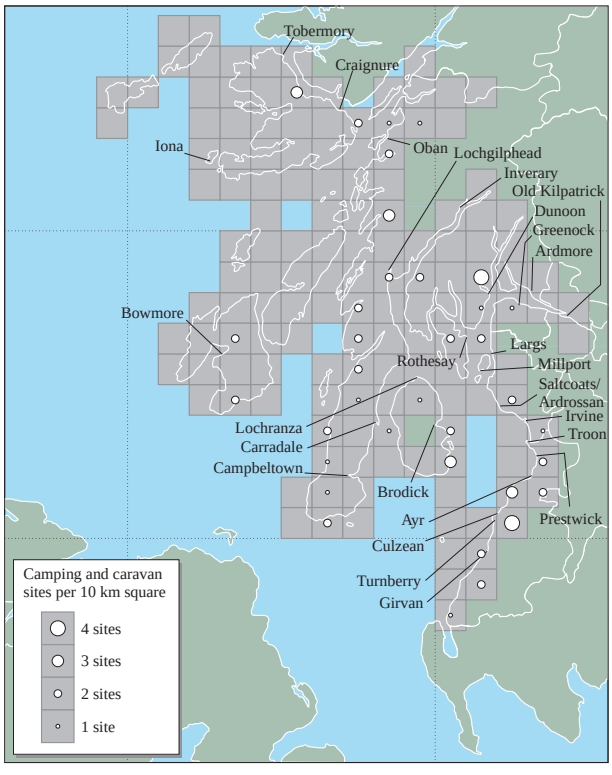
Water-based activities undertaken along the coast include sailing and boating, boat trips (including whale and dolphin watching), sea angling, swimming, surfing, canoeing, sail boarding and scuba diving. This region is very popular with yachtsmen. Infrastructure developments for water-based leisure in the region include marinas, yacht moorings, dinghy parks, launching slips and water sports centres. These are concentrated in the sheltered waters of the Firth of Clyde and near centres of population. Limited facilities (primarily recreational craft moorings) are also found in most of the small fishing ports and harbours around the coastline.

9.7.2 Important locations

The Scottish Sports Council's Countryside Sports Database, currently under development, held 883 records of sporting activities taking place within 10 km of the coast of this region, as at January 1996 (Table 9.7.1; Map 9.7.1)). The greatest numbers of records are for water sports, with sub aqua, angling, canoeing, windsurfing, sailing and power boating all well represented. For land-based sports, golf, orienteering, riding and clay target shooting are the most frequent. A single site may have several records listed on the database if several sports take place there; data gathering for all sports on a consistent basis is not yet complete.

The main land-based leisure sites are listed in Table 9.7.2. There are 34 camping sites and 49 caravan parks located in the 10 km squares adjacent to the coast of the region (Map 9.7.2), and 45 coastal golf courses (Map 9.7.3). Some top links courses are located in the region, on the Firth of Clyde between Turnberry and Glasgow.

Holiday camps and parks can occupy significant areas of land, comprising chalets and mobile homes with centralised supporting facilities such as bars, entertainment complexes and indoor swimming pools. There is a holiday camp at Ayr and a holiday park at Dunoon, but in general such intensive tourist development is not typical of this region. There are popular beaches at Ayr, Troon, Irvine Bay, Fairlie,



Map 9.7.1 Numbers of records of land- and water-based sports held on the Countryside Sports Database, by 10 km square. Source: Scottish Sports Council (pers. comm.).

Table 9.7.1 Records of recreational activities occurring at sites within 10 km of the coast

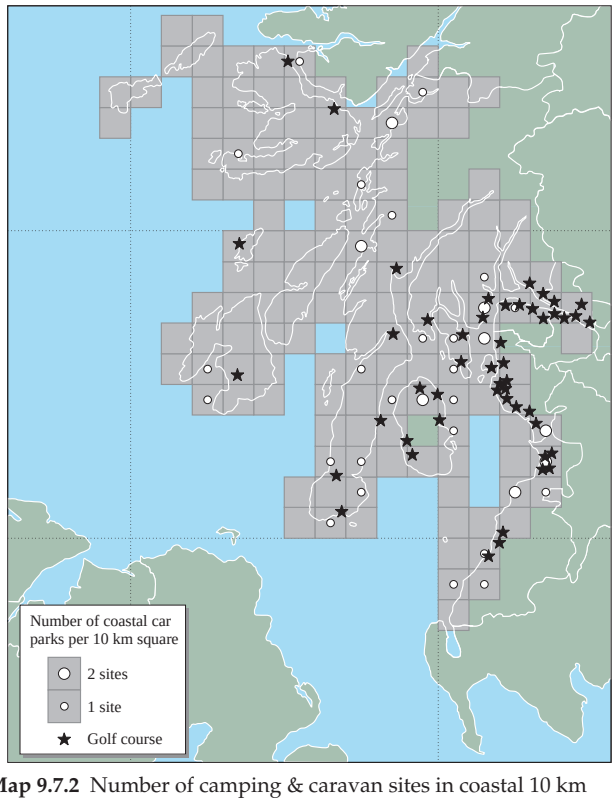
Local authority area	*No. of records*
South Ayrshire	51
North Ayrshire	116
Inverclyde	32
Renfrewshire	13
Glasgow	21
Dumbarton*	73
Argyll & Bute*	554
Others (including Stirling District around Loch Lomond, and other parts of Clyde valley)	23
Region 14	***883***

Source: Scottish Sports Council (pers. comm.). Key: *former District area; data not collated to correspond with new local authority boundaries.

Table 9.7.2 Land-based leisure and tourist facilities

Site	*Grid ref.*	*Notes*
South Ayrshire		
Girvan	NX1897	Bathing beach
Turnberry	NS2006	Championship golf course, bathing beach
Culzean	NS2209	Country Park, castle
Ayr	NS3220	Bathing beach, holiday camp, museum
Prestwick	NS3425	Bathing beach, museum
Troon	NS3131	Championship golf course, bathing beach
North Ayrshire		
Irvine	NS3137	Leisure centre, beach park, Scottish Maritime Museum, bathing beach
Saltcoats/Ardrossan	NS2342	Bathing beach, museum
Millport	NS1754	Aquarium, museum
Largs	NS2059	Vikingar (Viking centre) and indoor facilities, sports training centre
Brodick	NS0136	Museum, castle, Country Park
Lochranza	NR9350	Nature centre
Inverclyde		
Greenock	NS2776	Museum
Argyll & Bute		
Ardmore	NS3178	Nature trail
Old Kilpatrick	NS4673	Ecology Park with footpaths, nature trail and picnic site
Dunoon	NS1776	Holiday centre (chalets and central entertainment centre), golf courses
Rothesay	NS0864	Golf course
Inveraray	NN0908	Historic centres (Museum of Country Life, Inveraray Jail, castle), wildfowl park
Lochgilphead	NR8688	Golf course
Carradale	NR8037	Gardens
Campbeltown	NR7220	Golf course, museum
Oban	NM8630	Sealife Centre
Tobermory	NM5055	Tours
Craignure	NM7237	Castles, Isle of Mull railway
Iona	NM2824	Abbey

Sources: OS Landranger maps, Tourist Information Centres



Map 9.7.2 Number of camping & caravan sites in coastal 10 km squares in the region. Source: Ordnance Survey & Hamlyn (1995). © Ordnance Survey & Hamlyn.

Map 9.7.3 Locations of coastal golf courses and car parks. Source: Ordnance Survey & Hamlyn (1995). © Ordnance Survey & Hamlyn.

Skelmorlie, Wemyss Bay and Inverkip, while Arran provides more sandy beaches and rugged scenery. Bute is a popular holiday destination, with Rothesay being the largest single resort on the Clyde. Paragliding is practised from some of the hillier coastal locations, notably on the Isle of Arran.

The islands of the Hebrides support a low level of tourism, with Mull being the most developed. The many distilleries situated along the coast of the region provide further tourist attractions. 'Island hopping' is popular, using inter-island ferries, and Islay is particularly popular for bird watching and natural history rambles.

Water-based leisure locations, such as ports, marinas, harbours and anchorages, are listed in Table 9.7.3 and shown on Map 9.7.4. All the locations listed (apart from the anchorages of the islands) have sailing or watersports clubs. The River Clyde Project Group has proposed a weir on the Inner Clyde in Central Glasgow, to improve the amenity

Table 9.7.3 Important locations for water-based leisure activities

Site	*Grid ref.*	*Facilities*
South Ayrshire		
Ballantrae	NX0882	Small harbour used by yachts
Girvan	NX1898	Harbour, 25 berths
Maidens	NS2108	Small harbour used by yachts
Dunure	NS2516	Small harbour used by yachts
Ayr	NS3322	Yacht moorings, sea angling
Prestwick	NS3525	Windsurfing
Troon	NS3132	Marina 385 berths, sailing school, windsurfing
North Ayrshire		
Irvine	NS3138	Harbour, canoeing, sea angling
Saltcoats	NS2341	Harbour, sea angling
Hunterston Sands	NS1953	Canoeing
Millport	NS1754	Moorings, anchorage, major sailing school, sea angling
Largs	NS2159	Large marina (500 berths), windsurfing
Brodick	NS0237	Anchorage, diving and sea angling centres
Lamlash	NS0431	Anchorage, sea angling
Lochranza	NR9451	Anchorage, sea angling
Inverclyde		
Inverkip	NS2072	Large marina (740 berths), windsurfing
Greenock/Gourock	NS2577	Moorings
Argyll & Bute		
Bowling Basin, Bowling	NS4473	Marina with wintering berths
Rhu	NS2585	Marina (150 berths)Hunter's
Quay	NS1878	Sailing centre
Dunoon	NS1777	Sea angling
Rothesay	NS0965	Harbour and anchorage, pontoon and moorings
Tighnabruaich	NR9873	Moorings, sailing school
Ardrishaig	NR8585	Small harbour, entrance to canal
East Loch Tarbert	NR8769	Harbour with many yacht berths
Campbeltown	NR7320	Harbour with 40 yacht berths
Ardminish, Gigha	NR6548	Anchorage and moorings
Tayvallich	NR7487	Anchorage
Crinan	NR8093	Harbour, entrance to canal, canoeing
Tiree	NM0045	Windsurfing
Loch Craignish	NM8104	Moorings, anchorage
Craobh Haven	NM7907	Marina (250 berths)
Loch Melfort	NM8212	Moorings, anchorage, harbour at pier
Oban	NM8530	Moorings, anchorage, diving school, sailing and water-skiing
Craighouse	NR5366	Moorings, anchorage
Port Ellen	NR3644	Anchorage, moorings
Port Askaig	NR4369	Harbour, anchorage
Scalsaig	NR3994	Harbour, anchorage, berthage
Tobermory	NM5156	Moorings, anchorage
Craignure	NM7237	Moorings

Source: Walker (1996)

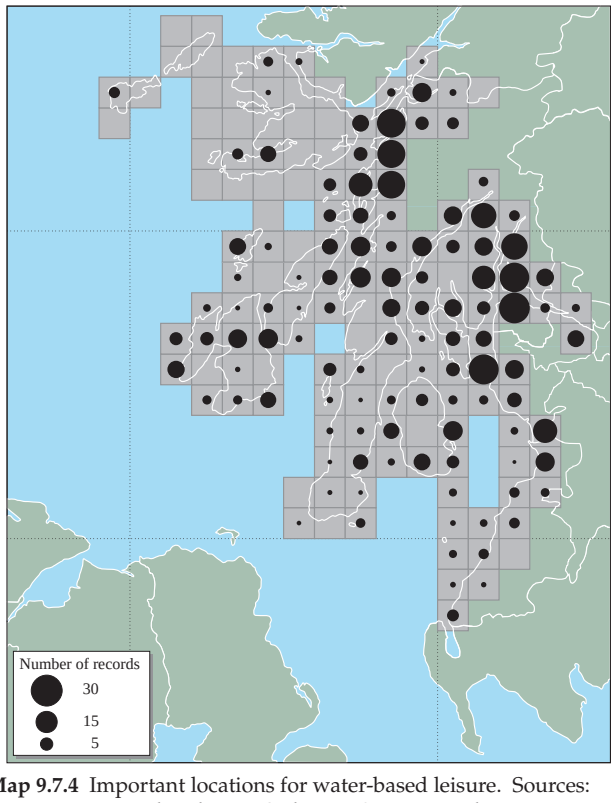
value of the waterfront area (River Clyde Project Group 1989). The beaches at Prestwick, Troon, Largs and Inverkip are popular locations for windsurfing, as is Tiree, where the 'Tiree Classic', an event of national importance, is held. Scuba diving is popular in the Clyde and on the west coast, particularly out of Oban. The Clyde has long been famous for its sea angling, and although catches have declined over the last ten years, this trend now seems to have been reversed (Bute and Cowal Tourist Board 1994). Sea angling trips are possible from many of the region's harbours, notably Ayr, Irvine, Saltcoats and Millport.

According to the JNCC's coastal database, wildfowling was being practised in 1989 on the Clyde Estuary, between Erskine and Langbank on the south side of the estuary and at Ardmore on the north side, as well as around Loch Crinan. Table 9.7.4 lists the British Association for Shooting and Conservation (BASC) affiliated wildfowling clubs in the region, some of which operate inland.

Table 9.7.4 BASC-affiliated wildfowling clubs in the region

Club name	*No. of members*
Champion Shell Rod and Gun Club	12
Tarbolton Field Sports Association	26
Clyde Base Shoot	6
Vale of Leven Wildfowlers Club	11
Ayrshire Wildfowling Association	53
Region 14	***108***

Source: the BASC (pers. comm.)



Map 9.7.4 Important locations for water-based leisure. Sources: tourist brochures, Ordnance Survey Landranger maps, RYA (1992) and D'Olivera & Featherstone (1993).

9.7.3 Management and issues

Although national planning guidance on sport and recreation has been drafted (Scottish Office 1995), it does not cover the many forms of recreation that lie outside the planning system. Furthermore, planning law specifically excludes areas below low water mark. This is significant in relation to the coast, and particularly to the firths.

Local authority policies and regional planning guidance recognise the need to conserve the natural qualities of the undeveloped coast while developing and managing the tourist and leisure industry (Scottish Office 1995). Priorities in the region include developing the range of leisure facilities that are currently available, with particular emphasis on the golfing industry, the redevelopment of redundant dockland sites, informal countryside recreation and the promotion of off-peak tourism.

The provision of recreational facilities is mainly the responsibility of local authorities. Tourism planning and policy is overseen by the Area Tourist Boards, which are coordinated by the Scottish Tourist Board and comprise elected members of local councils as well as representatives from the local business community and other interest groups. The Scottish Tourist Board is the agency responsible for marketing tourism in Scotland, with Scottish Enterprise responsible for tourist development. The Scottish Sports Council is the national body responsible for the promotion of sport and physical recreation in Scotland. Scottish Natural Heritage has a statutory duty to facilitate the enjoyment of the countryside and to promote recreation with regard to the conservation of Scotland's natural heritage.

Some of the land-based leisure developments in the area have had significant effects on coastal habitats; for example, links golf course developments on dunes have reduced the area of semi-natural vegetation at these sites. Dune systems have also been affected by car parks and campsites. Golfing organisations are becoming increasingly aware of their responsibilities for the environment. New golf course environmental management initiatives have been established within the national associations and the European Golf Association, as well as on individual sites, where conservation bodies and golf clubs are seeking to resolve existing and potential conflicts.

ASH Consulting Group (1994) has identified a number of locations where specific tourist activities and facilities have caused coastal erosion and where management to halt or reduce erosion has had to be undertaken. The list includes ten sites in the region, with case studies provided for three of these: Troon, Irvine and Lunderston Bay.

The sport of wildfowling is managed through wildfowling clubs. The representative body for sport shooting in the UK is the British Association for Shooting and Conservation (the BASC). The BASC has 19,000 wildfowling members, mostly in 200 affiliated wildfowling clubs. Targeted wildfowl species and shooting seasons are regulated through the Wildlife & Countryside Act 1981, and wildfowlers are bound by firearms legislation, principally the Firearms Act 1968 (as amended). The open season for coastal wildfowling varies from species to species, but mainly occurs between 1 September to 20 February. During periods of severe winter weather, disturbance to waterfowl (including non-target species) from shooting threatens the birds' survival (Bell & Fox 1991); at these times statutory wildfowling bans can be imposed after fourteen days of freezing conditions (voluntary restraint is called for after seven days).

9.7.4 Information sources used

Information on land-based leisure is derived from tourist brochures and Ordnance Survey & Hamlyn (1995). Buck (1993) provides information on activities on estuaries in the region. Information on water-based leisure was derived from Admiralty Charts and from a nautical almanac (D'Olivera & Featherstone 1993). The Royal Yachting Association (1992) lists affiliated organisations in the region. The Scottish Sports Council holds information about the geographical distribution of activities throughout Scotland. The data for Table 9.7.1 has been extracted from their database, which is still under development; coverage of sports and geographical areas is not yet uniform. Other sources include the British Marine Industries Federation (BMIF) Annual Marine Industry Statistics (1989-1994). BMIF have also carried out a *National survey of boating and water sports participation* (Market Research Solutions Ltd. 1994).

9.7.5 Acknowledgements

The authors wish to thank R. Irving for providing other material for this section. John Crawford kindly provided data from the Scottish Sports Council database.

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Sports Council. 1993. *Water skiing and the environment*. London, Sports Council.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Tourism information service - Britain	Commercial Information Library, British Tourist Authority, Thames Tower, Black's Road, Hammersmith, London W6 9EL, tel: 0181 846 9000 x 3011/3015
Tourist information - Scotland	Scottish Tourist Board, 23 Ravelston Terrace, Edinburgh EH4 3EU, tel 0131 332 2433
Tourist Information Centres	Burns House, Burns Statue Square, Ayr KA7 1UP, tel: 01292 288688 Promenade, Largs, Ayrshire KA30 8BG, tel: 01475 673765 7 Alexandra Parade, Dunoon, Argyll PA23 8AB, tel: 01369 703785 15 Victoria Street, Rothesay, Isle of Bute PA20 0AJ, tel: 01700 502151 The Pier, Brodick, Isle of Arran KA27 8AU, tel: 01770 302140/ 302401 Front Street, Inveraray, Argyll, tel: 01499 302063 Mackinnon House, The Pier, Campbeltown PA28 6EF, tel: 01586 552056 The Square, Bowmore, Isle of Islay PA43 7JJ, tel: 01496 810254 Boswell House, Argyll Square, Oban, Argyll PA34 4AR, tel: 01631 563122 Main Street, Tobermory, Isle of Mull PA75 6NU, tel: 01688 302182
Sports facilities including GIS-based maps of sea- and land-based sporting activities	Scottish Sports Council, Caledonia House, South Gyle, Edinburgh EH12 9DQ, tel: 0131 317 7200
Recreation pressures on nature conservation interests	*SNH, RASD, Edinburgh, tel: 0131 554 9797
Water quality of bathing beaches	*Marine Conservation Society, Ross-on-Wye, tel: 01989 566017
Marine leisure industries; small craft marine industries	British Marine Industries Federation, Meadlake Place, Thorpe Lea Road, Egham, Surrey TW20 8HE, tel: 01784 473377
Wildfowl and wetlands (conservation)	*Publicity Officer, Wildfowl & Wetlands Trust, Slimbridge, tel: 01453 890333
Wildfowling (general information on wildfowl, habitats and conservation)	*Enquiry Officer, RSPB HQ, Sandy, tel: 01767 680551
Severe weather wildfowling bans	*Licensing Officer, SNH HQ, Edinburgh, tel: 0131 447 4784
Leisure activities	
Angling	Scottish Anglers National Association, Caledonia House, South Gyle, Edinburgh EH12 9DQ, tel. 0131 339 8808
Board sailing	UK Board Sailing Association, PO Box 28, Fareham, Hants PO14 3XD, tel: 01329 664779
Canoeing	Administrator, Scottish Canoe Association, Caledonia House, South Gyle, Edinburgh EH12 9DQ, tel: 0131 317 7314
Field Sports	Secretary, British Field Sports Society (Scottish Branch), Green Burns, Coupar, Angus PH13 9HA, tel: 01828 27015
Golf	Secretary, Scottish Golf Union, The Cottage, 181a Whitehouse Road, Edinburgh EH4 6BY, tel: 0131 339 7546
Horse riding	Secretary, The Trecking and Riding Society of Scotland, Boreland Riding Centre, Fearnan, Aberfeldy PH15 2PG, tel: 01887 830274
Sailing, yachting and windsurfing	Royal Yachting Association, RYA House, Romsey Road, Eastleigh, Hants. SO50 9YA, tel: 01703 629962 RYA Scottish Region, Caledonia House, South Gyle, Edinburgh EH12 9DQ, tel: 0131 317 7388
Sub aqua	Scottish Sub Aqua Club, Administrative Secretary, Cockburn Centre, 40 Bogmoor Place, Glasgow G51 4TQ, tel: 0141 425 1021
Surfing	Secretary, Scottish Surfing Federation, 20 Strichen Road, Fraserburgh AB43 5QZ
Water skiing	Scottish Water Ski Association, Development Officer, Scottish Water Ski Centre, Town Loch, Town Hill, Dunfermline KY12 0HT, tel: 01383 620123
Wildfowling (general, including details of affiliated clubs)	Director, The British Association for Shooting and Conservation, Scottish Centre, Trochry, Dunkeld PH8 0DY, tel: 01350 723226
Wildfowling (the sport)	Press and Information Officer, British Field Sports Society, 59 Kennington Road, London SE1 7PZ, tel: 0171 928 4742
Wind surfing	Secretary, Scottish Windsurfing Association, c/o Royal Yachting Association, Scotland, Caledonia House, South Gyle, Edinburgh EH12 9DQ, tel: 0131 317 7388
Yacht harbours	The Yacht Harbour Association, Hardy House, Somerset Road, Ashford, Kent TN24 8EW, tel: 01303 814434
Forum for organisations interested in countryside access	Scottish Countryside Activities Council, c/o Harold Wilkinson, 23 Lochardil Place, Inverness IV2 4LN, tel: 01463 235720

*Starred contact addresses are given in full in the Appendix.

Chapter 10 Coastal management

S.L. Fowler

10.1 Introduction

This chapter describes national (section 10.2) and local and regional (section 10.3) coastal management initiatives taking place wholly or partly within Region 14. GB and UK national initiatives without a specific regional focus, notably those led by non-governmental agencies and user groups, are outside the scope of this chapter. However, as the whole chapter concludes with a list of contacts with a wider involvement or interest in coastal management (section 10.3.5 C), contact points for some of these organisations are included there. In addition, names and addresses of regional contacts are given in Table 10.3.1.

10.1.1 Coastal management in the UK

This section outlines the direction of UK policy-making, within which many of the regional initiatives operate. Many, frequently competing, issues and activities affect the coastal environment and inshore waters, making the task of coastal planning and management a very complex one, particularly as numerous different authorities are responsible for particular statutory duties. Coastal management promotes an inter-disciplinary approach to multiple use and conflict resolution between interest groups, "to ensure the long-term future of the resources of the coastal zone through environmentally sensitive programmes, based on the principle of balanced, sustainable use" (Gubbay 1990). Coastal management ensures that all land and sea use issues are co-ordinated, including development, conservation, waste disposal, fisheries, transport, and coast protection and flood defence. The advantages of this have been recognised by coastal planners in many areas, and several local authorities and other bodies now promote coastal management. However approaches differ from area to area, with overlap in some places and patchy coverage elsewhere (Earll 1994).

The House of Commons Environment Committee Second Report (House of Commons 1992), although limited in scope to England and the estuaries it shares with Wales and Scotland, made recommendations for the planning and implementation of coastal management that have had policy and practical implications throughout the UK. Amongst the Environment Committee's recommendations were:

- the endorsement of an integrated approach to coastal management, incorporating maritime land, sea and intertidal areas;
- a review of existing legislation;
- the need for international (EU-wide) policy initiatives;
- clearer responsibilities for planning and action in the coastal zone, based on a national strategic framework;
- appropriate funding for accountable bodies with responsibilities;
- research into the physical functioning of the coastal zone and associated protection and conservation measures;
- a review of planning mechanisms to allow effective safeguard of the coastal resource;
- monitoring and environmental assessment of coastal activities to assess their impacts;
- the involvement of local communities in coastal management planning;
- the integration of responsibility for coast protection and sea defence under one body;
- better statutory protection for sites of nature conservation importance;
- better provisions for control of marine pollution;
- the need for fisheries activities to take account of marine conservation issues.

Strategic planning guidelines for the Scottish coast were first set out in Scottish Development Department (1974), based on a series of maps published in Skinner (1974). These guidelines were updated by Scottish Development Department (1981) to cover most of the major developments for port, industrial and power generation purposes. More recently, the Scottish Office has commissioned a review of Scottish coastal issues (Burbridge & Burbridge 1994). This review urges the development of new coastal planning policies and guidelines to deal with the integration of coastal resource-based activities at the local and regional level. The report suggests that these should support planning authorities in dealing with planning applications and advise on the production of local and regional coastal management plans and strategies. It also suggests the promotion of a national strategy for the sustainable development and management of coastal land and water resources.

The Burbridge report of 1994 has since been followed up with the publication of a discussion paper *Scotland's coasts* (Scottish Office 1996). This provides a summary of Scottish coastal issues and identifies a range of actions that should be taken or investigated for the purposes of achieving sustainable management of the coast and its resources. The government has proposed that the establishment of a Scottish Coastal Forum, similar to those that have already been established in England and Wales, should be considered (Scottish Office 1996). The proposed forum would comprise representative bodies with a major interest or responsibility in coastal issues and would provide a national context for coastal management planning.

In 1994, the UK Government published its Regulations to implement the EC Habitats & Species Directive (Department of the Environment 1994). In Scotland, the EC Habitats Directive is implemented in accordance with Scottish Office Environment Division Circular 6/90/95 (Scottish Office 1995). As they relate to the coast, these regulations provide for single management groups to be set up for whole sites, making the production of unified management plans a practical proposition. Where these sites are of European importance for their nature

conservation interest, the conservation of that interest must be the primary consideration of the management plan. For this, the regulations require all relevant authorities to exercise a general duty of care for their long-term conservation. At the time of writing, discussions are continuing on how these requirements will work in practice (see also section 10.2.7).

In 1995 the European Commission adopted the *Communication on integrated management of coastal zones* (COM/511/95), which sets out proposals for EU funding for demonstration programmes of coastal management. The strategy is to be based on the principles of sustainability and sound ecological and environmental practice, but will have no legal standing.

In 1995 the Local Government Management Board (LGMB) issued 'Roundtable Guidance' on the implementation of Local Agenda 21 on the coast (LGMB 1995).

10.2 National coastal initiatives with regional elements

10.2.1 Introduction

Partly as a result of developments at a UK and international level, many national bodies, including several with no direct management role through a statutory remit or ownership of coastal land, are now becoming involved in the promotion of coastal management initiatives. These include non-governmental organisations with a particular interest in the conservation of the coastal zone, such as the Marine Conservation Society, World Wide Fund for Nature UK and the Royal Society for the Protection of Birds (RSPB) (see section 10.2.6). The National Trust for Scotland has recently been carrying out a complete review of its Coastal Strategy Plans and has an ongoing review of coastal site management plans. Many other diverse interest groups and organisations now have national policies with regard to coastal management and estuaries management, for example the British Association for Shooting and Conservation and the Royal Yachting Association. Only national initiatives that have distinct local elements in the region are described here. For further information on regionally-led coastal management initiatives, see section 10.3.

10.2.2 National coastal fora

At present there is no Scottish Coastal Forum (the Coastal Forum established by the Department of the Environment is solely for England), although it has been suggested by the Scottish Office (1996) that one be set up.

CoastNET: the Coastal Heritage Network

CoastNET was established in 1995 to link individuals and organisations working for the sustainable management of the coastal and marine environment, building on the achievements of its predecessor, the Heritage Coast Forum. CoastNET aims to provide a network for coastal managers and field staff on the UK coast, to improve the ways in which the coastal heritage of the UK is managed, and to ensure that the practical experience of coastal managers and field staff contributes to the formulation of policy for the coastal zone. CoastNET is a membership body open to all those with an interest in the practical management of the UK coastline.

10.2.3 Scottish Natural Heritage

Focus on Firths

The major national coastal management initiative currently under way in Scotland is 'Focus on Firths', instigated by Scottish Natural Heritage (SNH). It aims to promote the protection and better management of the natural resources of the major Scottish estuaries and firths by stimulating understanding and voluntary co-operation among the various users and statutory authorities. A local management forum is to be set up for each site, made up of statutory, industrial, voluntary agencies' and community representatives as appropriate, to develop proposals for its sustainable management. In Scotland, there are currently five coastal zone management initiatives, three of which, covering the Solway Firth, the Firth of Forth and the Moray Firth, are included in the Focus on Firths Initiative; the other two, for the Cromarty Firth and the Firth of Clyde, are partly funded by SNH under that initiative. A proposal for a Tay project is under development.

10.2.4 Scottish Environment Protection Agency (SEPA)

The Scottish Environment Protection Agency (SEPA) was established under the Environment Act 1995. It carries out the functions of the former River Purification Boards with respect to water resources, water pollution, enforcement of legislation in relation to releases of substances into the environment and flood warning systems. It has also been assigned the waste regulation and disposal functions formerly the responsibility of the local authorities and other functions with respect to pollution control, and must be consulted over land drainage proposals to controlled waters. It does not, however, have responsibilities for flood and coastal defence, unlike the Environment Agency (England and Wales). Unlike England and Wales, there is no system of river catchment management planning operational in Scotland (Macaulay Land Use Research Institute 1995), although there is widespread support from conservation bodies that this approach should be pursued.

10.2.5 Coastal (engineering) groups

At present there are no formal coastal (engineering) groups in Scotland and no shoreline management plans in this region. Hydraulics Research have recently carried out a study on coastal process cells in Scotland (HR Wallingford 1995), co-sponsored by Scottish Natural Heritage, the Scottish Office Environment Department and Historic Scotland. This study aims to set out for the first time a framework for management of coastal areas in Scotland and could be used to set up new coastal management initiatives, similar to the coastal (engineering) groups established in England and Wales. The final report is due in early 1997. HR Wallingford are also producing a series of eleven regional reports, summarising coastal processes for each of the coastal cells in Scotland.

10.2.6 Royal Society for the Protection of Birds

In 1990, the Royal Society for the Protection of Birds (RSPB) launched a national campaign to promote the importance of estuaries in the UK and the need for coordinated management (Rothwell & Housden 1990). The campaign ran for three years. The RSPB Estuaries Inventory project compiled information on land use and selected human activities for 57 major UK estuaries, including in this region the Clyde. In 1994, the RSPB launched its 'Marine Life' campaign, which aims to increase awareness of the problems facing the marine environment and its wildlife, including pollution, fisheries and shipping safety. It has recently published a *Review of coastal zone management powers* (RSPB 1995). RSPB (1993) reviews strategic planning and management initiatives in part of the region.

10.2.7 Designated sites

Site designations are discussed in detail in Chapter 7. However, statutory and non-statutory designations can also be relevant here because they can provide a degree of coastal management through their area or site management plans. These often tend to focus strongly on the conservation of landscapes, buildings and/or habitats and species, rather than on wider and more integrated coastal issues, although for some sites a focus on visitor use and community involvement is important. Designated sites include nature reserves, which are managed for nature conservation objectives by Scottish Natural Heritage or other bodies such as the Scottish Wildlife Trust, local authorities or the RSPB, and National Scenic Areas, which are managed for a broader range of conservation and recreational objectives. Of particular interest because of their specific requirement for wide consultation are Marine Special Areas of Conservation (SACs) and Marine Consultation Areas (see also sections 7.2.4 and 7.4.3).

Marine Special Areas of Conservation (SACs)

Under the EC Habitats & Species Directive 1992, a list of Special Areas of Conservation (SACs) to be designated in the UK must be agreed by the UK Government and the European Commission by 1998 (see section 7.2.4). A list of possible sites on which consultations will be carried out was published in March 1995. Marine SACs include intertidal areas and/or subtidal areas, and terrestrial SACs may include important coastal maritime habitats such as lagoons, saltmarshes or sand dunes. Under Scottish Office Environment Division Circular 6/90/95 (Scottish Office 1995), marine and terrestrial SACs will have to be managed in a way that secures their 'favourable conservation status'. A range of bodies and individuals will be involved, including all 'relevant and competent authorities', e.g. local authorities, the Scottish Environment Protection Agency, ports and harbour authorities, Sea Fisheries Committees and SNH, as well as owners and occupiers of foreshore land and representatives of those who rely on marine areas for their livelihood or for recreation (Scottish Natural Heritage 1995). Management will be coordinated through an agreed management scheme, backed by existing statutory measures. At the time of writing, the four country nature conservation agencies are, at the instigation of the Scottish Office, preparing a generic management model for marine SACs, giving an overview of how schemes of management should develop (Laffoley in prep.).

Marine Consultation Areas

This non-statutory designation is used by Scottish Natural Heritage to indicate important sites and stimulate consultation over developments there (NCC 1990). There are eight whole and part of one other Marine Consultation Area in the region (see section 7.4.3).

10.3 Regional coastal management groups and initiatives

10.3.1 Introduction

There are a number of regional coastal management initiatives around the coastline led by local planning, harbour and port authorities. Other locally-based coastal management initiatives, although not strictly integrated as defined in section 10.1.1, are also under way. These include the Esturiales project (section 10.3.2). Table 10.3.1 lists regional coastal management initiatives, in all of which local authorities are involved or take a leading role.

10.3.2 Esturiales

Esturiales is a European association of elected local authority representatives with experts or non-elected officials. It aims to achieve sustainable development in estuaries by restructuring historic ports, upgrading the environment, developing the economies of selected ports and assisting the implementation and development of EC objectives as specified in the EC Environment Programme or coastal zone management proposals. The economy and environment of the Firth of Clyde was the subject of one of the original case studies carried out in 1991. A forum has been established and a framework for integrated management is being developed (see also section 10.2.3).

10.3.3 Local planning authority and ports/ harbours initiatives

Local planning authorities in the region have published plans which provide the statutory planning frameworks for development control purposes. In most cases these plans are supplemented by regular reviews, monitoring documents and survey reports covering a variety of topics as well as the plans themselves. Port and Harbour Authorities have a statutory remit to control activities within their areas of authority, which may include coastal waters. For current information, including publications details, contact the appropriate authority (see Appendix A.2).

10.3.4 Acknowledgements

Thanks are due to Steven Atkins (SNH) and Vincent Goodstadt (Glasgow & Clyde Valley Joint Structure Plan Team, Renfrewshire Council).

10.3.5 Further sources of information

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Gubbay, S. 1990. *A future for the coast? Proposals for a UK coastal zone management plan*. Ross-on Wye, World Wide Fund For Nature. (Unpublished report by the Marine Conservation Society.)

House of Commons. 1992. *Coastal zone protection and planning.* London, HMSO. (Environment Committee Second Report.)

Table 10.3.1 Regional coastal management initiatives

Initiative name	*Activities*	*Organisations involved*	*Contact address & telephone no.*
Clyde Estuary Esturiales Environmental Study Group	Esturiales is an international programme for co-operation, the exchange of experience on estuarine management and personal contacts between local authority practitioners in Europe. Includes the Clyde Estuary. Estuary eco-audit proposed.	Councils surrounding Clyde Estuary	*Phil Murray, Project Officer, Glasgow City Council, Glasgow, tel: 0141 287 2000
Clyde Estuary Forum	Established following first Estuariales study and River Clyde Project report (River Clyde Project Group 1989). Vehicle for discussion and liaison between those with an interest in the future of the natural resource and development of the estuary. Enables identification of areas for co-operation beyond the scope of the Structure Plan.	Steering Group includes representatives of all interests. Core Group comprises all Councils in the region, SNH, Scottish Enterprise, Clyde Ports, Sports Council, SEPA and RSPB. Topic groups are convened to report back to the Core Group.	*Phil Murray, Clyde Estuary Forum Project Officer, Glasgow City Council, Glasgow, tel: 0141 287 2000
Craignish Coastal Forum	A local group that aims to maintain the attractiveness and conservation value of Loch Craignish and the Craignish Peninsula in the face of development pressures.	Local community council and other local interests.	Joe Lesley, Chairman, Craignish Coastal Forum, Ardfern, Argyll PA31 8QW, tel: 01852 500223

*Starred contact addresses are given in full in the Appendix.

HR Wallingford. 1995. *Coastal cells in Scotland.* Wallingford, HR Wallingford. (Draft report to Scottish Natural Heritage, the Scottish Office and Historic Scotland.)
Laffoley, D.d'A., *ed.* In prep. *A generic management model for marine SACs.* Peterborough, English Nature.
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Nature Conservancy Council. 1990. *Marine Consultation Areas*. Edinburgh, Nature Conservancy Council.
Rothwell, P.I.Y., & Housden, S.D. 1990. *Turning the tide, a future for estuaries.* Sandy, Royal Society for the Protection of Birds.
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River Clyde Project Group. 1989. *River Clyde Project: a corridor of growth*. Glasgow, Strathclyde Regional Council.

B. Further reading

Included in the following list of references are items relating to England and Wales that may be of interest to individuals and organisations involved in coastal management in Scotland.

Bown, D. 1988. *Coastal development: a planner's view.* Paper presented to the Council for the Protection of Rural Wales (CPRW) Annual Study Conference (unpublished).
Coastal Heritage Forum. 1995. *Heritage Coasts: a guide for councillors and officers.* Manchester.
Countryside Council for Wales. In prep. *Maritime Agenda 21: a policy framework.* CCW, Bangor.
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Department of the Environment/Welsh Office. 1992. *Planning policy guidance - coastal planning*. London, HMSO (PPG 20).
Department of the Environment/Welsh Office. 1993a. *Development below low water mark: a review of regulation in England and Wales.* London, HMSO.
Department of the Environment/Welsh Office. 1993b. *Managing the coast: a review of coastal management plans in England and Wales and the powers supporting them.* London, HMSO.
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Jones, R. 1993. Coastal cell studies - a basis for coastal zone management. *Earth Science Conservation, 32:* 12-15.
King, G., & Bridge, L. 1994. *Directory of coastal planning and management initiatives in England*. Maidstone, National Coasts and Estuaries Advisory Group.
Ministry of Agriculture, Fisheries and Food/Welsh Office/Association of District Councils/English Nature/National Rivers Authority. 1994. *Shoreline management plans: a guide for coastal defence authorities.* London, MAFF (PB2197).
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Scottish Wildlife and Countryside Link. 1993. *All at sea? Coastal zone management, the case for Scotland*. Perth, Scottish Wildlife and Countryside Link.
Williams, R. 1989. *A coastal strategy for Wales: pre-prints symposium and workshop: planning and management of the coastal heritage 10-12 October.* RTPI North West Update and Sefton Metropolitan Borough Council.
World Wide Fund For Nature UK. 1994. *Coastal management plans.* Godalming, World Wide Fund For Nature UK. (Marine Update, No. 18.)
World Wide Fund For Nature UK. 1994. *International commitments to integrated coastal zone management.* Godalming, World Wide Fund For Nature UK. (Marine Update, No. 17.)

Newsletters

Many national statutory, non-governmental and scientific bodies are now producing publications or newsletters on the subject of coastal management. These provide either information on particular local or national initiatives (such as the statutory or non-governmental organisations' estuaries and firths initiatives) or general information on a range of coastal news (for example the newsletters of Eurocoast UK and the European Union for Coastal Conservation). Some of these publications are listed below. Addresses of those publishing the newsletters are given in section 10.3.5C.

Coastline UK. Newsletter of the National Coasts and Estuaries Advisory group (NCEAG). Aimed at local authority planners. Published by NCEAG.
Coastline. Quarterly magazine of the European Union for Coastal Conservation (EUCC). Intended to establish a pan-European forum on coastal issues, including coastal management. Published by EUCC.
Coastline. The Bulletin of the Parliamentary All Party Coastal Group. Provides information summaries for MPs. Published by the All Party Coastal Group.
CoastNet. The Bulletin of the Coastal Heritage Network. A quarterly publication on all matters concerned with coastal management in the UK. Published by the Coastal Heritage Network.
CZM News. Occasional Newsletter of Eurocoast UK, reporting on projects and developments in the field of coastal zone management. Published by Eurocoast UK.

Marine Scene. Occasional marine newsletter of the statutory conservation agencies in UK. Aimed at marine scientists, and users and regulators of the sea. Published by JNCC.

Wavelength. The Coastal Forum newsletter. Reports the work of the Forum to a wider audience. Published by the Department of the Environment.

National planning/management publications

House of Commons Environment Committee. 1992. *Second report - coastal zone protection and planning*. London, HMSO. (Recommended that coastal zone management be adopted as the framework for all coastal zone planning and management practice in the United Kingdom. Called for a national coastal strategy, a review of the many organisations responsible for the coast, the extension of planning controls offshore, and the establishment of a Coastal Zone Unit in Department of the Environment.)

Scottish Office. 1995. *Nature conservation: implementation in Scotland of the EC Directives on the conservation of natural habitats and of wild flora and fauna, and the conservation of wild birds: the conservation (natural habitats, etc.) regulations 1994*. Edinburgh, Scottish Office Environment Division, Rural Affairs Department. (Circular 6/90/95.)

C. Contact names and addresses

(See also Table 10.3.1.)

Organisation/group	*Activities*	*Contact address and telephone no.*
CoastNET Coastal Heritage Network	Established in 1995 by the Countryside Commission, English Nature and Scottish Natural Heritage with a part-time secretariat. Links individuals and organisations working for the sustainable management of the coastal and marine environment.	Coastal Heritage Network, The Manchester Metropolitan University, St. Augustines, Lower Chatham Street, Manchester M15 6BY, tel: 0161 247 1067
Coastal Technical Officers Group	The coastal group of the statutory conservation agencies (English Nature, Scottish Natural Heritage, Countryside Council for Wales, Department of the Environment for Northern Ireland, Joint Nature Conservation Committee and the Countryside Commission)	*Coastal Technical Officers Group: English Nature, Maritime Team, Northminster House, Peterborough PE1 1UA, tel: 01733 45500 (secretariat)
Eurocoast UK	Eurocoast UK aims to improve the basis for protection, development and management of the coastal zone. Primarily a communication network.	Eurocoast UK Secretariat, Dept of Maritime Studies, UWCC, PO Box 907, Cardiff, CF1 3YP tel: 01222 874271
European Union for Coastal Conservation (EUCC)	International grouping of organisations and individuals with an interest in coastal nature conservation matters, including coastal management.	European Union for Coastal Conservation (EUCC) Secretariat, PO Box 11059, NL-2301 EB Leiden, tel: +31 71 122900/123952
Joint Nature Conservation Committee - Geology/Coastal Advisor	Advice and information on coastal conservation in Great Britain as a whole and internationally	*JNCC, Peterborough, tel: 01733 62626
JNCC Coastal Directories Team	Project to produce a series of publications (Coasts and seas of the United Kingdom) giving baseline coastal and marine environmental, management and human use information on a regional basis	*JNCC, Peterborough, tel: 01733 62626
Joint Nature Conservation Committee - Marine Advisor	Advice and information on marine nature conservation in Great Britain as a whole and internationally	*JNCC, Peterborough, tel: 01733 62626
JNCC Marine Nature Conservation Review	Project to extend knowledge of benthic marine habitats, communities and species in Great Britain and identify sites and species of nature conservation importance; producing a series of 15 reports (Coasts and seas of the United Kingdom. MNCR series.) on a coastal sector basis, as well as more detailed area summaries.	*JNCC, Peterborough, tel: 01733 62626
Les Esturiales Environmental Study Group	International programme for co-operation, the exchange of experience on estuarine management and personal contacts between local authority practitioners in Europe.	Esturiales Environmental Study Group, Prof. Graham King, CZM Associates, 2 Newton Villas, Newton, Swansea SA3 4SS, tel: 01792 367552
Marine Conservation Society	Provides advice and supports local coastal management initiatives: runs grant-aided coastal management workshops and courses for coastal managers; promotes the establishment of voluntary coastal groups.	*Marine Conservation Society, Ross-on-Wye, tel: 01989 566017
Marine Forum	National network provides forum for discussion of marine issues relating to the seas around UK. Members include governmental and non-governmental organisations and individuals. Occasional seminars are held, covering a range of topics including coastal management.	*Honorary Secretary, The Marine Forum for Environmental Issues, Scarborough, tel: 01723 362392

C. Contact names and addresses (continued)

(See also Table 10.3.1.)

Organisation/group	*Activities*	*Contact address and telephone no.*
National Coasts and Estuaries Advisory Group (NCEAG)	Primarily aimed at coastal local authority officers. Advises on the sustainable development of coastal and estuarine environments and promotes best practice in coastal zone management.	Alan Inder, Secretary, National Coasts and Estuaries Advisory Group (NCEAG), Hampshire County Council, The Castle, Winchester SO23 8UJ, tel: 01962 846749
Natural Environment Research Council Laboratory	Contributes to scientific research and the promotion of knowledge and teaching in the Scottish marine environment.	Centre for Coastal and Marine Sciences, Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244
Scottish Association for Marine Science (SAMS)	Charitable foundation with an active membership and quarterly newsletter. Contributes to scientific research and the promotion of knowledge and teaching in the Scottish marine environment.	Centre for Coastal and Marine Sciences, Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244
Scottish Environment Protection Agency (SEPA)	Carries out the function of the former River Purification Boards with respect to water resources, water pollution, enforcement of legislation in relation to releases of substances into the environment and flood warning systems. Also carries out the functions of the former Waste Regulation Authorities and disposal authorities, and other functions with respect to pollution control, and must be consulted over land drainage proposals to controlled waters.	*SEPA West Region HQ, East Kilbride tel: 01355 238181
National Trust for Scotland	Has extensive coastal land holdings in the region and in Scotland as a whole (see section 7.5.1).	National Trust for Scotland, 5 Charlotte Square, Edinburgh EH2 4DU, tel: 0131 226 5922
Royal Society for the Protection of Birds	Launched national campaign in 1990 to promote the importance of estuaries in the UK. Monitors the development of coastal zone initiatives around the UK. In 1994, launched Marine Life campaign, to increase awareness and to promote integrated coastal and marine management. Manages some coastal nature reserves. Produced a regional strategy.	*D. Huggett, Coastal Policy Officer, RSPB HQ, Sandy, tel: 01767 680551
Scottish Office Development Department	Coastal policy and planning. Preparation of Rural White Paper.	Dr Cath Murphy, Scottish Office, 2-6 Victoria Quay, Edinburgh EH6 6QQ, tel: 0131 556 8400
Scottish Office Agriculture, Environment and Fisheries Department	Departmental responsibility for flood defence and coast protection. May establish group to co-ordinate the work of local authorities.	SOAEFD, 27 Perth Street, Edinburgh EH3 5RB, tel: 0131 244 4042
Scottish Natural Heritage	Focus on Firths, Marine Consultation Areas, coastal cells in Scotland.	*Focus on Firths Project Manager, RASD, SNH, Edinburgh, tel: 0131 554 9797
The Wildlife Trusts	Has extensive coastal land holdings throughout the UK. Is actively involved in coastal zone initiatives in this region. Manages some voluntary conservation areas. Has extensive experience of coastal interpretation, marine survey and policy work.	Joan Edwards, Marine Conservation Officer, The Wildlife Trusts, The Green, Witham Park, Waterside South, Lincoln LN5 7JR, tel: 01522 544400
World Wide Fund for Nature - UK	Provides funding for research, local voluntary policy development and local initiatives, and publications on integrated coastal management. Draws on considerable international experience with coastal management initiatives.	*World Wide Fund for Nature - UK, Godalming, tel: 01483 426444

Addresses and telephone numbers of local planning authorities are given in full in the Appendix, as are *starred contact addresses.

Loch Fyne is famous for its numerous fish and shellfish farms, which produce salmon, oysters, mussels and halibut and are a significant source of revenue to the region. Photo: Lorne Gill, Scottish Natural Heritage.

Appendix

A.1 Frequently cited contact names and addresses

Name	*Contact address and telephone no.*
Statutory bodies	
British Oceanographic Data Centre - NERC (BODC), Proudman Oceanographic Laboratory	Bidston Observatory, Birkenhead, Merseyside L43 7RA, tel: 0151 653 8633
Department of the Environment (DoE), European Wildlife Division/ Dept. of Rural Affairs	DoE, Room 9/03B, Tollgate House, Houlton Street, Bristol BS2 9DJ, tel: 0117 987 8000
Highlands and Islands Enterprise	Bridge House, 20 Bridge Street, Inverness IV1 1QR, tel: 01463 234171
Institute of Terrestrial Ecology (ITE), Monks Wood	Abbots Ripton, Huntingdon, Cambridgeshire PE17 2LS, tel: 01487 773381
ITE, Merlewood	Institute of Terrestrial Ecology, Windermere Road, Grange-over-Sands, Cumbria LA11 6JU, tel: 01539 532264
Joint Nature Conservation Committee (JNCC), Headquarters	Monkstone House, City Road, Peterborough, Cambs. PE1 1JY, tel: 01733 62626
JNCC, Seabirds and Cetaceans Team	Seabirds and Cetaceans Team, Joint Nature Conservation Committee, 11 Dunnet House, 7 Thistle Place, Aberdeen AB10 1UZ, tel: 01224 655702
Scottish Environment Protection Agency (SEPA), Head Office	Erskine Court, The Castle Business Park, Stirling FK9 4TR, tel: 01786 457700
SEPA West Region HQ	Rivers House, Murray Road, East Kilbride G75 0LA, tel: 01355 238181
Scottish Natural Heritage (SNH), HQ	12 Hope Terrace, Edinburgh EH9 2AS, tel: 0131 447 4784
SNH Research & Advisory Services Directorate (RASD)	2 Anderson Place, Edinburgh EH6 5NP, tel: 0131 554 9797
SNH South-west Region Head Office	Caspian House, Mariner Court, Clydebank Business Park, Clydebank G81 2NR, tel: 0141 951 4488
SNH Ayrshire and Arran Sub-area Office	2 Beresford Terrace, Ayr KA7 2EG, tel: 01292 261392
SNH Mid & South Strathclyde Area Office	Caspian House, Mariner Court, Clydebank Business Park, Clydebank G81 2NR, tel: 0141 951 4488
SNH Dunoon Sub-area Office	17 John Street, Dunoon PA23 8BN, tel: 01369 705377

Name	*Contact address and telephone no.*
Statutory bodies (continued)	
SNH Argyll & Bute Area Office	1 Kilmory Estate, Kilmory, Lochgilphead, Argyll & Bute PA31 8RR, tel: 01546 603611
SNH North Argyll Sub-area Office	Glensalloch Road, Barcaldine, Oban, Argyll & Bute PA37 1SF, tel: 01631 720363
SNH Islay, Jura & Colonsay Sub-area Office	Main Street, Bowmore, Isle of Islay, Argyll & Bute PA43 7JJ, tel: 01496 810711
SNH Clyde Valley Sub-area Office	22F Barratyre Street, Lanark ML11 7JR, tel: 01555 665928
Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD)	Pentland House, 47 Robb's Loan, Edinburgh EH14 1TY, tel: 0131 556 8400, or Victoria Quay, Edinburgh EH6 6QQ, tel: 0131 244 0213
SOAEFD Environment Department	New St. Andrew's House, Edinburgh EH1 3TG, tel: 0131 244 4042
SOAEFD Marine Laboratory	Fisheries Research Services, PO Box 101, Victoria Road, Aberdeen AB9 8DB, tel: 01224 876544
Wildlife Trusts	
Scottish Wildlife Trust (SWT) HQ	Cramond House, Kirk Cramond, Cramond Glebe Road, Edinburgh EH4 6NS, tel: 0131 312 7765
SWT Western Office	25 Bloomgate, Lanark, Lanarkshire ML11 9ET, tel: 01555 666868
SWT Ayr Office	2 Callender Road, Heathfield, Ayr KA8 9AF, tel: 01292 610529
SWT Urban Wildlife Office	2nd Floor, 18 High Street, Paisley PA1 2BS, tel: 0141 840 4044
National voluntary bodies	
The British Trust for Ornithology	The Nunnery, Thetford, Norfolk IP24 2PU, tel: 01842 750050
Marine Conservation Society	9 Gloucester Road, Ross-on-Wye, Herefordshire HR9 5BU, tel: 01989 566017
The National Trust for Scotland	5 Charlotte Square, Edinburgh EH2 4DU, tel: 0131 226 5922
Royal Society for the Protection of Birds (RSPB) HQ	The Lodge, Sandy, Bedfordshire SG19 2DL, tel: 01767 680551
RSPB Strathclyde Office	Unit 31, West of Scotland Science Park, Kelvin Campus, Glasgow G20 0ST, tel: 0141 945 5224

Name	*Contact address and telephone no.*
National voluntary bodies (continued)	
The Wildfowl & Wetlands Trust (WWT), HQ	Slimbridge, Gloucestershire GL2 7BT, tel: 01453 890333
Worldwide Fund For Nature - UK (WWF-UK)	Panda House, Weyside Park, Cattershall Lane, Godalming, Surrey GU7 1XR, tel: 01483 426444
WWF Scotland	1 Crieff Road, Aberfeldy, Perthshire PH15 2BJ, tel: 01887 820449

Name	*Contact address and telephone no.*
Others	
Clyde Estuary Forum	Clyde Estuary Forum Project Officer, Glasgow City Council, City Chambers, George Square, Glasgow G2 1DU, tel: 0141 221 9600
Marine Forum for Environmental Issues	c/o University College of Scarborough, Filey Road, Scarborough, Yorkshire YO11 3AZ, tel: 01723 362392

A.2 Local planning authorities; port and harbour authorities

Authority	*Contact address and telephone no.*
Ardrossan Harbour	Ardrossan Harbour Company Limited, Harbour Office, Ardrossan, Ayrshire KA22 8DB, tel: 01294 63972/4
Argyll & Bute Council	Kilmory, Lochgilphead, Argyll PA31 8RT, tel: 01546 602127
Ayr & Troon Ports	Associated British Ports, Port Office, Ayr, Ayrshire KA8 8AH, tel: 01292 281687
Clyde Ports (Glasgow, Greenock, Hunterston and Ardrossan)	Clyde Ports plc, 16 Robertson Street, Glasgow G2 8DS, tel: 0141 221 8733
Glasgow City Council	City Chambers, George Square, Glasgow G2 1DU, tel: 0141 287 2000

Authority	*Contact address and telephone no.*
Inverclyde Council	Municipal Buildings, Greenock PA15 1LY, tel: 01475 724400
North Ayrshire Council	Cunninghame House, Irvine KA12 8EE, tel: 01294 324100
Renfrewshire Council	Municipal Buildings, Cotton Street, Paisley PA1 1LE, tel: 0141 842 5000
South Ayrshire Council	County Buildings, Wellington Square, Ayr KA7 1DR, tel: 01292 612000
West Dunbartonshire Council	Council Offices, Garshake Road, Dumbarton G82 3PU, tel: 01389 727000

A.3 Core reading list

There are a number of important publications that either provide information on a variety of topics covered in these regional reports (and so are frequently referred to) or give a good overview of regional and national information on coasts and seas. They are listed below.

Barne, J., Davidson, N.C., Hill, T.O., & Jones, M. 1994. *Coastal and marine UKDMAP datasets: a user manual*. Peterborough, Joint Nature Conservation Committee.

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides*. London, Collins.

British Oceanographic Data Centre. 1992. *UKDMAP (United Kingdom digital marine atlas)*. Birkenhead, BODC (Computer software.).

Brown, A. 1992. *The UK environment*. London, HMSO

Buck, A.L. 1993. *An inventory of UK estuaries. 3. North-west Britain*. Peterborough, Joint Nature Conservation Committee.

Burbridge, P.R., & Burbridge, V. 1994. *Review of Scottish coastal issues*. Edinburgh, Scottish Office.

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*. Peterborough, Nature Conservancy Council.

Donn, S., & Wade, M. 1994. *UK directory of ecological information*. Chichester, Packard.

Eno, N.C., *ed*. 1991. *Marine conservation handbook*. 2nd ed. Peterborough, English Nature.

Gubbay, S. 1988. *A coastal directory for marine conservation*. Ross-on-Wye,Marine Conservation Society.

Lee, A.J., & Ramster, J.W. 1981. *Atlas of the seas around the British Isles*. Lowestoft, MAFF.

Robinson, A., & Millward, R. 1983. *The Shell book of the British coast*. Newton Abbot, David and Charles.

Scottish Office. 1996. *Scotland's coasts - a discussion paper*. Edinburgh, HMSO Scotland for the Scottish Office.

Steers, J.A. 1964. *The coastline of Scotland*. Cambridge, Cambridge University Press.

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