Coasts and seas of the United Kingdom

Regions 15 & 16 North-west Scotland: The Western Isles and west Highland

edited by
J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody,
N.C. Davidson & A.L. Buck

Joint Nature Conservation Committee
Monkstone House, City Road
Peterborough PE1 1JY
UK

©JNCC 1997

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

JNCC Coastal Directories Project Team

Project directors	Dr J.P. Doody, Dr N.C. Davidson
Project management and co-ordination	J.H. Barne, C.F. Robson
Editing and publication	S.S. Kaznowska, R. Sumerling, J. Plaza, P. Smith
Administration & editorial assistance	N.M. Stevenson

Regions 15 and 16 were merged and formated and consultees comments were incorporated by M. Irvine and I. Fuller.

The project receives guidance from a Steering Group which has more than 200 members. More detailed information and advice comes from the members of the Core Steering Group, which is composed as follows:

Dr J.M. Baxter	*Scottish Natural Heritage*
R.J. Bleakley	*Department of the Environment, Northern Ireland*
R. Bradley	*The Association of Sea Fisheries Committees of England and Wales*
Dr J.P. Doody	*Joint Nature Conservation Committee*
B. Empson	*Environment Agency*
C. Gilbert	*Kent County Council & National Coasts and Estuaries Advisory Group*
N. Hailey	*English Nature*
Dr K. Hiscock	*Joint Nature Conservation Committee*
Prof. S.J. Lockwood	*MAFF Directorate of Fisheries Research*
C.R. Macduff-Duncan	*Esso UK (on behalf of the UK Offshore Operators Association)*
Dr D.J. Murison	*Scottish Office Agriculture, Environment & Fisheries Department*
Dr H.J. Prosser	*Welsh Office*
Dr J.S. Pullen	*WWF UK (Worldwide Fund for Nature)*
Dr P.C. Reid	*Plymouth Marine Laboratory*
Dr M.J. Roberts	*Water Resources and Marine, Department of the Environment*
S.L. Soffe	*Countryside Council for Wales*
M.L. Tasker	*Joint Nature Conservation Committee*
R.G. Woolmore	*Countryside Commission*

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. Regions 15 & 16. North-west Scotland: the Western Isles and west Highland*. 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. Regions 15 & 16. North-west Scotland: the Western Isles and west Highland*, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody, N.C. Davidson & A.L. Buck, 77-80. 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
Region 7: ISBN 1 873701 81 0
Region 8: ISBN 1 873701 82 9
Region 9: ISBN 1 873701 83 7
Region 10: ISBN 1 873701 84 5
Region 11: ISBN 1 873701 85 3
Region 12: ISBN 1 873701 86 1
Region 13: ISBN 1 873701 87 x
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			5
How to use this book			6
Acknowledgements			7
Chapter 1	**Overview**	Dr J.P. Doody	9
1.1	The Coastal Directories Project		9
1.2	Introduction to the regions		13
Chapter 2	**Geology and physical environment**		19
2.1	Coastal geology	British Geological Survey & R. Threadgould	19
2.2	Offshore geology	British Geological Survey	25
2.3	Wind and water	British Geological Survey	31
2.4	Sediment transport	British Geological Survey	37
2.5	Sea-level rise and flooding	British Geological Survey	40
2.6	Coastal landforms	British Geological Survey	42
Chapter 3	**Terrestrial coastal habitats**		47
3.1	Cliffs and cliff-top vegetation	Dr T.C.D. Dargie	49
3.2	Sand dunes	Dr T.C.D. Dargie	53
3.3	Vegetated shingle structures and shorelines	Dr R.E. Randall	62
3.4	Coastal lagoons	Dr R.S.K. Barnes & Dr R.N. Bamber	65
3.5	Wet grassland	Dr H.T. Gee	68
3.6	Saltmarsh	Dr M.I. Hill	72
Chapter 4	**Marine and estuarine environments**		77
4.1	Estuaries	Dr N.C. Davidson	77
4.2	The sea bed	R.A. Irving	81
4.3	Plankton	M. Edwards & A.W.G. John	95
Chapter 5	**Important species**		99
5.1	Terrestrial lower plants	N.G. Hodgetts	99
5.2	Flowering plants and ferns	V.M. Morgan	105
5.3	Land and freshwater invertebrates	M.S. Parsons & A.P. Foster	110
5.4	Rare sea-bed species	J. Plaza & Dr W.G. Sanderson	116
5.5	Exploited sea-bed species	C.F. Robson	122
5.6	Amphibians and reptiles	Dr M.J.S. Swan	126
5.7	Fish: exploited sea fish	C.F. Robson	131
5.8	Fish: salmon, sea trout and eels	C.F. Robson	136
5.9	Fish: other species	Dr G.W. Potts & S.E. Swaby	138
5.10	Seabirds	M.L. Tasker	141
5.11	Other breeding birds	R.T. May & A.B. Law	145
5.12	Migrant and wintering waterfowl	D.M. Craddock & A.B. Law	151
5.13	Land mammals	Dr C.E. Turtle & K.D. Meakin	155
5.14	Seals	C.D. Duck	158
5.15	Whales, dolphins and porpoises	Dr P.G.H. Evans	162

Chapter 6 History and archaeology A. Gale & V. Fenwick 169

Chapter 7 Coastal protected sites R.G. Keddie & J. Plaza 177

7.1 Introduction 177
7.2 Sites designated under international conventions and directives 180
7.3 Sites established under national statute 185
7.4 Sites identified by statutory agencies 189
7.5 Other types of protected site 193

Chapter 8 Land use, infrastructure and coastal defence 197

8.1 Introduction M.J. Dunbar & S.L. Fowler 197
8.2 Land use M.J. Dunbar & S.L. Fowler 198
8.3 Infrastructure M.J. Dunbar & S.L. Fowler 202
8.4 Coastal defence S.L. Fowler 209

Chapter 9 Human activities 213

9.1 Fisheries D. Murison & C.F. Robson 213
9.2 Mariculture C.F. Robson 223
9.3 Quarrying and landfilling C.A. Crumpton & M.J. Goodwin 229
9.4 Marine aggregate extraction, dredging and solid waste disposal at sea C.A. Crumpton & M.J. Goodwin 233
9.5 Oil and gas development C.A. Crumpton & M.J. Goodwin 237
9.6 Water quality and effluent discharges M.J. Goodwin & C.A. Crumpton 240
9.7 Leisure and tourism M.J. Dunbar, S.L. Fowler, I. Fuller & M. Irvine 244

Chapter 10 Coastal management S.L. Fowler 251

10.1 Introduction 251
10.2 National coastal initiatives with regional elements 252
10.3 Regional coastal management groups and initiatives 254

Appendix 259

A.1 Frequently cited contact organisations and addresses 259
A.2 Local planning authorities; port and harbour authorities 260
A.3 Core reading list 260
A.4 Contributing authors 261

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 National Rivers Authority (now the Environment Agency), the Countryside Commission, the Welsh Office, the Department of the Environment, the Department of the Environment (Northern Ireland), 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 & Species 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 regions. 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 regions and sets the regions in a national context.
- **Important locations and species**: gives more detail on the regions' features in relation to the topic.
- **Human activities**: describes management and other activities that can have an effect on the resource in the regions.
- **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 regions 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 'Regions 15 & 16') is used throughout this book to refer to the coastal and nearshore zone, broadly defined, of the area given in the title. 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 from the coast out to the median line between the UK and neighbouring states. Areas inland of these limits are not included unless specifically stated.

'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 by region, 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. Information on sites mentioned as important, numbers and distributions of species, archaeological features discovered and all the other elements of the natural and man-made environment are as up-to-date and complete as reasonably practicable at the time of publication (February 1997). 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 & the Environment
Isle of Man Government, Department of Transport
Kyle and Carrick District Council
Lancashire County Council
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.

We thank publishers and authors indicated in the figure captions for permission to reproduce illustrations. Crown Copyright material is reproduced with the permission of the Controller of HMSO.

This collaborative project involved many other staff of JNCC in addition to the project team listed on page 2. They were: Jo Brooksbank, Deirdre Craddock, Steve Gibson, Tim Hill, Keith Hiscock, Nick Hodgetts, Alan Law, Eva Leck, Becci May, Jenny Mitchell, Sonia Palasiuk, Deborah Procter, Bill Sanderson, Catherine Smith, David Stroud, Mark Tasker, Andy Webb, Martin Wigginton and Lissie Wright. 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, particularly Stewart Angus (SNH) and Amanda Bryan (Ross & Cromarty Enterprise), as well as those who gave editorial assistance:

Stewart Angus, SNH; Patrick Ashmore, Historic Scotland; Steve Atkins, SNH; John Baxter, SNH; Tricia Bradley, RSPB; Keith Bray, Western Isles Council; Andrew Burr, Department of Transport; Marsailidh Chisholm, Scottish Sports Council; Dominic Counsell, SNH; Martyn Cox, The Crown Estate; Peter Cranswick, The Wildfowl and Wetlands Trust; Andrew Currie (independent); Isabel Drummond-Murray, Scottish Office; Kathy Duncan, SNH; Joan Edwards, The Wildlife Trusts; David Green, Centre for Remote Sensing and Mapping, University of Aberdeen; Paul Harding, Institute of Terrestrial Ecology; Robin Harvey, Dunstaffnage Marine Laboratory; John Hislop, SOAEFD; Duncan Huggett, RSPB; David Hughes, Dunstaffnage Marine Laboratory; Julian Hunter, SEPA North Region; Graham King, National Coasts and Estuaries Advisory Group; George Lees, SNH; Ben Leyshon, SNH; Colin Macduff-Duncan, ESSO; Derek Moore SOAEFD; Derek Murison, SOAFED; Diana Murray, Royal Commission on the Ancient and Historical Monuments of Scotland; Brendan O'Hanrahan, SNH; Julian Overnell, Dunstaffnage Marine Laboratory; Ken Pugh, SEPA North Region; Ro Scott, SNH; Pauline Simpson, Institute of Oceanographic Sciences; Alastair Somerville, SWT; Jill Strawbridge, SNH; Chris Stroud, Whale and Dolphin Conservation Society; Chris Sydes, SNH; Rob Threadgould, SNH; Paul Tyler; University Marine Biological Station, Millport; Chris Vivian, MAFF; Sarah Welton, Marine Conservation Society; Colin Wishart, Highland Regional Council; and Chris Wright, SNH.

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

The island of Lingerabay, typical of the wild, unspoilt landscapes of the Western Isles, is backed by a massive mountain comprising rocks of the South Harris Igneous Complex. It is this complex that would be exploited by the proposed superquarry. Photo: P.A. Macdonald, Scottish Natural Heritage.

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 usable 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 undertook 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.

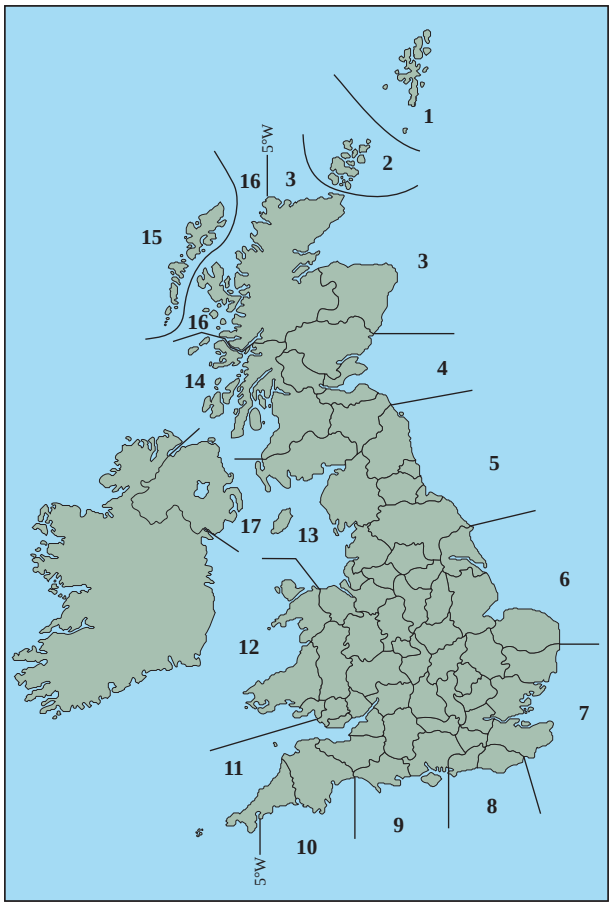
At the second meeting of the NSTF, in 1989, the UK suggested that the North Sea QSR should include consideration of terrestrial habitats and species. This was to involve the collection of information dealing with the coastal margin of the North Sea (defined as being east of longitude 5° West - i.e. from 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), 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, encouraged 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 and 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 United Kingdom. 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 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 January 1994 resulted in a decision to make the completion of the regional volumes the priority, rather than the overview *West Coast Directory*. At the meeting of the main steering group in February 1996 it was decided not to publish the *West Coast Directory* at all, as it would duplicate material already published in the regional volumes.

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; further participants are still coming forward. 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*

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

report back on their experiences (February 1996). The meeting to be held in February 1997 will focus on the theme *Coastal zone information provision: the future.* In addition the core steering group also meets at least annually.

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) and *Scotland's coast: a discussion paper* (Scottish Office Agriculture, Environment and Fisheries Department 1996). 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.

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	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
Regions 14, 15 & 16	1997
Other regions	Following book publication

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 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

A. References cited

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.

Department of the Environment. 1995. *Policy guidelines for the coast.* London, HMSO.

DoE/Welsh Office. 1992. *Planning policy guidance - coastal planning.* London, HMSO. (PPG 20.)

DoE/Welsh Office. 1993a. *Development below Low Water Mark - a review of regulation in England and Wales.* London, HMSO.

DoE/Welsh Office. 1993b. *Managing the coast: a review of coastal management plans in England and Wales and the powers supporting them.* London, HMSO.

Doody, J.P., Johnson, C., & Smith, B. 1993. *Directory of the North Sea coastal margin.* Peterborough, Joint Nature Conservation Committee.

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.

Scottish Office Agriculture, Environment and Fisheries Department. 1996. *Scotland's coast: a discussion paper.* Edinburgh, HMSO.

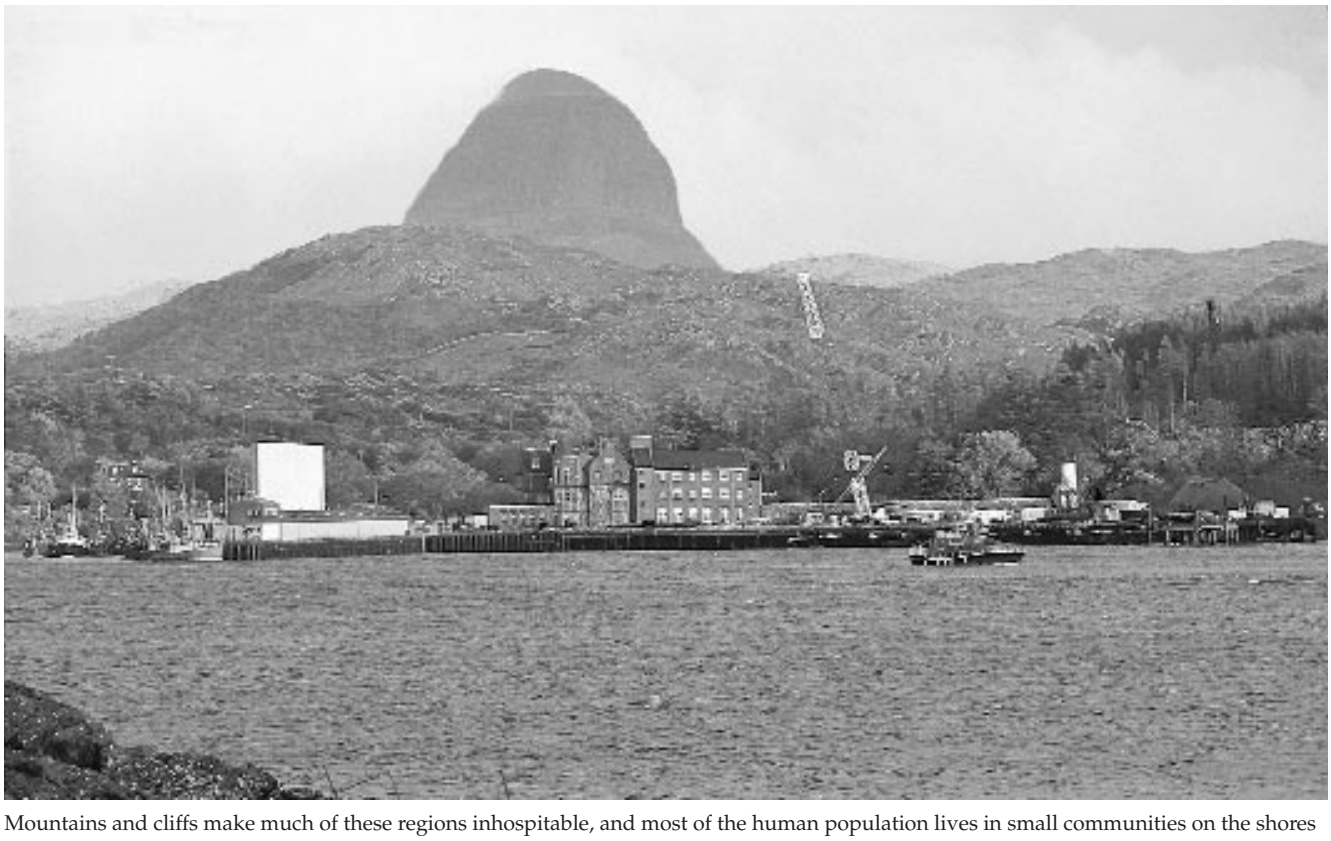
B. Further reading

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	*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	NHBS Ltd, 2-3 Wills Road, Totnes, Devon TQ9 5XN, tel: 01803 865913

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



Mountains and cliffs make much of these regions inhospitable, and most of the human population lives in small communities on the shores of sheltered sea lochs. Cargo shipping and ferries are vital to life on the mainland and the islands. Pictured is Lochinver, with the impressive bulk of Suilven brooding over it. Photo: Lorne Gill, Scottish Natural Heritage.

1.2 Introduction to the regions

Dr J.P. Doody

1.2.1 Introduction

This section gives a brief introduction to the character of Regions 15 (Western Isles) and 16 (west Highland), their wildlife and the extent of 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 regions.

Region 15 covers the Western Isles, including offshore islands, and Region 16 the north-west mainland of Scotland, including the islands of the Inner Hebrides north of the Sound of Mull. The total coastline length for Region 15 is 2,103 km, and for Region 16, 2,474 km. This extensive length of coastline arises from the indented nature of the coast and the presence of numerous large and small islands in both regions. These include the Western Isles themselves, as well as Skye, Rum and the smaller islands of Eigg, Canna and Raasay in Region 16. Together they represent 40% of the total coastline of Scotland and 25% of that of Great Britain. The geology of both regions is dominated by some of the oldest rocks in the UK. Region 15 has low but steeply shelving coastlines of Lewisian Gneiss (2,800 million years old), while Region 16 has a more varied geology, including gneiss and steep and spectacular cliffs of Torridonian Sandstone. The predominantly rocky coasts of the northern islands of Region 15 and most of Region 16 are interspersed with bays and pocket dunes. Extensive sand dunes and machair occur along the western coast of Region 15 from South Harris to the island of Barra. Exposed western coasts in both regions are subject to severe wave action, but because of the presence of the large islands and the highly indented nature of the sea lochs, many areas are sheltered; as a result there is great variation in maritime influence across the regions.

The rugged and open coast is a popular tourist destination for those wishing to experience wildlife and scenic beauty. This is one of the least populated areas of the UK and the whole area is free from major human infrastructure development. Crofting is the main agricultural use and much of the hinterland is in low-intensity sheep grazing. Cultivation takes place only on the few areas of land with any depth of soil, notably those with sandy deposits.

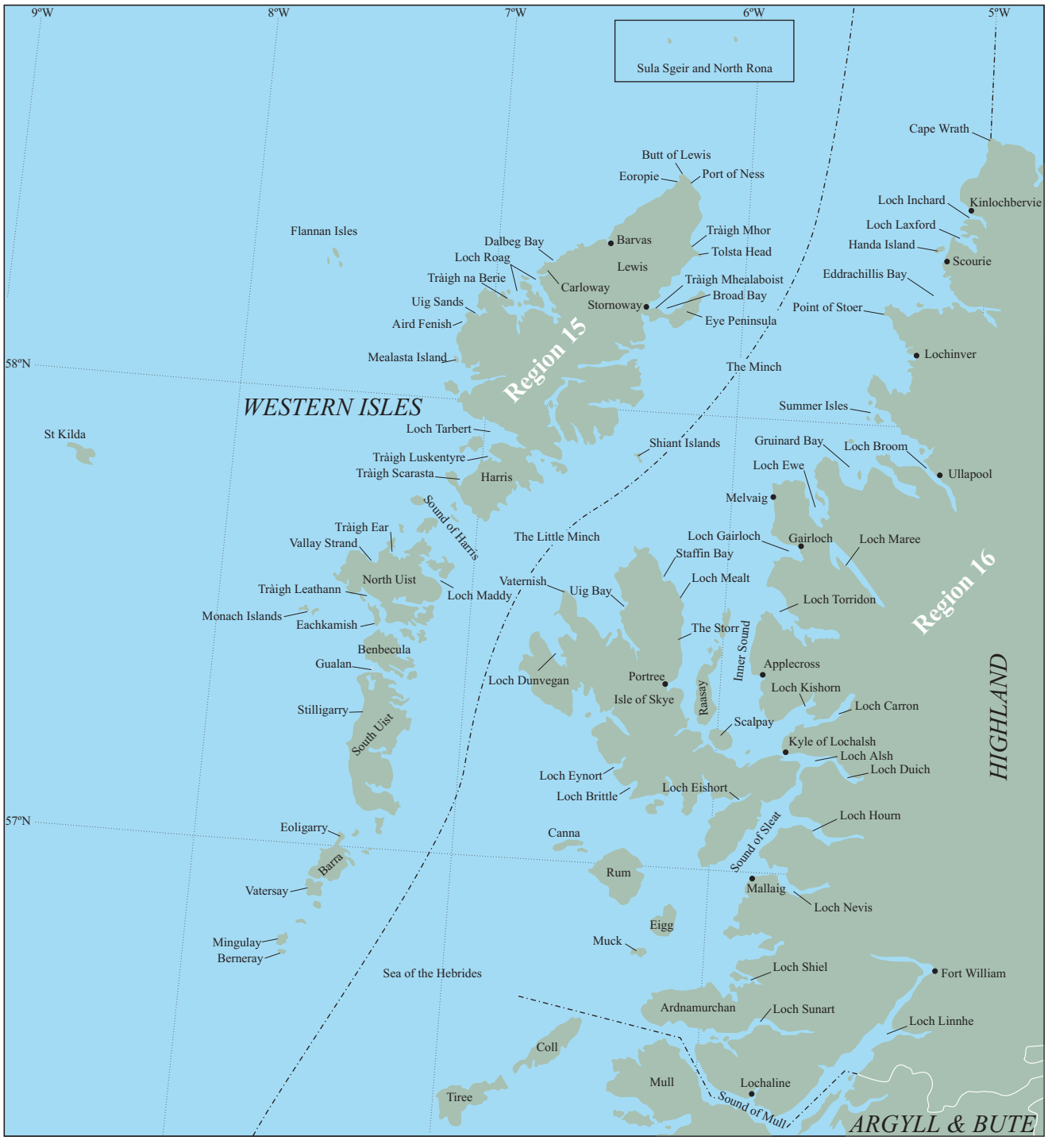
The combination of islands, sand dunes, cliffs and lochs against a backdrop of mountains make these some of the most beautiful scenic areas in the UK. Lochs may occur as typical fjordic features, such as Loch Torridon, with steep sided valleys, as well as more low-lying, shallow fjardic areas, such as Eddrachillis Bay. The wide range of habitat types in unbroken sequence, the remoteness of much of the area, the low intensity of agricultural use and the sparse industrial activity contribute to the species richness of the extensive open landscapes. The presence of birds of prey such as peregrine falcons and eagles and the thriving otter population indicate the relative freedom from pollution and human disturbance of much of the regions.

1.2.2 Structure and landscape

The solid geology of the regions provides the basis for much of the landscape. Region 15 and much of Region 16 are composed of Precambrian rocks (>540 million years old). In Region 15 and between Upper Loch Torridon and Cape Wrath in Region 16, Lewisian Gneiss forms the bulk of the low coastline. To the south, the islands of Skye and Rum and the Ardnamurchan peninsula were three of the main centres of Tertiary volcanic activity in western Scotland; St. Kilda was another. The resulting lava flows helped to form the spectacular cliffs which abound in the area, and the western coast of Skye has some of the finest sheer cliffs anywhere in the UK.

As in much of the rest of the UK, the land surface of the regions was completely covered by ice during the Pleistocene glacial period, and in Region 16 the ice sheets were thicker and the depression of the land surface probably greater than anywhere else in the country. The subsequent melting of the ice at the end of the last glaciation and the resulting upward movement of the land, which continues today, have had a major influence on the nature of the coast. The scouring by ice of pre-existing valleys helped to create the fjords that are significant landscape features in parts of the regions. During the melting of the ice the rate of rise in sea level was faster than the vertical 'rebound' of the land, resulting in the development of shorelines higher and further inland than today. In the south of Region 16 a series of beaches were formed at progressively lower levels. These survive today as raised beaches, which, on the smaller islands, have been found at 30 m, 21-24 m and 6 m above the present shoreline. There is evidence that in Region 15 and the northern part of Region 16 the depression of the land surface during the Ice Age was less than in the south of Region 16 and that the subsequent 'rebound' has also been less. Sea level is now thought to be rising relative to the land at Stornoway. In parts of Region 16, as in much of the rest of Scotland, the land is still rising, so although global sea level rise is thought to be approximately 1-2 mm per year overall, relative sea level appears to be falling.

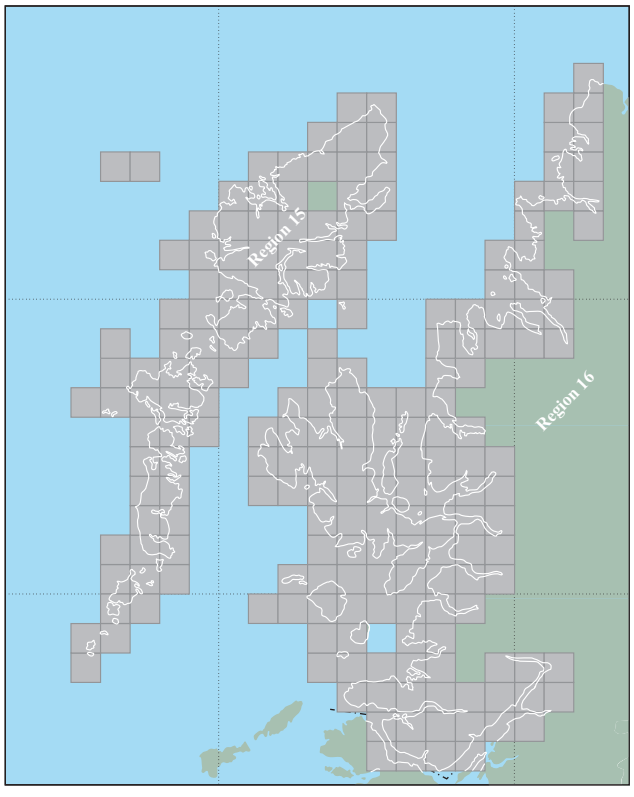
The coasts of the two regions are, along with Orkney (Region 2) and Shetland (Region 1), the windiest parts of the UK. Generally the west and south-west facing coasts, particularly of the Western Isles, are exposed to the full force of the wind. There is a great contrast between east and west-facing coasts, particularly in Region 15. Whereas exposed west-facing coasts may experience gales on 50 days a year, wind speeds may be 50% lower on sheltered shores. The tidal range is moderate and the mean spring tidal range for both Regions 15 and 16 is around 4.0 m. These figures are greatly influenced by storm surges, which may increase high tide levels by 25% during a 'once in 50-years' storm surge event. Wave heights may be extreme and the '50-year' wave height has been estimated to be as much as 35 m a few tens of kilometres west of Region 15. However the threat of flooding and coastal erosion affects only a few areas in the regions because of the combined effects of land uplift, the prevalence of hard cliff shorelines and the absence of major land claim.



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

1.2.3 The natural environment

The coasts of these regions present great contrasts and all the main coastal habitat types are present. The rocky shorelines, boulder shores, sandy beaches and fringing saltmarsh bordering the sea lochs and embayments are predominantly natural and frequently have transitions to non-tidal vegetation. In Harris, Lewis and much of the eastern coast of the Uists in Region 15, as well as over much of Region 16, steep rocky shores and sea cliffs make up a high proportion of the total length of the coastline. The size of the sand dune resource in Region 15 reflects the extensive areas of wind-blown sand in the Western Isles, where they form the flat cultivated machair plains of North and South Uist, Benbecula, Barra, Pabbay and Berneray; in Region 16 similar but smaller machair landscapes occur, scattered throughout the north of the area, generally on exposed west-facing coasts. Raised beaches are a notable feature of the landscape, characterising long sections of shoreline. Saltmarshes in the regions tend to be small and isolated, occurring along the margins and at the heads of the sea lochs. The regions' most significant and characteristic maritime habitats and their associated wildlife are described further below.



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

The sea and sea bed

The sea bed between Regions 15 and 16 falls steeply to a depth of more than 240 m to the east of Barra Head on Berneray. In the Inner Sound between Raasay and the mainland depths exceed 240 m; north-east of Raasay they reach 316 m. To the west of the Western Isles the sea bed falls more gently and uniformly to a depth of 120 m. Around the islands of the St. Kilda group, further to the west, the sea bed lies at a depth of only 60 m, defining the limits of the volcanic activity that created the islands. To the west of Region 15 the offshore area receives little sediment, from either onshore sources or tidal currents, and the sea bed is covered with a veneer of shelly sand and gravel. To the east, by contrast, the surface is covered with sometimes thick deposits of Pleistocene sediments up to 200 m deep, as for example to the south-west of Rum. Many of the sea lochs are of a characteristic form, with deep inner waters (reaching 100 m in Loch Torridon, for example) and shallow sills to seaward (leaving a water depth of only 24 m at the mouth of Loch Torridon).

The sea bed in Regions 15 and 16 supports a good range of communities of both plants and animals. This reflects the range of substrata, the variation in exposure to wave action and tidal currents, and the influence of the warm waters of the Gulf Stream. Many of the rarer species are northern in their distribution and include sea fans, cup corals and soft corals, but species from warmer southern areas are also present. Coastal nearshore waters around the islands are among the most diverse marine areas in Europe. The combination of clear water, tidal sills and the salinity gradients within the sea lochs makes them of considerable marine importance. This has been recognised in the proposal to designate several marine areas in the regions as Special Areas of Conservation under the EC Habitats & Species Directive. Overall, however, the diversity of the regions' non-exploited fish species in the coastal waters is slightly lower than might be expected on the basis of comparison with other regions, perhaps because fish records here are incomplete or because specimens caught have not been identified to species level. Basking sharks *Cetorhinus maximus* are known to occur in the regions.

The seas around Regions 15 and 16 abound in fish species that are exploited by fisheries, both for human food and for industrial or agricultural use. Of these, herring, mackerel, cod, haddock, whiting and Norway pout occur mainly in the deeper waters of the Minch and west of the Western Isles, sprat are more frequently found in shallower, inshore waters, and plaice and dab are abundant and widespread throughout. Atlantic salmon *Salmo salar* and sea trout *S. trutta,* which migrate between the rivers and lochs of the regions and the ocean, have a widespread distribution in the regions seas, as in the UK generally.

Common seals *Phoca vitulina* are found throughout the regions, where their numbers represent approximately 18% of the Great Britain population of the species, based on numbers of moulting individuals. Breeding occurs on many of the islands, and the regions account for approximately 18% of the pups born in Great Britain. Grey seals *Halichoerus grypus* are also found throughout the regions, especially on the remoter islands. The breeding grey seal population in Region 15 is of international importance. The coastal waters of the regions form one of the richest areas in the UK for whales, dolphins and porpoises. Nineteen and twenty species of cetaceans have been recorded in Regions 15 & 16 respectively, of which eight (30% of the 27 British species) are present throughout the year or are regular visitors.

The importance of areas at sea in both regions for seabirds varies depending on species. Generally, the areas near colonies are of greatest importance in summer, with the Minches and some parts of the Sea of Hebrides remaining important throughout the year. The offshore area over the continental shelf break is important for much of the year, partly because this provides a focus for fishing vessels, which in turn can produce much edible waste. The Minch is important for lesser black-backed gull *Larus fuscus,* great black-backed gull *L. marinus,* herring gull *L. argentatus* and kittiwakes *Rissa tridactyla* for much of the year, and for guillemots *Uria aalge* and razorbills *Alca torda* in July and, especially, August. Guillemots and razorbills also occur at high densities in the Sea of Hebrides in these months. The Minch remains important for guillemots throughout the winter, and there is a large influx of great black-backed gulls into the offshore waters in winter. Kittiwakes use waters to the west of the regions in winter.

There are only two natural lagoons in Region 15, but there are also a large number of other brackish pools, as well as reduced-salinity sea lochs in which the tidal regime is restricted by a narrow entrance or sill, that are quais-lagoonal in character. Some of the larger of these are over 100 ha in extent; they occur within the fjardic systems, such as Loch Maddy in North Uist. Under the EC Habitats & Species Directive all true lagoons and quais-lagoonal areas are considered a priority habitat type because of their rarity in Europe. The area of such habitats in these regions represents a major part of the British resource. There are no natural lagoons in Region 16, although a small inlet, Duart Lochan near Drumbeg, approaches lagoonal conditions.

Estuarine shores

Eleven estuaries, as defined and identified in the Nature Conservancy Council's Estuaries Review (Davidson *et al.* 1991), occur in the regions. They comprise one fjord, eight fjards and two embayments, mostly lying in Region 15. 6The largest of these is Oitir Mhór, Benbecula. This fjard - a shallow, glacially-scoured system - has over 4,000 ha of intertidal land, more than four times as much as any of the other sites. Many of the larger fjords and fjards that characterise the coast, especially in Region 16, have narrow shores composed of shingle rather than soft sediments of sand or mud and do not meet the definition of an estuary used in Davidson *et al.* (1991).

Saltmarshes in the regions occur mainly at the heads of lochs and are characteristically small (usually <10 ha), with little sediment input. As a result the saltmarsh vegetation is usually mid- to upper marsh or transitional to other vegetation types, rather than displaying the full series of saltmarsh zones typical in environments with greater rates of deposition. Approximately 80% and 70% (Regions 15 and 16 respectively) of the marsh is classified as mid-upper marsh and a further 15% in Region 15 forms a transition to adjacent grasslands, wet meadows and brackish swamp. The total area of saltmarsh is not large (only 451 ha and 738 ha or 1% and 1.7% of the GB resource respectively for Regions 15 and 16). The grasslands often include yellow iris *Iris pseudacorus*, which is a characteristic species on the margins of many of the sea lochs. The majority of upper marshes are grazed. The upper marsh vegetation communities in the Western Isles are especially rich where they grade into sand dune machair, wet grassland and peatland. Here the northern species saltmarsh flat-sedge *Blysmus rufus* and slender spike-rush *Eleocharis uniglumis* are frequent.

Non-estuarine shores

The coast of Region 15 has a large area of sand dune (7,964 ha), representing approximately 16% of the British resource. By contrast Region 16 only has 630 ha, or 1% of the British resource. The sand dunes of Region 15 are dominated by the machairs of the western shores of North and South Uist. These are the most extensive examples of the rare machair dune landscape, which is restricted to the western and northern shores of Scotland (including the Western Isles) and the west of Ireland. Machair comprises a particular form of hindshore dune, which can be extensive when the prevailing westerly winds drive sand inland above a wide beach. Continual landward progression and deflation of the surface, probably influenced by human use, results in the creation of a flat, sandy plain (the machair) and transitions to wet grassland, calcareous wetlands and peat. In these regions the machair is largely used for traditional cultivation and grazing sheep and cattle. This management is important for maintaining their conservation interest, which includes grassland rich in plant species, including agricultural weeds. The machair vegetation is particularly rich, supporting (amongst other species) the nationally rare holy-grass *Hierochloë odorata* and several nationally scarce higher plants. The wetlands associated with the machair plains are also very important for a number of aquatic plants, including two-thirds of Britain's pondweed *Potamogeton* species. Together with the adjacent crofting land the machair provides important feeding and nesting areas for the corncrake *Crex crex*, one of Britain's rarest birds, and breeding waders, such as the dunlin *Calidris alpina*.

In a number of very exposed locations, a veneer of sand may be blown over steep slopes and deposited over inland terrain. An important example occurs on the island of Pabbay, between Harris and North Uist in Region 15, where the climbing dune reaches a height of 196 m, and another on low-lying cliffs either side of the bay at Sandwood Loch, in Region 16. On the north side of this loch the climbing dune vegetation is dominated by a rare arctic-alpine plant, mountain avens *Dryas octopetala*, here occurring near sea level.

In both regions there are short lengths of shingle shoreline. These include those currently at the water's edge as well as those now out of reach of normal tides, deposited at the end of the last glaciation, when sea levels were much higher. Associated with the shingle shores is a highly distinctive flora, which includes the oysterplant *Mertensia maritima*, a characteristic but declining species of this unstable habitat. However, in Region 16 the plant has not been recorded since 1979. Other species include the endemic Scottish scurvygrass *Cochlearia scotica* and Scots lovage *Ligusticum scoticum*.

The sea cliffs of these regions show a great variety of form. Of the total 215 km cliff length in Region 15 (5% by length of the British cliff resource) more than 45% is made up of cliffs more than 20 m high; many of the regions' cliffs are much higher than this. Region 16 has 578 km of cliffs, 14% of the British resource and the highest figure for any coastal region. Some spectacular cliff landscapes occur in these regions, associated with the Tertiary volcanic rocks of Skye, Rum (rising to 380 m on the non-vertical Bloodstone Hill) and Eigg. St. Kilda has the most spectacular cliffs - near-vertical granites that rise to 426 m. Exposure to Atlantic storms has helped create extensive areas of maritime vegetation, for which St. Kilda is proposed as a Special Area for Conservation representative of 'vegetated sea cliff of the Atlantic and Baltic coasts', under the EC Habitats & Species Directive. The cliff tops have fine areas of grassland and maritime heath. Two nationally scarce plants (sea kale *Crambe maritima* and sea radish *Raphanus maritimus*) occur on cliff tops in Region 15 and in Region 16. Several arctic-alpine species, such as roseroot *Sedum rosea* and purple saxifrage *Saxifraga oppositifolia,* and the (more usually upland) nationally scarce species thyme broomrape *Orobanche alba*, occur at or near sea level on exposed cliffs and rocky shores throughout the regions.

The regions' cliffs are internationally important both for the numbers of seabirds they support and the existence of several very large breeding colonies. Eight seabird colonies on cliffs hold at least one species in numbers of European importance, with St. Kilda, Flannan Isles, North Rona, Sula Sgeir and the Shiant Islands (Region 15) and Summer Isles and Handa Island (Region 16) being among the most significant. A number of other colonies hold nationally important number (i.e. >1% of the GB population) of one or more species. The cliffs of St. Kilda are the haunt of some of the rarer birds of prey, such as peregrine falcon *Falco peregrinus* and eagles, including the re-introduced white-tailed eagle *Haliaeetus albicilla*.

The regions' cliffs, cliff- top habitats and rocky coasts support all the three terrestrial reptile species that occur in the regions: adders, slow worms and lizards. They also host

a rich invertebrate fauna; some species, such as the burnet moths *Zygaena* spp., the chequered skipper *Carterocephalus palaemon* and the grey moth *Hadena caesia*, have their major strongholds in the UK in Region 16, and coastal cliffs are especially important for them.

1.2.4 Landscape and nature conservation

The high value of the regions for landscape and nature conservation is reflected in the number and combined extent of sites afforded official protection (Table 1.2.1). The considerable landscape value of the regions, particularly Region 16, is reflected in the fact that together they have >71% of Scotland's National Scenic Areas. The voluntary conservation movement also plays an important role, with the John Muir Trust, the National Trust for Scotland and (in Region16) the Scottish Wildlife Trust all having large areas of reserves. There are also a number of proposed Special Areas of Conservation (SACs) in each region. The area covered by the each of the main designations is given in Table 1.2.1, although it should be noted that sites frequently have more than one designation, whose boundaries are not necessarily the same.

1.2.5 Human activities, past and present

After the Ice Ages, hunter-gathers were probably the first people to use the regions. These roaming hunters found the coast rich in wildfowl, seabirds, fish and molluscs, and on Rum human presence is shown by evidence of a Mesolithic camp site for fishermen. A chambered cairn near Scourie suggests that some settled communities may have used the mainland from about 4,500 years ago. The introduction of cereal growing is considered to have reached Scotland by 3,500 BC; in Region 15 the early Bronze Age shows continuity with the preceding Neolithic period, as communities farmed the land, which by then had been largely cleared of trees. However, deterioration of the climate led to the development of peat bogs and a reduction in the area of productive land.

Regions 15 and 16 were largely unaffected by the Roman occupation and Saxon migrations. Located on the sea routes between south-west Europe, Ireland and Scandinavia, they experienced instead the influence of Irish missionaries and Viking raiders and settlers. From the 6th century the area was greatly influenced by the Christians, who came from Celtic Ireland via Iona. Monastic settlements became focal points and overseas links brought both imported goods and an expanded knowledge of farming. Their success made them targets for Viking raids of the late 8th century; the Vikings had a great influence on the area up to the thirteenth century. A herring fishery flourished, and by the 1790s Loch Roag was host to some 90 UK herring boats and Uig boasted 275 net makers. In the 1870s around 80,000 barrels of herring were cured annually at Stornoway.

During the nineteenth century the decline of the kelp industry and the potato famine of the 1840s resulted in the government providing money for public works, including road building. The century also saw the development of country estates, which required labour for their maintenance. Inverewe Gardens, for example, were established in 1865. Around this time the Highland Clearances were causing wide-ranging impacts on the life and landscape of the Highlands of Scotland. Between the late eighteenth and late nineteenth centuries the people who had lived on the land for many generations were removed to make way for livestock farming, notably sheep. Displaced people moved to the coast, including the islands. The sandy machair plains of the exposed west coast of the Uists and other smaller localities provided cultivable soils, and a system of agriculture developed on them that survives today, notably in South Uist.

Agriculture, especially crofting, remains the principal land use but is often supplemented by other activities such as fish farming and tourism. Sheep grazing occurs over a large part of the moorland along the coast, although the practice of moving sheep to the uplands in the summer (transhumance) largely disappeared after the last war.

Table 1.2.1 Main landscape and nature conservation designations in the regions

Designation	*No. of sites*		*Total area (ha)*		*% of GB coast total in region*	
	Region 15	*Region 16*	*Region 15*	*Region 16*	*Region 15*	*Region 16*
World Heritage Sites	1	0	853	0	100	0
Biosphere Reserves	2	1	2,530	10,684	9.3	39.2
Possible Special Areas of Conservation (SACs)	9	8.5[a]	n/a	n/a	8	7.6
Ramsar sites	2	0	5,386	0	1.6	0
Special Protection Areas (SPA)	5	3.5[a]	2,756	11,692[a]	0.8	3.2
National Nature Reserves (NNRs)	4	5	3,237	22,246	3.7	25.5
Sites of Special Scientific Interest (SSSIs)	43	78	31,155	62,814	4.3	8.8
Marine Consultation Areas	7	7	27,557	17,634	24.6	15.8
National Trust for Scotland sites	1	6	846	18,283	1.3[c]	29.0[c]
National Scenic Areas[b]	3	9.5[a]	116,600	417,700[a]	15.6[b]	56.0[b]
Scottish Wildlife Trust	0	6	0	9,563	0	36.9[d]
John Muir Trust	0	4	0	14,173	0	100
Royal Society for the Protection of Birds (RSPB) reserves	1	3	658	400	1.7	1.0

Source: JNCC. Key: [a]includes site lying partly within Region 16 and partly within Region 14; half the relevant site area has been included in the total; [b]designation applies in Scotland only; [c]GB total includes National Trust sites; [d]GB total includes figures for all Wildlife Trusts.
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.

Widespread ploughing of the open moorland has not occurred, largely because the soils are thin, but non-native conifer planting has influenced both landscape and wildlife in the regions since the 1930s. Although fishing is still an important industry, it is not as significant as in some other areas of the country. Herring and mackerel are the main commercial species and are still landed in large numbers at Ullapool and elsewhere; over a quarter of the British and Isle of Man total catch of pelagic species (e.g. herring) is landed in the regions. However, the fisheries for herring and mackerel have declined markedly in the second half of the 20th century, owing to the collapse of stocks of the former and a change in the migration pattern of the latter. The bulk of the present catch is bought by eastern European factory vessels, which process the catch and export it. As elsewhere in the UK, the industry is in decline, although a recent injection of funds to increase the area of Mallaig port may improve prospects of increased landings there. Local fishing takes place for a range of shellfish, with landings representing about 11% of the British total. Atlantic salmon *Salmo salar* and sea trout *Salmo trutta* are fished regularly, for sport and commercially, both in the rivers and lochs and at netting stations along the coast. The sporting fishery has traditionally attracted fishermen from the south.

Infrastructure development is sparse in both regions. As along much of the west coast of Scotland, the most significant commercial activity in the regions is associated with fish farming. Undeveloped shores predominate over the majority of the area, and, apart from in the scattered harbours, Tong/Melbost Sands on Lewis has the only example of land claim for infrastructure development. The only town of any size in Region 15 is Stornoway, and in Region 16 Ullapool is the largest port and Fort William a centre for industry and the tourist trade. Access to the area has always been difficult and the islands rely on regular ferry services for most of their provisions. Short distance air transport also provides a vital link, and the beach airstrip on Barra in the southern part of the Western Isles is one of Britain's more unusual landing strips. Coastal defence occupies a very small proportion of the regions' coastline by comparison with south and south-east England. The majority in these regions are located to protect buildings and industry around the ports.

Neither oil developments nor marine aggregate extraction are important issues in either region at present. However recent proposals for coastal superquarries to supply aggregate to England may have an impact on the landscape and people in parts of the regions. There is already one large coastal quarry, at Glensanda.

Tourism is a major revenue earner for the regions, attracting visitors for the landscape, cultural and wildlife value of the area. The area includes a wide range of recreational facilities including several golf courses. Walking, climbing and natural history are also important. The last activity represents a significant use of the area. Some smaller fishing boats are used to take parties on island trips or sea mammal watching, though charter boats come mostly from outside the regions. The Isle of Skye, now connected to the mainland by a bridge, and nature reserves such as Rum and some of the other smaller islands are popular destinations for botanists and birdwatchers.

1.2.6 Further sources of information

A. References cited

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.

B. Further reading

Robinson, A., & Millward, R. 1983. *The Shell book of the British coast*. Newton Abbot, David and Charles.

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

The ring dykes of the Ardnamurchan Peninsula are internationally famous, although their origin is still disputed. Like much of the more visible geology of the regions, they were formed during the Tertiary Igneous period, around 60 million years ago, and may represent the base of an eroded volcano or dykes intruded into the surrounding bedrock. Photo: P.A. Macdonald, Scottish Natural Heritage.

Chapter 2 Geology and physical environment

2.1 Coastal geology

British Geological Survey & R. Threadgould

2.1.1 Introduction

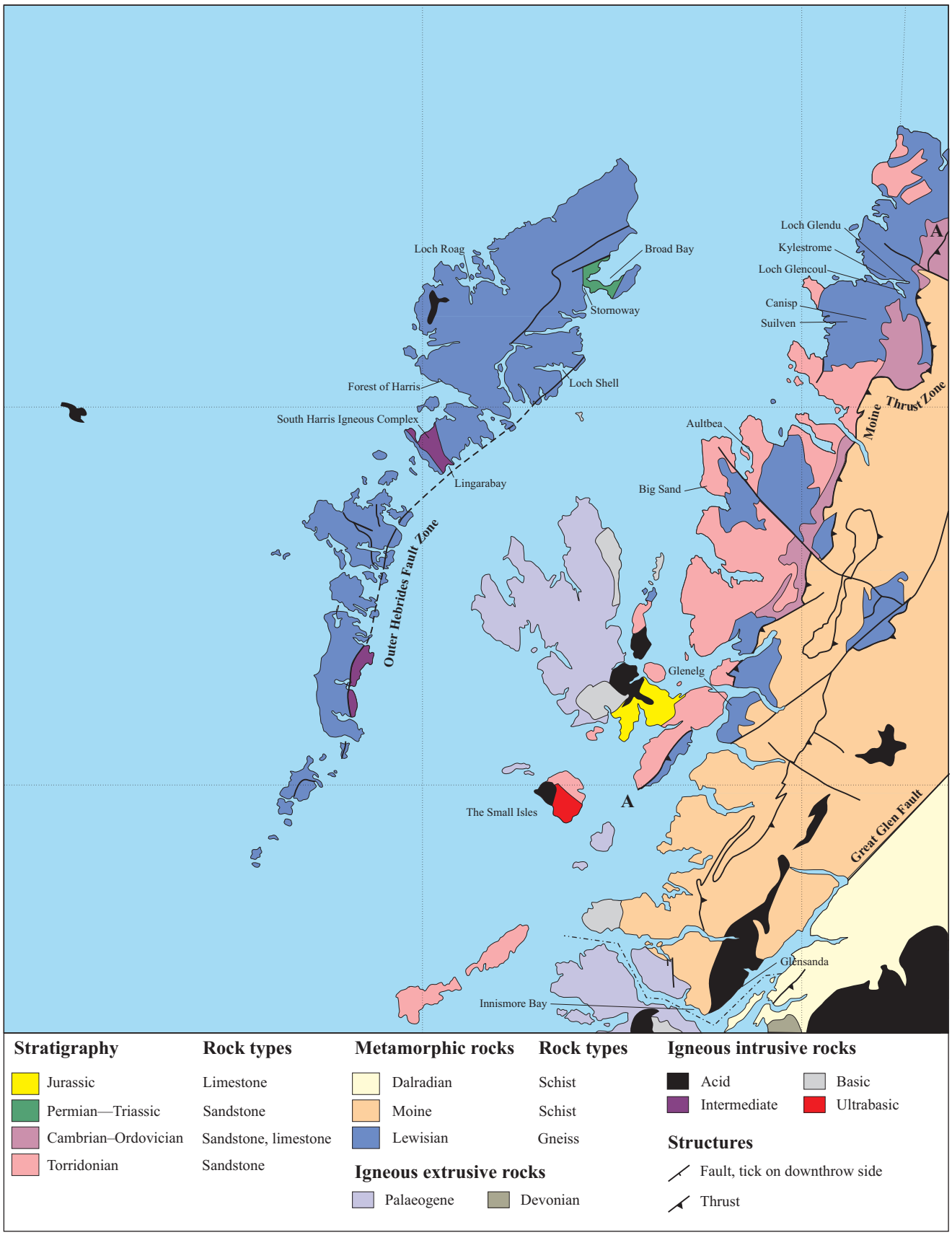
The Western Isles and west Highland are composed of a wide variety of metamorphic, igneous and sedimentary rocks that range in age from Precambrian to Tertiary. With the exception of much of Skye and the Small Isles, the coastline is represented by Precambrian rocks (i.e. older than 540 million years) comprising four main groups: the Lewisian Complex, the Moine, the Torridonian and the Dalradian. Elsewhere, small proportions of Cambro-Ordovician sediments crop out along Lochs Glencoul, Broom, Kishorn and Eishort, whilst younger Permo-Triassic sandstones are restricted to small pockets along the mainland seaboard, and a larger outcrop around Stornoway, on Lewis. Much of the Mesozoic outcrop of Jurassic sediments is found on Skye, Raasay and Eigg and a tiny outcrop of Cretaceous sediment occurs in the Sound of Mull. Tertiary intrusions, lavas and sediment dominate the igneous centres of Skye, Rum and Ardnamurchan and the associated lava fields of Eigg, Canna and Muck.

Structurally, the regions are divided into two by the line of the Moine Thrust Zone. The area to the west of the thrust zone represents 'unmoved' crust, whilst to the east the rocks have been folded and transported towards the north-west by movements associated with the development of the Caledonian Mountain Belt. (The Highlands represent the eroded remains of mountains that perhaps were once as high as the Himalayas are today.) The mountain-building event culminated in the collision of continental plates carrying 'Scotland' and 'England', some 400 million years ago. The coastline of Region 15 is marked by the Outer Hebrides Fault Zone, a complex structure that has formed a line of crustal weakness since perhaps 2,500 million years ago. This fault zone has been active on a number of occasions and is

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	1.8	Devensian ice sheet	Series of ice sheets cover the region
	Tertiary (Neogene)	Pliocene	5		
		Miocene	23		
	Tertiary (Palaeogene)	Oligocene	38		
		Eocene	54		Uplift and erosion in the western part of the regions
		Palaeocene	65		Intrusion of Tertiary Igneous Complexes
Mesozoic	Cretaceous		146		Marine deposition
	Jurassic		208	Great Estuarine Group Lias	Deposition in offshore basins; some deposition extended on land
	Triassic		245	Stornoway Beds	Igneous activity. Deposition in isolated basins.
Palaeozoic (Upper)	Permian		290		
	Carboniferous	Stephanian Westphalian Namurian		Coal Measures	
		Dinantian	360		
	Devonian		410		Closure of Iapetus Ocean
Palaeozoic (Lower)	Silurian		440		Caledonian Orogeny
	Ordovician		505	Durness Limestone	Ocean floor sediments and emplacement of igneous rocks
	Cambrian		544		
Precambrian				Dalradian - Southern Highland Group Torridonian, Moine Lewisian	Series of major metamorphic events modified Lewisian rocks

Note: shaded boxes show ages of rocks with important or extensive exposures in the regions.



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

thought to have been a controlling factor in the generation of the Sea of Hebrides Basin. Early shear zones also occur within the Lewisian Complex. Intrusions associated with the mountain-building event occur throughout Region 16; the largest, the Strontian granite, is exploited by the Glensanda Quarry. A number of dyke swarms occur within both regions, although the majority are restricted to Region 16. The last major igneous event occurred during the Tertiary, when volcanoes, centred on St. Kilda, Skye, Rum and Ardnarmurchan, developed in response to the opening of the North Atlantic Ocean (Map 2.1.1; Table 2.1.1).

Most major locations referred to in this chapter are indicated on Map 1.2.1; only those of particular relevance to this chapter are shown on maps contained within it.

2.1.2 Stratigraphy

Region 15 - Western Isles

The greater part of Region 15 is composed of rocks belonging to the Lewisian Complex, a suite of rock types ranging from 2,800 million years to 1,700 million years old. Geochemical studies suggest that the majority of the rocks are of igneous origin, although some sediments occur, e.g. the Leverburgh and Langavat metasediments of South Harris. Put simply, the geological history of the Lewisian Complex can be divided into three stages: an early phase of Scourian gneiss (grey gneisses and areas of basic and ultrabasic rock) development (*c.* 2,800 million years); a middle phase (*c.* 2,400 million years) of Scourie dyke emplacement forming distinct black bands of variable width within the earlier gneisses; and a later phase (*c.* 1,700 million years) of Laxfordian granitic veining. On weathering, the Complex develops the distinctive, subdued, hummocky landscapes typical of parts of Lewis.

Throughout this history, the whole Lewisian Complex was affected repeatedly by phases of deformation and metamorphism (mineral changes caused by heat and pressure). Some of the best preserved metamorphosed sediments of the Lewisian Complex in Region 15 occur in South Harris, at Leverburgh and Langavat. The sediments are intruded by the South Harris Igneous Complex, which is dated between 2,400-2,000 million years. Composed of anorthosite, metamorphosed gabbro and diorite, it is this Complex that would be exploited by the proposed Lingarabay Superquarry.

Although early deformation, pre-dating the emplacement of the Scourie dykes, has been attributed to the development of intense fabrics and a series of regional folds and shear zones within the Scourian gneisses, the majority of deformation relates to the Laxfordian event. The Laxfordian is also associated with intense shearing and the generation and intrusion of granitic dykes and veins.

The most prominent structural feature of the region is the Outer Hebrides Fault Zone, which extends for over 200 km from south of Barra to north Lewis. The zone is marked by a series of fault-related rock types, from crushed gneiss, through mylonites to phyllonite, representing increasing strain. The fault zone's history is long and complex and still not fully understood. Initial movements may have occurred as long ago as 2,500 million years, since some of structures appear to be cut by Scourie dykes. Later movements, during the late Palaeozoic and Mesozoic, led to the development of a number of sedimentary basins across the Inner Hebrides.

The only significant younger sedimentary rocks preserved on Lewis are the Permo-Triassic Stornoway Beds, a thick sequence of sandstones and conglomerates which occur as a downfaulted block around Stornoway. They were probably laid down at the edge of the Mesozoic sedimentary basin of the northern Minch and now support good agricultural land around Broad Bay. As the Outer Hebrides probably constituted land for much of the Mesozoic, it is unlikely that younger sediments were deposited there until perhaps the Cretaceous.

The minor islands around the Outer Hebrides contain additional evidence of the geological history of the region during Mesozoic and Tertiary times. A few metres of Liassic (Jurassic) shales and marls occur between Tertiary basic sills on the Shiant Islands. East-west igneous dykes of Permo-Carboniferous age up to 35 m across are found as a narrow swarm between North Barra and South Uist. Dykes of Tertiary age with a north-west/south-east trend are found on Lewis between Loch Roag and Loch Shell. The scattered islands making up the St. Kilda group are formed principally of early Tertiary gabbro with minor ultrabasic and granophyric intrusives.

The Pleistocene glaciations of mainland Scotland also affected the region. The main islands are covered by a variable glacial till cover, and the typical rounded, low topography of much of the southern islands is a product of glacial erosion. Evidence from ice striations and glacial erratic pebbles suggests that an ice sheet moved westwards across the region, and that an independent ice cap covered the southern islands during the late Devensian. Offshore evidence indicates that more than one Pleistocene glaciation crossed the region, but the age and effects of the older glaciations are uncertain.

Region 16 - west Highland

Lewisian

The Lewisian gneiss on the coast of the Scottish mainland to the west of the Moine Thrust Zone is similar to that of Region 15; there are, however variations in the lithology across the region. Biotite and muscovite gneiss are more common on Raasay and around Gruinard Bay, while at Loch Maree the gneiss consists of a schistose assemblage of metasediments including marbles and graphitic schists. Further north, pyroxene gneiss is typical of the district from Loch Broom to Scourie, and hornblende and biotite gneiss are predominant towards Cape Wrath. Pegmatites (coarse-grained low-temperature granitic rocks) are locally common. Scourie and Laxford have given their names to metamorphic events detected in the Lewisian gneiss.

Torridonian-Moine-Dalradian

The Torridonian, Moine and Dalradian represent three groups of rock of Precambrian age. The Moine and Dalradian largely represent metamorphosed sediments of marine origin that were deposited on a subsiding continental shelf between 1,000-600 million years ago. There is some speculation that the Dalradian is a continuation of the Moine, but this relationship is obscured by the Great Glen

Fault. The Torridonian represents continental sediments, predominantly sandstones, deposited between 1,000-800 million years ago in rivers, lakes and alluvial fans.

The fact that the Torridonian and Moine are of similar ages has led to speculation that they are related. The two units are separated by the Moine Thrust, with the Torridonian to the west and the Moine rocks to the east. Unlike the Torridonian sediments, the rocks of the Moine have been severely deformed and metamorphosed. Subsequent movement along the Moine Thrust has led to the juxtaposition of the two units.

The Torridonian rocks form the spectacular mountains - including Suilven and Canisp - on the north-western coast of the region, and are also exposed on several of the Hebridean islands. The rocks form a sequence many hundreds of metres thick that rests on the eroded surface of the Lewisian Complex. They consist, primarily, of red sediments of continental (non-marine) origin, the majority of which were deposited in large braided river systems and now form well-bedded sub-horizontal units, owing to later tilting.

Moine rocks occur along the coast in the south of the region, where the Moine Thrust Zone lies offshore to the west. They exhibit intense folding on a range of scales related to a number of fold episodes. The Moine is divided into a number of groups: the oldest, the Morar Group, occurs along the coast from the Sound of Mull to Glenelg and consists predominantly of metamorphosed sandstones, with some mudstones in which a wide range of sedimentary structures are still visible; the Glenfinnan Group, a unit of alternating metamorphosed sandstones and mudstones, a small part of which crops out along the Sound of Mull; and the Loch Eil Group, exposed along the northern shores of Loch Linnhe, which is composed largely of psammitic schist (derived from quartz sand) with pelitic bands (metamorphosed silt and clay).

Dalradian rocks, belonging to the Grampian and Appin Groups and representing shelf sediments, crop out along the eastern shore of Loch Linnhe.

Lower Palaeozoic rocks

Cambrian and Lower Ordovician strata in the north-west Highlands occupy a narrow band lying to the west of the Moine Thrust, running from the southern part of the Isle of Skye to Durness. Coastal outcrops of these rocks lie at the heads of certain lochs, such as Loch Eishort (on Skye), Loch Kishorn, Loch Broom and Lochs Glendhu and Glencoul to the east of Kylestrome. The strata consist of basal quartzite units overlain by calcareous mudstones and grits, which give way to dark and light dolomitic limestone which in turn yield to limestone with chert nodules. The limestones are fossiliferous, and there are interbedded grey siltstones rich in trilobites.

Upper Palaeozoic rocks

Strata of Carboniferous age crop out at Inninmore Bay on the north-east of the Sound of Mull within a small faulted outlier. The sediments consist of sandstones, locally pebbly with some lenses of coal. Upper Palaeozoic igneous activity is represented by the quartz dolerite dykes to the west of Loch Linnhe and a series of dykes on Ardnamurchan, which may be of late Carboniferous or Permian age.

Mesozoic rocks

Remnants of Mesozoic rocks are preserved onshore at isolated localities across the region and form landward extensions of the more extensive deposits preserved offshore in the Minch. The disposition of these rocks suggests that during the late Mesozoic the region may have been overlain by a more extensive cover of Mesozoic rocks. Uplift and erosion related to the early Tertiary volcanism and mid-Tertiary fault movements have led to the removal of most of this cover from the present land area.

Small outliers of unfossiliferous sandstones and conglomerates of probable Triassic age rest unconformably on Torridonian rocks along the coast from Loch Alsh to Edrachillis Bay. The largest outlier, between Big Sand and Aultbea, contains over 150 m of red, cross-bedded sandstone. Similar outliers occur at Applecross and on the northern shores of Loch Gairloch.

Jurassic rocks overlie the Triassic sandstones at Applecross, but the most complete succession of Jurassic rocks, in total nearly 800 m thick, is preserved at Ardnamurchan and on Skye and Raasay. An almost complete succession of Liassic (Lower Jurassic) ammonite zones has been recognised in the sequence, which consists of a basal limestone followed by shales and sandstone. The distinctive ironstone found in the upper part of the Lias was formerly worked for ore on Raasay. The 530 m Middle Jurassic sequence on Skye is the thickest known in north-west Europe. The lower part of the unit consists of coarse marine sandstones with massive cross bedding, and the upper part, the Great Estuarine Group, contains over 200 m of interbedded fossiliferous shales, clays and limestones. Thinner representatives of these units are found on Ardnamurchan and Raasay. The most complete exposures of Upper Jurassic are found on northern Skye, where they form a 150 m section of sandstones and siltstones, locally containing bituminous shale. Minor outliers of these units are also found on the islands of Eigg and Scalpay.

Thin, isolated sections of Cretaceous rocks are found across the region. They are best developed on Morvern, between Loch Linnhe and Loch Sunart, where about 13 m of Cenomanian glauconitic sand is overlain by a white sandstone of such purity that it has been worked as a glass sand at Lochaline. Similar patches of Cretaceous sediments are found on Eigg, Skye and Raasay.

Tertiary volcanic rocks

Ardnamurchan, Rum and Skye are the sites of early Tertiary volcanic centres, which produced an outpouring of largely basaltic lava, led to the emplacement of igneous rocks beneath the volcanoes and caused the intrusion of sills and dykes into the surrounding bedrock. The volcanism occurred between 63 and 52 million years ago, with the youngest dates obtained from the lavas of Eigg. Erosion has deeply dissected the volcanic centres so that today only the exposed roots of the volcanoes remain, but the preserved thickness of basaltic lavas on Skye is 600 m. A wide range of igneous rocks is exposed in the centres, ranging in composition from ultrabasic peridotite to acid granite and in form from dyke swarms to plutonic bodies. The study of these volcanic centres during the latter part of the last century led to great advances in the understanding of igneous rocks, and they remain sites of great interest to both professional and amateur geologists.

Pleistocene events

The mountainous parts of the region were covered by major ice sheets at least three times during the Pleistocene, when ice tongues flowed from the Highlands down the steep western mountain slopes onto areas presently offshore. The last major ice sheet, during the late Devensian, removed all traces of earlier glaciations from the onshore parts of the region, but evidence is still preserved offshore. Evidence from Pleistocene deposits offshore suggests that the ice sheets reached the edge of the continental shelf on at least two occasions.

Onshore, sheets of boulder clay (also known as till) cover substantial areas of the southern part of the region. Further north, the ice sheet scoured the surface to leave extensive areas of bare rock. Local gravel accumulations have been formed by subglacial features such as eskers and by late glacial outwash fans.

2.1.3 Structure

The gross geological structure of the regions is aligned from NNE-SSW, following the trend of the Moine Thrust and the Minch Fault. The islands of Region 15 lie on a ridge bounded to the east by the Outer Hebrides Fault Zone. The Lewisian rocks were part of a large crustal block, the Laurentian Shield, which included much of Greenland and northern Canada. The opening of the North Atlantic Ocean during the Mesozoic led to the break up of the block and its separation into widely dispersed fragments.

The major structural feature of Region 16 is the easterly-dipping Moine Thrust Zone, which is traceable from east of Loch Eriboll southwards to the southern coast of Skye and offshore southwards to the channel separating Iona from Mull (Map 2.1.1). In the vicinity of the thrust zone, Moinian rocks have been pushed westwards to lie on top of the Lewisian and Torridonian rocks, which lie to the west of the thrust zone. Lewisian rocks can also be found lying to the east of the thrust zone and constituting the basement under the Moinian rocks of the Scottish Highlands.

2.1.4 Further sources of information

A. Maps

British Geological Survey. 1986. *Little Minch. Sheet 57N 08W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1986. *Rona. Sheet 59N 06W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1986. *Rona. Sheet 59N 06W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1986. *Tiree. Sheet 56N 08W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1987. *Argyll. Sheet 56N 06W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1987. *Argyll. Sheet 56N 06W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1988. *Little Minch, including part Great Glen 57N 06W. Sheet 57N 08W, sea-bed sediments and Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1988. *Sula Sgeir. Sheet 59N 08W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1988. *Sula Sgeir. Sheet 59N 08W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1988. *Tiree, including part Argyll 56N 08W. Sheet 56N 08W, sea-bed sediments and Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Geikie. Sheet 58N 10W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Geikie. Sheet 58N 10W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Geikie. Sheet 58N 10W, Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Great Glen. Sheet 57N 06W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Lewis. Sheet 58N 08W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Lewis. Sheet 58N 08W, Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Sutherland. Sheet 58N 06W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Sutherland. Sheet 58N 06W, sea-bed sediments and Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1990. *Lewis. Sheet 58N 08W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1990. *Rona. Sheet 59N 06W, Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1990. *Sula Sgeir. Sheet 59N 08W, Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1991. *St. Kilda. Sheet 57N 10W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1991. *St. Kilda. Sheet 57N 10W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1992. *St. Kilda. Sheet 57N 10W, Quarternary.* Keyworth, British Geological Survey.

B. References cited

British Geological Survey. 1991. *Geology of the United Kingdom, Ireland and the adjacent continental shelf (North Sheet).* 1:1,000,000 scale. Keyworth, British Geological Survey.

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.

Craig, G.Y., *ed*. 1983. *Geology of Scotland.* 2nd ed. Edinburgh, Scottish Academic Press.

Ellis, N.V. (*ed.*), Bowen, D.Q., Campbell, S., Knill, J.L., McKirdy, A.P., Prosser, C.D., Vincent, M.A., & Wilson, R.C.L. 1995. *An introduction to the Geological Conservation Review.* Peterborough, Joint Nature Conservation Committee. (Geological Conservation Review series, No. 1.)

Emeleus, C.H., & Gyopari, M.C. 1992. *British tertiary volcanic province*. London, Chapman and Hall. (Geological Conservation Review series, No. 4.)

Fettes, D.J., Mendum, J.R., Smith, D.I., & Watson, J.V. 1992. *Geology of the Outer Hebrides. Memoir for 1:100,000 (solid edition) geological sheets, Lewis and Harris, Uist and Barra (Scotland).* London, British Geological Survey, HMSO.

Gibbons, W., & Harris, A.L., *eds*. 1994. *A revised correlation of Precambrian rocks in the British Isles*. London, Geological Society of London. (Special Report, No. 22.)

Gordon, J.E., & Sutherland, D.G., *eds*. 1993. *Quaternary of Scotland*. London, Chapman and Hall. (Geological Conservation Review series, No. 6.)

Gregory, K.J., *ed.* In prep. *Fluvial geomorphology of Great Britain.* London, Chapman and Hall. (Geological Conservation Review series, No. 13.)

Harris, A.L., & Pitcher, W.S. 1975. The Dalradian Supergroup. *In: A correlation of Precambrian rocks in the British Isles*, ed. by A.L. Harris *et al.*, 52-75. London, Geological Society. (Special Report of the Geological Society of London, No. 6.)

Johnson, M.R.W. 1983. Dalradian. *In: Geology of Scotland*, 2nd ed., ed. by G.Y. Craig, 77-98. Edinburgh, Scottish Academic Press.

Johnson, M.R.W. 1983. Torridonian-Moine. *In: Geology of Scotland*, ed. by G.Y. Craig. Edinburgh, Scottish Academic Press.

Nature Conservancy Council. 1977. *Outer Hebrides: localities of geological and geomorphological importance*. Newbury, Nature Conservancy Council.

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 Regions 15 & 16 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
Geological Conservation Review sites, Scotland	*Scottish Natural Heritage HQ, Edinburgh, tel: 0131 447 4784
Geological Conservation Review sites in Region 15	*Scottish Natural Heritage, Stornoway, Isle of Lewis, tel: 01851 705258
Geological Conservation Review sites in Region 16	*Scottish Natural Heritage, Inverness, tel: 01463 239431

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

The St. Kilda archipelago sits on an underwater plateau whose surface lies at about 60 m depth and which stands proud of the surrounding St Kilda Basin, itself about 200 m deep. A rocky rim around the plateau may mark the limits of the igneous complex that formed the islands. Further west, beyond the edge of the continental shelf, the sea bed plunges to 2,000 m or more between St Kilda and Rockall. Photo: Mark Tasker, JNCC.

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 in Regions 15 (Western Isles) and 16 (west Highland). The bulk of the information is shown on the maps, with some additional explanation provided by the text; named locations are shown on Map 1.2.1.

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 early Holocene. The lithology (rock-type) and thickness of the sediments have been determined by sampling, high resolution seismic profiling and sidescan sonar.

Sea-bed sediments are shown on Map 2.2.1. The waters west of Region 15 are supplied with little sediment from onshore or by tidal currents. The sea-bed sediment is very thin and is commonly a carbonate (shell fragment) sand with some gravel. West of the islands of North and South Uist side-scan sonar records show the sea bed for some 40 km westwards (to a depth of about 120 m) to be predominantly rocky knolls, with limited sediment cover in the intervening lows. West of this rocky area, in the broad depression south of St. Kilda (the St. Kilda Basin), the Holocene sands form a continuous sheet less than one metre thick. Present-day sedimentation in this area is negligible.

The Minch and the Sea of the Hebrides serve as a sink for a limited volume of sediment, which mainly originates from the mainland to the east. Sea-bed sediments are largely derived from reworked glacial deposits and shell fragments. Shell-rich sands may contain fragments of bivalves, barnacles, gastropods, tubeworm tubes and sea urchins. A diverse range of sediments are found in Region 16, with algal gravels in shallow, sheltered tidal channels, for example in Loch Dunvegan in north-west Skye. Carbonate-rich sand ribbons and sandwaves occur along the main tidal streams, and highly burrowed muds occur in the deeper, lower-energy areas, many with examples of cementation taking place shortly after deposition (Farrow 1983).

Erosion of the mud component from glacial deposits commonly leaves a gravel 'lag' (winnowed relict) in shallow water and over shoals, containing a variety of rock types. Muddy sands, reworked from glacial (moraine and outwash) deposits, have accumulated in the hollows excavated by glaciers. Thus sediments in the deep waters of the regions are predominantly muddy, with coarser sediments commonly restricted to the shallower areas, although in areas where sediment supply is limited shell or barnacle fragments may become a more significant component.

2.2.2 Pleistocene geology

Offshore Pleistocene deposits are shown on Map 2.2.2. The ice sheet associated with the last glaciation (during the late Devensian) covered most of Region 15 and removed almost all traces of any older Pleistocene deposition. The only remnants of these older units are preserved on the northern coast of Lewis, where the sediments indicate deposition under glacial and then milder interglacial conditions. There is no evidence that the late Devensian ice sheet impinged on the St. Kilda group but there are indications that an earlier glaciation may have covered part of the largest island (Hirta). West of the Western Isles a thick Quaternary succession has accumulated on the continental shelf to the south and west of St. Kilda. At least two ice sheets crossed the continental shelf to the south and west of the islands, and the ice limit was near the present continental shelf break (approximately at the 150-160 m isobath (see Map 2.3.3)).

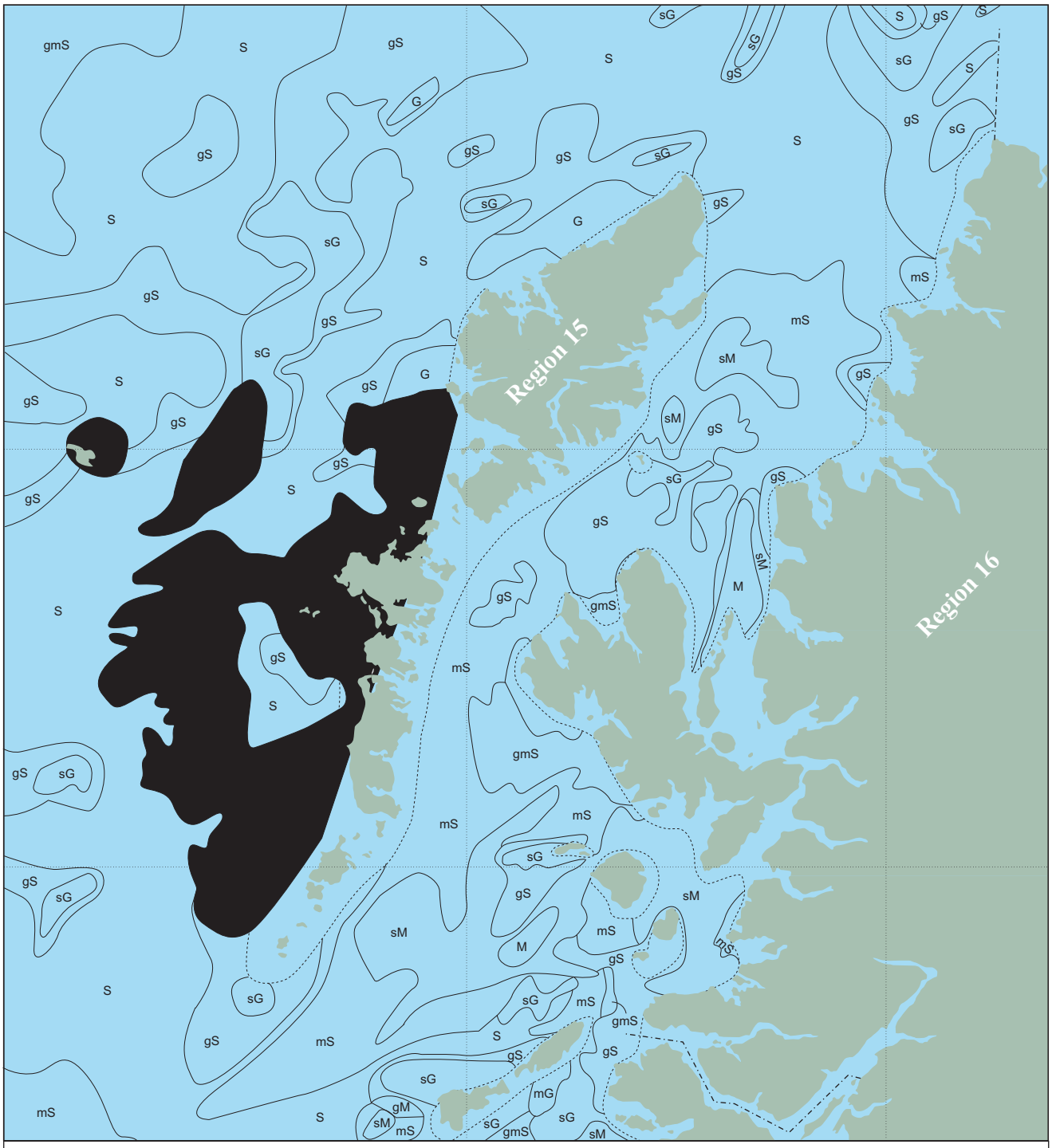
The major ice sheets which covered the Scottish Highlands in numerous episodes during the Pleistocene caused deep erosion of the western coast and offshore parts of Region 16, excavating deep sea lochs and inter-island channels. Unlike onshore, a much fuller Pleistocene succession is preserved on the sea bed between Regions 15 & 16, and its stratigraphy has been established based on seismic profiles and drilling, although it is difficult to correlate the successions in the Minch and the Sea of the Hebrides. The thickness of the Quaternary succession in the Minch is 20-50 m, being greatest in the deepest water. Thicknesses are similar in the Sea of the Hebrides, athough locally they reach 200 m in narrow infilled troughs south-east of Barra.

In the Minch two sequences, consisting of a stiff till overlain by a dark grey glaciomarine clay, are overlain by a late Devensian pebbly clay. The inclusion of an arctic microfauna within the clay indicates that it was laid down under glaciomarine conditions (either underneath or immediately in front of an ice sheet). In the Sea of the Hebrides the late Devensian till is overlain by a glaciomarine unit up to 130 m thick. An additional late glacial sequence is well developed at the top of the Pleistocene section. Examination of the microfauna within this soft silty clay unit highlights changes in the climate since the end of the last glaciation.

2.2.3 Solid (pre-Quaternary) geology

Rocks formed before the start of the Quaternary Period (1.6 million years BP) are included by geologists in the category of 'solid geology' (Map 2.2.3). The Lewisian basement rocks of Region 15 extend west of the islands as the Outer Hebrides Platform. The Tertiary igneous rocks forming the St. Kilda group of islands is intruded into this basement and forms a circular submarine plateau. Seismic profiles show that Tertiary lavas and sediments overlie the basement to the west of the islands, but these are covered across the outer continental shelf by Quaternary sediments up to 100 m thick.

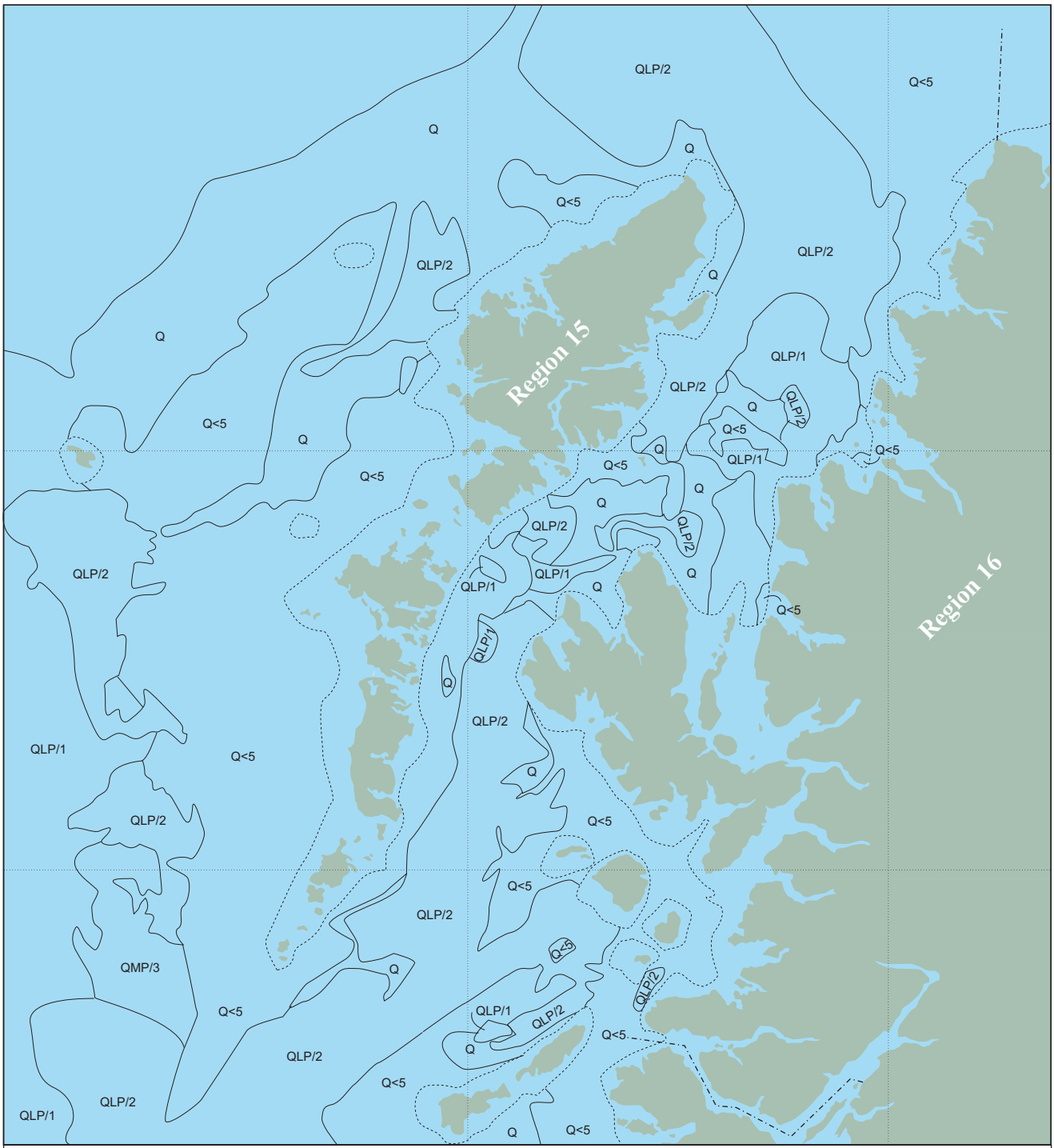
Around the coasts of the Western Isles the early Tertiary igneous activity led to the emplacement of sills within offshore Mesozoic sediments, and these more resistant rocks rise above sea level to form the Shiant Islands. Mid-Tertiary deposition in the area was limited to a small basin east of the Minch Fault south of Harris, which contains grey,



Key to sea-bed sediment symbols

M	Mud	mS	Muddy sand	mG	Muddy gravel		Outcrop of bedrock on the seabed
sM	Sandy mud	gmS	Gravelly muddy sand	sG	Sandy gravel		Landward limit of data
gM	Gravelly mud	gS	Gravelly sand				
S	Sand	G	Gravel				

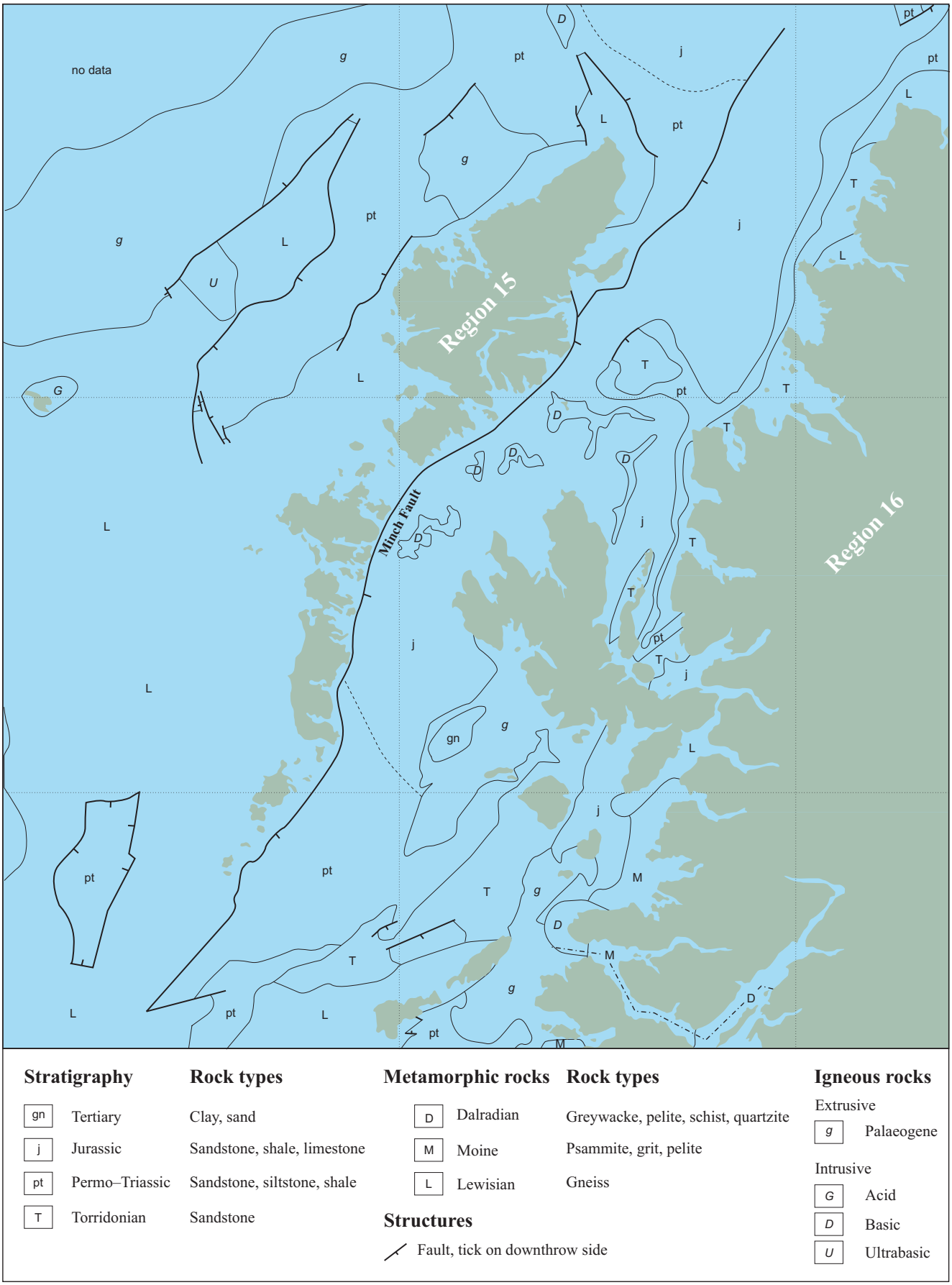
Map 2.2.1 Sea-bed sediments. Sources: British Geological Survey (1987); sediment classification modified after Folk (1954).



Key to sea-bed sediment symbols

QLP	Late Pleistocene to Early Holocene	1	Predominantly till		No information landward of this line
Q	Quaternary, undivided	2	Predominantly mud		
Q<5	Quaternary generally < 5 m thick	3	Predominantly interbedded mud and sand		

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



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

carbonaceous mudstones, lignites and gritty sandstones of Oligocene age.

The Mesozoic sediments within the Sea of the Hebrides and the Minch occupy a fault-bound sedimentary basin which infills much of the area. The Minch Fault, lying close to the east coast of Region 15, forms the boundary between the Lewisian basement and the basin, while the eastern boundary of the basin coincides approximately with the present mainland coast: Mesozoic sediments along this boundary extend to within a few kilometres of the coast, and extend onto the land in a few places. The basin is infilled with Permo-Triassic red sandstones and conglomerates, which are up to 1,000 m thick offshore and up to 1,200 m thick around Stornoway, where the rocks outcrop onshore (see section 2.1). The overlying Jurassic sediments are locally up to 1,500 m thick, with the thickest sequence preserved close to, and east of, the Minch Fault.

Tertiary intrusions and lavas in the Little Minch and the Sea of the Hebrides occur locally on the sea bed and commonly have a rugged form. These igneous bodies are absent from the Minch, which displays a smoother sea floor at a depth of about 100 m.

A full succession of Jurassic rocks is exposed on a number of the islands forming the Inner Hebrides. The presumption that a thicker succession is preserved offshore in the basin has led to interest in hydrocarbons in the area. The onshore succession has been recognised within boreholes offshore, but there has been insufficient drilling to map the offshore units. A ridge extending southwards from Skye to Rum and onwards to Coll and Tiree (Region 14) separates the Sea of the Hebrides basin to the west from the Inner Hebrides Trough to the east. Lower Jurassic and Permo-Triassic sediments have been drilled offshore in this basin, and seismic profiles suggest that the former cover much of the basin but may be thinner towards the south. Upper Cretaceous Chalk was probably deposited across the area but was removed during a major erosional episode that preceded the development of the Tertiary igneous centres.

The extensive basalt lava flows of early Palaeogene age on Skye extend offshore south-westwards, onto and south-west of Canna. A similar irregular patch of basaltic lavas around Mull extends northwards to Muck and Eigg. To the west of this basalt ridge the main manifestation of the igneous activity is the occurrence of basaltic sills within Jurassic sediments. Some of the sills crop out to produce a locally rugged sea bed. The Canna Basin south-west of Skye contains up to 1,000 m of mid-Tertiary sediments occupying a syncline within the early Tertiary basalts. A basin containing sediments of a similar age abuts the Minch Fault within the Little Minch. The basins contain carbonaceous mudstones with lignites, and thin, poorly sorted sandstones of Oligocene age.

2.2.4 Further sources of information

A. Maps

British Geological Survey. 1986. *Little Minch. Sheet 57N 08W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1986. *Rona. Sheet 59N 06W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1986. *Rona. Sheet 59N 06W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1986. *Tiree. Sheet 56N 08W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1987. *Argyll. Sheet 56N 06W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1987. *Argyll. Sheet 56N 06W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1988. *Little Minch, including part Great Glen 57N 06W. Sheet 57N 08W, sea-bed sediments and Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1988. *Sula Sgeir. Sheet 59N 08W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1988. *Sula Sgeir. Sheet 59N 08W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1988. *Tiree, including part Argyll 56N 08W. Sheet 56N 08W, sea-bed sediments and Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Geikie. Sheet 58N 10W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Geikie. Sheet 58N 10W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Geikie. Sheet 58N 10W, Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Great Glen. Sheet 57N 06W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Lewis. Sheet 58N 08W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Lewis. Sheet 58N 08W, Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Sutherland. Sheet 58N 06W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1989. *Sutherland. Sheet 58N 06W, sea-bed sediments and Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1990. *Lewis. Sheet 58N 08W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1990. *Rona. Sheet 59N 06W, Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1990. *Sula Sgeir. Sheet 59N 08W, Quaternary.* Keyworth, British Geological Survey.

British Geological Survey. 1991. *St. Kilda. Sheet 57N 10W, solid geology.* Keyworth, British Geological Survey.

British Geological Survey. 1991. *St. Kilda. Sheet 57N 10W, sea-bed sediments.* Keyworth, British Geological Survey.

British Geological Survey. 1992. *St. Kilda. Sheet 57N 10W, Quarternary.* Keyworth, British Geological Survey.

B. References cited

British Geological Survey. 1987. *Sea bed sediments around the United Kingdom (North and South Sheets).* 1:1,000,000 scale. Keyworth, British Geological Survey.

British Geological Survey. 1991. *Geology of the United Kingdom, Ireland and the adjacent continental shelf.* 1:1,000,000 scale. Keyworth, British Geological Survey.

British Geological Survey. 1994. *Quaternary geology around the United Kingdom (north and south sheets).* 1:1,000,000 scale. Keyworth, British Geological Survey.

Farrow, G.E. 1983. Recent sediments and sedimentation in the Inner Hebrides. *Proceedings of the Royal Society of Edinburgh, 83B:* 91-105.

Folk, R.L. 1954. The distinction between grain size and mineral composition in sedimentary rock nomenclature. *Journal of Geology, 62*: 344-359.

C. Further reading

Fyfe, J.A., Long, D., & Evans, D. 1993. *United Kingdom Offshore Regional Report: the geology of the Malin-Hebrides Sea area*. London, HMSO, for the British Geological Survey.

Holmes, R., Jeffrey, D.H., Ruckley, N.A., & Wingfield, R.T.R. 1993. *Quaternary geology around the United Kingdom (north & south sheets)*. Edinburgh, British Geological Survey.

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

Stoker, M.S., Hitchen, K., & Graham, C.C. 1993. *United Kingdom Offshore Regional Report: the geology of the Hebrides and West Shetland Shelves, and adjacent deep-water areas*. London, HMSO, for the British Geological Survey.

D. Contact names and addresses

Type of information	*Contact address and telephone no.*
Geological information for Regions 15 & 16 and the whole of Britain	Coastal Geology Group, British Geological Survey, Keyworth, Nottingham NG12 5GG, tel: 0115 936 3100
UKDMAP (United Kingdom digital marine atlas) Version 2; Oceanographic maps	*BODC, Birkenhead, tel: 0151 653 8633

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

2.3 Wind and water

British Geological Survey

Most major locations referred to in this chapter are indicated on Map 1.2.1; only those of particular relevance to this chapter are shown on maps contained within it.

2.3.1 Wind

Unsheltered western coasts of Regions 15 (Western Isles) & 16 (west Highland) are exposed to high mean wind speeds (Maps 2.3.1 and 2.3.2). The Meteorological Office maps of mean hourly wind speeds (Caton 1976) show that these regions, along with Orkney (Region 2) and Shetland (Region 1), are the windiest parts of the British Isles. For 75% of the time wind speeds exceed 4 m/sec (8 knots, Force 3) across the outer headlands and islands, and 3 m/sec (6 knots) across the whole area. For 0.1% of the time wind speeds exceed 20 m/sec (40 knots, Force 9) across the more exposed parts and 19 m/sec across nearly all the area. Figure 2.3.1 shows the percentage frequencies of winds from different directions recorded at Stornoway (Region 15) and Tiree (Region 14) in the period 1923-1959 (Shellard 1968). (Data on prevailing wind direction were not available for Region 16.)

Predominant wind speeds and directions in both regions are strongly influenced by local topography. In Region 15 wind speeds along the western coasts are greater than those on the east, especially those sectors of the east coast, such as south-east Lewis, that are protected by a hilly hinterland. At Stilligarry on the west coast of South Uist the prevailing and strongest wind direction in both summer and winter is between west and south. In contrast, Stornoway on the eastern coast of Lewis experiences strong winds from the south. In January, at the Butt of Lewis, gales (winds with speeds exceeding about 17 m/sec) blow on average for 48% of the time (Manley 1979). At Benbecula the mean wind

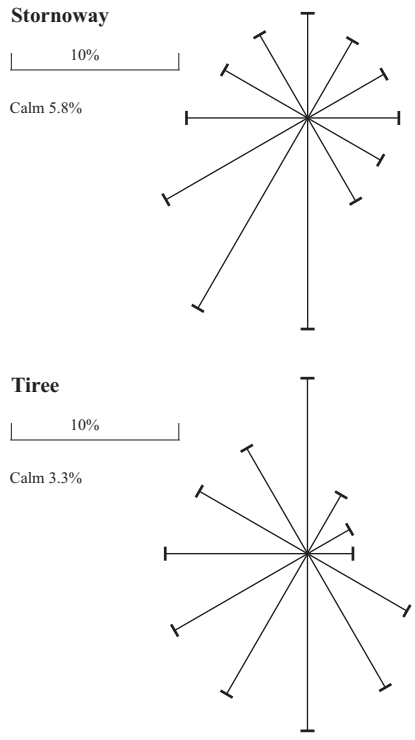
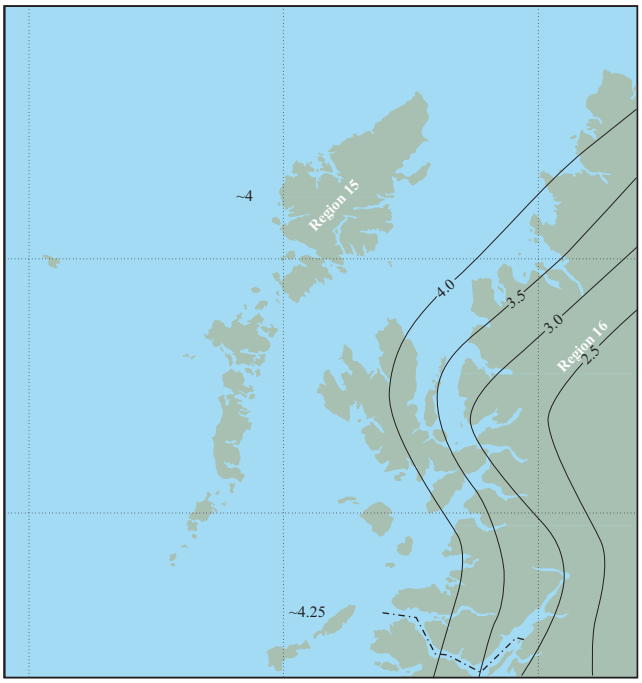
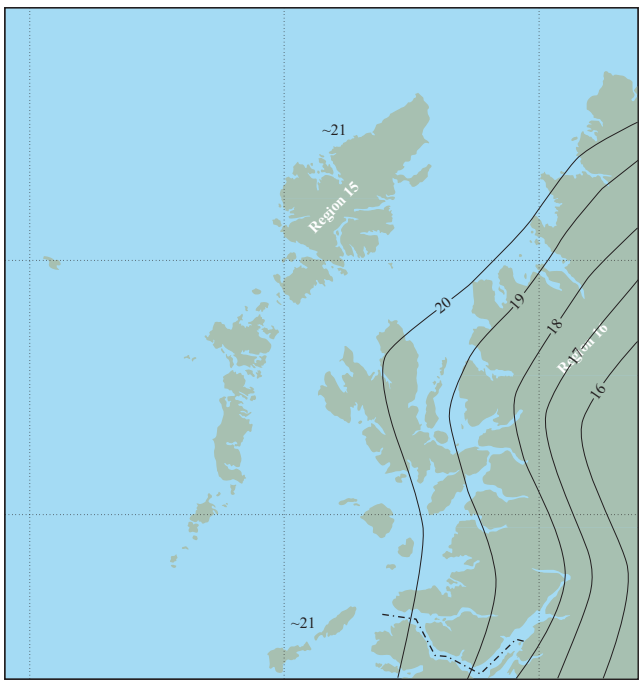


Figure 2.3.1 Wind directions at Stornoway (Region 15) and Tiree (Region 14) shown as % of observations during the years 1923-1959. Source: Shellard (1968). Comparable data for Region 16 not available.



Map 2.3.1 Region 16: hourly mean windspeed (in m/s) exceeded for 75% of the time: 1965-1973. Source: Caton (1976). Comparable data for Region 15 not available.



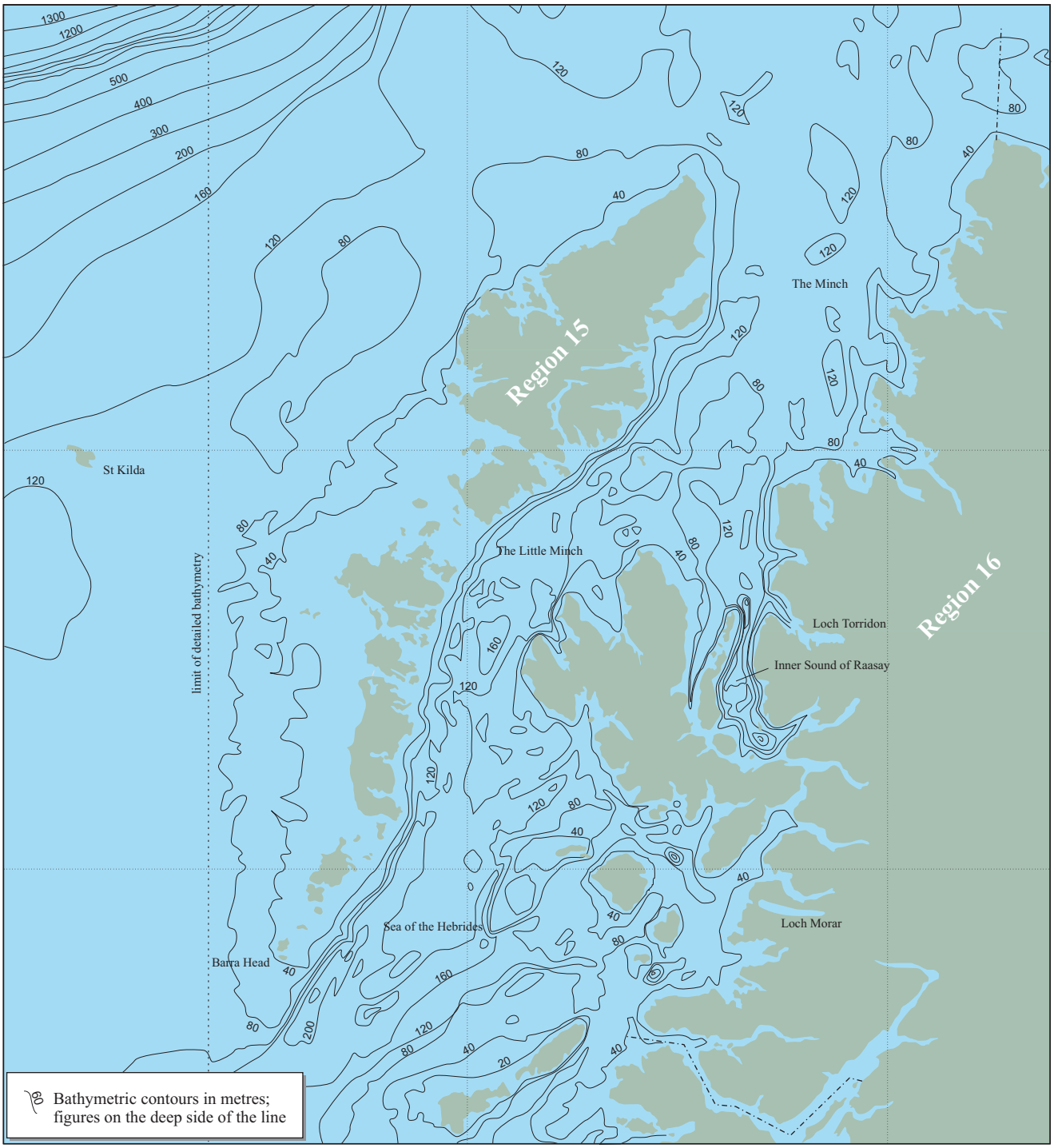
Map 2.3.2 Region 16: hourly mean windspeed (in m/s) exceeded for 0.1% of the time: 1965-1973. Source: Caton (1976). Comparable data for Region 15 not available.

speed between 1963 and 1978 varied from 8.5 m/sec in November and December to about 6.5 m/sec in July and August, with the maximum wind speed varying between 21 and 25 m/sec during this time span (Fortnum 1981).

In Region 16, as in Region 15, local topography has a major influence on both wind direction and strength. For example, the mean wind speed on the exposed island of Tiree (Region 14) is 50% greater than within the more sheltered glades on Rum, although both islands experience some 50 days of gales per year.

2.3.2 Water depth

Map 2.3.3 shows a simplification of the bathymetry of the sea bed of Regions 15 & 16; at a small scale, however, the sea bed displays complex variation in form. The bathymetry largely reflects the Late Tertiary and Pleistocene history of the area (Steers 1973). The deeps of the lochs and sounds represent former river valleys overdeepened by glaciers flowing off the major ice sheets, which covered the Western Highlands at least three times during the Pleistocene.



Map 2.3.3 Bathymetry. Contours not shown where they lie close to the shore. Less detail is mapped to the west of the Western Isles. Source: British Geological Survey (1987).

There is a significant difference between the bathymetry of the areas off the eastern and western coasts of the Western Isles. West of the archipelago the sea bed slopes uniformly and gently away from the land to a depth of about 120 m. Enclosed deeps are absent, but at a small scale the bathymetry is highly variable owing to the outcropping of Lewisian rocks on the sea bed. Below a depth of about 120 m the sea bed becomes smoother as bedrock is covered by Quaternary deposits. The sea bed from which the islands of the St. Kilda group emerge stands proud of the surrounding area as a plateau at a depth of about 60 m. A slightly raised rock rim around the outer margin of the plateau may mark the limits of the igneous complex forming the islands.

The area between Regions 15 & 16, embracing the Sea of the Hebrides, the Little Minch and the Minch, is an extension of the glacially overdeepened waters off the west coast of the mainland. Enclosed deeps are common and reach a maximum depth in excess of 240 m to the east of Barra Head on Berneray. Tertiary igneous bodies are absent from the Minch, which displays a smoother sea floor, at a depth of about 100 m, than the sea bed further south. The absence of deep channels in the flatter sea bed of the northern part of the Minch is due to the coalescing of the ice tongues, resulting in a broader distribution of the erosional force exerted at their base.

The coast of Region 16 is one of deep sea lochs, linear offshore basins and local rocky shoals and islands; only in the deeper parts of the Minch does the sea bed become gentler in form. The shallow sills at the entrances to some sea lochs testify to glacial erosion being the dominant process in their excavation: for example, in the upper part of Loch Torridon water depths exceed 100 m, but at the sill near its entrance depths are less than 24 m. Loch Morar (south of Loch Nevis), the deepest loch in Scotland, with depths of 305 m in its mid-part, is not connected to the sea, as the low ground to the west of the loch represents a sill that is above present sea level. The Inner Sound of Raasay is an offshore linear deep with a maximum depth of 243 m, whilst north-east of Raasay depths reach 316 m.

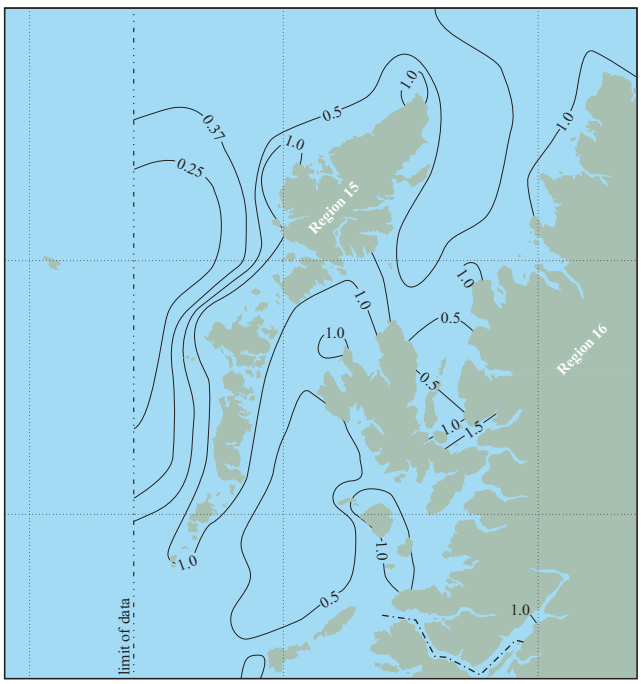
2.3.3 Tidal currents

Maximum tidal currents during mean spring tides are generally between 0.5 and 1 m/s in Region 15, and between 0.75 and 1.25 m/s in Region 16 (Map 2.3.4). These are approximately average values for the UK, although lower than those in the North Channel (Regions 14 and 17) or in Orkney (Region 2). In both Regions 15 and 16 higher tidal current speeds are recorded near the coast and especially within the narrow channels between islands. There is an unusual feature in the Sound of Harris: at neap tides in the summer, the south-east going stream runs all day and the north-west going stream runs all night; the effect is reversed at neaps in winter (Ellett 1979).

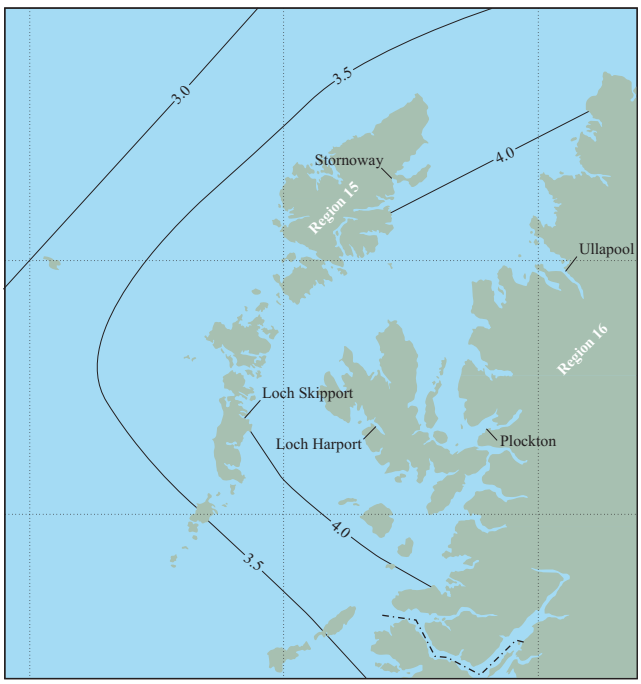
In the northern Minch between Cape Wrath and the Butt of Lewis, maximum speeds vary from 0.4 m/s at spring tides to 0.15 m/s at neap tides, these currents flowing approximately north-south. Within the Little Minch between Skye and South Uist the maximum current is 0.5 m/sec, again in a north-south direction, though values are greater around headlands and over shoaling areas. A few kilometres south of Barra Head on Berneray the maximum surface current during spring tides is 0.75 m/s, flowing in an easterly direction.

2.3.4 Tidal range

Map 2.3.5 shows average values of tidal range at mean spring tides for the area. Values in Region 15 vary from about 3.5 to 4.25 m, while across Region 16 values are slightly greater than 4 m. The Admiralty Tide Tables indicate mean spring tidal ranges of 4 m at Stornoway, 3.9 m at Loch Skipport (South Uist), 4.5 m at Ullapool, 4.8 m



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.

Plockton (Loch Carron) and 4.6 m at Loch Harport (Skye).

Storm surges cause tidal levels to be greater than predicted, and calculations on the heights of the 50-year storm surge around the UK suggest that across Region 16 such an exceptional surge could cause sea levels, for a limited time period measured in hours, to be up to 1.0 m higher than predicted values (Flather 1992).

2.3.5 Wave exposure and sea state

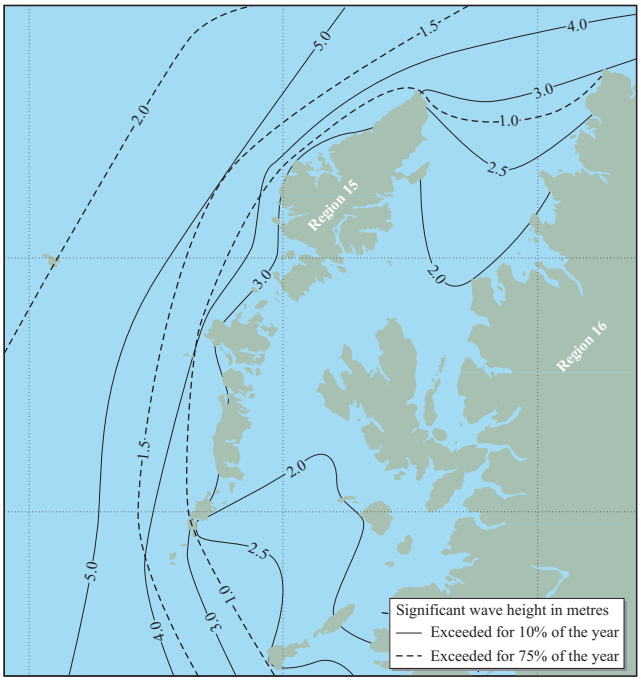
The maximum predicted 50-year wave has a height of over 30 m in the northern Minch but this value decreases to under 15 m along the eastern coast of Region 15, where wave climate is more benign, though the effects of southerly gales in the Minch are notorious (Manley 1979). Along the western coasts of the Western Isles archipelago, the combination of exposure to prevailing winds and deep, open offshore waters produces a high energy wave regime. Off these coasts significant wave heights exceed 3 m for over 10% of the time and 1 m for 75% of the time (Map 2.3.6) (Draper 1991). Off the coasts of Region 16 significant wave heights are lower: 75% of the time they are less than 1 m and only during 10 % of the year do they exceed 2.0 m, or at most 2.5 m in the extreme north. The predicted 50-year wave height is estimated to be 35 m a few tens of kilometres off the west coast of Region 15, a figure which is significantly greater than for other parts of the UK coast (Lee & Ramster 1981).

Between 1976 and 1978 the wave climate at a site 15 km west of South Uist was investigated in some detail so as to evaluate the possibilities of wave power along the coasts of the region (see Fortnum (1981) and Stanton (1984) for further information). The results showed that the monthly mean significant wave height at the site varied from about 1.5 m in August to about 3.75 m in November, with a maximum significant wave height of 9 m.

The irregular coastline of Region 16 results in a diverse range of wave climates, and most of the available data refers to open sea conditions rather than specific sites. The northernmost coasts between Point of Stoer and Cape Wrath are exposed to both northerly and westerly winds, and experience a wave climate only slightly less energetic than that of western coasts of Region 15. The western coasts of the southern islands such as Rum and parts of Skye that are not sheltered by the Western Isles are equally exposed to the prevailing winds and energetic waves.

2.3.6 Water characteristics

The waters of Regions 15 & 16 are derived from three sources: oceanic or Atlantic water, Clyde/Irish Sea water and coastal water derived from the land. These waters mix as they proceed northwards through the area at a rate of a few kilometres per day, both through the Minch and across the western Hebridean shelf. However, some of the water flowing northwards through the Sea of the Hebrides is turned back at the Little Minch to flow southwards along the east coast of Barra. As the water flows northwards it becomes more mixed, and caesium-137 values (showing the presence of water that has flowed past Sellafield in Cumbria) decrease by about one fifth between the North Channel and Cape Wrath (Ellett 1979).



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

Water temperature

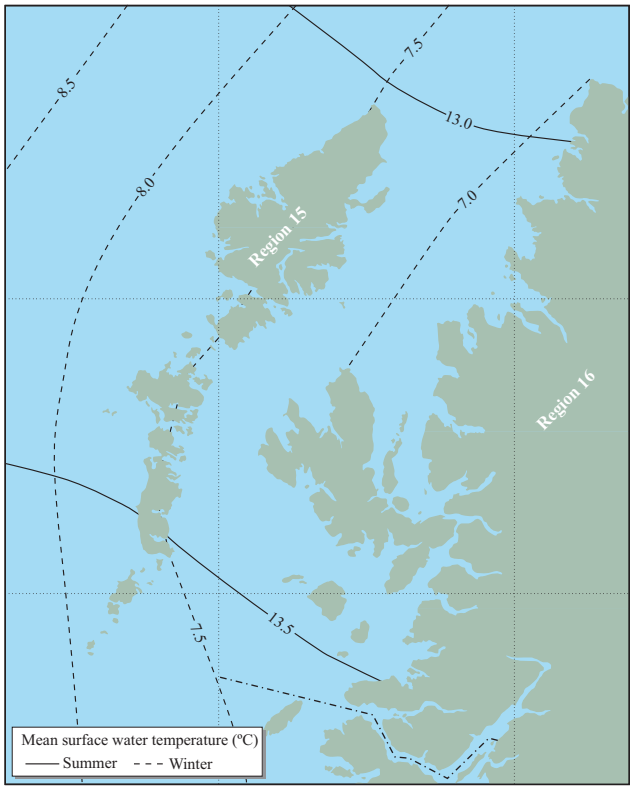
In these regions the dominance of the Atlantic water mass over Clyde/Irish Sea water and land-derived coastal water limits the differences between summer and winter temperatures. In winter, water on the Hebridean shelf is stirred throughout its depth by frequent gales, and relatively warm Atlantic water covers most of the shelf west of the islands. By April less dense water from the coast spreads westward and, after the onset of surface heating and the development of a thermocline (temperature gradient over depth), forms the surface water for much of the outer shelf north of Barra Head.

In winter, temperature values decrease eastwards from about 8.5°C across the outer continental shelf to less than 7.0°C off the northern coast of Region 16 (Map 2.3.7). Ellett & Edwards (1983) suggest that summer temperatures across the regions are slightly lower than those shown by Lee & Ramster (1981), giving values ranging from about 12°C in the southern entrance to the Sea of the Hebrides and the northern entrance to the Minch, to less than 10.5°C in the southern part of the Minch. Throughout the year values are more extreme in the shallow waters near coasts. Similarly, slightly more extreme temperatures may occur within the low-salinity surface layer that can develop on sea lochs, especially near river mouths (Ellett & Edwards 1983).

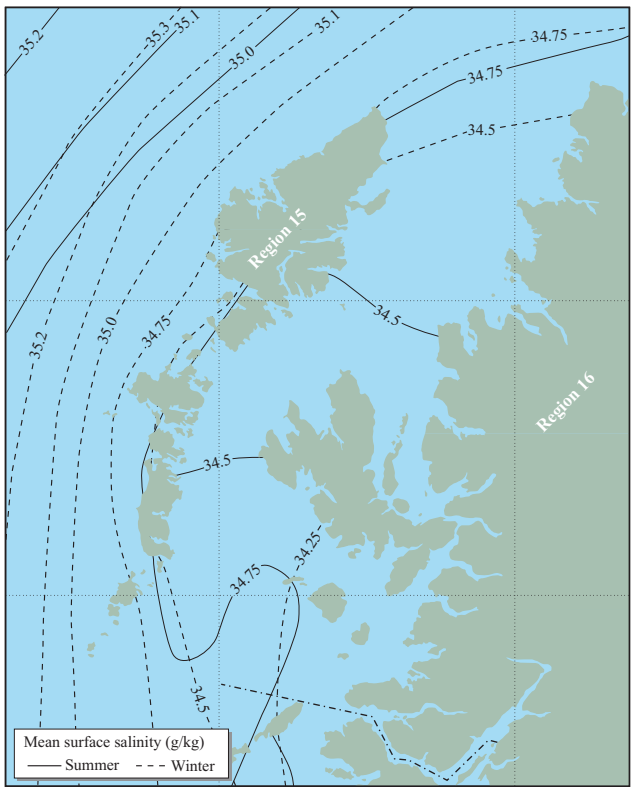
A series of measurements across the shelf west of South Uist in 1976 and 1977 showed winter temperatures through the water column to be about 10°C, with little horizontal or vertical variation. In summer a horizontal temperature gradient developed in the water column, with maximum values of 12°C across the outer shelf and values of 8.4°C within mid-water levels (Ellett 1979).

Salinity

Mean surface salinities for Regions 15 & 16 for summer and winter are shown on Map 2.3.8. Salinity values decrease



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



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.

from west to east across the Hebridean shelf as high salinity Atlantic water becomes mixed with fresher coastal water derived from land run-off. In the southern part of the Sea of the Hebrides the stronger influx of Atlantic water results in higher salinities south-east of Barra. The sea lochs of Region 16 receive more freshwater as run-off and direct precipitation than they lose through evaporation, and often have surface layers of reduced salinity, especially near rivers, while the deeper parts retain sea water of oceanic salinity. Ellett (1979) shows that in winter the lower salinity values extend down through the water column, but horizontal stratification develops in the spring and becomes most pronounced in the summer, especially across the middle and outer shelf (Region 15), where wind and the tides are not sufficiently energetic to mix the water column.

Results derived from transects carried out over a number of years show considerable year on year variation in salinity in the Sea of the Hebrides, as well as local and seasonal variability. In winter, salinity contours within the Sea of the Hebrides and the Minch parallel the mainland coast, and decrease eastwards from values of over 34.5 g/kg in the western part of the Sea of the Hebrides and the Minch to about 34 g/kg near the coast of Ardnamurchan. In summer, as a result of a thermocline (separation of the water masses into a warmer lower-salinity surface unit and a deeper unit) across the deeper waters west of Region 15, surface isohalines are displaced westward (i.e. salinities are lower).

2.3.7 Further information

A. References cited

British Geological Survey. 1987. *Seabed sediments around the United Kingdom (North and South Sheets).* 1:1,000,000 scale. Keyworth, British Geological Survey.

Caton, P.G. 1976. *Maps of hourly wind speed over the UK 1965-73.* Bracknell, Meteorological Office. (Climatological Memorandum, No. 79.)

Draper, L. 1991. *Wave climate atlas of the British Isles.* London, HMSO.

Ellett, D.J. 1979. Some oceanographic features of Hebridean waters. *Proceedings of the Royal Society of Edinburgh, 77B*: 61-74.

Ellett, D.J., & Edwards, A. 1983. Oceanography and inshore hydrography of the Inner Hebrides. *Proceedings of the Royal Society of Edinburgh, 83B*: 143-160.

Flather, R.A. 1992. *Tidal range and storm surges. Global warming and climatic change.* Liverpool, University of Liverpool. (The Irish Sea Forum. Report of seminar held on 26 April 1992.)

Fortnum, B.C.H. 1981. Waves recorded off South Uist in the Hebrides. *Institute of Oceanographic Sciences Report,* No. 115.

Lee, A.J., & Ramster, J.W. 1981. *Atlas of the seas around the British Isles.* Lowestoft, Ministry of Agriculture, Fisheries and Food.

Manley, G. 1979. The climatic environment of the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, 77B:* 47-59.

Sager, G., & Sammler, R. 1968. *Atlas der Gezeitenströme für die Nordsee, den Kanal und die Irische See.* Rostock, Seehydrographischer Dienst der DDR.

Shellard, H.C. 1968. *Tables of surface wind speed and direction over the United Kingdom.* London, HMSO.

Stanton, B.R. 1984. Return wave heights off South Uist estimated from seven years of data. *Institute of Oceanographic Sciences, Report,* No. 164.

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

B. Further reading

Angus, I.S. 1991. Climate and vegetation of the Outer Hebrides. *In: Flora of the Outer Hebrides*, ed. by R.J. Pankhurst & J.M. Mullin, 28-31. London, Natural History Museum.

Banner, F.T., Collins, M.B., & Massie, K.S., *eds*. 1980. *The north-west European shelf seas: the sea bed and the sea in motion. Vol. 2. Physical and chemical oceanography, and physical resources*. Amsterdam, Elsevier.

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*. Birkenhead, Natural Environment Research Council.

Department of the Environment. 1992. *Digest of environmental protection and water statistics.* London, HMSO (Government Statistical Service).

Graff, J. 1981. An investigation of the frequency distributions of annual sea level maxima at ports around Great Britain. *Estuarine, Coastal and Shelf Science, 12:* 389-449.

Green, F.H.W., & Harding, R.J. 1983. Climate of the Inner Hebrides. *Proceedings of the Royal Society of Edinburgh, 83B:* 121-140.

Hydrographic Office. 1993. *Admiralty Tide Tables. Vol. 1. European waters*. London, Hydrographic Office.

McManus, J. 1992. A hydrographic framework for marine conservation in Scotland. *Proceedings of the Royal Society of Edinburgh, 100:* 3-26.

Pantin, H.M. 1991. *The sea bed sediments around the United Kingdom: their bathymetric and physical environment, grain size, mineral composition and associated bedforms*. London, HMSO. (British Geological Survey Research Report SB/90/1.)

Ritchie, W. 1971. *The beaches of Barra and the Uists*. University of Aberdeen, Department of Geography. (Report commissioned by the Countryside Commission for Scotland.)

Ritchie, W., & Mather, A. 1970. *The beaches of Lewis and Harris*. University of Aberdeen, Department of Geography. (Report commissioned by the Countryside Commission for Scotland.)

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
UKDMAP (United Kingdom digital marine atlas) Version 2; Oceanographic maps	*BODC, Birkenhead, tel: 0151 653 8633
Monthly, seasonal and annual windroses	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.

Sandwood Loch, just south of Cape Wrath, lies in a glaciated valley which slices through cliffs of Torridonian Sandstone at Sandwood Bay (pictured). There is very little sediment transport along the coast here, and a broad sandy beach has accumulated, separating the loch from the sea; the stack called Am Buachaille can be seen in the distance. There are few beaches elsewhere in this region, in which hard cliffs predominate. Photo: Lorne Gill, Scottish Natural Heritage.

2.4 Sediment transport

British Geological Survey

2.4.1 Description

Sediment transport (of sand and gravel 'bed load', not suspended sediments) 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. However, the irregular form and aspect the coastline in Regions 15 and 16 presents to the prevailing winds, and thus to waves, results in a highly variable sediment transport regime. This restricts littoral transport to individual bays, between which there is little or no interchange of material. Cells and sub-cells in these regions have therefore been delimited according to additional factors such as exposure and physical character. HR Wallingford (1995) divide the coast of mainland Scotland into seven major littoral cells, and the Western Isles into two cells. The east and west coasts of Region 15 are covered by Cells 8 and 9 respectively; Cell 8 is divided into four sub-cells, 8a - 8d, and Cell 9 into six sub-cells, 9a - 9f. Region 16 is covered by part of Cell 5, which extends from the Mull of Kintyre to Cape Wrath and is divided into three sub-cells, 5a - 5c. These cells and sub-cells are described below and shown on Map 2.4.1.

In these regions there is little input of sediment from the rivers and the erosion of the coast is slow in comparison with rates elsewhere in Britain. In both Regions 15 & 16 the bulk of beach sediment is derived from offshore, being moved onshore by wave-generated currents. In Region 15 much of the beach sediment along the west coast of the islands is formed of shell fragments derived from the shallow shelving rocky platform offshore. Tidal currents in the regions are generally weak and net sediment transport offshore is generally northwards, determined by residual currents.

Map 2.4.1 Sediment transport and coastal cells (as numbered). Source: HR Wallingford (1995). Adapted with permission from SNH, SOAEFD and Historic Scotland.

Region 15 - Western Isles

Sub-cell 8d: Butt of Lewis to Tolsta Head

Wide sandy beaches, derived largely from offshore deposits, are seen at Port of Ness, Traigh Geiraha and Traigh Mhor. At Port of Ness the eroded material from soft till cliffs appears to be experiencing some northerly drift. Traigh Geiraha is suffering erosion caused by human activities, including excessive stock grazing, while Traigh Mhor, which has formed next to the natural groyne of Tolsta Head, is accumulating material driven onshore by wave action.

Sub-cell 8c: Tolsta Head to Tiumpan Head

Broad Bay captures the southward-moving sediments, and significant beaches occur along the western shores of the bay. Cliffs around the bay are formed of conglomerates and sandstones of the Triassic Stornoway Formation, which are more easily eroded than the Lewisian gneiss that makes up much of the islands and thus provide some onshore sediment input into the bay. Coastal defences have been built along the isthmus and by Stornoway Airport, which may have modified sedimentation in Traigh Mhealaboist. There is dune erosion at Gress and Coll, and accretion at Branahuie at the head of Broad Bay.

Sub-cell 8b: Tiumpan Head to Stornoway Harbour

Like sub-cell 8c, this sub-cell has softer rocks than most of the coastline of the Western Isles. These are slowly eroding to produce sand and shingle beach material. A long shingle beach fronts the isthmus at Braigh na h-Aoidh, with slight accretion at the western end. Coastal defences along the isthmus of the Eye Peninsula have slowed the rate of westward littoral drift.

Sub-cell 8a: Stornoway Harbour to Barra Head

This long stretch of coastline is rocky and cliffed, with many sea lochs. It has no significant beaches and no detectable littoral drift. Seawalls front the towns of Stornoway and Lochboisdale, but there is little sign of accretion or erosion.

Sub-cell 9f: Barra Head to Sound of Barra

Pocket beaches between rock headlands are a feature of this coastline, with a larger expanse of sand at Eoligarry, where machair lies behind the dunes. Wave erosion of the machair edge is occurring at the northern end of Traigh Mhor and at Traigh Cille-bharra. Wind erosion is evident on all the dune systems of this sub-cell, and the shingle ridge on Vatersay's

western beach shows evidence of storm damage. Littoral drift is largely controlled by the wind, with northerly movement evident at Halaman Bay and sand transport from Traigh Eais onto Traigh Mhor.

Sub-cell 9e: Sound of Barra to Griminish Point

Long sandy beaches, backed by shingle and machair, form extensive lengths of this sub-cell. Most of the sand is derived from offshore and once on the beach is blown onshore to form extensive areas of dunes and machair. There are large shingle ridges at Aird on Benbecula. Dune erosion is evident where there is little protection from shingle ridges, and these may be overwashed, as at Baleshare. The large intertidal areas of North and South Fords act as sinks for the slight northward drift. There is low accretion at Ardivachar Point at the north end of South Uist. Coastal defences have been constructed to protect roads in several places.

Sub-cell 9d: Griminish Point to Sound of Harris

Dune erosion is taking place in all parts of this cell. There are large sandy intertidal areas at Vallay and Vallaquie, backed by dunes and machair. The lack of natural sediment supply has caused the breaching of the Aird a' Mhorain spit that lies between them. Wave attack from south-westerly storms is causing dune erosion on the beaches exposed to the north and west. Longshore drift is low, with no indication of a net direction.

Sub-cell 9c: Sound of Harris to Hushinish Point

This is a coastline with pocket sandy beaches and two large areas of intertidal flats, at Traigh Scarasta (north of Northton) and Traigh Luskentyre. Most of the sandy beaches are backed by machair. Littoral drift is thought to be southward at Traigh Scarasta but generally northerly at Traigh Luskentyre. Storm waves and winds are the dominant coastal processes, causing erosion at the northern end of Traigh Scarasta and at Traigh Seilebost, but leading to accretion of dunes at the southern end of Traigh Scarasta and at Traigh Rosamol.

Sub-cell 9b: Hushinish Point to Tiumpan

This indented coastline shelves relatively steeply seawards and the wave climate is extreme. Storm wave action has caused erosion at Camas na Clibhe and to a lesser extent at Valtos and Traigh na Berie. The shingle ridge at Mangersta has been overwashed. There is little net littoral drift, although wind action moves sand eastwards at Traigh na Berie. Dunes are accreting here and at Uig.

Sub-cell 9a: Tiumpan to Butt of Lewis

Along the northern coast of Lewis the low cliffs formed of gneiss are covered with drift, but locally deep ravines or geos have been eroded along narrow zones of weaker bedrock. Erosion of the gneiss bedrock is slow and provides little material for the beaches of this region, most of which is derived from shell fragments moved onshore by waves. At Eoropie waves erode the drift cliffs backing the beach, and the released sediment moves northwards along the littoral zone. There is a wide sandy beach here with some accretion, but elsewhere beaches are of shingle, some having machair behind them. Brackish lochs occur behind the shingle at Shawbost, Bragar, Arnol and Barvas. Storm waves cause most littoral movement, mainly to the southward. Storms cause erosion of the soft till cliffs and there is machair erosion due to overgrazing at Dalmore, Barvas and Swainbost.

Region 16 - west Highland

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

Only a small part of this sub-cell lies in Region 16. Shingle fringing beaches and glacial features such as outwash fans and raised beaches are common within Loch Linnhe and may be reworked by marine action. Most beaches are protected from wave and wind attack by the offshore islands. There is little erosion, accretion or net drift.

Sub-cell 5b: Ardnamurchan Point to Rubha Reidh

This sub-cell is sheltered from the Atlantic swell by the Western Isles. Beaches are generally small and independent of each other. Along parts of the eastern Skye coast, the sea is eroding the toes of the large landslips, such as that of the Quirang, resulting in more or less continuous movement. At Gairloch there is littoral drift to the south-east, and there is wave and wind erosion on the beaches around Gairloch, between Redpoint and Big Sand.

Sub-cell 5a: Rubha Reidh to Cape Wrath

Dunes and machair lie behind many of the small sandy beaches of this part of the coastline. Wind and wave erosion is occurring in many places, for example at Cove and Gruinard. Littoral drift is strongly influenced by the orientation of the coastline but is generally low.

2.4.2 Further sources of information

A. References cited

HR Wallingford. 1995. *Coastal cells in Scotland.* Wallingford, HR Wallingford. (Draft Report No. EX 3176 for SNH, SOAEFD and Historic Scotland.)

B. Further reading

HR Wallingford. 1995. *Survey of coastal erosion in the Western Isles.* Wallingford, HR Wallingford. (Report No. EX 3155 for the Minch Project, Scottish Natural Heritage, and the Western Isles Island Council.)

Motyka, J.M., & Brampton, A.H. 1993. *Coastal management - mapping of littoral cells.* Oxford, HR Wallingford. (Report No. SR 328.)

Rendel Geotechnics. 1995. *Coastal planning and management: a review of earth science information needs*. London, HMSO.

Ritchie, W. 1966. The post-glacial rise in sea level and coastal changes of South Uist. *Transactions of the Institution of British Geographers, 39:* 79-86.

Ritchie, W. 1971. *The beaches of Barra and the Uists*. University of Aberdeen, Department of Geography. (Report to the Countryside Commission for Scotland.)

Ritchie, W., & Mather, A. 1970. *The beaches of Lewis and Harris*. University of Aberdeen, Department of Geography. (Report to the Countryside Commission for Scotland.)
Ritchie, W., & Mather, A.S. 1984. *The beaches of Scotland*. Perth, Countryside Commission for Scotland.
Steers, J.A. 1973. *The coastline of Scotland*. Cambridge, Cambridge University Press.
Von Weymarn, H. 1974. *Coastline development of Lewis and Harris, Outer Hebrides, with particular reference to the effects of glaciation*. University of Aberdeen, unpublished Ph.D. thesis.

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
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
Sediment cells	HR Wallingford Ltd, Howbury Park, Wallingford, Oxfordshire OX10 8BA, tel: 01491 835381
Coastal defence, sediment cells, erosion and deposition	*Earth Science Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797

*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 regions

Apparent sea-level change in the regions 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. 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). Data from a tide gauge at Stornoway in Region 15 suggests that sea-level there is rising relative to the land at about 4 mm/year (Angus & Elliott 1992), which would indicate a pattern of sea-level change very different from areas such as the Clyde Estuary (Region 14) and at Inverness (Region 3), where levels are falling. The change in relative sea-level across the coasts of Regions 15 & 16 is therefore uncertain, though it is thought to be falling at least across the southern half of Region 16.

Boulton (1992) describes the uplift of the UK in the last 9,500 years due to isostatic processes, but no data are shown for these regions. 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, at a rate faster than the land recovered its former level after the removal of the weight of the ice. Consequently, extensive raised beaches at several levels are common across the southern part of Region 16. They are less common elsewhere in Regions 15 & 16; where they do occur, some may be associated with 'highstands' in sea-level that occurred before the last glaciation rather than after it.

An indication of the rise and tilting of the area due to the isostatic effect is given by the changing altitude of the two raised beach platforms described by McCann (1961) between the Firth of Lorne and Loch Broom. The altitude of both beaches falls north-westwards, away from the presumed centre of the main ice sheet. The '25 ft' beach is at an altitude of about 7-11 m on the south side of Loch Linnhe and falls northwards to an altitude of about 4 m around Loch Broom. The higher 30 m beach level also decreases in altitude northwards. The disappearance of the raised beaches northwards along the coast may be explained by a reduction in the isostatic uplift in that direction.

2.5.2 Flooding risk

Flooding is rarely a problem across Regions 15 & 16, which have largely cliffed coastlines and are in any case sparsely populated. Extreme storms may lead to beach erosion and local flooding along sections of low-lying coasts. Susceptibility to flooding across Regions 15 & 16 is not likely to alter rapidly with time as a result of sea-level changes. However, a more important factor might be any change in the storminess of the Atlantic as a result of global climate change, which could alter the wave energy on exposed western coasts and possibly increase the heights of storm surges.

2.5.3 Further sources of information

A. References cited

Angus, S., & Elliott, M.M. 1992. Erosion in Scottish machair with particular reference to the Outer Hebrides. *In: Coastal dunes: geomorphology, ecology and management for conservation*, ed. by R.W.G. Carter, T.G.F. Curtis & M.J. Sheehy-Skeffington, 93-112. Rotterdam, Balkema.

Boulton, G.S. 1992. Chapter 14. Quaternary. *In: Geology of England and Wales*, ed. by P.McL.D Duff & A.J. Smith, 413-444. London, The Geological Society.

Carter, B. 1989. Rising sea level. *Geology Today, 5:* 63-67.

Emery, K.O., & Aubrey, D.G. 1985. Glacial rebound and relative sea levels in Europe from tide-gauge records. *Tectonophysics, 120:* 239-255.

McCann, S.B. 1961. *The raised beaches of western Scotland*. Cambridge, University of Cambridge. Ph.D Thesis.

Shennan, I. 1989. Holocene crustal movements and sea-level changes in Great Britain. *Journal of Quaternary Science, 4*(1): 77-89.

Woodworth, P.L. 1987. Trends in UK mean sea level. *Marine Geodesy, 11*: 57-58.

Woodworth, P.L. 1992. Sea-level changes. *In: Global warming and climatic change.* University of Liverpool. (Seminar Report, Irish Sea Forum.)

B. Further reading

Barrett, M.G. 1991. Future sea-level rise: a working paper. *Proceedings of the Institution of Civil Engineers, 1*(90): 205-208.

Boorman, L.A., Goss-Custard, J.D., & McGrorty, S. 1989. *Climatic change, rising sea level and the British coast.* London, HMSO/Natural Environment Research Council. (Institute of Terrestrial Ecology Research Publication, No. 1.)

Burd, F., & Doody, P. 1990. *Sea level rise and nature conservation. A review of NCC experience.* Peterborough, Nature Conservancy Council. (Coastal Ecology Branch, Coastal Habitat Network Paper, No. 3.)

Cannell, M.G.R., & Hooper, M.D. 1990. *The greenhouse effect and terrestrial ecosystems of the UK.* London, HMSO/Natural Environment Research Council. (Institute of Terrestrial Ecology Research Publication, No. 4.)

Carter, W.E. 1989. *Geodetic fixing of tide gauge bench marks. Report of the IAPSO commission on mean sea level and tides.* Santa Barbara, California, USA, Woods Hole Oceanographic Institution. (Technical Report CRC-89-5.)

Climate Change Impacts Review Group. 1991. *The potential effects of climate change in the United Kingdom. Report 1.* London, HMSO. (Department of the Environment.)

Department of the Environment. 1988. *Possible impacts of climate change on the natural environment in the United Kingdom.* London, HMSO.

Department of the Environment. 1992. *The UK environment: coast erosion, flooding and sea level change.* London, HMSO.

Department of the Environment & the Meteorological Office. 1990. *Global climate change.* London, HMSO.

Doornkamp, J.C., *ed*. 1990. *The greenhouse effect and rising sea levels in the UK*. Nottingham, M1 Press.
Environmental Risk Assessment Unit, School of Environmental Sciences, University of East Anglia. 1988. *The concept of 'tolerable risk'*. Norwich, Wolfson Foundation.
Hekstra, G.P. 1989. Global warming and rising sea levels: the policy implications. *The Ecologist, 19*(1): 4-15.
HR Wallingford. 1995. *Coastal cells in Scotland*. Wallingford, HR Wallingford. (Report EX 3176 for SNH, SOAEFD and Historic Scotland.)
Pethick, J. 1993. Shoreline adjustments and coastal management: physical and biological processes under accelerated sea-level rise. *The Geographical Journal, 159*(2): 162-168.
Pugh, D.T. 1990. Is there a sea level problem? *Proceedings of the Institution of Civil Engineers, 1*(88): 347-366.
Shennan, I. 1993. Sea-level changes and the threat of coastal inundation. *The Geographical Journal, 159*(2): 148-156.
Shennan, I., & Woodworth, P.L. 1992. A comparison of late Holocene and twentieth-century sea-level trends from the UK and North Sea region. *Geophysical Journal International, 109:* 96-105.
Steers, J.A. 1973. *The coastline of Scotland*. Cambridge, Cambridge University Press.
Tooley, M.J., & Shennan, I., *eds*. 1987. *Sea level changes*. Oxford, Basil Blackwell. (Institute of British Geographers Special Publication Series, No. 20.)
Woodworth, P.L. 1990. Measuring and predicting long term sea level changes. *NERC News, 15:* 22-25. Swindon, NERC.
Woodworth, P.L. 1990. A search for accelerations in records of European mean sea-level. *International Journal of Climatology, 10:* 129-143.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Flood and coastal defence policy (see also section 8.4)	*Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD), Edinburgh, tel: 0131 244 0213
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	*BODC, Birkenhead, tel: 0151 653 8633

*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.

Region 15: Western Isles

The Western Isles are almost entirely composed of Lewisian rocks, which give the landscape its hummocky character, although in the north of Lewis the bedrock is covered by later glacial drift. The coasts of many of the islands are intricate, with many sea lochs, most of which were carved along river valleys by the late Devensian icesheet, which moved across the region from the east. Glacial erosion did not result in significant overdeepening of the lochs.

Low cliffs, commonly incised into the glacial drift, surround the Butt of Lewis and the northern end of the island, where there are raised beaches backed by older cliff lines. Central Lewis forms a plateau with extensive drift cover and prominent cliffs along the east coast. In contrast, South Lewis and Harris are generally high, with bare glaciated hills and low western coasts. In the Uists and Benbecula there is a major difference in coastal landforms between the east coasts, which are hilly, and the west coasts, which are for the most part low, with extensive areas of dunes and machair. This topographic gradient is largely due to tilting of the region during the Tertiary, possibly in response to movement along the Minch Fault.

Butt of Lewis to the Sound of Harris (east coast)

The east coast of Lewis from the Butt of Lewis south to Traigh Mhor is largely cliffed, broken by numerous inlets and small gullies. Further south, the largest area of 'soft' shoreline is Traigh Mhealaboist, which has extensive intertidal flats of mud and sand. The southern end of Broad Bay is formed by the tombolo which links the Eye Peninsula, with its largely cliffed coast, to mainland Lewis. The rest of the east coast of Lewis and Harris is a rocky and glaciated landscape, cliffed in many places and deeply dissected by a number of sea lochs, including Lochs Erisort, Shell, Claidh and Seaforth.

North Uist, Benbecula and South Uist (east coast)

The island-studded Sound of Harris, some 12 km wide, separates Harris from North Uist. Both North Uist and Benbecula have complex indented eastern coastlines and much of their coast is steep and cliffed. North Uist is separated from Benbecula by a channel varying in width from a few kilometres to a few hundred metres, with a mass of small rocky islets at the eastern end. The east coast of South Uist is steep and rocky, rising to 620 m at Beinn Mhor, and indented with inlets and sea lochs.

Barra and the southern islands

The coast of Barra and the southern islands is deeply indented and largely cliffed, but pocket beaches backed by dunes have accumulated in places, especially along the western coasts. The main beach on Barra lies on the northern end of the island, where a tombolo-like feature joins the main island to Eoligarry. The beach along the western side of the feature is straight and narrow, while that to the east is wider and irregular in form. Most of the smaller islands to the south of Barra have totally cliffed rocky coasts but a tombolo joins the northern and southern parts of Vatersay.

South Uist (west coast)

This coast is low-lying, with an almost continuous cover of dune grading landward into machair, backed by numerous lochs. The beaches, machair and lochs are almost continuous along this western coast, but rock underlies them at a shallow depth, and there is only enough sand to maintain equilibrium without adding significantly to the dune growth. The main growth of the machair is thought to have occurred between about 5,700 and 2,000 years ago. Archaeological evidence suggests that for much of the past few hundred years there has been extensive sand erosion and drifting of the machair, perhaps as a result of overgrazing and cultivation, and only in this century has the land become stabilised. Separating South Uist from Benbecula is a large intertidal sandflat known as Bagh nam Faoilean or South Ford. The long, narrow sand-capped spit of Gualan projects across the width of the ford, sheltering the sandflats to the east from the Atlantic waves.

North Uist and Benbecula (west coast)

The west coasts of North Uist and Benbecula are low and irregular in form. Complex sand-infilled bays are common, separated by rocky headlands and minor boulder-strewn beaches. From the north coast of Benbecula along much of the west coast of North Uist there are extensive areas of sand flats, dunes and machair, whose morphology is largely determined by their exposure to the prevailing winds. The offshore spit and dune complex of Eachkamish lies at the western entrance to the channel between Benbecula and North Uist and shelters a large area of intertidal sandflats. Further north, the dune spits of Slugan and Kirkibost serve a similar function, protecting the sandy beaches of Traigh Leathann and Oitir Mhor. On the north coast of North Uist there are again extensive sandflats and machair at Vallay Strand, Traigh Ear and Vallaquie Strand, separated by the peninsula of Machair Leathann.

Sound of Harris to Aird Fenish

Traigh Scarasta and Traigh Luskentyre are large sediment-infilled inlets along the western coast of South Harris, which otherwise has a rocky shoreline. The former has developed in the shelter of Toe Head and comprises a beach of shell

Map 2.6.1 Major coastal landforms.

sand that grades into saltmarsh and machair. At Traigh Luskentyre wide sand flats are exposed in the inlets at low tide, and a prominent northward-extending peninsula has developed along its south-western shores. The beach at Luskentyre Banks, at the northern entrance to the inlet, is backed by dune and machair. Sea lochs occur northwards to Mealasta Island; many of them, such as Loch Resort, are surrounded by steeply rising ground and have a fiord-like aspect. Between Mealasta Island and Aird Fenish the coast is generally cliffed and indented with numerous inlets.

Aird Fenish to Butt of Lewis

North of Aird Fenish the coast is indented by the large sea lochs of East and West Loch Roag. The form of the largely rocky, cliffed coast is complex, with numerous small islands offshore and freshwater lochs to landward. Beaches have accumulated in some places along the edges of the lochs, as at Uig Sands and Traigh na Berie, which are partly supplied by erosion of glacial deposits. The beaches are backed by dunes and machair, and erosion and accretion along these beaches are the results of the wind climate.

A series of sea lochs with entrances commonly ponded by shingle bars lies along the coast from Dalbeg Bay to Barvas. Boulder beaches overlying a rock platform lie to seaward of the bars. From Barvas northwards, the coast consists of low drift-covered cliffs fronted by a wave-cut rock platform and dissected by a number of open, wide valleys. At Eoropie a cobble ridge along the back of the beach changes abruptly landwards to machair.

Region 16: west Highland

The coast of Region 16 is among the most rugged and exposed coasts in Britain. Cliffs and steep rocky shores predominate along much of the coastline, as a result of the underlying rocks' resistance to weathering and the tectonic and glacial history of the region. Some of Britain's highest mountains, for example those around Glencoe and Ben Nevis, and those of Knoydart, Glen Shiel and Kintail, as well as the Cuillin and Torridon Hills, lie close behind the coastline and provide a magnificent backdrop to the coastal scenery. Despite a high-energy wave regime, erosion rates along the exposed parts of the coast are very low, and (with a few exceptions) areas of intertidal sediment are limited to the upper reaches of sea lochs and isolated pocket beaches. In sheltered areas, particularly along lochs, the shoreline is fringed with shingle. The variations in sea level during the Pleistocene (see also section 2.5) have led to the formation of raised beach platforms, commonly backed by fossil cliffs, particularly across the southern part of the region.

Loch Linnhe to Kyle of Lochalsh

In general, the southern part of the region shows the most dramatic effects of glaciation, including the steep-sided fiords of Lochs Leven, Linnhe, Eil and Sunart. Although most of these lochs have small areas of mud or sand at their heads, Kentra Bay and Loch Moidart have the only significant areas of intertidal mud and sand in this section, or indeed the whole region.

Many of the minor coastal landforms around the rocky coast of the Ardnamurchan Peninsula reflect the rocks of the Tertiary igneous complex centred on the peninsula, which give rise to an irregular, hummocky landscape. Raised beach platforms are found on the peninsula at 4 m and 26 m above high-water mark.

The freshwater Loch Sheil is fronted by an extensive gravel outwash system, within which glacial features such as eskers and kettle holes are preserved. The coast of Arisaig, between Loch nan Ceall and the River Morar, is relatively low and many of the bays have fine beaches, mainly of calcareous sand. The numerous low-lying islands and reefs off this coast are an example of a skerry-guard, a drowned terrain whose low, hummocky form is due to glacial erosion. Loch Morar is the deepest loch in Scotland, having a maximum depth of 305 m, and is connected to the sea by a narrow trench cut by the River Morar through the low rock sill at the western end of the loch. Much of the rock platform is covered by poorly sorted gravels locally heaped into mounds; later sand dunes line the coast to the north of this glacial overflow channel.

Further north the mountainous hinterland becomes more rugged, and Lochs Nevis, Hourn and Duich stretch 15-20 km inland from the more open water of the Sound of Sleat and the Inner Sound.

The Inner Hebrides

The landscape of Skye and the Small Isles (Rum, Eigg, Canna and Muck) strongly reflects the properties of the Tertiary lavas and coarser intrusive igneous rocks of which they are largely composed. Dramatic cliffs and waterfalls abound, particularly on Eigg, Rum, Canna and around the north-west and north-east coasts of Skye, mainly fringing the horizontal lava flows which often produced a flat, plateau-like terrain. At Talisker on the west coast of Skye the cliffs are nearly 300 m high. The intrusive rocks of the volcanic centres on Rum and in the main range of the Cuillins on Skye have weathered to produce high, sharp peaks or (in the case of the Red Cuillins) more rounded granite mountains. The Torridonian rocks of south-east Skye give rise to a less dramatic topography.

Traces of high beach levels are common on the smaller islands around Skye, and on Canna remnants of beach platforms occur at heights of 6 m, 21-24 m and 30 m. Similar beach levels occur on Rum, and some of the beaches probably pre-date the last glaciation.

The upper part of Loch na Dal on Skye is filled with sand and boulders and there are remnants of a 30 m raised beach fringing the loch. Spectacular mountain scenery flanks the coast around Loch Coruisk to the south of the Cuillin Hills and at Loch Brittle the wide beach contains sand rich in dark heavy minerals. The beaches of Vaternish in north Skye are formed largely of white nullipore (a calcareous alga). In Trotternish, in the north-east of the island, pocket beaches are developed at Staffin Bay and Uig Bay, and waterfalls, generally descending from the dolerite or basalt cliffs, are a common feature: the stream that drains Loch Mealt falls vertically for 60 m. The eastern coast of Skye displays the most extensive landslips in Britain, the most spectacular of which is The Storr with its famous standing pillar, the Old Man of Storr.

Kyle of Lochalsh to Cape Wrath

North of Loch Alsh, the Torridonian sandstones are typically associated with steep or cliffed coasts and

spectacular mountains in the hinterland. By contrast the Lewisian gneiss around Lochinver, Drumbeg and Loch Laxford typically produces a low, rounded landscape with an abundance of small freshwater lochs.

Extensive gravel terrace deposits, considered to be glacial outwash deposits reworked by the sea, occur along the sides of Loch Kishorn and Loch Carron. Applecross Bay is flanked by a wide sandflat rimmed with cobble ridges. Between Applecross and Loch Torridon a raised beach platform at 30 m height lies along most of the coast, backed by fossil cliffs. The platform is well developed and the old cliffs are locally capped by boulder clay. Most of the coast northwards to Loch Gairloch is generally low and covered with boulder clay, but small beaches are found at Port Henderson, Opinan and Redpoint. Northwards to Loch Ewe the coast is cliffed, with numerous fossil cliffs and geos (steep, narrow gullies in the cliffs), although narrow sandy and pebble beaches front the coast around Melvaig. Small beaches occur along the shores of Loch Ewe and Gruinard Bay, many of them backed by fossil cliff lines and raised beaches. The town of Ullapool stands on a raised beach in Loch Broom, and the River Broom has infilled the upper part of the loch with alluvium.

North of Ullapool the Torridonian Sandstone mountains of Coigach abut the coast, although north of Enard Bay the coastal land is lower. Two small lochs occupy the low ground between Achiltibuie and Achnahaird Bay, and during higher sea-level stands the peninsula of Rubha Mor to the west of the lochs may have been cut off from the mainland. Achnahaird Bay in the southern part of Enard Bay has a broad intertidal upper reach, flanked on the west by sand dunes. The coast to the north is rocky and indented on a fine scale: beaches, such as those in Loch Kirkaig and Loch Inver, are small. The terrain of the coastal hinterland is controlled by the rock type, Lewisian rocks forming low undulating ground with numerous small lochs and Torridonian rocks forming more rugged terrain including spectacular peaks such as Suilven and Quinag. The Stoer Peninsula is formed of rugged Torridonian rocks and the few small sandy beaches along its coast are formed of reddish-coloured sand backed by cobbles and machair.

North of Eddrachillis Bay the coast continues to be irregular and is indented by the sea lochs of Loch Laxford and Loch Inchard. The bathymetry and form of these lochs indicate that they are more likely to be drowned river valleys than glacial features. Traigh Bad na Baighe at the head of Loch Laxford is one of the few significant areas of intertidal sediment in this area, although sandy beaches are found north of Kinlochbervie at Oldshoremore, Oldshorebeg and Sheigra. To the north, the Torridonian Sandstone returns to the coast and there are steep cliffs, except at Sandwood Loch, which is dammed up behind a beach of coarse sand. Sand is abundant in the intertidal zone in front of the loch and extends north along the coast, with dunes covering bedrock along the western shores of the loch.

2.6.2 Further sources of information

A. Further reading

Charlesworth, J.K. 1955. Late-glacial history of the Highlands and Islands of Scotland. *Transactions of the Edinburgh Geological Society, 62:* 769-928.

Gordon, J.E., & Sutherland, D.G. 1993. *Quaternary of Scotland*. London, Chapman & Hall. (Geological Conservation Review series, No. 6.)

Mather, A.S., & Ritchie, W. 1977. *The beaches of the highlands and islands of Scotland*. Aberdeen, Countryside Commission for Scotland.

Ritchie, W. 1966. The post-glacial rise in sea level and coast and changes of South Uist. *Transactions of the Institution of British Geographers, 39:* 79-86.

Shennan, I. 1989. Holocene crustal movements and sea-level changes in Great Britain. *Journal of Quaternary Science, 4:* 77-89.

Sissons, J.B. 1967. *The evolution of Scotland's scenery*. Edinburgh, Oliver & Boyd.

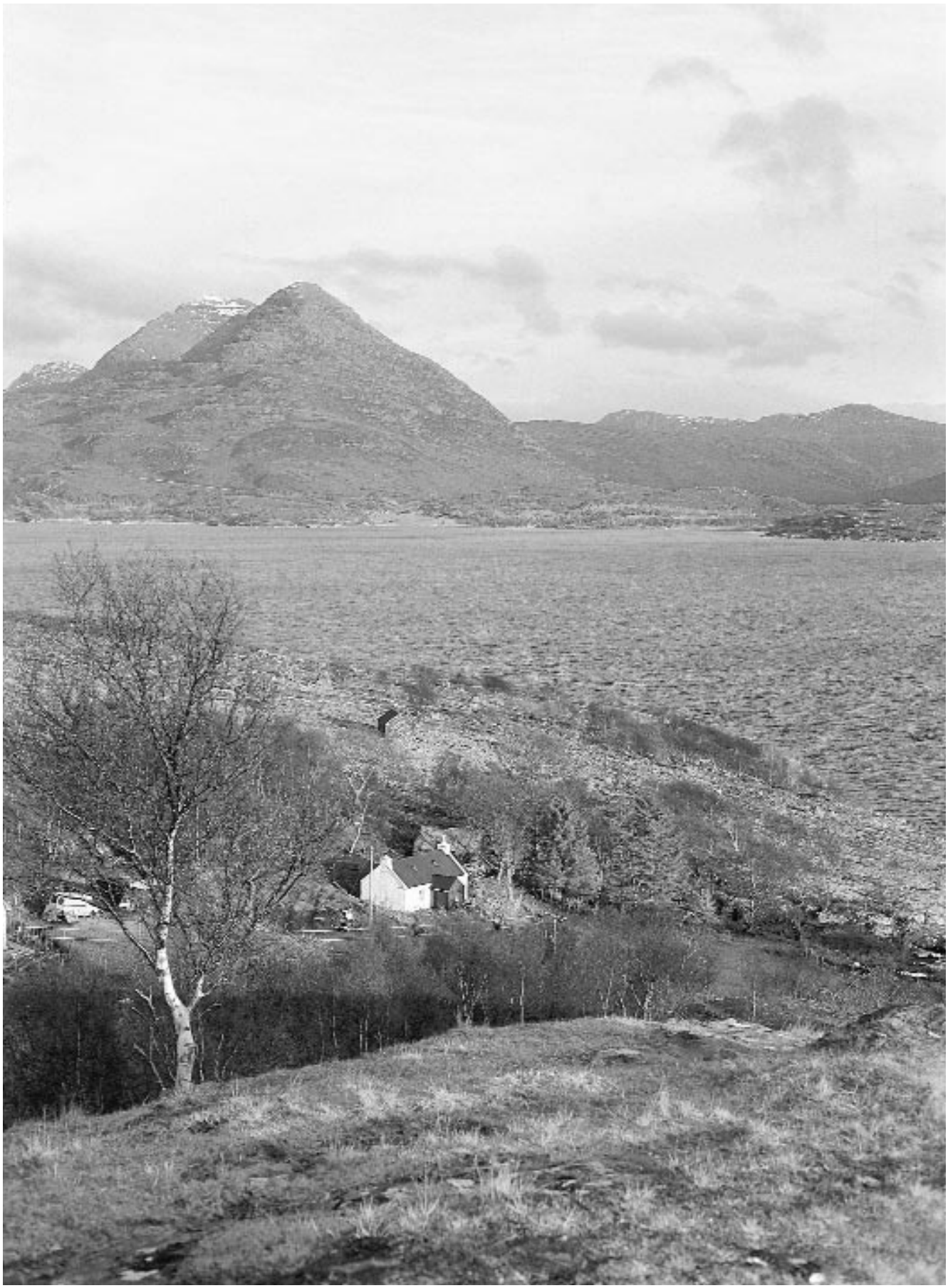
Steers, J.A. 1973. *The coastline of Scotland*. Cambridge, Cambridge University Press.

Von Weymarn, H. 1974. *Coastline development of Lewis and Harris, Outer Hebrides, with particular reference to the effects of glaciation*. University of Aberdeen, unpublished Ph.D. thesis.

B. Contact names and addresses

Type of information	*Contact address and telephone no.*
Coastal protection, policy, sediment cells	*Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD), Edinburgh, tel: 0131 244 0213
Geomorphology of the regions	*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.



Region 16 has some of the most varied and spectacular landscapes in the UK. It is internationally important for heathlands and arctic-alpine habitats, amongst many others. Pictured are the mighty Ben Damph Mountains, on the shores of Lake Torridon. Photo: S. Whitehorne, Scottish Natural Heritage.

Chapter 3 Terrestrial coastal habitats

The inaccessibility of the west Highland coast and the Western Isles and their relatively small human populations means that much more of the coast and hinterland retains its natural or semi-natural character than is the case for most other regions in the UK. Because of the mountainous nature of the hinterland and the strongly indented coast, complete suites of habitats, from fully marine, through coastal, woodland and moorland to arctic-alpine, exist over considerable expanses within the coastal Regions 15 and 16. Later sections in this chapter cover coastal terrestrial habitats (habitats that are maritime influenced, i.e. are distinctive because of their association with the coast and coastal processes) in Regions 15 and 16. Other semi-natural habitats adjacent to the coast but not directly influenced by the sea are described in this introduction.

In Region 15 the main non-maritime habitats of interest are peat bogs and brackish or freshwater lochs; in Region 16 these are augmented by woodland, heathland and mountains. The regions' resource of non-maritime habitats makes an outstanding contribution to UK biodiversity; many sites are internationally important and have been considered on a number of counts as possible Special Areas of Conservation (SACs) under the EC Habitats & Species Directive. Such sites falling partly or wholly within the coastal zone of the regions include the Lewis Peatlands (active blanket bogs), North Harris (wet heaths), North and South Uist (machair lochs, lake vegetation), Loch Etive (old oak woods), Loch Sunart Woods (old oak woods, otters), Claish Moss & Kentra Moss (active blanket bog), Rum (wet and dry heaths, scree, montane grassland), Strath, Skye (alpine grassland, limestone pavements, petrifying springs), and Trotternish Ridge, Skye (montane grassland, scree), Loch Maree (montane heathland complex, Caledonian pine forest, old oak woods), Inchnadamph (arctic-alpine heath, alpine limestone grassland, scree, limestone pavements, petrifying springs, sub-arctic willow scrub), and Ben Dearg (montane grassland/heathland complex).

The regions contain extensive, relatively intact peat bogs and numerous fresh- and brackish-water lochs. Scotland is internationally important for its raised bogs, and the UK holds a large proportion of the European resource. The regions' inland lochs, especially in areas of limestone or Tertiary igneous rocks (e.g. Rum, Trotternish, Ardnamurchan) are amongst the key higher plant sites in the regions. Many of the lochs in Region 15 are brackish, and this results in the development of a specialised aquatic flora. On North and South Uist, the machair lochs hold strong populations of the rare slender naiad *Najas flexilis*. Some of the characteristic plant species of the regions' lochs rely on unpolluted water: the geographical position of the regions, together with the prevailing westerly winds, has largely protected the sites from air pollution. Lochs in these regions act as roost sites to internationally important numbers of passage and wintering geese, notably Greenland barnacle geese *Branta leucopsis*. The freshwater lochs are also a major stronghold of the red-throated and black-throated divers *Gavia stellata* and *G. arctica*. The wetland habitats of Regions 15 & 16 are also vital to Scotland's nationally important populations of otters *Lutra lutra*, for which Region 15 is extremely important.

Because of the oceanic climate, wet heath predominates over much of the lowland to mid-altitude heathland in the regions, with *Sphagnum* bogs and large tracts of oceanic mosses. The wet heaths of North Harris comprise the most extensive area of the vegetation type in Great Britain. Areas of wet heath at medium altitude support a community of large oceanic liverworts that is virtually confined to the west coast of Scotland and Ireland; in the extremely oceanic climate of Region 15 this community is found at lower altitudes than is usual in Region 16. The heathland complex around Loch Maree in Region 16 is superlative for heaths characteristic of the far north-west Highlands and for a range of north-western forms of alpine and sub-alpine heath, including stands of juniper *Juniperus communis*. 'Waved' heaths, in which the heather and other dwarf shrubs have been shaped by the extreme winds, are a characteristic feature of the most exposed northern coasts of Region 16. Ben Dearg, the most outstanding heathland site in the north-west Highlands, has a wide range of extensive heaths and grasslands that contain several rarities, including alpine plants.

Montane areas in the regions are important for a range of species. Summit ridges, cliffs and rock ledges, high-altitude flushes and other montane habitats all support their own distinctive lower plant communities. In Region 15 the salt-laden winds enable some higher plant species that are usually strictly maritime to grow at higher altitudes. Conversely, in Region 16, a number of arctic or arctic-alpine species that are more typical of uplands grow at lower levels in sheltered areas. Limestone uplands support a distinctive flora, as at Inchnadamph, a classic botanical montane locality in Region 16; the limestone there also gives rise to some of the best petrifying springs in Europe. A particularly important habitat type found in Region 16 is sub-arctic willow scrub; in Europe this is found only in Sweden, Finland and the UK. The largest extent in the UK occurs at Inchnadamph, at a relatively low altitude. Uncommon birds of prey that breed in the regions' mountains include golden eagle *Aquila chrysaetos*, peregrine falcon *Falco peregrinus* and the white-tailed eagle *Haliaeetus albicilla*, Britain's largest raptor, which has been successfully re-established in these regions.

Region 15 is one of the least wooded regions in Britain: the islands are virtually devoid of tree cover. The few woodlands on Lewis and Harris are important roosting sites for wintering ravens *Corvus corax*. Conversely, Region 16 includes numerous areas of coastal woodland, particularly in the south. These are primarily conifer plantations, but also include some important ancient semi-natural woodland, particularly along the steeper sides of some of the lochs. Woodlands at Loch Etive, Taynish Woods and Loch Maree have stands of ancient oak with holly *Ilex aquifolium* and hard fern *Blechnum spicant*, and at Loch Maree there are areas of Caledonian pine forest; Scottish examples of this woodland type are extremely important in a European context as they represent genetically distinct oceanic variants.

Oceanic woodland is probably the single most important

lower plant habitat in Region 16, with an exceptionally high diversity of bryophytes, lichens and fungi, particularly slime moulds *Myxomycetes*. Many species (most notably small liverworts) are virtually confined to oceanic woodland. It also offers a wide range of invertebrate habitats. Loch Sunart Woodlands comprise the most extensive and richest complex of atlantic bryophyte-rich woodland in the UK, and is also the British stronghold for the rare chequered skipper butterfly *Carterocephalus palaemon*.

Woodlands in Region 16 are important for four mammals with restricted distributions in the UK: the otter, the red squirrel *Sciurus vulgaris*, the wildcat *Felis silvestris* and the pine marten *Martes martes*. Loch Sunart Woodlands have large numbers of otters, a species that is absent from much of Great Britain. The pine marten is declining in both distribution and numbers throughout Great Britain and is reduced to relict populations in England and Wales. The red squirrel *Sciurus vulgaris* is extinct over much of England and Wales but is still widespread in wooded parts of Scotland. The wildcat is restricted in Britain to Scotland; its distribution in the region, and that of the red squirrel and the pine marten, is linked to the distribution of conifer plantations.

Cliffs in the regions range from the storm-lashed sheer granite walls surrounding the islands of St Kilda to lower, more broken cliffs, as found here at Western Cliff, Sandwood Bay. Mainland cliff sites such as these often lie within sea lochs or are sheltered by islands, and their vegetation may therefore, as here, be more montane than maritime in character. Photo: Pat Doody, JNCC.

3.1 Cliffs and cliff-top vegetation

Dr T.C.D. Dargie

3.1.1 Introduction

Geology and geological structure, together with environmental history (past and present marine erosion and glacial processes), determine cliff form. The most distinctive cliff types are consolidated (hard cliffs developed from resistant bedrock, covering most of the regional resource) and unconsolidated (soft cliffs developed in easily-eroded, predominantly Quaternary - Pleistocene and Holocene - deposits).

The coasts of Regions 15 (Western Isles) and 16 (west Highland) contain a large, diverse and often spectacular length of cliff and cliff-top habitat. Regions 15 & 16 have a total cliff length of 215 km and 578.5 km respectively (Table 3.1.1), almost all of it hard cliff. The total cliff length in Region 15 represents 5% of the British resource and is therefore of average importance in the national context. The total cliff length in Region 16 represents 14% of the British resource, the largest percentage in any Coastal Directories region, and is therefore of great importance in the national context.

Table 3.1.1 Regions 15 & 16 cliff resource in context

	Length (km)*	*% in Region 15*	*% in Region 16*
Region 15	215	-	-
Region 16	578	-	-
Scotland	2,455	8.8	23.6
West Coast**	2,261	9.5	25.6
GB	***4,061***	***5.3***	***14.2***

Source: JNCC Coastal Resources Database. Key: *to nearest whole km; **of Britain.

Sea cliffs are generally steep slopes (>15°), but in Regions 15 and 16 they 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, including fossil raised beaches, above a currently intertidal rock platform. These cliff landforms are determined by the contrasting lithologies of each region. Resistant Lewisian gneiss is the predominant substrate in Region 15, and the most extensive cliffs (45% of the total length) are high (>20 m) vertical types, largely restricted to the exposed north-western coasts of Lewis and Harris and the eastern coastline of the Uists. However, the highest cliffs are made of granite; they are the near-vertical cliffs on St. Kilda (Conachair 426 m, Soay 373 m and Boreray 380 m), the highest group of sea cliffs in Britain. Other high cliffs in Region 15 include those on Mingulay (210 m), which are made of Lewisian gneiss. Region 16, in contrast, is geologically more diverse than Region 15 and is particularly noted for exposures of Tertiary volcanic rocks on the coasts of Skye, Rum and Eigg. The most extensive cliffs in the region (41% of the total length) are high (>20 m) non-vertical types, which are evenly distributed throughout the region. The highest cliffs are non-vertical, reaching 380 m on Bloodstone Hill, Rum. Table 3.1.2 summarises the extent of cliffs of different forms in the regions.

Cliff and cliff-top vegetation vary markedly even over short distances, changing in relation to slope angle, soil type, salt spray deposition, with much local variability possible with changing exposure around headlands. 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. Seabird colonies may contribute a high level of nutrient enrichment to the soil, for example on Mingulay and Berneray, St. Kilda, North Rona and Sula Sgeir in Region 15, and on Handa Island in Region 16. Very sheltered cliffs and cliff-top sectors that receive very little salt spray input are not here treated as coastal habitats. However, it should be noted that relict woodlands and scrub, with very important Atlantic bryophyte and lichen floras, are present on some such sheltered cliffs in Region 16. In addition, cliff tops with low exposure to salt spray are extensive in sheltered fjardic inlets of the eastern shores of the Western Isles.

The National Vegetation Classification (NVC - Rodwell in press) covers twelve maritime cliff communities in the UK, though almost all refer to hard cliff habitats. Of the twelve (excluding MC7, for which no distribution map is available), nine are found in Scotland, 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

Table 3.1.2 Lengths (km*) of cliff types

	Vertical >20 m height		*Vertical <20 m height*		*Non-vertical >20 m height*		*Non-vertical <20 m height*	
Area	*Length (km)*	*% of total length in Regions 15 & 16*	*Length (km)*	*% of total length in Regions 15 & 16*	*Length (km)*	*% of total length in Regions 15 & 16*	*Length (km)*	*% of total length in Regions 15 & 16*
Region 15	97	-	36	-	58	-	24	-
Region 16	120	-	111	-	236	-	113	-
Regions 15 & 16	217	-	147	-	294	-	137	-
Scotland	663	32	725	20	724	41	343	40
West Coast**	722	30	435	34	816	36	281	49
Great Britain	***1,327***	***16***	***817***	***18***	***1,376***	***21***	***541***	***25***

Source: JNCC Coastal Resources Database. Key: *to nearest whole km; **of Britain.

the nine, five are recorded for Region 15 and seven for Region 16, and five are found in both regions, including perched saltmarsh on spray-soaked cliff-tops and spray-affected variants of inland vegetation types, including maritime heath (Rodwell in press). Detailed NVC survey based on mapping has not been carried out in these regions, and existing information is insufficient to detail the regional extent of individual cliff and cliff-top habitats.

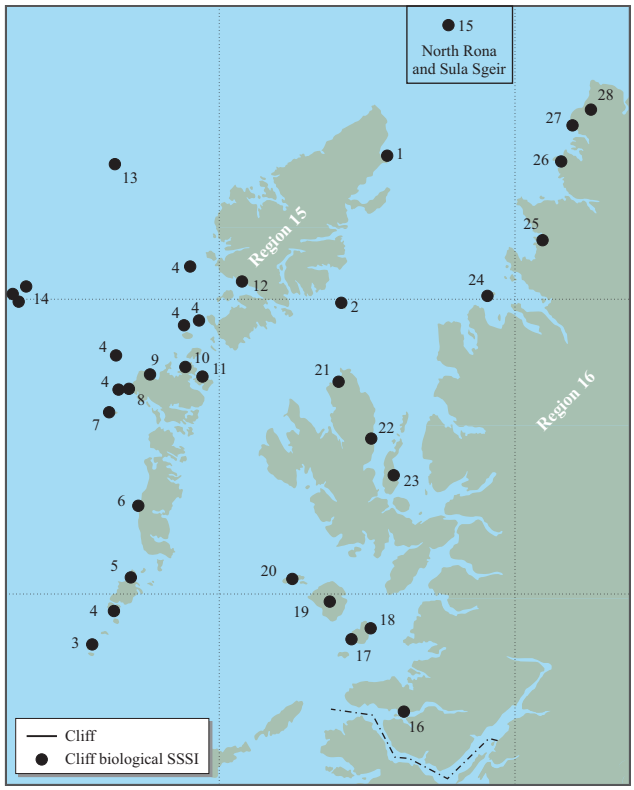
The scenic contribution of sea cliffs is important in both regions (see also section 7.3.3). In Region 15 they form the main landscape component of the St. Kilda National Scenic Area (NSA) and contribute to two other NSAs: South Lewis, Harris and North Uist, and South Uist Machair NSA. In Region 16 sea cliffs are an additional dramatic landscape component to the outstanding mountainous character of seven NSAs: Morar, Moidart and Ardnamurchan; The Small Isles; Knoydart; The Cuillin Hills; Trotternish; Wester Ross; and Assynt - Coigach.

3.1.2 Important locations and species

The locations of cliffs, including cliff sites that are biological SSSIs, in the regions are shown on Map 3.1.1. The regions are particularly noted for cliffed headlands. These include (in Region 15) Barra Head (on Berneray, south of Mingulay) and the Butt of Lewis, and (in Region 16) Dunvegan Head, Waternish Point, Rubha Hunish, Point of Stoer and Cape Wrath. Notable caves and stacks are also present, including (in Region 15) Stac an Armin on St. Kilda, which rises to 191 m and is the highest rock stack in Britain, and (in Region 16) a stack called Am Buachaille, in Sandwood Bay. Outstanding island bird cliffs are also found in the regions, including St. Kilda, the Flannan Isles, North Rona, the Shiants, Sula Sgeir and Mingulay in Region 15, and Handa in Region 16. Blown sand from adjacent beaches is present on the flanks of sea cliffs in several locations in both regions (e.g. Pabbay (south of Barra) and Pabbay (Sound of Harris) in Region 15, and Sandwood Bay in Region 16) (see also section 3.2). Region 16 contains raised beaches bearing low modern cliffs on their seaward side and taller striking fossil cliffs inland (best developed on the western coast of Rum) (see also section 2.6).

Within Regions 15 and 16, 28 cliff and cliff-top habitat sites are designated as Sites of Special Scientific Interest (SSSIs) (Table 3.1.3; Map 3.1.1). There are fifteen SSSIs containing maritime cliff and cliff-top habitat in Region 15. Three sites are included in National Nature Reserves (St. Kilda, North Rona and Sula Sgeir, Monach Isles), and St. Kilda is also a World Heritage Site (see also Chapter 7). Many of the SSSIs containing maritime cliffs in Region 15 have other interests as their main features, particularly machair-type sand dunes (see also section 3.2). In Region 16 there are thirteen SSSIs containing maritime cliff and cliff-top habitat, which include three National Nature Reserves (Rum, Loch a' Mhuillin and Inverpolly). The major SSSIs noted for maritime cliff habitats in the region are An Sgurr & Gleann Charadail (Eigg), Canna and Sanday, Rubha Hunish, Priest Island, Loch a' Mhuillin, Handa Island, and Sheigra to Oldshoremore. The list in Table 3.1.3 excludes some SSSIs with very sheltered cliffs without maritime habitat and a large set of sea cliff SSSIs designated for their geological interest alone, found mainly on Skye.

In Great Britain nine nationally rare and four nationally



Map 3.1.1 Cliffs, cliff-top habitat and cliff biological SSSIs. Marked sectors have >90% cliffed coast. Sources: JNCC Coastal Database; Research and Advisory Services, Scottish Natural Heritage.

scarce species or subspecies of higher plant are found mainly or exclusively on cliffs. Most are restricted to cliff habitats in the south and west of Britain, and none is found in these regions. Other nationally rare and scarce species more typical of other habitats also occur on cliffs; of these none is present in the cliff-top habitats of Region 15, while in Region 16 one nationally scarce species (thyme broomrape *Orobanche alba*, found elsewhere in Britain more typically in south-western and upland areas) occurs (see also section 5.2). Maritime heath is an important national feature of cliff-top habitat and is probably very extensive on most cliffed coast in both regions. In Region 15, the lichen flora of maritime grassland on St. Kilda is considered to be of national and possibly international importance, although there are no other similar sites for comparison in Europe. No lichen heath of national importance is recorded for Region 16 cliffs (Fletcher *et al*. 1984). The Atlantic bryophyte communities of Rigg - Bile SSSI (Skye) and Rubha Hunish SSSI, both in Region 16, include some nationally rare and scarce species (see also section 5.1).

The breeding bird fauna of cliffs in Regions 15 & 16 is of national and international importance (see also section 5.10). Seabird numbers, either in total or for individual species, are sufficiently high at six cliff sites to warrant Special Protection Area (SPA) status. These are: the Shiants, St. Kilda and the Flannan Isles in Region 15, and Rum, Priest Island (the Summer Isles) and Handa Island in Region 16. Breeding birds are found in comparable numbers at Tolsta Head, North Rona and Sula Sgeir and Mingulay and Berneray in Region 15 (Stroud *et al*. 1990). St. Kilda holds the largest British breeding colonies of fulmar *Fulmarus glacialis*, Leach's petrel *Oceanodroma leucorhoa*, gannet *Morus*

Table 3.1.3 Regions 15 & 16 biological SSSIs that include coastal cliff and cliff-top habitat

Site no. on Map 3.1.1	*Location*	*Grid ref.*
	Region 15	
1	Tolsta Head	NB564471
2	Shiant Isles, Harris	NG415980
3	Mingulay,	NL560830
	Berneray	NL560800
4	'Small seal islands':	
	Flodday, Barra	NL613923
	Causamul, North Uist	NL660705
	Haskeir, North Uist	NF615820
	Shillay, Harris	NF880914
	Coppay, Harris	NF933938
	Gasker, Harris	NA875115
5	Eoligarry, Barra	NF698065
6	Bornish and Ormiclate Machairs	NF753309
7	Monach Isles	NF625625
8	Balranald Bog and Loch nam Feithean	NF712705
9	Vallay	NF775765
10	Machairs Robach and Newton	NF873763
11	Loch an Duin	NF935740
12	North Harris	NB065115
13	Flannan Isles, Lewis	NA715460
14	St. Kilda	NF095995
15	North Rona,	HW810325
	Sula Sgeir	HW620305
	Region 16	
16	Ben Hiant & Ardnamurchan Coast	NM600610
17	An Sgurr & Gleann Charadail	NM453858
18	Eigg - Laig to Kildonnan	NM495885
19	Rum	NM370980
20	Canna and Sanday	NG250060
21	Rubha Hunish	NG410739
22	Rigg - Bile	NG515535
23	Raasay	NG585400
24	Priest Island	NB925022
25	Inverpolly	NC065145
26	Handa	NC138480
27	Sheigra - Oldshoremore	NC192589
28	Southern Parphe	NC240630

Source: Research and Advisory Services Directorate, Scottish Natural Heritage. Note: other cliff in the regions have been notified as SSSIs for their geological interest (see section 7.3.2).

bassanus and puffin *Fratercula arctica*. Its total breeding seabird population is in excess of 500,000 individuals and it is rated as the most important seabird breeding locality in Europe (Tasker *et al.* 1988). The Flannan Isles are internationally important for guillemot *Uria aalge* and razorbill *Alca torda* and nationally important for breeding populations of storm petrel *Hydrobates pelagicus*, Leach's petrel and puffin. The Shiant Isles support internationally important numbers of fulmar, shag *Phalacrocorax aristotelis*, razorbill and guillemot. Cliffs and maritime grassland in the Monach Isles are of international importance for black guillemot *Cepphus grylle*. Mingulay is of international importance for breeding fulmar and razorbill and of national importance for shag and guillemot. Berneray is of international importance for breeding guillemot and razorbill and supports nationally important populations of kittiwake *Rissa tridactyla*. Rum, in Region 16, holds the world's largest breeding colony of Manx shearwater *Puffinus puffinus*. Priest Island (one of the Summer Isles) has the largest colony of storm petrel in Scotland. Handa is of international importance for razorbill, guillemot, kittiwake and great skua *Stercorarius skua*.

No systematic survey of invertebrates in cliff and cliff-top habitats has been carried out, but these environments have a rich habitat diversity and thus can be expected to support large numbers of species (Mitchley & Malloch 1991). A few cliffs within the regions are known to have good invertebrate lists, based on data from the JNCC's Invertebrate Site Register. These sites include St. Kilda in Region 15, and Rum, Canna, Sanday and Ardnamurchan in Region 16.

Cliff recession is not a significant problem in Region 15 or, on the whole, in Region 16 (Jones & Lee 1994). However, the north-west coast of Skye is characterised by eroding basalt cliffs. On the island's north-east coast there are large multiple rotational slides at the Storr and Quirang, developed in basalts overlying Jurassic sedimentary rocks. These are amongst the largest and most spectacular landslides in Great Britain. Similar features occur on the east coast of Raasay.

3.1.3 Human activities

Cliffs are among the least modified of terrestrial habitats, although nationally the cliff-top zone, especially its inner sectors, can be affected by a variety of human impacts, sometimes leading to major habitat loss. This is not the case in Regions 15 and 16, where many cliffs are rarely visited. Large coastal settlements on cliffs are absent and there is no industrial development. There is little caravan park development close to cliffs and there are few car parks; in Region 15 such development is restricted to Harris and Lewis. In general, path erosion and wildlife disturbance are the only impacts of note and these are rarely serious; footpaths along cliffs in the regions are not heavily used. Virtually none of the cliff base has been protected by coastal defences and hence natural coastal erosion is prevalent.

At a national scale the most extensive influences upon hard cliff vegetation are grazing and burning, the major management techniques for cliff-top habitats (Mitchley & Malloch 1991). Little is known of their role within Regions 15 & 16. Some of the cliffed coast is developed for agriculture, especially crofting. Maritime grassland and heath support stock in both regions, although in Region 15 stock grazing on cliffs is restricted to the islands of Harris and Lewis. St. Kilda sheep populations have been well-studied as a classic demonstration of cyclic population dynamics ('boom and bust' phases, linked to availability of food) (Malloch & Okusanya 1979). The bird cliffs once provided a vital food source for the inhabitants of these isolated islands, probably limiting bird populations last century. The only site now exploited is the gannetry on Sula Sgeir.

3.1.4 Information sources used

In general, no maritime cliff vegetation in Regions 15 & 16 has been mapped using the NVC. With the exception of St. Kilda, no area data for vegetation or habitat types have been collated. Existing information is therefore insufficient

to detail the regional extent of individual cliff and cliff-top habitats. Cliff vegetation mapping on St. Kilda is based on a survey by R.E.C. Ferreira using 1965 aerial photography and a photogrammetric map published by the Nature Conservancy in 1970. Survey of the sea cliffs of St. Kilda using NVC methodology commenced in 1996 and is due to be completed in 1997, under the direction of Scottish Natural Heritage.

3.1.5 Acknowledgements

Assistance with sources was kindly provided by John Barne and Deborah Proctor (JNCC), and Gail Churchill, Joan Cumming and Kathy Duncan (SNH). Thanks also go to Rendel Geotechnics for information on landsliding and cliff erosion.

3.1.6 Further sources of information

A. References cited

Fletcher, A., Coppins, B.J., Gilbert, O.L., James, P.W., & Lambley, P.W. 1984. Survey and assessment of lowland heathland lichen habitats. *Nature Conservancy Council, CSD Report,* No. 522.

Jones, D.K.C., & Lee, E.M. 1994. *Landsliding in Great Britain.* London, HMSO.

Malloch, A.J.C., & Okusanya, O.T. 1979. An experimental investigation into the ecology of some maritime cliff species. 1. Field observations. *Journal of Ecology, 67*: 283-292.

Mitchley, J., & Malloch, A.J.C. 1991. *Sea cliff management handbook for Great Britain*. Lancaster, University of Lancaster.

Rodwell, J.S., *ed*. In press. *British plant communities. Volume 5: maritime and open vegetation communities.* Cambridge, Cambridge University Press.

Stroud, D.A., Mudge, G.P., & Pienkowski, M.W. 1990. *Protecting internationally important bird sites*. Peterborough, Nature Conservancy Council.

Tasker, M.L., Moore, P.R., & Schofield, R.A. 1988. The seabirds of St. Kilda, 1987. *Scottish Birds 15*: 21-29.

B. Further reading

Further details on coastal habitat sites, including cliffs, are available on the *Coastal & Marine UKDMAP datatsets 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.

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides.* London, Collins. (New Naturalist series.)

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

Bryan, A. 1994. *The Minch review*. Stornoway, Scottish Natural Heritage/Western Isles Islands Council.

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, Joint Nature Conservation Committee.

Gubbay, S. 1988. *Coastal directory for marine nature conservation.* Ross-on-Wye, Marine Conservation Society.

Mitchley, J. 1989. *A sea cliff bibliography*. Peterborough, Nature Conservancy Council. (Research & survey in nature conservation, No. 18.)

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.*
Flora, fauna, habitat information, location of site reports, site management	*Coastal Ecologist, Aquatic Environments Branch, SNH, Edinburgh, tel: 0131 554 9797
Advice on national and international policy and cliff conservation	*Geology/Coastal Advisor, JNCC, Peterborough, tel: 01733 62626
Cliff erosion, National Landslide Databank	Rendel Geotechnics, Norfolk House, Smallbrook Queensway, Birmingham B5 4LJ, tel: 0121 627 1777
Invertebrate fauna	*Invertebrate Site Register (ISR), 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 coasts of Regions 15 (Western Isles) and 16 (west Highland) contain a large and varied set of sand dune systems associated with (in Region 15) open shores and (in both regions) bays and hard cliffs. Region 15 has 98 dune sites containing 7,964 ha and Region 16 has 63 dune sites containing 630 ha of vegetated sand and other land cover (Table 3.2.1; Map 3.2.1). Regions 15 and 16 contain 16% and 1% of the British sand dune resource respectively; Region 15 is therefore nationally important.

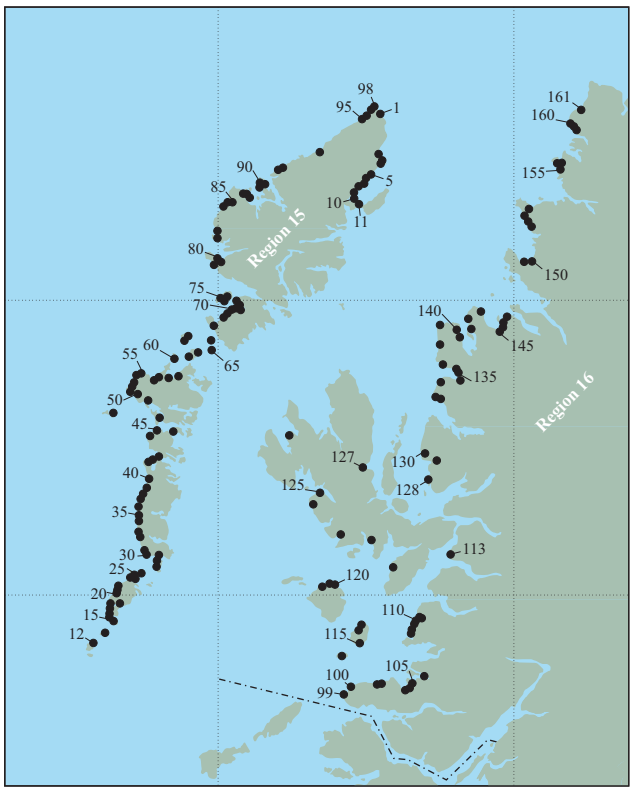
Table 3.2.1 Region 15/16 vegetated dune resource[a] in context

	Total area (ha)*	*% of total in Region 15*	*% of total in Region 16*
Region 15	7,964	-	-
Region 16	630	-	-
Scotland	31,540	25	2
West Coast**	31,308	25	2
GB	***50,200***	***16***	***1***

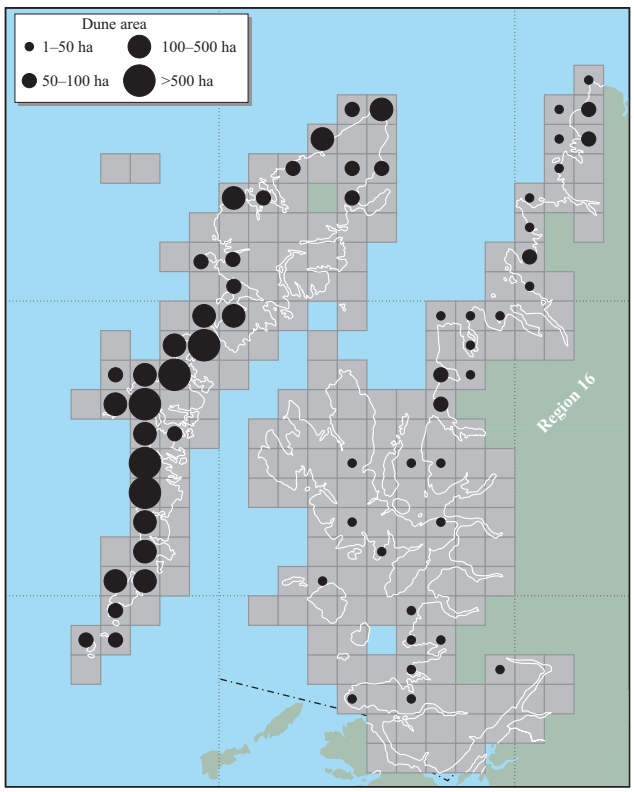
Sources: Dargie (1993, 1995), Radley (1994), JNCC Coastal Resources Database. Key: [a]to the nearest whole hectare; *survey data for Scotland are incomplete and therefore regional totals and those for Scotland and thus the West Coast and Great Britain are provisional estimates; **of Britain.

On the basis of a survey of a sample of dune sites in the region (Dargie 1993), an estimate of the extent of dune habitat types in the regions is used here to allow some form of GB context to be indicated (Table 3.2.2). The machair hindshore type is probably restricted world-wide to Scotland and western Ireland, and Region 15 has much of the total Scottish extent, although Region 16 contains only a very small proportion of the Scottish total. In Region 15 vegetated blown sand (Map 3.2.2) is largely confined to the western side of the main islands, except to the north and south of the archipelago. There are a number of very lengthy stretches of contiguous sand, spanning several large bay dune systems. The longest of these, and the second longest continuous dune system in Britain, occupies all of the western side of South Uist. The distribution of wind-blown sand is widespread along the mainland coast of Region 16 and there are a large number of dune sites, although their total area is not great. The precise size of most dune sites in Region 16 is unknown, but the region contains no large dune systems and those on the offshore islands (e.g. Skye) are particularly small. The small size of the sites restricts the range of habitat conditions that can occur.

The sand dunes of Region 15 are of great interest because of their very great extent and diverse range of site and habitat types. 25 sand dune sites are covered by SSSI designation, two sites are in National Nature Reserves (NNRs) (Monach Isles, Loch Druidibeg), and 39 sites are in the 'Machair of the Uists and Benbecula, Barra and Vatersay' Environmentally Sensitive Area (ESA) (see also Chapter 7). The dune fringe of the islands, together with the adjacent



Map 3.2.1 Sand dune sites. Numbers refer to Table 3.2.3. See Table for sources.



Map 3.2.2 Extent of vegetated windblown sand in coastal 10 km squares. Source: JNCC Coastal Database.

Table 3.2.2 Areas* of dune vegetation types (ha[a])

	Strand and embryo dune	*Mobile and semi-fixed dune*	*Acidic fixed dune grass-land*	*Neutral and calcareous fixed dune grassland*	*Dune heath and bracken*	*Dune slack*	*Other dune wetland*	*Dune woodland and scrub*	*Transitions to saltmarsh*	*Transitions to maritime cliff*	*Other land cover*
Region 15	49	284	353	5,858	0	0	1,185	0	0	0	235
Region 16	7	37	7	447	0	0	132	0	0	0	0
Scotland	61	4,059	4,125	10,513	2,113	1,095	3,817	5,500	217	41	587
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: [a]to the nearest whole hectare; n/a = not available; *survey data for Scotland are incomplete and therefore regional totals and those for Scotland and thus the West Coast and Great Britain are provisional estimates; **of Britain.

transitional habitats of moorland (termed 'black-land') and peatland, open water and bare rock, creates a distinctive scenery contributing to two National Scenic Areas (NSAs) (South Uist Machair; and South Lewis, Harris and North Uist) containing 48 sites. The conservation importance of the sand dune resource in Region 15 is stressed by Ratcliffe (1977) and discussed fully by Angus (1994). Only ten sites in Region 16 lie within SSSI designations (including three in Rum NNR); however, 40 sites are located within the NSAs at Morar, Moidart and Ardnamurchan; Small Isles; Knoydart; Wester Ross; Assynt - Coigach; and North-west Sutherland.

3.2.2 Important locations and species

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

The largest dunes in these regions 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 (Ritchie 1976), with comparatively low outer mobile and semi-fixed dunes and an extensive inland dune plain, the result of the high average windspeeds (see section 2.3). The machair plain in its most mature form includes inland dune scarps and large depressions containing hummocky dune grassland, extensive wet grasslands, machair fens and machair lochs. The finest examples of mature machair complexes in Region 15, and probably the best examples in Britain, are on South Uist (Daliburgh, Bornish and Ormiclate, Loch Bee), and Balranald on North Uist. Notable features in Region 15 are a machair hindshore-saltmarsh transition, which is extensive at Loch Bee, Baleshare and Kirkibost, and the development of machair on islands of varying size and shape (e.g. Monach Isles, Kirkibost, Vallay). In Region 15 dune plains can extend inland for up to 2 km (e.g. west of Loch Bee, South Uist). By comparison, the small size of dune sites in Region 16 makes mature machair plain features rare. The largest examples of machair in Region 16 are at Oldshoremore and Sandwood Bay. A large machair loch is present at Sandwood Bay, where it is subject to frequent changes in level because Strath Shinary, which flows into it, drains a large catchment area. The main beach at Sandwood Bay is one of the most exposed in Britain; it has a variety of foredune types and many large blowouts, illustrating the instability of dunes under extreme conditions.

Ness/foreland dunes gradually extend seawards on shores with sand supply coming from two directions. There are two in Region 15, at Scarasta and Luskentyre (both Harris), and only one very small example in Region 16, at Morar. Spit dunes develop at the mouths of estuaries; they are rare in Region 15 (Seilebost (on Harris), Gress, Tong, Coll, Baleshare, and Melbost (on Lewis)) and absent from Region 16. In Region 15 there is a single example of an offshore island dune system based on shingle (Gualan, between South Uist and Benbecula), although none in Region 16. Bay dunes are common in both regions, but most are small sites, developed upon sand trapped within the shelter of rock headlands.

Climbing dunes represent 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. In Region 15 these are typical features of exposed dune systems with high adjacent bedrock, most notably on islands such as Pabbay (Barra), Fuday and Pabbay (Sound of Harris); at this last site 'climbing machair' rises to 196 m. This type is also very common adjacent to the most exposed machair hindshores (Traigh Eais at Eoligarry and other beaches on the west coast of Barra), climbing to 102 m on Ben Eoligarry. In Region 16 these features are restricted to the most exposed dune systems, usually at the edge of larger machair hindshore systems (e.g. Oldshoremore, Sandwood Bay).

Many of the dune systems in Region 15, and the larger ones in Region 16, develop a water table 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 machair lochs of Region 15, which have a sandy floor on their seaward side and occasionally a brackish-water influence, are an important characteristic of machair in the region. In Region 15, machair fens are particularly well-developed, forming the machair edge to the 'blackland' transition, and are often found adjacent to machair lochs (e.g. west of Loch Hallan at Daliburgh, around Loch nam Feithean, Balranald). The small size of most sites in Region 16 restricts slack habitat to very small areas.

Some 85 National Vegetation Classification (NVC) communities have been recorded for surveyed Scottish dunes, with a total of 116 types for communities and sub-

Table 3.2.3 Sand dune sites in Regions 15 & 16

No. on Map 3.2.1	*Location*	*Grid ref.*	*Area (ha*)*	*Dune type*	*Conservation status*	*Survey type*
	Region 15					
1	Port of Ness	NB538637	-	Bay	SSSI	
2	Garry	NB535500	-	Machair hindshore, climbing dune	SSSI	CCS
3	Traigh Mhor Tolsta	NB545485	-	Bay, climbing dune		CCS, ITE
4	Giordale Sands	NB544466	-	Bay		
5	Sheilavig Mor	NB514432	-	Bay, climbing dune		
6	Gress	NB492415	-	Spit, bay, climbing dune	SSSI	CCS
7	Traigh Rebac	NB491402	-	Bay		
8	Coll	NB464388	-	Spit, bay		CCS
9	Tong	NB452359	-	Spit, bay	SSSI	CCS, ITE
10	Melbost	NB460340	-	Spit, bay	SSSI	CCS, ITE
11	Branahuie	NB474326	-	Bay		CCS
12	Mingulay Bay	NL567832	-	Bay, climbing dune	SSSI, SPA	
13	Pabbay (Barra)	NL609874	-	Machair hindshore, climbing dune		
14	Sandray Main Beach	NL653910	-	Bay, climbing dune		
15	Sandray Sheader	NL631921	-	Bay, climbing dune		
16	Bagh a'Deas	NL635939	37	Machair hindshore, climbing dune	ESA	ITE, SDVSGB, SFU
17	Vatersay Bay	NL634950	84	Machair hindshore, climbing dune	ESA	ITE, SDVSGB, SFU
18	Traigh Varlish	NL619972	-	Machair hindshore, climbing dune	ESA	ITE, SFU
19	Uidh	NL657961	6	Bay, climbing dune	ESA	SDVSGB
20	Halaman Bay	NF646005	83	Machair hindshore, climbing dune	ESA	ITE, SDVSGB, SFU
21	Borve	NF653022	64	Machair hindshore, climbing dune	ESA	CCS, ITE, SDVSGB, SFU
22	Allasdale	NF655035	112	Machair hindshore, climbing dune	ESA	CCS, ITE, SDVSGB, SFU
23	Eoligarry	NF697077	-	Machair hindshore, climbing dune	SSSI, ESA	CCS, ITE, SFU
24	Traigh Scurrival	NF705084	-	Machair hindshore	ESA	CCS, ITE, SFU
25	Traigh Cille Barra	NF709070	-	Machair hindshore, climbing dune	ESA	CCS, ITE, SFU
26	Fuday	NF730086	228	Bay, climbing dune		SDVSGB
27	Coilleagh Phrionnsa	NF786105	-	Bay, climbing dune		
28	Rhuban	NF783120	-	Bay, climbing dune		
29	South Glendale	NF792146	-	Bay, climbing dune		
30	Smerclate	NF744150	-	Machair hindshore	ESA, NSA	CCS, SFU
31	Garrynamonie	NF738163	-	Machair hindshore	ESA, NSA	CCS, SFU
32	Kilpheder	NF728195	114	Machair hindshore	ESA, NSA	CCS, SDVSGB, SFU
33	Daliburgh	NF730213	-	Machair hindshore	SSSI, ESA, NSA, pSAC	CCS, ITE, SFU
34	Frobost and Askernish	NF727250	-	Machair hindshore	SSSI, ESA, NSA, pSAC	CCS, ITE, SFU
35	Milton	NF727262	-	Machair hindshore	ESA, NSA	CCS, ITE
36	Bornish and Kildonan	NF723290	-	Machair hindshore	SSSI, ESA, NSA, pSAC	CCS, ITE, SFU
37	Ormaclett	NF730320	-	Machair hindshore	SSSI, ESA, NSA, pSAC	CCS, ITE, SFU
38	Stoneybridge	NF735342	-	Machair hindshore	ESA, NSA	CCS, ITE, SFU
39	Howmore	NF749362	85	Machair hindshore	SSSI, ESA, NSA, pSAC	CCS, ITE, SDVSGB, SFU
40	Eochar to Dremisdale	NF754400	245	Machair hindshore	SSSI, NNR, ESA, pSAC	CCS, ITE, SDVSGB, SFU
41	Linique	NF756466	-	Machair hindshore	ESA	CCS, SFU
42	Gualan	NF775478	-	Offshore island	ESA	CCS, ITE
43	Southwest Benbecula	NF790480	-	Machair hindshore	ESA	CCS, ITE, SFU
44	Culla Bay	NF763540	-	Machair hindshore	ESA	CCS, SFU
45	Balivanich	NF780560	-	Machair hindshore	ESA	CCS, SFU
46	Rosinish	NF870540	-	Machair hindshore, climbing dune		
47	Baleshare	NF780610	-	Machair hindshore, spit	SSSI, ESA, pSAC	CCS, ITE, SFU
48	Monach Isles	NF634620	-	Machair hindshore	SSSI, NNR,, SPA, pSAC	ITE
49	Kirkibost	NF752650	-	Machair hindshore	SSSI, ESA	CCS, ITE, SFU
50	Paible	NF720690	-	Machair hindshore	ESA	CCS, ITE, SFU
51	Balranald	NF698695	-	Machair hindshore, climbing dune	RSPB, SSSI, ESA, pSAC	CCS, ITE, SFU
52	Tigharry and Hougharry	NF707715	-	Machair hindshore, climbing dune	ESA	CCS, SFU
53	Hosta	NF715729	-	Machair hindshore, climbing dune	ESA	CCS, ITE
54	Scolpaig	NF728756	-	Bay, climbing dune	NSA	CCS
55	Foshigarry	NF745763	-	Machair hindshore, climbing dune	NSA	CCS, SFU
56	Vallay	NF780750	-	Machair hindshore, climbing dune	SSSI, ESA, NSA	CCS, ITE, SFU
57	Sollas	NF805762	454	Machair hindshore, climbing dune	ESA, NSA	CCS, ITE, SDVSGB
58	Oronsay	NF845756	-	Machair hindshore	ESA, NSA	CCS
59	Newton	NF880780	-	Machair hindshore, climbing dune	SSSI, ESA, NSA, pSAC	CCS, ITE, SFU
60	Boreray	NF855810	-	Machair hindshore, climbing dune	ESA, NSA	
61	Berneray West Coast	NF900821	-	Machair hindshore, climbing dune	ESA, NSA	CCS, ITE, SFU
62	Berneray Beasdair	NF933824	-	Machair hindshore, climbing dune	ESA, NSA	CCS

Table 3.2.3 Sand dune sites in Regions 15 & 16 (continued)

No. on Map 3.2.1	Location	Grid ref.	Area (ha*)	Dune type	Conservation status	Survey type
	Region 15 (continued)					
63	Pabbay Chaisteil	NF897867	-	Machair hindshore, climbing dune	NSA	ITE, SFU
64	Pabbay Baile Fo Tuath	NF906876	-	Machair hindshore, climbing dune	NSA	ITE, SFU
65	Killegray	NF978840	-	Machair hindshore, climbing dune	NSA	
66	Ensay	NF975868	-	Machair hindshore, climbing dune	NSA	
67	Northton	NF985904	-	Machair hindshore, climbing dune	SSSI, NSA	CCS, ITE
68	Scarasta	NG000930	-	Ness/foreland	SSSI, NSA	CCS, ITE
69	Borvemore	NG024944	-	Machair hindshore, climbing dune	NSA	CCS
70	Borvebeg	NG032952	-	Machair hindshore, climbing dune	NSA	CCS
71	Nisabost	NG048970	-	Machair hindshore, climbing dune	NSA	CCS
72	Seilebost	NG062978	-	Spit, climbing dune	SSSI, NSA	CCS, ITE
73	Crago	NG075975	-	Climbing dune	SSSI, NSA	CCS, ITE
74	Luskentyre	NG070988	-	Ness/foreland, climbing dune	SSSI, NSA	CCS, ITE
75	Traigh a Siar	NB009009	-	Bay, climbing dune	NSA	
76	Corran Taransay	NB044003	-	Machair hindshore, climbing dune	NSA	
77	Paible Taransay	NG033993	-	Machair hindshore, climbing dune	NSA	
78	Husinish	NA990120	-	Bay	SSSI, NSA, pSAC	
79	Traigh Mheilen	NA998145	-	Machair hindshore, climbing dune	SSSI, NSA, pSAC	
80	Cravadale	NB014134	-	Machair hindshore, climbing dune	SSSI, NSA, pSAC	
81	Mealasta Island	NA983218	-	Bay, climbing dune	NSA	
82	Mealasta	NA992245	-	Bay, climbing dune	NSA	
83	Mangersta	NB008308	-	Machair hindshore, climbing dune	SSSI, NSA	CCS, ITE
84	Carnish	NB029325	-	Machair hindshore, climbing dune	NSA	ITE
85	Ardroil	NB040327	-	Machair hindshore, climbing dune	NSA	CCS, ITE
86	Traigh na Clibhe	NB083365	-	Machair hindshore, climbing dune	NSA	CCS, ITE
87	Traigh Valtos	NB097368	-	Bay	NSA	CCS
88	Traigh na Berie	NB105359	-	Machair hindshore, climbing dune	NSA	CCS, ITE
89	Traigh Mhor (Little Bernera)	NB145412	-	Bay, climbing dune	NSA	
90	Unnamed (Little Bernera)	NB137412	-	Bay, climbing dune	NSA	
91	Bosta	NB136403	-	Machair hindshore, climbing dune	NSA	
92	Dalmore Bay	NB216451	-	Machair hindshore, climbing dune		CCS
93	Dalbeg Bay	NB226459	-	Machair hindshore, climbing dune		CCS
94	Barvas	NB344515	-	Machair hindshore, climbing dune		CCS, ITE
95	Dell	NB489625	-	Bay		
96	Cross	NB494529	-	Machair hindshore, climbing dune		
97	Swainbost	NB505638	-	Machair hindshore, climbing dune		CCS, ITE
98	Eoropie	NB512647	-	Machair hindshore, climbing dune		CCS, ITE
	Region 16					
99	Ardnamurchan Point	NM415675	-	Bay	NSA	CCS
100	Sanna Bay	NM443690	-	Machair hindshore, climbing dune	NSA	CCS, ITE
101	Achateny	NM518705	-	Bay	NSA	CCS
102	Kilmory	NM524707	-	Bay	NSA	CCS
103	Camas an Lighe	NM613690	-	Bay	NSA	CCS
104	Cul na Croise	NM623698	-	Bay	NSA	CCS
105	Ardtoe	NM627707	-	Bay	NSA	CCS
106	Dorlin	NM663722	-	Bay	NSA	CCS
107	Back of Keppoch	NM645884	-	Machair hindshore		CCS
108	Bunacaimb	NM648889	-	Machair hindshore		CCS
109	Traigh	NM656906	-	Machair hindshore		CCS
110	Camusdarroch	NM660917	-	Machair hindshore		CCS
111	Achaidh Mhor	NM663924	-	Bay, climbing dune		CCS
112	Morar	NM676925	-	Ness/foreland	NSA	CCS
113	Sandaig	NG772147	-	Bay	NSA	CCS
114	Galmisdale	NM483837	-	Bay, climbing dune	NSA	CCS
115	Bay of Laig	NM470881	-	Machair hindshore, climbing dune	NSA	CCS
116	Camas Sgiotaig	NM472898	-	Bay, climbing dune	SSSI, NSA	CCS
117	Bagh a Ghallanaich	NM405802	-	Bay	NSA	CCS
118	Kilmory	NG364040	-	Bay, climbing dune	SSSI, NNR, NSA	CCS
119	Sahmnan Insir	NG378045	-	Bay, climbing dune	SSSI, NNR, NSA	CCS
120	Unnamed, Rum	NG394035	-	Bay	SSSI, NNR, NSA, pSAC, SPA	CCS

Table 3.2.3 Sand dune sites in Regions 15 & 16 (continued)

No. on Map 3.2.1	*Location*	*Grid ref.*	*Area (ha*)*	*Dune type*	*Conservation status*	*Survey type*
	Region 16 (continued)					
121	Tarskavaig	NG584094	-	Bay		CCS
122	Camasunary	NG515186	-	Bay, climbing dune	NSA	CCS
123	Glen Brittle	NG410205	-	Bay	NSA	CCS
124	Talisker	NG314303	-	Machair hindshore		CCS
125	Fiscavaig	NG333345	-	Bay		CCS
126	Coral Beaches	NG227536	-	Bay		CCS
127	Camas Ban	NG495424	-	Bay		CCS
128	Ard Bhan	NG700400	-	Bay		CCS
129	Applecross	NG714454	-	Bay		CCS
130	Sand	NG683488	-	Bay		CCS
131	Redpoint South	NG735673	-	Machair hindshore		CCS, ITE
132	Redpoint North	NG726688	-	Machair hindshore		CCS, ITE
133	Opinan	NG743725	-	Machair hindshore		CCS
134	Loch Kerry	NG809738	-	Bay	NSA	CCS
135	Gairloch	NG804765	-	Bay	NSA	CCS
136	Strath	NG799772	-	Bay	NSA	CCS
137	Little Sand	NG757782	-	Machair hindshore	NSA	CCS
138	Seana Chamas	NG742845	-	Bay	NSA	CCS
139	Camas Mor	NG758918	-	Bay	NSA	CCS
140	Cove	NG810906	-	Bay	NSA	CCS
141	Mellangaun	NG816886	-	Bay, climbing dune	NSA	CCS
142	Mellon Charles	NG844911	-	Bay	NSA	CCS
143	Slaggan Bay	NG840942	-	Bay	NSA	CCS
144	Mellon Udrigle	NG893958	-	Machair hindshore	NSA	CCS
145	Gruinard South	NG949891	-	Bay	NSA	CCS
146	Gruinard North	NG953906	-	Bay, climbing dune	NSA	CCS
147	Camas a Chruthaith	NG952916	-	Bay, climbing dune	NSA	CCS
148	Mungasdale	NG966933	-	Bay	NSA	CCS
149	Achnahaird Bay	NC020130	-	Machair hindshore	NSA	CCS, ITE
150	Garvie Bay	NC040137	-	Bay	NSA	CCS
151	Achmelvich	NC055249	-	Machair hindshore	NSA	CCS
152	Clachtoll	NC040270	-	Machair hindshore	NSA	CCS
153	Stoer	NC038283	-	Machair hindshore	NSA	CCS
154	Clashnessie	NC057310	-	Bay	NSA	CCS
155	Scourie	NC150447	-	Bay		CCS
156	Traigh na Teampuill	NC147476	-	Bay, climbing dune	SSSI, SWT, NSA	CCS
157	Traigh Shourie	NC132473	-	Bay, climbing dune	SSSI, SWT, NSA	CCS
158	Oldshoremore	NC198587	-	Bachair hindshore, climbing dune	SSSI, pSAC	CCS, ITE, SDVSGB
159	Oldshorebeg	NC191592	-	Machair hindshore, climbing dune	SSSI	CCS, SDVSGB
160	Sheigra	NC182599	-	Machair hindshore, climbing dune	SSSI	CCS, ITE, SDVSGB
161	Sandwood	NC220653	-	Machair hindshore, climbing dune	SSSI	CCS, ITE, ONVC

Sources: Crofts & Mather (1972); Dargie (1993); Mather & Crofts (1972); Mather *et al.* (1975); Pitkin *et al.* (1983); Ritchie (1971); Ritchie & Mather (1969, 1970, 1984); Shaw *et al.* (1983); RASD, SNH. Key: *to the nearest whole hectare; - = area not known. Key to conservation status: ESA = Environmentally Sensitive Area; SPA = Special Protection Area for birds; pSAC = possible Special Area of Conservation under the EC Habitats & Species Directive; NNR = National Nature Reserve; NSA = National Scenic Area; RSPB = Royal Society for the Protection of Birds Reserve; SSSI = Site of Special Scientific Interest; SWT = Scottish Wildlife Trust Reserve. Survey type abbreviations: CCS = Countryside Commission for Scotland (University of Aberdeen beach reports); ITE = Institute of Terrestrial Ecology Scottish Coastal Survey; ONVC = Other NVC survey (SNH); SDVSGB = Sand Dune Vegetation Survey of Great Britain (NCC/JNCC); SFU = Scottish Field Unit, NCC.

communities combined (Dargie 1993). Western Scotland is particularly notable for very large extents of species-rich grazed dune, SD8 red fescue *Festuca rubra* - ladies' bedstraw *Galium verum* fixed grassland, which replaces SD7 marram *Ammophila arenaria* - red fescue *Festuca rubra* semi-fixed dune under grazing on calcareous sands and can extend inland for a great distance. Several NVC sub-communities are largely restricted to western Scotland and reflect a cool oceanic climate with high rainfall. In addition, NVC dune surveys in Vatersay, Barra, Fuday, South Uist and North Uist in Region 15 and from Sheigra to Oldshoremore in Region 16 have encountered strandline, semi-fixed dune, fixed dune, mire and scrub vegetation that does not closely resemble published NVC types and which may represent potential new NVC sub-communities (Dargie 1993).

In Great Britain four nationally rare and thirteen nationally scarce higher plants are found mainly or exclusively on dunes. No nationally rare higher plant species confined to dunes are found in Scotland, but both regions have three nationally scarce species. Variegated horsetail *Equisetum variegatum* and Baltic rush *Juncus balticus* are nationally scarce species present on dunes in both

regions, curved sedge *Carex maritima* is found in Region 15, and seaside centaury *Centaurium littorale* is found in Region 16. Other nationally rare or scarce species more typical of other habitats also occur on dunes in the regions. Holy-grass *Hierochloë odorata,* found in Region 15, is nationally rare. Oysterplant *Mertensia maritima* is a nationally scarce species encountered in both regions, while bog hair-grass *Deschampsia setacea* and cowbane *Cicuta virosa* grow in Region 15. Climbing dunes on the north side of Sandwood Bay in Region 16 have large extents of the rare calcareous NVC community CG13b mountain avens *Dryas octopetala* - glaucous sedge *Carex flacca* heath, creeping willow *Salix repens* - crowberry *Empetrum nigrum* sub-community. The NVC communities of Region 15 have not been studied in sufficient detail to distinguish rare communities. The bryophyte floras of several dune systems in Region 16 are very rich (see section 5.1), with several nationally rare species present at Achnahaird Bay (including the liverwort *Petalophyllum ralfsii*). Nationally rare and scarce bryophytes are also associated with machair in Region 15 (Pitkin *et al*. 1983). The aquatic macrophyte flora of machair lochs in Region 15 is also notable (Angus 1994). No site in either region is rated of national or international importance for its lichen flora, but the lichen flora has not been closely examined (Fletcher *et al*. 1984).

Detailed ecological studies on animal populations have not been undertaken for dunes in Region 16. Studies on animal populations in Region 15 have concentrated on birds, plus some studies of small mammals on offshore islands. The machair of Region 15 is considered amongst the important breeding grounds in the north-west Palaearctic for waders (Fuller *et al*. 1988), and is especially important for its strong corncrake *Crex crex* population. Other interests include high numbers of breeding wildfowl, including a resident population of greylag goose *Anser anser*, and important numbers of resident mute swans *Cygnus olor*, and wintering whooper swans *Cygnus cygnus* and Greenland white-fronted goose *Anser albifrons* subsp. *flavirostris* (Stroud *et al.* 1990) (see also sections 5.10, 5.11 and 5.12). No dune site in either region is outstanding in terms of Invertebrate Site Register records, although many machair sites in Region 15, such as Traigh Luskentyre, have low numbers of nationally scarce species (see also section 5.3).

3.2.3 Human activities

In general, sand dunes are among the least heavily modified of terrestrial habitats. Very little of the dune resource in either region 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 either for arable farming (rye and oats as fodder crops, potatoes), mainly in Region 15, or as extensive grazing for sheep and cattle, in both regions. In Region 15 relatively low grazing pressure, especially using only cattle, promotes high species diversity for dune plant communities and high breeding bird densities for dune sites without mammalian predators. Year-round grazing by sheep is common, especially in apportioned land in the common grazings of crofting townships, and produces a dune sward with a lower plant diversity and less cover for breeding birds. It also often leads to an increase in erosion because dune blowouts cannot stabilise as a result of rubbing by sheltering stock. High rabbit numbers further exacerbate blowout erosion.

Very active erosion occurs at Oldshoremore, Oldshore Beg and Sheigra in Region 16 (Lucas & Ritchie 1987), requiring special techniques to stabilise blowout surfaces, applied under the direction of Scottish Natural Heritage. Wind erosion by blowouts is also common in Region 15, with a probable alternation of stable and unstable phases throughout the history of machair development, regardless of human activity (Angus & Elliot 1992; Ritchie & Whittington 1994). Changes in blowout development have been mapped at Luskentyre and Barvas (Harris & Ritchie 1989a, b) and major rehabilitation treatment has been employed at Eoligarry by Scottish Office Agriculture, Environment and Fisheries Department (Angus & Elliot 1992; Hansom & Comber 1995). Other rehabilitation is being undertaken at Dalmore and Garry, Loch na Cartach SSSI (ASH Consulting Group 1994). Sites with high natural erosion owing to beach exposure are noted at Mangersta and Eoligarry (both SSSIs), with high rabbit numbers being cited as the major factor threatening further local erosion in many machair systems (Angus & Elliot 1992).

Cultivation of the machair is rare in Region 16, apart from small potato plots, but remains common in Region 15, where the fallows (areas of dune that are uncultivated for three years out of four) support a distinctive flora (Crawford 1989, 1991). Region 15 is the only region in Britain with a large area of traditional arable cultivation on dunes, particularly on machair hindshore dunes. The importance of low-intensity crofting agriculture for maintaining bird interest and, to a lesser extent, plant diversity is recognised in the designation of the Machair of the Uists, Benbecula, Barra and Vatersay Environmentally Sensitive Area.

A few beaches in Regions 15 & 16 have been affected by sand and shingle extraction, usually on a small scale; elsewhere, for example in Northern Ireland, such extraction has been known to cause serious erosion (Carter *et al.* 1992). There are also a few small sand quarries in Region 15 (e.g. Daliburgh). Some sand extraction sites are likely to become operational in future as part of the Western Isles Island Council Minerals Strategy. A draft strategy is under discussion (S. Angus pers. comm.)

Recreational pressure on dunes in Region 15 is low. Formal car parks, caravan and camp sites are rare (caravans have been excluded from Hushinish and Luskentyre) but a few sites have some damage from unauthorised camping (e.g. Northton). Informal car and caravan parking with associated small areas of visitor trampling and erosion is also rare in Region 15, with damage reported at Dalbeg, Northton Bay SSSI and Traigh na Berie (ASH Consulting Group 1994). Golf courses associated with dunes are rare in both regions, and fairway modification is very slight, but courses can be important for local tourism, e.g. at Gairloch South Beach. Formal and informal car parks and caravan and camp sites are common on many small dune sites in Region 16, mainly adjacent to roads bearing relatively modest numbers of tourist vehicles in the summer season. Many dunes in Region 16, therefore, probably receive large numbers of visitors (Ritchie & Mather 1984). Turf trampling and erosion are present at Sanna, Achnahaird, Gruinard Bay (South), Inverasdale, Little Sand, Mellon Udrigle, Opinan and Red Point (Mather & Ritchie 1978; Countryside Commission for Scotland 1980; ASH Consulting Group 1994), reaching severe proportions at Clachtoll. Such sites have therefore required visitor management, dune grass planting, sand stabilisation, boardwalks, improved car

parking and, in one case, beach recharge.

Coastal erosion by storm waves is very widespread in both regions and there is evidence of a slow retreat inland of the outer dune edge in Region 15. Sea defences are rare on beaches in Region 16 (Davidson *et al*. 1991), while in Region 15 short lengths of sea defences protect vulnerable roads (notably the Branahuie isthmus east of Stornoway) and land in front of property, but in general the coastal edge is natural.

The hedgehog *Erinaceus europaeus* has been recently introduced in Region 15 to South Uist, Benbecula and North Uist to control garden slugs, and there is concern that it will become a predator of the eggs of ground-nesting birds, especially internationally important wader populations. In north-west Lewis the invasion of sand dunes by the perennial herb butterbur *Petasites hybridus* is becoming a problem. This plant has large leaves and propagates vegetatively, smothering areas of species-rich dune sward. Small areas of marram are mown for housing thatch at Benbecula Aerodrome. Many archaeological sites are present in the machair of Region 15, but few settlements are now located on dunes; crofting houses are mostly set back on the edge of the blacklands, possibly to avoid the recurrence of the sand inundation that occurred in the past (Angus & Elliot 1992). Industrial development on dunes is rare: there is a shell sand factory currently operating at Eoligarry (Barra) and the remains of a seaweed processing factory are present at North Boisdale (South Uist). Military activity is important on South Uist: a rocket firing range is set within machair west of Loch Bee, and an administration/residential housing complex is present on machair at Balivanich on Benbecula. A large airfield is developed on machair at Benbecula for military and civilian use. The fine sheltered beach of Traigh Mhor on Barra is used for light civilian aircraft (the only commercial beach landing site in Britain) and airport buildings and car parking occupy a small area of adjacent machair. There is a proposal to site a new runway on Barra on the Eoligarry SSSI machair, requiring reduction in the height of very dynamic mobile dunes adjacent to Traigh Eais and the loss of dry and damp fixed dune grassland on the main machair plain (Hansom & Comber 1995). Dumping of cars, agricultural and household scrap in machair blowouts is very common, and many small dump sites are present, with larger extents of old military scrap and rubble in the rocket range on South Uist and Benbecula Aerodrome.

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. Four main sets of surveys cover Region 15 and three cover Region 16. Details of site coverage by survey type are given in Table 3.2.3. Dune geomorphology is covered in Aberdeen University beach reports commissioned by the Countryside Commission for Scotland: for Region 15, Ritchie & Mather (1970, 1984) and Ritchie (1971); and for Region 16, Crofts & Mather (1972), Mather & Crofts (1972), Mather *et al.* (1975) and Ritchie & Mather (1969, 1984). Secondly, vegetation has been examined by the Institute of Terrestrial Ecology (ITE) (Shaw *et al.* 1983) for selected areas covering 44 sites. The vegetation categories employed are broad and are not easily related to the finer detail available in the NVC (Dargie 1992). Thirdly, a rapid survey of the flora and vegetation of major machair sites in Region 15 was undertaken by the Scottish Field Unit of the Nature Conservancy Council (Pitkin *et al*. 1983). This contains detailed site evaluation information and covered 34 sites but used an *ad hoc* classification which is not easily related to NVC types; also not all sites are covered by maps. Fourthly, three sites in Region 16 and fifteen sites in Region 15 have been surveyed as part of the Sand Dune Vegetation Survey of Great Britain (Dargie 1993). These studies have used the NVC (Rodwell 1991a, b, 1992, 1995, in press) and an additional NVC survey of other dunes, initiated by SNH in 1995, will cover all remaining unsurveyed areas in Region 15 from North Uist southwards (including the Monach Isles). The Sand Dune Vegetation Survey of Great Britain was initiated by the Nature Conservancy Council in 1987 and continued after 1992 by the JNCC on behalf of country conservation agencies. Completion of the sand dune survey of Scotland is funded by Scottish Natural Heritage and is scheduled to finish in 1998.

The NVC surveys, all carried out in the summer months, are very detailed and use a consistent methodology. The vegetation is mapped and described, and information on coastal erosion and accretion, atypical vegetation and adjoining land use is also recorded. 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).

No other comprehensive surveys exist for sand dunes in Regions 15 & 16, though specific information on invertebrates exists for a small number of sites (Institute of Terrestrial Ecology 1979).

3.2.5 Acknowledgements

Assistance with sources was kindly provided by Stewart Angus, Gail Churchill, Joan Cumming, Mary Harman and John Love (SNH NW Region), Kathy Duncan (SNH Research and Advisory Services Directorate), Deborah Proctor and John Barne (JNCC) and Andrew Currie.

3.2.6 Further sources of information

A. References cited

Angus, S. 1994. The conservation importance of machair systems of the Scottish islands, with particular reference to the Outer Hebrides. *In: The islands of Scotland: a living marine heritage*, ed. by M. Usher & J. Baxter, 94-119. Edinburgh, HMSO.

Angus, S., & Elliott, M.M. 1992. Erosion in Scottish machair with particular reference to the Outer Hebrides. *In: Coastal dunes: geomorphology, ecology and management for conservation*, ed. by R.W.G. Carter, T.G.F. Curtis & M.J. Sheehy-Skeffington, 93-112. Rotterdam, A.A. Balkema.

ASH Consulting Group. 1994. *Coastal erosion and tourism in Scotland*. Edinburgh, Scottish Natural Heritage. (SNH Review, No. 12.)

Carter, R.W.G., Eastwood, D.A., & Bradshaw, P. 1992. Small-scale sediment removal from beaches in Northern Ireland: environmental impact, community perception and conservation management. *Aquatic conservation: marine and freshwater ecosystems, 2:* 95-113.

Countryside Commission for Scotland. 1980. *Highland beach management project 1977-79: final report*. Perth, Countryside Commission for Scotland.
Crawford, I. 1989. *The machairs of the Uists - land use and vegetation.* Peterborough, Nature Conservancy Council. (Contract Surveys, No. 64.)
Crawford, I. 1991. Agriculture, weeds and the Western Isles machair. *Transactions of the Botanical Society of Edinburgh, 45:* 483-492.
Crofts, R., & Mather, A.S. 1972. *The beaches of Wester Ross*. Perth, Countryside Commission for Scotland.
Dargie, T.C.D. 1992. A comparison of ITE soft coast vegetation types and NVC units on selected Scottish dune systems. *JNCC Report,* No. 119.
Dargie, T.C.D. 1993. *Sand dune vegetation survey of Great Britain. Part 2 - Scotland*. Peterborough, Joint Nature Conservation Committee.
Dargie, T.C.D. 1995. *Sand dune vegetation survey of Great Britain. Part 3 - Wales*. 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, Joint Nature Conservation Committee.
Fletcher, A., Coppins, B.J., Gilbert, O.L., James, P.W., & Lambley, P.W. 1984. Survey and assessment of lowland heathland lichen habitats. *Nature Conservancy Council, CSD Report,* No. 522.
Fuller, R.J., Reed, T.M., Webb, A., Williams, T.D., & Pienkowski, M.W. 1988. Populations of breeding waders *Charadriidae* and their habitats on the crofting lands of the Outer Hebrides, Scotland. *Biological Conservation, 37*: 333-361.
Hansom, J.D., & Comber, D.P.M. 1995. *Eoligarry SSSI: documentation and management prescription.* Edinburgh, Scottish Natural Heritage. (Unpublished report.)
Harris, T., & Ritchie, W. 1989a. *Dune and machair erosion in the Luskentyre area: a preliminary survey*. Inverness, Nature Conservancy Council (Scotland). (Unpublished report.)
Harris, T., & Ritchie, W. 1989b. *Dune and machair erosion in the Barvas area: a preliminary survey*. Inverness, Nature Conservancy Council (Scotland). (Unpublished report.)
Institute of Terrestrial Ecology. 1979. The invertebrate fauna of dune and machair sites in Scotland. *Nature Conservancy Council, CSD Report,* No. 255.
Lucas, C., & Ritchie, W. 1987. *Dune and machair erosion in the Sheigra - Oldshoremore area: a preliminary survey*. Inverness, Nature Conservancy Council (Scotland). (Unpublished report.)
Mather, A.S., & Crofts, R. 1972. *The beaches of West Inverness-shire and North Argyll*. Perth, Countryside Commission for Scotland.
Mather, A.S., & Ritchie, W. 1978. *The beaches of the Highlands and Islands of Scotland*. Perth, Countryside Commission for Scotland.
Mather, A.S., Smith, J.S., & Ritchie, W. 1975. *The beaches of the Northern Inner Hebrides*. Perth, Countryside Commission for Scotland.
Pitkin, P., Barter, G., Curry, P., Mackintosh, J., Orange, A., & Urquhart, U. 1983. *A botanical review of the SSSIs of the north and west coasts of the Uists and nearby islands*. Edinburgh, Nature Conservancy Council (Scotland). (Unpublished report.)
Radley, G.P. 1994. *Sand dune vegetation survey of Great Britain. Part 1 - England*. Peterborough, Joint Nature Conservation Committee.
Ratcliffe, D.A. 1977. *A nature conservation review.* 2 vols. Cambridge, Cambridge University Press.
Ritchie, W. 1971. *The beaches of Barra and the Uists.* Perth, Countryside Commission for Scotland.
Ritchie, W. 1976. The meaning and definition of machair. *Transactions and Proceedings, Botanical Society of Edinburgh, 42*: 431 - 440.
Ritchie, W., & Mather, A.S. 1969. *The beaches of Sutherland*. Perth, Countryside Commission for Scotland.
Ritchie, W., & Mather, A.S. 1970. *The beaches of Lewis and Harris*. Perth, Countryside Commission for Scotland.
Ritchie, W., & Mather, A.S. 1984. *The beaches of Scotland*. Perth, Countryside Commission for Scotland.
Ritchie, W., & Whittington, G. 1994. Non-synchronous aeolian sand movements in the Uists: the evidence of the intertidal organic and sand deposits at Cladach Mór, North Uist. *Scottish Geographical Magazine, 110*: 40-46.
Rodwell, J.S., *ed*. 1991a. *British plant communities. Volume 1: woodlands and scrub.* Cambridge, Cambridge University Press.
Rodwell, J.S., *ed*. 1991b. *British plant communities. Volume 2: mires and heaths.* Cambridge, Cambridge University Press.
Rodwell, J.S., *ed*. 1992. *British plant communities. Volume 3: grasslands and montane vegetation*. Cambridge, Cambridge University Press.
Rodwell, J.S., *ed*. 1995. *British plant communities. Volume 4: aquatic communities, swamps and tall herb fens.* Cambridge, Cambridge University Press.
Rodwell, J.S., *ed*. In press. *British plant communities. Volume 5: maritime and weed communities.* Cambridge, Cambridge University Press.
Shaw, M.W., Hewett, D.G., & Pizzey, J.M. 1983. *Scottish coastal survey main report: a report on selected soft coast sites in Scotland.* Bangor, Institute of Terrestrial Ecology.
Stroud, D.A., Mudge, G.P., & Pienkowski, M.W. 1990. *Protecting internationally important bird sites*. Peterborough, Nature Conservancy Council.

B. Further reading

Further details of coastal habitat sites, including sand dunes, 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.
Brooks, A., & Agate, E. 1986. *Sand dunes: a practical conservation handbook*. Wallingford, British Trust for Conservation Volunteers.
Doody, J.P., *ed*. 1985. *Sand dunes and their management*. Peterborough, Nature Conservancy Council. (Focus on nature conservation, No. 13.)
Doody, J.P. 1989. Conservation and development of the coastal dunes in Great Britain. *In: Perspectives in coastal dune management*, ed. by F. van der Meulen, P.D. Jungerius & J. Visser: 53-67. The Hague, SPB Academic Publishing.
Doody, J.P., *ed*. 1991. *Sand dune inventory of Europe*. Peterborough, Joint Nature Conservation Committee.
Nature Conservancy Council. 1990. *On course conservation: managing golf's natural heritage*. Peterborough, Nature Conservancy Council.
Radley, G.P., & Woolven, S.C. 1990. *A sand dune bibliography*. Peterborough, Nature Conservancy Council. (Contract Surveys, No. 122.)
Ranwell, D.S. 1972. *Ecology of salt marshes and sand dunes*. London, Chapman and Hall.
Ranwell, D.S., & Boar, R. 1986. *Coast dune management guide*. Huntingdon, Institute of Terrestrial Ecology.

C. Contact names and addresses

Type of information	*Contact address and telelphone no.*
Flora, fauna, habitat information, location of site reports, site management	*Coastal Ecologist, Aquatic Environments Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797
Issues and coastal zone management initiatives in the Minches	*Project Officer, Minch Project, SNH, Western Isles Office, Stornoway, tel: 01851 705258
Advice on national and international policy and 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 (see section 3.2) have developed on it. 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 sites where the sand cover is greater than 20 cm in depth are discussed in section 3.2.

Much of the west coast of Region 15 comprises calcareous sandy beaches, dunes and machair pasture (Ritchie 1971) (see section 3.2). However, in glacial times ice spread over much of the rock platform west of the Outer Hebrides, bringing non-calcareous sand, cobbles and shingle from further east. This now forms long ridges at the rear of many beaches and in a few places becomes the dominant substrate. However, Regions 15 and 16 have no major shingle structures; the scale of the national resource is shown in Table 3.3.1.

Table 3.3.1 Areas of vegetated shingle structures

	Area (ha)
Regions 15 & 16	0
West Coast*	656.8
Scotland	672.6
Great Britain	***5,129.1***

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

Shingle plant communities around Britain are distinctive (Sneddon & Randall 1993a; Rodwell in press), with some communities being widespread and others limited to a particular region or substrate. The regions are not significant in national terms for shingle vegetation communities. The high rainfall, low summer temperatures and poor drainage conditions result in communities akin to freshwater marsh at the head of some beaches. The enrichment of some fringing beaches with wrack (seaweed) and the generally large sediment size are significant factors influencing the vegetation types present.

3.3.2 Important locations and species

The major shingle sites (all fringing shingle beaches) in Regions 15 and 16 are shown on Map 3.3.1 and listed in Table 3.3.2.

Sandy shingle is present at Askernish, Howmore and West Gerinish in South Uist and around Boreray, Berneray and Pabbay (Elton 1938). At Culla, Benbecula, the shingle is fine and acts as a matrix between cobbles, whereas at Baleshare and Balranald on North Uist and Ceann Ear on the Monach Isles the shingle is large and has a matrix of wrack. On Stockay the western beach is a mixture of coarse sand, fine gravel and wrack. The north-west coast of Lewis

Map 3.3.1 Fringing shingle beaches. Source: Randall (undated).

suffers considerable wind erosion and bay-head shingle beaches occur at Uig (Campbell 1945), Shawbost and Barvas, where they pond back a series of lochs. This material is also glacial debris, some of which has been reworked by the sea and some deposited *in situ* (Ritchie & Mather 1970). There is a complex series of sand and shingle bars, spits and tombolos around Melbost on the shores of Loch a Tuath, but over most of the area the shingle is too deeply buried by sand to influence the vegetation.

In Region 16, on the north shore of Loch Linnhe at Inversanda and Loch a' Choire, there are short stretches of outwash gravels that have been deposited by glaciers descending from Ardgour and Morvern (McCann 1966) and have subsequently been modified by marine action into beach shingle. Loch Nevis, Loch Hourn (Arnisdale and Corran) and Loch Alsh (Ardintoul) have expanses of raised beach shingle that are frequently rearranged by present-day waves on their shoreward edges. There are small areas of coarse pebble beach in Loch Ewe, resulting from adjacent inliers of Triassic rock. Raised beach gravels occur on the north shore of Loch Broom at Ullapool, and Isle Martin is almost tied to the mainland by two shingly spits, one jutting out from its south-eastern corner and the other running out from the north-east towards another raised spit on the adjacent mainland. The bayhead cobble beach at Clachtoll is the most northerly location for shingle-sized sediments until Cape Wrath.

The most important plant species on shingle in Regions 15 and 16 is the nationally scarce oysterplant *Mertensia maritima*, found on damper, wrack-rich shingle foreshores.

Table 3.3.2 Fringing shingle beaches (late 1980s survey)

Site name	*Grid ref.*	*Length (km*)*	*Site type*
Region 15			
Melbost	NB4534	1.0	Sand and shingle
Askernish	NF7224	1.0	Calcareous sandy shingle
Howmore	NF7536	0.5	Calcareous sandy shingle
West Gerinish	NF7442	0.5	Calcareous sandy shingle
Culla	NF7554	0.5	Fine shingle and cobbles
Baleshare	NF7858	1.0	Calcareous sand, shingle and wrack
Stockay	NF6663	0.5	Coarse sand, fine gravel and wrack
Ceann Ear	NF6360	0.5	Shingle and wrack
Balranald	NF7068	0.5	Calcareous sand, shingle and wrack
Boreray	NF8581	0.5	Calcareous sandy shingle
Berneray	NF9383	0.5	Calcareous sandy shingle
Pabbay	NF8787	0.5	Calcareous sandy shingle
Uig	NA9828	0.5	Sand, shingle and wrack
Shawbost	NB2547	2.0	Sand, shingle and wrack
Barvas	NB3451	3.0	Sand, shingle and wrack
Region 16			
Inversanda	NM9459	1.0	Outwash gravel
Loch a' Choire	NM8652	0.5	Outwash gravel
Loch Nevis	NM7698	1.5	Silty shingle
Corran	NG8409	1.0	Silty shingle
Arnisdale	NG8410	1.0	Silty shingle
Ardintoul	NG8324	1.0	Silty shingle
Loch Ewe	NG8788	0.5	Coarse shingle
Ullapool	NH1294	0.5	Shingle and wrack
Isle Martin	NH1098	0.5	Large shingle and wrack
Enard Bay	NC0718	0.5	Large shingle and wrack
Clachtoll	NC0327	1.0	Large shingle and wrack

Source: Randall (unpublished late 1980s survey data). Key: *to nearest 0.5 km.

It is present in Region 15; however it has not been recorded at Clachtoll (its last known site in Region 16) since 1979. The endemic Scottish scurvygrass *Cochlearia scotica* occurs at two sites in Region 16 and is frequently present at salt-laden sites in Region 15. Scots lovage *Ligusticum scoticum*, a plant restricted in the UK to Scottish and north Irish cliffs and shingle, is common in both regions. The coastal form of cleavers *Galium aparine* is also found in both regions.

Because many of the beaches in Regions 15 and 16 are exposed to an environment of high wind and wave energy, pioneer vegetation is sparse, except where there is some protection from offshore rocks. In some places there is no clear National Vegetation Classification (NVC: Rodwell in press) equivalent for the pioneer shingle communities found at sites in these regions. In the more inland parts of sea lochs in Region 16, silty shingle may have more terrestrial vegetation almost to the shoreline, with a narrow band of saltmarsh rush *Juncus gerardii*, silverweed *Potentilla anserina* and scurvygrass *Cochlearia officinalis* by the water's edge. In Regions 15 and 16 the northern wrack shingle community contains spear-leaved orache *Atriplex prostrata*, Babington's orache *A. glabriuscula*, sea mayweed *Tripleurospermum maritimum*, cleavers and scurvygrass (or occasionally Scottish scurvygrass *C. scotica*). A widespread secondary pioneer community on some spits is dominated by sea mayweed and curled dock *Rumex crispus*, with English stonecrop *Sedum anglicum* and sea couch *Elymus pycnanthus* subsp. *boreoatlantica*. Yellow flag *Iris pseudacorus* is present in Regions 15 and 16 to the rear of bars influenced by drainage from the land. On the most stable areas of shingle and cobbles, Scots lovage occurs. Sandy sites in Region 15 contain sea sandwort *Honkenya peploides*. Organically rich sites in both regions (e.g. wrack sites) support sea mayweed and spear-leaved orache. The oysterplant grows on some organically rich sites in Region 15, for example at Culla (Uist) and Stockay (Monach Isles).

None of the shingle beaches in Regions 15 & 16 is known to support an important invertebrate fauna, but the more remote locations are important roosting/nesting locations for waterfowl (see also sections 5.10, 5.11 and 5.12). In Region 15, Ceann Ear is an overwintering site for barnacle goose *Branta leucopsis* and Stockay has a large cormorant *Phalacrocorax carbo*/shag *P. aristotelis* colony and is a haul-out and pupping site for Atlantic grey seals *Halichoerus grypus*. Corncrake *Crex crex* are sometimes found in the iris beds to the rear of shingle beaches. Beaches adjacent to the machair suffer extensive rabbit grazing (Randall 1972).

3.3.3 Human activities

In Region 15, the machair beaches of the Outer Hebrides are SSSIs and the sites on the Monach Isles are part of the National Nature Reserve. The shingle areas of this region experience some slight impacts from the small numbers of visitors, though grazing is commonplace at all sites except Stockay and Baleshare. The beaches of Region 16 have come under increasing recreational pressure from tourists. Trampling is the likely cause of loss of the oysterplant. Grazing is ubiquitous.

3.3.4 Information sources used

The fringing beaches in Regions 15 and 16 were examined by the author in 1986/7 as part of the Nature Conservancy Council's rare species monitoring scheme (Randall 1988). Beaches visited were only examined qualitatively, except for data on the oysterplant, and target notes were used to describe physical and biological features of interest. This information became the basis of the geographical variation data published in Randall (1989). Sites in Region 16 are described geomorphologically by Ritchie & Mather (1969) and Mather & Crofts (1972a, b) and in Region 15 by Ritchie (1971), Ritchie & Mather (1970) and Steers (1973).

3.3.5 Further sources of information

A. References cited

Campbell, M.S. 1945. *The flora of Uig*. Arbroath, T. Buncle & Co.

Elton, C. 1938. Notes on the natural history of Pabbay and other islands in the Sound of Harris. *Journal of Ecology, 26*: 275 -287.

Mather, A., & Crofts, R. 1972a. *The beaches of West Inverness-shire and North Argyll*. Aberdeen, Department of Geography, University of Aberdeen.

Mather, A., & Crofts, R. 1972b. *The beaches of Western Ross*. Department of Geography, University of Aberdeen.

McCann, S.B. 1966. The limits of the late-glacial Highland, or Loch Lomond, re-advance along the West Highland seaboard from Oban to Mallaig. *Scottish Journal of Geology, 2*: 84-95.

Randall, R.E. 1972. *Vegetation in a maritime environment: The Monach Isles*. Ph.D. thesis, Cambridge University. (Unpublished.)
Randall, R.E. 1988. *A field survey of* Mertensia maritima *(L.) Gray oyster plant in Britain during 1986 and 1987*. Peterborough, Nature Conservancy Council. (Contract surveys, No. 20.)
Randall, R.E. 1989. Geographical variation in British shingle vegetation. *Botanical Journal of the Linnean Society, 101:* 3-18.
Ritchie, W. 1971. *The beaches of Barra and the Uists*. Department of Geography, University of Aberdeen.
Ritchie, W., & Mather, A. 1969. *The beaches of Sutherland*. Department of Geography, University of Aberdeen.
Ritchie, W., & Mather, A. 1970. *The beaches of Lewis and Harris*. Department of Geography, University of Aberdeen.
Rodwell, J.S., *ed*. In press. *British plant communities. Volume 5: maritime and weed communities.* Cambridge, Cambridge University Press.
Sneddon, P., & Randall, R.E. 1993a. *Coastal vegetated shingle structures of Great Britain: main report*. Peterborough, Joint Nature Conservation Committee.
Sneddon, P., & Randall, R.E. 1993b. *Coastal vegetated shingle structures of Great Britain: Appendix 1. Wales.* Peterborough, Joint Nature Conservation Committee.
Sneddon, P., & Randall, R.E. 1994. *Coastal vegetated shingle structures of Great Britain: Appendix 2. Scotland.* Peterborough, Joint Nature Conservation Committee.
Steers, J.A. 1973. *The coastline of Scotland.* London, Cambridge University Press.

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, J., Davidson, N.C., Hill, T.O., & Jones, M. 1994. *Coastal and marine UKDMAP datasets: a user manual.* Peterborough, Joint Nature Conservation Committee.
Burnett, J.H., *ed*. 1964. *The vegetation of Scotland*. Edinburgh, Oliver & Boyd.
British Oceanographic Data Centre. 1992. *United Kingdom digital marine atlas. User guide. Version 2.0.* Birkenhead, Natural Environment Research Council, British Oceanographic Data Centre.
Chapman, V.J. 1976. *Coastal vegetation*. Oxford, Pergamon Press.
Fuller, R.M. 1987. Vegetation establishment on shingle beaches. *Journal of Ecology, 75:* 1,077-1,089.
Gimingham, C.H. 1974. Maritime and sub-maritime communities. *In: The vegetation of Scotland,* ed. by J.H. Burnett, 67-143. Edinburgh, Oliver & Boyd.
Oliver, F.W. 1912. The shingle beach as a plant habitat. *New Phytologist*, *11:* 73-99.
Perring, F.H., & Randall, R.E. 1972. An annotated flora of the Monach Isles National Nature Reserve, Outer Hebrides. *Transactions and Proceedings of the Botanical Society of Edinburgh, 41:* 431-444.
Ratcliffe, D.A., *ed.* 1977. *A nature conservation review.* London, Cambridge University Press.
Scott, G.A.M. 1963. Biological flora of the British Isles: *Mertensia maritima* (L.) S.F. Gray. *Journal of Ecology, 51:* 733-742.
Scott, G.A.M. 1963. The ecology of shingle beach plants. *Journal of Ecology, 51:* 517-527.
Sneddon, P., & Randall, R.E. 1989. *Vegetated shingle structures survey of Great Britain: bibliography.* Peterborough, Nature Conservancy Council. (Research & survey in nature conservation, No. 20.)

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Shingle sites - Region 15	*Area Officer, SNH, Stornoway, tel: 01851 705258
Shingle sites - Region 16	*Area Officer, SNH, Inverness, tel: 01463 239431
Shingle sites - Inner Hebrides	*Area Officer, SNH, Portree, Skye, tel: 01478 3329
Inverpolly National Nature Reserve	*Area Officer, SNH, Elphin, tel: 01854 666234
Loch Druidibeg National Nature Reserve	*Area Officer, SNH, South Uist, tel: 01870 620238
Shingle sites in the regions	*Scottish Wildlife Trust, Dingwall, tel: 01349 877625

*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

Coastal lagoons are pond- or lake-like, virtually tideless bodies of saline water either wholly or partially separated from the adjacent sea, but with some influx of sea water (Barnes 1988). 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).

There are two true coastal lagoons in Region 15 - Loch Ordais and Loch Arnol; there are no true coastal lagoons in Region 16. The contribution of the regions to the Great Britain lagoonal (*sensu* Barnes 1988) resource is shown in Table 3.4.1.

Table 3.4.1 Lagoonal[a] resource in region in context

	Lagoonal area (ha)[a]*	*Overall % of GB total*	*% of GB total excl. The Fleet*
Region 15	30	2.4	3.8
Region 16	0	0	0
Regions 15 & 16	30	2.4	3.8
West Coast**	98	7.8	12.5
Great Britain	1,261	-	-

Key: *to the nearest whole hectare; [a]*sensu* Barnes (1988); **of Britain.

Other definitions of 'lagoon' and 'lagoonal' are also current. In North and South Uist and Benbecula (Region 15) there are many lochs and pools in which the tidal regime is restricted by a very narrow mouth, a sill (fjards) or a culvert and which have recently been described as 'lagoonal' by Thorpe *et al.* (in prep.). A few of the larger complex fjardic systems, for example the Loch Maddy system and Loch Obisary on North Uist and Loch Bee on South Uist, each over 100 ha in overall area, approach lagoonal conditions in part, as shown by their fauna and flora (see also section 4.2). A number of culverted pools also support a significant range of 'lagoonal' species. In Region 16 there are some small brackish-water side-lochs and marine inlets where the tidal regime is restricted by a very narrow mouth or by a sill; one of these, Duart Lochan near Drumbeg, a 3 ha marine inlet, approaches lagoonal conditions, as indicated by its molluscan fauna (see also section 4.2). These lagoon-like inlets are not included in the figures in Tables 3.4.1 or 3.4.3. Table 3.4.2 indicates the relative importance of the regions if these lagoonal areas (*sensu* Thorpe *et al.* in prep.) are included: Regions 15 and 16 hold nearly 36% of the national resource of lagoonal areas as so identified, if The Fleet is excluded.

Loch Ordais, Region 15, was regarded by Barnes (1989) as being "especially noteworthy in the national context" and represents 12.5% of the national area of lagoons so classified, excluding The Fleet, at 480 ha Britain's biggest such lagoon by far. The scale of the contribution of the 'nationally noteworthy' lagoonal resource of Regions 15 and 16 to that of Britain as a whole is shown in Table 3.4.3.

Lagoons as defined by the European Commission, whose definition differs from that used to compile the figures in Table 3.4.1 and Table 3.4.3 and more closely matches that used by Thorpe *et al.* (in prep.), are a nationally rare habitat and a 'priority habitat type' under Annex I of the EC Habitats & Species Directive. Therefore, although the lagoonal resource of Region 16 is not significant nationally in terms of its extent, examples of the habitat type in both regions are of national and international importance.

3.4.2 Important locations and species

Map 3.4.1 shows the location of the lagoonal and other saline pools mentioned; Table 3.4.4 details the surveyed lagoonal or lagoon-like areas in Regions 15 and 16.

True lagoons support only three types of aquatic vegetation, namely stands of green algae (*Chaetomorpha* spp., *Ulva* spp. and *Enteromorpha* spp.), sea-grasses and similar plants (predominantly tasselweeds *Ruppia* spp.) and, much more rarely, stoneworts (especially *Lamprothamnium papulosum*). 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.

Most of the former lagoons on the north coast of Lewis have evolved into freshwater lochs, and the two remaining

Table 3.4.2 Surveyed lagoonal areas* (including silled inlets, fiards and pools) for Regions 15 & 16 in context

Region	*Lagoonal area (ha)[a]*	*Overall % of GB total*	*% of GB total excl. The Fleet*
Region 15	>777	>29.2	>35.7
Region 16	3	0.1	0.1
Regions 15 & 16	>780	>29.3	>35.8
Great Britain	***2,658***	-	-

Key: [a]to the nearest whole hectare; *including areas classified as 'lagoonal' by Thorpe *et al.* (in prep.).

Table 3.4.3 'Nationally noteworthy' lagoonal areas for region and country

Region	*Lagoonal area (ha)[a]*	*Overall % of GB total*	*% of GB total excl. The Fleet*
Region 15	8	1.5	12.5
Region 16	0	0	0
West Coast*	839	32	38
Great Britain	***545***	-	-

Source: Barnes (1989). Key: [a]to the nearest whole hectare; *of Britain.

lagoons, Loch Ordais and Loch Arnol, into which sea water can still pass (during high tide), are of low to very low salinity for much of the time and are subject to marked salinity variation. For this reason no significant vegetation communities occur in them: they are species-poor and lack any particularly notable species; they are, however, of interest for their physiography and low salinity. However dense beds of the rare foxtail stonewort *Lamprothamnium papulosum* are found in the fjards and culverted pools of North Uist, notably within the Loch Maddy system. Region 15 includes the only sites in Great Britain outside Hampshire and Dorset for this species, which is protected under the Wildlife and Countryside Act 1981. Tasselweeds *Ruppia spiralis* and *R. maritima*, eelgrass *Zostera* spp. and algae *Chaetomorpha* spp. are also common in the lower salinity side-pools of the sea lochs, including Loch Bee, South Uist. Other charophytes (including stoneworts *Chara aspera, C. baltica* and *C. hispida*) occur in the less saline parts of the Uist lochs. None of these communities occurs in Region 16, although there is an historic record of tasselweeds in the Loch of Rieff (Drinkwater 1951).

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 and Countryside Act 1981. None of these protected species occurs in Regions 15 or 16, although in Region 16 the lagoonal snail *Hydrobia ventrosa* is recorded in Duart Lochan. In Region 15 the lagoonal cockle *Cerastoderma glaucum* and the lagoonal mud snails *H. ventrosa* and *H. neglecta* are recorded from the Uist lochs mentioned above. The majority of the lochs and culverted pools support a typically marine/estuarine fauna (see also section 4.2).

Map 3.4.1 Coastal lagoons and lagoonal systems.

3.4.3 Human activities

Little or no active management is applied to the lagoons in Region 15 or 16. In Region 15 a number of the sea lochs are designated SSSIs; the very diverse Loch Maddy system is a

Table 3.4.4 Surveyed lagoonal habitat areas

Location	*Grid ref.*	*Area (ha)**	*Type*
Region 15			
Lewis (east coast)			
Loch Cromore, Loch Erisort	NB400205	22	Culverted pool
North Uist			
Oban Honary	NF895753	15	Silled fjard
Aird nan Laogh inlet	NF918737	15	Silled inlet
Loch an Duin, Loch Maddy	NF890740	43	Silled fjard
Pool east of Loch Portain, Loch Maddy	NF950717	<0.1	Percolation pool
Loch an Strumore, Loch Maddy	NF900695	60	Silled fjard
Oban nan Stearnan, Loch Maddy	NF912687	10	Silled fjard
Loch na Ciste & Loch Stromban, Loch Maddy	NF910680	12	Silled fjard
Leiravay Bay, Loch Maddy	NF910677	9	Silled fjard
Oban nam Fiadh, Loch Eport	NF847629	41	Silled fjard
Oban Sponish, Loch Eport	NF880646	15	Silled fjard
Locheport pool, Loch Eport	NF852635	2	Silled pool
Loch Obisary, Loch Eport	NF895620	370	Silled fjard
Benbecula			
Pool south-west of Oban Haka	NF838520	1	Silled inlet
Loch ba Alasdair	NF855495	33	Silled basins
Region 15 (continued)			
South Uist			
Ardmore Pool	NF798460	5	Silled inlet
Loch Ceann a Bhaigh	NF765303	17	Silled inlet
Loch a Bharp & Auratote	NF782208	27	Restricted inlet
Loch Bee	NF765435	n/a	Silled fjard
North Uist			
Oban Trumisgarry, Vallaquie Strand	NF873745	5	Culverted pool
Loch Iosal an Duin pools	NF919772	8	Silled inlets
Lewis (west coast)			
Tob Valasay, Loch Roag	NB144380	30	Silled inlet
Loch Shader, Loch Roag	NB188389	7	Silled inlet
Loch Ordais estuarine lagoon	NB283486	8	Natural
Loch Arnol	NB300488	22	Natural estuarine lagoon
Region 16			
Duart Lochan	NC134331	3	Restricted inlet
Regions 15 & 16		***>780***	

Sources: Barnes (1988, 1989); Thorpe *et al.* (in prep.). Key: *to the nearest whole hectare; n/a = not available.

Marine Consultation Area. All inlets are under potential threat from fish farming, although pressure from angling appears to be low.

3.4.4 Information sources used

Candidate 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 (1989), from which many of the data given here are derived. Recent JNCC Marine Nature Conservation Review (MNCR) surveys (e.g. Thorpe *et al.* in prep.) identified six sites in Region 16, which have been studied in detail. Smith (1984) collated information on the restricted estuaries and harbours in Regions 15 and 16, principally for their molluscan fauna. Smith also refers to other surveys covering the lagoon-like habitats in the regions.

3.4.5 Acknowledgements

We are grateful to Roger Covey for discussions on the sites, and to David Connor and Kath Thorpe of the MNCR for information from Thorpe *et al.* (in prep.). Thanks are also due to Brendan O'Hanrahan (SNH).

3.4.6 Further sources of information

A. References cited

Barnes, R.S.K. 1988. The coastal lagoons of Britain: an overview. *Nature Conservancy Council, CSD Report,* No. 933.

Barnes, R.S.K. 1989. The coastal lagoons of Britain: an overview and conservation appraisal. *Biological Conservation, 49*: 295-313.

Drinkwater, J. 1951. *Report of the Kings College Exploration Club, Wester Ross Expeditions, 1949-51.* Durham, Durham University Exploration Society.

Smith, S.M. 1984. Scottish saline lagoons with emphasis on the Mollusca. *Nature Conservancy Council, CSD Report,* No. 526.

Thorpe, K., Dalkin, M.J., Fortune, F., & Nichols, D. In prep. *Marine Nature Conservation Review Sector 14. Lagoons in the Outer Hebrides: area summaries.* Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR series.)

B. Further reading

Further details of coastal habitat sites are available on the *Coastal & marine UKDMAP datasets* module (Barne *et al.* 1994) disseminated by the JNCC Coastal Conservation Branch, Peterborough. Further details of lagoons and quasi-lagoonal features are available on the UKDMAP datasets module disseminated by the British Oceanographic Data Centre (BODC 1992).

Bamber, R.N., Batten, S.D., & Bridgwater, N.D. 1992. On the ecology of brackish water lagoons in Great Britain. *Aquatic conservation: marine and freshwater ecosystems, 2*: 65-94.

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.

Earll, R.C., & Pagett, R.M. 1984. A classification and catalogue of the sea lochs of the Western Isles. *Nature Conservancy Council, CSD Report,* No. 525.

Gubbay, S. 1988. *Coastal directory for marine nature conservation.* Ross-on-Wye, Marine Conservation Society.

Mitchell, R., Dipper, F.A., & Earll, R.C. 1981. The survey and nature conservation evaluation of selected marine and brackish lochs in the Uists, Outer Hebrides. *Progress in Underwater Science, 6*: 37-42.

Nicol, E.A.T. 1936. The brackish-water lochs of North Uist. *Proceedings of the Royal Society of Edinburgh, 56*: 169-195.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Saline lagoons in the regions	*MNCR Team, JNCC, Peterborough, tel: 01733 62626
Brackish lagoons in the regions	Dr R.S.K. Barnes, St. Catharine's College, Cambridge CB2 1RL, tel: 01223 336606
Lagoons in Scotland	*Aquatic Environments Branch, SNH, Edinburgh, tel: 0131 554 9797

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

3.5 Wet grassland

Dr H.T. Gee

3.5.1 Introduction

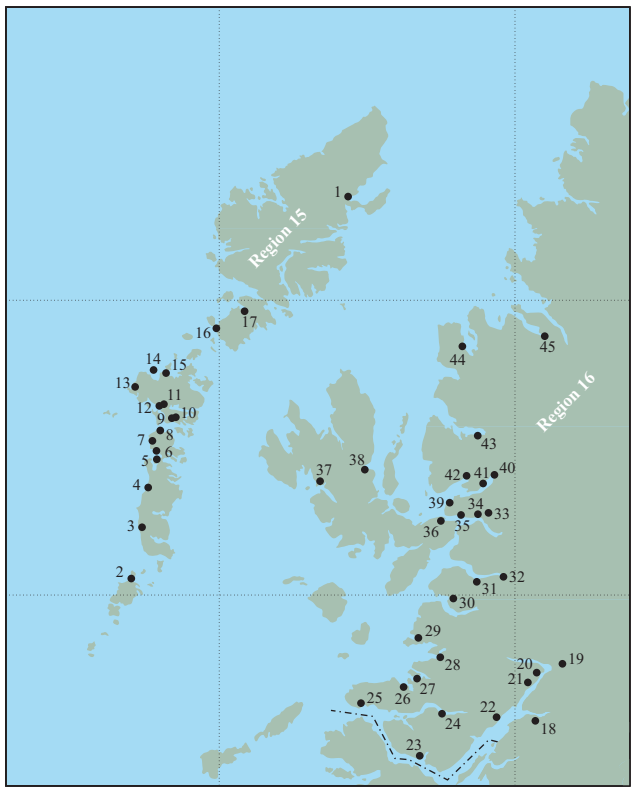
Wet grassland includes both coastal grazing marsh subject to maritime influence and lowland wet grassland adjacent to tidal reaches of estuaries. Coastal grazing marsh is a distinctive habitat consisting of low-lying grassland drained by a series of ditches that may be either brackish or freshwater. Much grazing marsh was formed by the enclosure of saltmarsh behind sea walls. Smaller areas of freshwater 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 as such is generally considered to be a rare habitat in Scotland (Doody *et al.* 1993). No major areas of coastal grazing marsh exist in either of Regions 15 (Western Isles) or 16 (west Highland), where, in contrast to much of Britain, there are no large areas of land claim behind sea walls. Those small parcels of land that have been improved by ditch drainage are often claimed freshwater marsh at the head of estuaries and tidal areas, or wet areas of the machair or loch margins. Information available at present has not given any reason to identify this region as important for wet grassland in either a British or a Scottish context.

3.5.2 Important locations and species

Wet grassland sites in Regions 15 & 16 are listed in Table 3.5.1 and shown on Map 3.5.1. Although many of these sites are small, they demonstrate an interesting diversity of wetlands, ranging from wet grassland with yellow iris *Iris pseudacorus* beds and rushes *Juncus* spp. to species-rich meadows, fens and mires.

Small areas of wet grassland with drainage ditches are spread around the coast of Region 15. Pye & French (1993) refer to significant land claim of saltmarsh at Tong/Melbost Sands on Lewis, and small areas of ditch-drained wet grassland are shown on maps for twelve of the sites covered by the saltmarsh survey of the Western Isles (Law & Gilbert 1986). At Knock-cuien and Clett-feora on North Uist, ditch-drained wet grasslands have been created by partial conversion of saltmarsh behind the embankment of the coast road. Similar habitat is present behind a small coastal track on the south side of the saltmarsh sites at Eilean Cuithe nam Fiadh and Gualan on the north coast of South Uist. At some, if not all, of these sites exclusion of tidal waters is incomplete and they experience a brackish influence. All these pockets of ditch-drained wet grassland are small, being only a few hectares in size at most, but they contribute to the habitat diversity of these sites and thus their conservation interest. Many of the wet grassland sites in Region 15 are transitions from saltmarsh to machair or peatlands and may thus demonstrate features typical of these habitats.



Map 3.5.1 Wet grassland sites. Numbered sites are listed in Table 3.5.1.

In Region 16 Pye & French (1993) identified only three sites where significant areas of land-claimed wet grassland exist (Loch Long, Loch Carron and Little Loch Broom). Elsewhere, the rocky and comparatively steep character of the coastline accounts for the absence of large areas of wet grassland. Small areas are, however, widespread around the coast, particularly at the head of lochs, in bays and where streams enter the sea. Many are associated with saltmarshes and include transitional communities between tidal and non-tidal habitats (see also section 3.6). Some are of high ecological interest. Typical habitats include the fresh and brackish marshes at the upper limit of saltmarshes; fen and wet grassland communities associated with raised beaches along the coastline, and coastal raised bogs (see sections 3.2 for transitions to machair and 3.6 for saltmarsh transitions).

There are no Sites of Special Scientific Interest (SSSIs) notified specifically for wet grassland in either region. Nine SSSIs in Region 15 and two in Region 16 do, however, contain small patches of wet grassland. In Region 15 the SSSI and RSPB reserve at Balranald Bog and Loch nam Feithean on North Uist includes areas of ditch-drained marshland associated with Loch nam Feithean and the machair. The drainage system on the wet machair in South Uist, notably on the Loch Hallan SSSI, has been extensively modified by man (Angus & Elliott 1992). The ditches on Loch Hallan SSSI are noted for the aquatic macrophyte communities they support, which include nationally notable species such as pondweeds *Potamogeton* spp.

The sites which contain wet grassland in Region 16 are Kentra Bay and Moss SSSI and Kinloch-Moidart SSSI. At

Table 3.5.1 Wet grassland sites in Regions 15 & 16

No. on Map 3.5.1	*Location*	*Grid ref.*	*Conservation status of wet grassland*	*Notes*
	Region 15			
	Lewis			
1	Tong/Melbost Sands	NB440358	Undesignated; adjacent to SSSI	Grazing marsh
	Barra			
2	Eoligarry	NF707076		Ditch-drained pasture to north of Ben Eoligarry
	South Uist			
3	Loch Hallan	NF738224	SSSI	Ditch-drained pasture adjacent to lochs
4	Howbeg	NF756357	SSSI	Ditch-drained pasture
5	Eilean Cuithe nam Faidh	NF785471		Ditch-drained pasture behind coastal road/track
6	Gualan	NF779486		Some ditch-drained pasture at north end of site
	Benbecula			
7	West Benbecula Lochs	NF771521	SSSI	Ditch-drained pasture west of Loch Mór, Loch Fada and Loch chinn Uacraich
8	Benbecula Aerodrome	NF797564		Ditch-drained grassland behind sea wall
	North Uist			
9	Knock-cuien	NF848601		Ditch-drained fields behind coast road causeway
10	Clett-feora	NF838598		Ditch-drained fields to south of saltmarsh and road
11	Illeray	NF785632	SSSI	Ditch-drained pasture
12	Lag Gorm	NF775625	SSSI	Ditch-drained pasture
13	Balranald Bog and Loch nam Feithean	NF712705	SSSI and RSPB reserve	Ditch-drained pasture adjacent to loch
14	Vallay	NF775765	SSSI	Small areas of ditch-drained freshwater marsh
15	Grenitote	NF819756		Area of ditch-drained pasture adjacent to saltmarsh
	Harris			
16	Northton	NF990910	SSSI	Patches of wet grassland on east and south-west sides of Traigh an Taoibh Thuath
17	Seilebost (East) Sands	NG084967	SSSI	Ditch drained pasture
	Region 16			
18	Glencoe	NN097588		Ditch-drained pastures behind coastal road
19	Lochy Estuary	NN107750		Ditch-drained fields on bank of estuary
20	Stronchreggan	NN075722		Ditch-drained pasture on delta formed by Abhainn Sron a' Chreagain
21	Inverscaddle	NN025685		Ditch-drained pasture behind seawall
22	Inversanda Bay	NM943595		Coastal brackish marsh, land-claimed, improved and ditch-drained
23	Loch Aline	NM701474	Undesignated; adjacent to SSSI	Partially enclosed and ditch-drained saltmarsh
24	Loch Sunart	NM835605		Loch head brackish marsh, land-claimed
25	Kilchoan	NM484635		Marsh/grassland with rushes *Juncus* spp. and irises *Iris* spp., partially drained
26	Kentra Bay	NM650680	SSSI	Transition from saltmarsh to moss; partially ditch-drained
27	Kinloch-Moidart	NM707722	SSSI	Coastal grazing marsh
28	Lochailort	NM763820		Upper marshes land-claimed to landward side of coast road
29	Arisaig	NM660862		Some ditch-drained pasture behind track and adjacent to canal
30	Inverie Bay	NM771988		Wet pasture/arable
31	Barrisdale Bay	NG867047		Bay-head marsh rough pasture with some ditches
32	Kinlochourn	NG948067		Saltmarsh land-claimed in the inner estuary
33	Nonach (Loch Long)	NG928305		Brackish and freshwater marsh partially ditch-drained
34	Ardelve	NG870267		Ditch-drained coastal pasture
35	Kirkton	NG831269		Ditch-drained coastal pasture
36	Kyle	NG745261		Some ditch-drained pasture by inlet An t-Ob
37	Loch Beag	NG363388		Ditch-drained marshy grassland at edge of loch head saltmarsh
38	Loch Portree	NG478412		Ditch-drained pasture and marshy grassland
39	Duirinish	NG790322		Brackish marsh behind coast road
40	Loch Carron	NG930405		Loch head marsh and coastal wet heath partially drained by ditches
41	Slumbay	NG895390		Marshy grassland adjacent to upper saltmarsh
42	Kishorn	NG833418		Wet heath and marsh behind coastal embankment
43	Torridon	NG896555		Small fringe of grazing marsh at head of Loch
44	Inverasdale	NG817874		Freshwater/brackish marsh behind coast road
45	Little Loch Broom	NH087885		Grazing marsh at loch head. Past land claim of saltmarsh.

Sources: Scottish Natural Heritage; Law & Gilbert (1986); Penn (1982); Scott (1984a, b); Scott & Law (1984); SSSI citations. Key: SSSI = Site of Special Scientific Interest; RSPB=Royal Society for the Protection of Birds.

Kentra Bay and Moss the transition from saltmarsh to raised bog confers significant botanical interest to the site. The margins to the Moss adjacent to the estuary have been subject to some drainage by ditches, and it is likely that the ditch communities support an interesting and diverse flora and invertebrate fauna. In winter, Kentra Moss supports a wintering flock of Greenland white-fronted geese *Anser albifrons flavirostris*.

There is very little available information on the aquatic flora and fauna of the ditch systems of wet grassland sites in either Region 15 or Region 16. There are, however, likely to be similarities with the adjacent saltmarsh transition zones, with lowland mire communities and with freshwater and brackish lochs. Beds of yellow iris dominate the transitional marshes at the upper end of some saltmarshes and are an important component of the adjacent wet grasslands and associated ditch systems. Stands of common reed *Phragmites australis* and grey club-rush *Schoenoplectus tabernaemontani* are present at some sites (for example, they form extensive reedbeds on Loch Hallan SSSI in Region 15) and are likely to invade areas of wet grassland and ditches. Other plant communities that are likely to colonise the ditches in Region 15 include the herb-rich marsh communities dominated by lesser tussock-sedge *Carex diandra* and common sedge *C. nigra* of the Loch Hallan SSSI, and the greater tussock-sedge *C. paniculata* fens adjacent to the water bodies on the West Benbecula Lochs SSSI. On Vallay, the ditch-drained fresh marshes support unusual marsh plants such as long-bracted sedge *C. extensa*, distant sedge *C. distans*, lesser marshwort *Apium inundatum* and whorl-grass *Catabrosa aquatica*. Whilst this information about the sites identified in Table 3.5.1 is limited, it gives an indication of the type of sedge-rich fen and marsh vegetation likely to be present on many of the ditch-drained sites in the regions.

Many of the sites listed in Table 3.5.1 are of value for breeding birds, notably waders. However, breeding waders are more widely distributed in these regions than elsewhere in Britain, where breeding waders are often restricted to grazing marsh and saltmarsh, and so the contribution grazing marsh and coastal wetlands make to the overall populations is far less significant than in, for example, southern England. Of note are dunlin *Calidris alpina*, which breed at particularly high densities on these sites in Region 15. The low-intensity agricultural use of wet grasslands, as hay meadows, for example, means that some sites in both regions support breeding corncrake *Crex crex*. Corncrakes are known to breed at Eoligarry SSSI on Barra and on the RSPB reserve at Balranald, both in Region 15, and on Skye and Canna in Region 16. Balranald is of note for breeding wildfowl and waders, including shoveler *Anas clypeata*, little grebe *Tachybaptus ruficollis*, tufted duck *Aythya fuligula*, oystercatcher *Haematopus ostralegus*, lapwing *Vanellus vanellus*, dunlin *Calidris alpina* and snipe *Gallinago gallinago* (see section 5.11).

3.5.3 Human activities

Most areas of ditch-drained lowland wet grassland in Regions 15 and 16 are used for pasture or for hay production. Some wet grassland has been improved and there has been some conversion to low-intensity arable use. There is no industrial development that is likely to affect wet grassland within either region. Threats to the conservation interest of wet grassland in both regions are most likely to be further agricultural improvement and drainage. In the current economic climate, however, funds for such improvements are no longer forthcoming and so the rate of semi-natural habitat loss due to agriculture is much reduced. Parts of Region 15 have been designated as an Environmentally Sensitive Area (ESA) by the UK Government (see section 7.3). This scheme provides financial support for works that enhance the ecological value of sites, and for agricultural practices sympathetic to conservation interests. Specifically the scheme supports traditional farming of the machair and good ditch management and so should lead to an enhancement of the conservation interest of the regions' wet grassland resource.

3.5.4 Information sources used

Many of the sites discussed are adjacent to sites covered in saltmarsh surveys of the regions (Region 16: Penn 1982; Scott 1984a, b; Scott & Law 1984; Region 15: Law & Gilbert 1986), which give useful descriptive information about adjacent habitats, but none of these wet grasslands have been surveyed specifically. Survey information on species and communities on wet grassland sites is sparse. Some of the sites mentioned in this section may have been surveyed for breeding waders by the RSPB (O'Brien 1994) as part of the survey of breeding waders on Scottish lowland sites. Habitats associated with sandy substrates, including fen and wet machair, are covered by the National Sand Dune Survey (see section 3.2).

3.5.5 Acknowledgements

Thanks are due to staff of the SNH area offices for providing information on lowland wet grasslands in their districts.

3.5.6 Further sources of information

A. References

Angus, S., & Elliott, M.M. 1992. Erosion in Scottish machair with particular reference to the Outer Hebrides. *In: Coastal dunes: geomorphology, ecology and management for conservation*, ed. by R.W.G. Carter, T.G.F. Curtis & M.J. Sheehy-Skeffington, 93-112. Rotterdam, Balkema.

Doody, J.P., Johnston, C., & Smith, B. 1993. *Directory of the North Sea coastal margin*. Peterborough, Joint Nature Conservation Committee.

Law, D., & Gilbert, D. 1986. *Saltmarsh survey - NW Scotland: The Western Isles*. Peterborough, Nature Conservancy Council.

O'Brien, M. 1994. *Survey of breeding waders on Scottish lowland. Interim report*. Sandy, Royal Society for the Protection of Birds.

Penn, S. 1982. *A preliminary survey of the salt marshes of Wester Ross*. Inverness, Nature Conservancy Council.

Pye, K., & French, P.W. 1993. *Erosion and accretion processes on British saltmarshes*. Cambridge Environmental Research Consultants Ltd. (Report to Ministry of Agriculture, Fisheries and Food, London. Contract No. CSA 1976.)

Scott, K. 1984a. *Saltmarsh survey - NW Scotland: Lochaber*. Peterborough, Nature Conservancy Council.

Scott, K. 1984b. *Saltmarsh survey - NW Scotland: Skye and Lochalsh*. Peterborough, Nature Conservancy Council.

Scott, K., & Law, D. 1984. *Saltmarsh survey - NW Scotland: Caithness and Sutherland.* Peterborough, Nature Conservancy Council.

B. Further reading

Further details of coastal habitat sites, including wet grassland, are available on the *Coastal & marine UKDMAP datasets* module disseminated by JNCC Coastal Conservation Branch, Peterborough.

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: a natural history*. London, Collins.

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

Coleshaw, T. 1995. Rising to the water levels challenges. *Enact*, *3*(1): 7-9.

Currie, A. 1979. The vegetation of the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, 77B:* 219-265.

Davidson, N.C. 1991. Breeding waders on British estuarine grasslands. *Wader Study Group Bulletin, 61* (*Supplement)*: 36-41.

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.

Owen, M., Atkinson-Willes, G.L., & Salmon, D.G. 1986. *Wildfowl in Great Britain.* 2nd ed. Cambridge, Cambridge University Press.

Perring, F.H., & Farrell, L. 1977. *British Red Data Books: 1. Vascular plants.* Lincoln, Royal Society for Nature Conservation.

Perring, F.H., & Walters, S.M. 1990. *Atlas of the British flora.* London, Botanical Society of the British Isles.

Rodwell J.S., *ed.* 1995. *British plant communities. Volume 4: aquatic communities, swamps & tall-herb fens.* Cambridge, Cambridge University Press.

RSPB. 1994. *Enjoying wildlife: a guide to RSPB nature reserves*. Sandy, Royal Society for the Protection of Birds.

Scholey, G. 1995. Return of the "drowners". *Enact*, *3*(1): 10-11.

Thomas, G., José, P., & Hirons, G. 1995. Wet grassland in the millenium. *Enact*, *3*(1): 4-6.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Wet grassland in Scotland	*Aquatic Environments Branch, SNH, Edinburgh, tel: 0131 554 9797
Wet grassland in Lochaber, Skye and Lochalsh	*Area Officer, SNH, Fort William, tel: 01397 704716
Wet grassland in Wester Ross	*Area Officer, SNH, Kinlochewe, tel: 01445 760254
Wet grassland in Sutherland	*Area Officer, SNH, Elphin, tel: 01854 666234
Wet grassland in Lewis and Harris	*Area Officer, SNH, Stornoway, Isle of Lewis, tel: 01851 705258
Wet grassland in the Uists	*Area Officer, SNH, South Uist, Western Isles, tel: 01870 620238

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

3.6 Saltmarsh

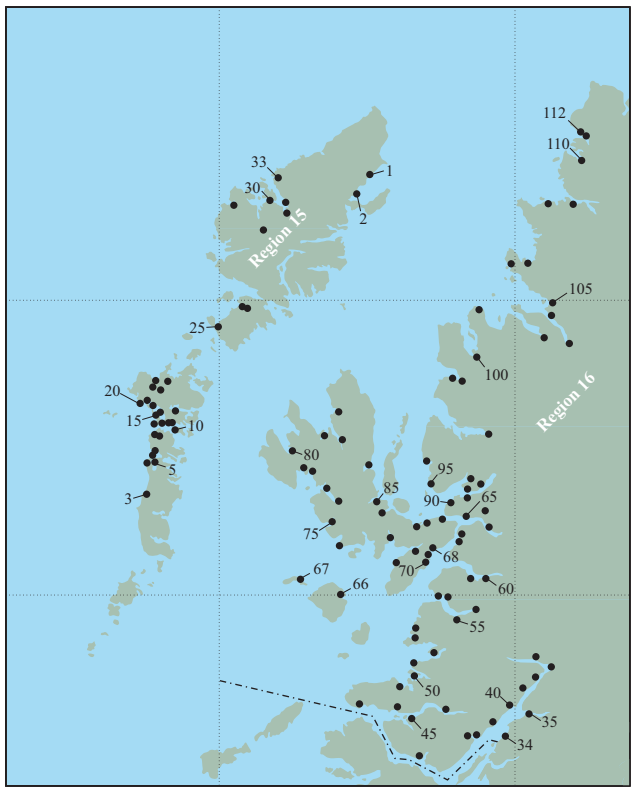
Dr M.I. Hill

3.6.1 Introduction

In Regions 15 (Western Isles) and 16 (west Highland) there are respectively 451 and 738 ha of saltmarsh. These figures represent 2.0% and 3.3% of the total saltmarsh area found on the west coast of Britain, 7.4% and 12.1% of that in Scotland and 1.0% and 1.7% of the total British resource (Table 3.6.1) (Burd 1989a, b).

The substrates on which saltmarsh has formed vary from silts to sands and gravels. Most of the sites have a low input of tide-borne sediment. The saltmarshes tend not to show rapid changes in extent or morphology, with stability, slow extension seawards or slow erosion being the norm (Pye & French 1993). As a result, for sites surveyed in the national survey, 80% of the saltmarsh area in Region 15 and 70% in Region 16 was mid to upper marsh (Table 3.6.1). This is a higher proportion than in either Scotland or Britain as a whole, where 36% and 59% respectively of the saltmarsh was mid to upper marsh. The extent of low and pioneer saltmarsh zones is correspondingly very small in Regions 15 and 16. Rainfall in the region is high and freshwater seepage from adjacent land has a strong influence. 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 regions' saltmarshes. In Region 15, 15% of the saltmarsh area was transitions to other habitats, while in Scotland and Britain as a whole the figures are 4% and 12%.

In Region 15, the postglacial rise in relative sea level continues to the present day, although at a declining rate. This has caused submergence and erosion of the coastline, and most saltmarshes are experiencing slow erosion of their seaward edge. However, by breaching the dunes and forming barrier features, such as the tidal strand islands of Baleshare and Vallay, postglacial submergence has created suitable, sheltered embayments where saltmarsh can develop. Saltmarshes in Region 16 vary in their erosion/accretion status, with some showing slow seaward spread and others erosion.



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

3.6.2 Important locations and species

In Region 15 saltmarshes are scattered throughout the larger islands, with most on North Uist (178 ha) and Lewis (140 ha). Most sites are under 10 ha in extent, and only one exceeds 40 ha (Tong/Melbost Sands). On the very indented coastline of Region 16 there are more than 100 saltmarsh sites, mostly small (<10 ha), with few exceeding 20 ha (Burd 1989b). The saltmarsh sites surveyed during the national survey (Burd 1989a, b) (see section 3.6.4) are listed in Table 3.6.2 and shown on Map 3.6.1.

Few saltmarshes in the regions (listed in Table 3.6.3) are within SSSIs. In Region 15, all the larger saltmarshes are covered by SSSI designation. In Region 16, with the exception of Kentra Bay and Moss, the saltmarshes are only minor parts of the sites and not the main reason for designation.

Only 1.3% of the coastline length of Region 15 (at mean high water) supports saltmarsh, although they vary

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

	Spartina	*Pioneer*	*Low-mid*	*Mid-upper*	*Drift-line*	*Upper swamp*	*Trans-ition*	*Wet depression*	*Total*	*% of total in Region 15*	*% of total in Region 16*
Region 15	<1	<1	11	360	<1	<1	69	0	451	-	-
Region 16	0	2	120	519	<1	3	91	<1	738	-	-
Regions 15 & 16	<1	2	131	879	<1	3	160	<1	1,189	-	-
West Coast*	3,487	1,340	4,159	11,270	473	410	1,327	<1	22,593	2.0	3.3
Scotland	102	361	499	3,608	63	587	748	2	6,089	7.4	12.1
GB	***6,948***	***3,470***	***12,353***	***16,042***	***1,824***	***1,475***	***1,670***	***2***	***44,370***	***1.0***	***1.7***

Sources: National Saltmarsh Survey (Burd 1989a, b). Key: [a]to the nearest whole hectare; *of Britain. Note: sites not surveyed in detail are included in totals (10 ha in Region 15 and 1 ha in Region 16) but are not subdivided by community.

Table 3.6.2 Main saltmarsh sites surveyed

Site no. on Map 3.6.1	Location	Grid ref.	Area (ha)*
	Region 15		
	Lewis (east coast)		
1	Back Saltings/Gress	NB485415	26
2	Tong/Melbost Sands	NB442355	96
	South Uist		
3	Howbeg	NF756357	4
4	Balgarva	NF765465	10
5	Gualan	NF779486	6
6	Eilean Cuithe nam Faidhe	NF785471	10
	Benbecula		
7	Liniclate	NF784495	8
8	Benbecula aerodrome	NF797564	7
9	Gramsdale/Uachdar	NF809559	9
10	Seannabhaile/ Gearradubh and Grimsay	NF862579	6
	North Uist		
11	Knock - Cuien	NF848601	15
12	Clett - Feora	NF840600	6
13	Carinish	NF822603	7
14	Traigh Eachkamish	NF795607	37
15	Illeray	NF785632	36
16	Lag Gorm	NF775625	12
17	Langass	NF834649	6
18	Ardheisker/Horisary	NF763673	3
19	Bayhead	NF750683	6
20	Loch Paible	NF724684	29
21	Vallay	NF777763	12
22	Ceann nan Clachan	NF770740	2
23	Ceann a' Baigh	NF789730	2
24	Grenitote	NF819756	6
	South Harris		
25	Northton	NF990910	40
26	Seilebost - west	NG066973	10
27	Seilebost - east	NG084967	23
	Lewis (west coast)		
28	Uig Sands	NB052335	10
29	Little Loch Roag	NB138240	1
30	Barraglom	NB166346	2
31	Loch Grimersta	NB216298	1
32	Loch Gealavet	NB216337	3
33	Loch Carloway	NB202426	2
	Region 16		
34	Cuil Bay	NM978545	2
35	Loch Leven	NN168620, NN180621, NN097588	17
36	Caol Spit	NN107750	15
37	Loch Eil	NM980780, NM967790, NN023783	19
38	Stronchreggan	NN075722	1
39	Inverscaddle Bay	NN025685	31
40	Sallachan Point	NM988619	2
41	Inversanda Bay	NM943595	6
42	Camas na Croise	NM865526	4
43	Loch a' Choire	NM838525	8
44	Loch Aline	NM701474	3
45	Kinlochteacuis	NM653545	7
46	Loch Sunart Head	NM813613, NM835605	14
47	Glenmore	NM588620	11
48	Kilchoan	NM484635	14
49	Kentra Bay	NM651686,NM647697, NM642678	41
	Region 16 (continued)		
50	Loch Moidart	NM707722, NM658716, NM644708	27
51	Glenuig	NM672773	1
52	Lochailort	NM763820	9
53	Arisaig	NM660862	3
54	Bunacaimb	NM548772	3
55	Kylesmorar	NM805932	4
56	Loch Nevis Head	NM862957, NM868947	30
57	Inverie Bay	NM771988	6
58	Rubha Raonuill	NM729999	2
59	Barrisdale Bay	NG867047	17
60	Kinlochhourn	NG948067	7
61	Eilanreach	NG804181	1
62	Glenelg	NG812201	9
63	Loch Duich	NG932189, NG 951210	27
64	Nonach (Loch Long)	NG928305	30
65	Loch Alsh	NG870267, NG855268, NG831269, NG801256	18
66	Loch Scresort, Rum	NM403906	2
67	Canna Harbour, Canna	NG268048	1
68	Loch na Dal	NG702159	7
69	Isleornsay	NG699124	3
70	Camascross	NG699115	2
71	Tokavaig	NG598118	2
72	Loch Eisort	NG682174	1
73	Loch Slapin	NG565224	10
74	Loch na h'Airde	NG394161	2
75	Loch Eynort	NG380262	6
76	Loch Harport	NG405314	16
77	Loch Beag	NG363388	3
78	Loch Caroy	NG302437	1
79	Pool Roag	NG275448	11
80	Loch Dunvegan	NG249462, NG254472	4
81	Loch Greshornish	NG344510	3
82	Loch Snizort Beag	NG398517, NG413490, NG417518	11
83	Uig	NG393639	2
84	Loch Portree	NG478412	7
85	Loch Sligachan	NG492308	12
86	Loch Ainort	NG538272	8
87	Broadford Bay	NG656233	4
88	Rubha Ardnish	NG668240	6
89	Kyle	NG745261	4
90	Duirnish	NG790322	2
91	Fernaig	NG843338	1
92	Loch Carron	NG931418, NG895390, NG924391	84
93	Reraig Bay	NG836362	2
94	Kishorn	NG833418	15
95	Toscaig	NG712381	3
96	Applecross Bay	NG714455	2
97	Loch Torridon	NG896553, NG872571	29
98	Badachro	NG780738	2
99	Loch Gairloch	NG811751, NG813738, NG806726	2
100	Poolewe	NG862816	2
101	Opinan	NG884970	5
102	Little Loch Broom	NH087885	17
103	Loch Broom	NH175854	9
104	Ullapool	NH124947	2
105	Strathkanaird	NC120005	4
106	Reiff	NB964147	2
107	Achnahaird Bay	NC020127	13

Table 3.6.2 Main saltmarsh sites surveyed (continued)

Site no. on Map 3.6.1	Location	Grid ref.	Area (ha)*
	Region 16 (continued)		
108	Loch na Leobaig	NC102333	3
109	Loch Ardbhair	NC166333	1
110	Traighe bad na Baighe (Loch Laxford)	NC221475	5
111	Rhiconich	NC253523	2
112	Loch Sheigra	NC245552	3

Source: National Saltmarsh Survey (Burd 1989a, b). Key: *to the nearest whole hectare. Note: this table contains only sites with more than 1 ha of saltmarsh. Some sites are amalgamations of sites in Burd (1989a).

Table 3.6.3 SSSIs containing saltmarsh in Regions 15 & 16

Name	Grid ref.
Region 15	
Gress Saltings, Lewis	NB487414
Tong Saltings, Lewis	NB440358
Eoligarry, Barra	NF700061
Howmore Estuary, Lochs Roag and Fada, South Uist	NF756356
Loch Bee, South Uist	NF770430
Baleshare and Kirkibost, North Uist	NF785623
Balranald Bog and Loch nam Feithean, North Uist	NF712705
Vallay, North Uist	NF775765
Northton Bay, Harris	NF990920
Luskentyre Banks and Saltings, Harris	NG080973
Region 16	
Salen to Woodend	NM738633
Ben Hiant and Ardnamurchan Coast	NM600610
Kentra Bay and Moss	NM650685
Loch Moidart	NM672734
Rum	NM370980
Canna and Sanday	NG250060
Ob Lusa - Ard Nis Coast, Skye	NG676245

Source: JNCC Coastal Database.

considerably in type. Open embayment (e.g. Northton, Traigh Eachkamish), restricted entrance embayment (e.g. Tong, Back/Gress) and loch head locations (e.g. Loch Paible, Loch Grimersta) are the most common, with some fringing marshes (e.g. Howbeg) (Pye & French 1993; Law & Gilbert 1986). Several saltmarshes are part of sites of high geomorphological interest. A particular feature of Region 15 is the marshes on sandy substrates at the heads of tidal strands. Saltmarsh vegetation communities are also found in some non-tidal situations, such as around the margins of brackish lochs in the machair and on cliff-tops affected by sea-spray, for example at Uig and Ness. The highest quality sites in Region 15 are: Back Saltings/Gress and Tong/Melbost Sands on Lewis; Northton and East Seilebost (Luskentyre) on Harris; Illeray; and Lag Gorm, Traigh Eachkamish, Vallay and Loch Paible on North Uist (Law & Gilbert 1986). These are generally the larger sites and those with the most extensive transitions from saltmarsh to other habitats. It is clear that many of the high quality sites are associated with the tidal strand islands, especially Baleshare. Loch Paible was originally a freshwater machair loch but has developed extensive saltmarshes since being connected to the sea.

The saltmarsh sites in Region 16 represent only 2.1% of the region's coastal length at mean high water. However, saltmarsh is more widespread than the national survey data suggest, since patches of saltmarsh vegetation are widely distributed on rocky shores and shingle beaches (Gimingham 1964). Sites identified in Burd (1989a, b) include 29 on Skye and small areas of saltmarsh on Rum and Canna. Saltmarshes are found at the heads of all the main sea lochs and in embayments, such as Inverscaddle Bay, Kentra Bay and Barrisdale Bay (Loch Hourn). Elsewhere, saltmarshes have formed at the mouths of rivers, often associated with small bays. The raised beaches that are characteristic of parts of Region 16 can support upper saltmarsh and swamp communities. Along the north shore of Loch Linnhe there are fringing marshes, some protected behind shingle spits. Saltmarsh is also found around the edge of brackish lochs, such as Loch na h'Airde on Skye. The most extensive saltmarshes in Region 16 are at the heads of Lochs Carron, Moidart, Nevis, Duich, Long, Torridon and in Inverscaddle Bay on Loch Linnhe. Saltmarshes in Region 16 often lack species and habitat diversity, which means that the most important sites in nature conservation terms are those with a complex structure and a wide range of plant communities, as in Region 15. Sites showing zonation from low marsh to transition zones are of most interest. The best sites are generally ungrazed or lightly grazed, and therefore contained a more diverse vegetation. Examples include Arisaig and Glencoe (Loch Leven) in Lochaber; Kyle and Loch Greshornish on Skye; Kishorn, Loch Carron and Opinan in Wester Ross.

Saltmarshes in Regions 15 and 16 are characterised by a limited number of plant communities but typically have a high species diversity in the upper marsh, owing to the influence of freshwater seepage and high rainfall plus the unbroken transition to non-tidal areas (Adam 1978). 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 Firth (Adam 1990). Common cord-grass *Spartina anglica* is not an important pioneer species here: it has been recorded only at East Seilebost (Luskentyre) in Region 15 and is absent from Region 16.

A typical saltmarsh in both regions comprises a grazed grassy turf, with common saltmarsh-grass as the main pioneer species, often with glasswort *Salicornia* spp. or annual sea-blite *Suaeda maritima*. Thrift *Armeria maritima*, sea plantain *Plantago maritima*, sea milkwort *Glaux maritima* and sea aster *Aster tripolium* are abundant in both regions. Fucoid algae can be an important component, particularly on peaty substrates and in loch head marshes; on sand they tend to be less frequent (Adam 1978, 1981). On the higher

parts of the marsh, red fescue *Festuca rubra* and saltmarsh rush *Juncus gerardi* become the dominant species, with autumn hawkbit *Leontodon autumnalis*, creeping bent *Agrostis stolonifera*, glaucous sedge *Carex flacca*, buck's-horn plantain *Plantago coronopus* and sea arrowgrass *Triglochin maritima*. Pools and channels within the saltmarsh contain beaked tasselweed *Ruppia maritima* and are often fringed by sea arrowgrass. The characteristic driftline plant is silverweed *Potentilla anserina*. Upper marsh swamps of common reed *Phragmites australis* and sea club-rush *Scirpus maritimus* are not widespread and on most sites the community is restricted to drainage ditches.

A feature of the marshes in both regions is the vegetation of wet depressions, gravel spreads and areas of freshwater seepage on the upper levels of the marsh. The vegetation is a mixture of halophytes (i.e. salt-loving plants) and non-halophytes. Saltmarsh flat-sedge *Blysmus rufus*, slender spike-rush *Eleocharis uniglumis* and common spike-rush *E. palustris* are the characteristic species. The *Eleocharis*-dominated vegetation type is also found around brackish lochs. Good examples of this are found at Back Saltings and Loch Paible in Region 15 and Inverie Bay (Loch Nevis), Arisaig, Pool Roag and Loch Portree in Region 16. Saltmarsh flat-sedge and slender spike-rush, found in both regions, are northern elements in the saltmarsh flora and occur mainly on the west coast of Britain from mid Wales northwards. Whilst neither is regarded as a nationally scarce species, their extent as vegetation types on British saltmarshes is very limited and these regions hold a important proportion of the total resource.

Natural transitions between saltmarsh and other habitats are often areas of particular interest, with a high diversity of both plants and invertebrates. In Regions 15 and 16 transitions are varied and widespread. Most often the saltmarsh grades into a marshy grassland of creeping bent, Yorkshire-fog *Holcus lanatus* and red fescue with silverweed, yellow iris *Iris pseudacorus*, soft rush *Juncus effusus* and marsh marigold *Caltha palustris*. Many sites have a transition from saltmarsh to moorland, through a grassland rich in sedges, such as glaucous sedge *Carex flacca*, long-bracted sedge *C. extensa* and common sedge *C. nigra*. Some sites, such as Northton and Traigh Eachkamish, show transitions from saltmarsh to sand dune vegetation.

An endemic species of eyebright, *Euphrasia heslop-harrisonii*, which is listed in the Red Data Book and classed as nationally rare, is present in the upper and transition zones of some saltmarshes in Region 16. Several nationally scarce species also occur: spiral tasselweed *Ruppia cirrhosa* (Loch na h'Airde on Skye) and two of the three British eelgrass species, eelgrass *Zostera marina* and narrow-leaved eelgrass *Z. angustifolia* (Stewart *et al.* 1994); however, both these *Zostera* species are found outside saltmarsh habitats and *Z. marina* also occurs subtidally. Baltic rush *Juncus balticus*, although mainly a dune slack species, is found at the margins of some saltmarshes in Region 15.

Saltmarshes in both regions provide roosts for wintering and migrant waders and food for wildfowl such as wigeon *Anas penelope* and Greenland white-fronted geese *Anser albifrons flavirostris* (see also section 5.12). Some sites also support breeding waders such as redshank *Tringa totanus* and oystercatcher *Haematopus ostralegus* (see also section 5.11). However, where grazing is heavy, the short turf means that the saltmarshes are of lesser importance for breeding birds.

3.6.3 Human activities

The saltmarshes in both regions have experienced less human interference and land claim than in most of Britain. Saltmarshes in Region 15 could be damaged in future as a result of the need to widen roads. Saltmarsh has been claimed for agriculture at the head of some sea lochs, such as Little Loch Broom and Loch Carron in Region 16, but land claim is not generally widespread. However, on a smaller scale, the landward edge of many saltmarshes is affected by agricultural improvement, particularly by digging drainage ditches. Saltmarsh vegetation has been damaged in both regions by turf cutting, by ploughing to set ploughshares, and by gravel excavation for road repairs. Roads along the top of the saltmarsh have interrupted the zonation at some sites.

Most of the marshes in both regions are grazed by sheep or cattle and in Region 16 some are grazed by deer and ponies. Overgrazing and poaching (destruction by trampling) of the turf appears to be a problem in some places, and grazing has a strong influence on site quality. It has been suggested that, compared with most British saltmarshes, grazing has less impact on the composition of the vegetation in these regions since many of the species that are sensitive to grazing are absent for climatic reasons (Adam 1978).

3.6.4 Information sources used

Saltmarshes in Region 15 were surveyed in 1984, and those in Region 16 in 1982 and 1984, as part of the NCC's national saltmarsh survey (Burd 1989a, b). The survey reports (Penn 1982; Scott 1984a, b; Scott & Law 1984; Law & Gilbert 1986) provide detailed site descriptions and evaluation. Based on these surveys, Scott (1985) gives a summary of the saltmarsh resource for the whole of Highland Region. The results of these studies are incorporated into the national saltmarsh survey reports (Burd 1989a, b) which should be consulted for the areas of sites and their plant communities. 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, areas of saltmarsh vegetation in non-tidal areas, or areas of eelgrass *Zostera* spp. Some known sites such as Coll (Lewis), Trumisgarry (North Uist) and Camas Uig (Lewis) were not covered by Law & Gilbert (1986), but their size suggests that they may also be important sites. This means that the national survey gives only a minimum figure for the extent of saltmarsh in the regions, particularly since many areas of saltmarsh vegetation on beaches were initially excluded and because there is no information about saltmarshes of the smaller and outlying islands of Region 15. Further surveys of the saltmarsh 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.

3.6.6 Further sources of information

A. References cited

Adam, P. 1978. Geographical variation in British saltmarsh vegetation. *Journal of Ecology, 66:* 339-366.

Adam, P. 1981. The vegetation of British saltmarshes. *New Phytologist, 88*: 143-196.

Adam, P. 1990. *Saltmarsh ecology*. Cambridge, Cambridge University Press.

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. 13. North-west Scotland.* Peterborough, Nature Conservancy Council.

Gimingham, C.H. 1964. Maritime and submaritime communities. *In: The vegetation of Scotland*, ed. by J.H. Burnett, 67-142. Edinburgh, Oliver & Boyd.

Law, D., & Gilbert, D. 1986. *Saltmarsh survey - North-west Scotland: The Western Isles.* Edinburgh, Nature Conservancy Council.

Penn, S. 1982. *A preliminary survey of the saltmarshes of Wester Ross.* Inverness, Nature Conservancy Council.

Pye, K., & French, P.W. 1993. *Erosion and accretion processes on British saltmarshes*. *Volumes 1 - 5.* London, Ministry of Agriculture, Fisheries and Food.

Scott, K. 1984a. *Saltmarsh survey - North-west Scotland: Lochaber.* Edinburgh, Nature Conservancy Council.

Scott, K. 1984b. *Saltmarsh survey - North-west Scotland: Skye & Lochalsh.* Edinburgh, Nature Conservancy Council.

Scott, K. 1985. *The saltmarshes of Highland Region.* Edinburgh, Nature Conservancy Council.

Scott, K., & Law, D. 1984. *Saltmarsh survey - North-west Scotland: Caithness & Sutherland*. Edinburgh, Nature Conservancy Council.

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 & marine UKDMAP datasets: a user manual*. Peterborough, Joint Nature Conservation Committee.

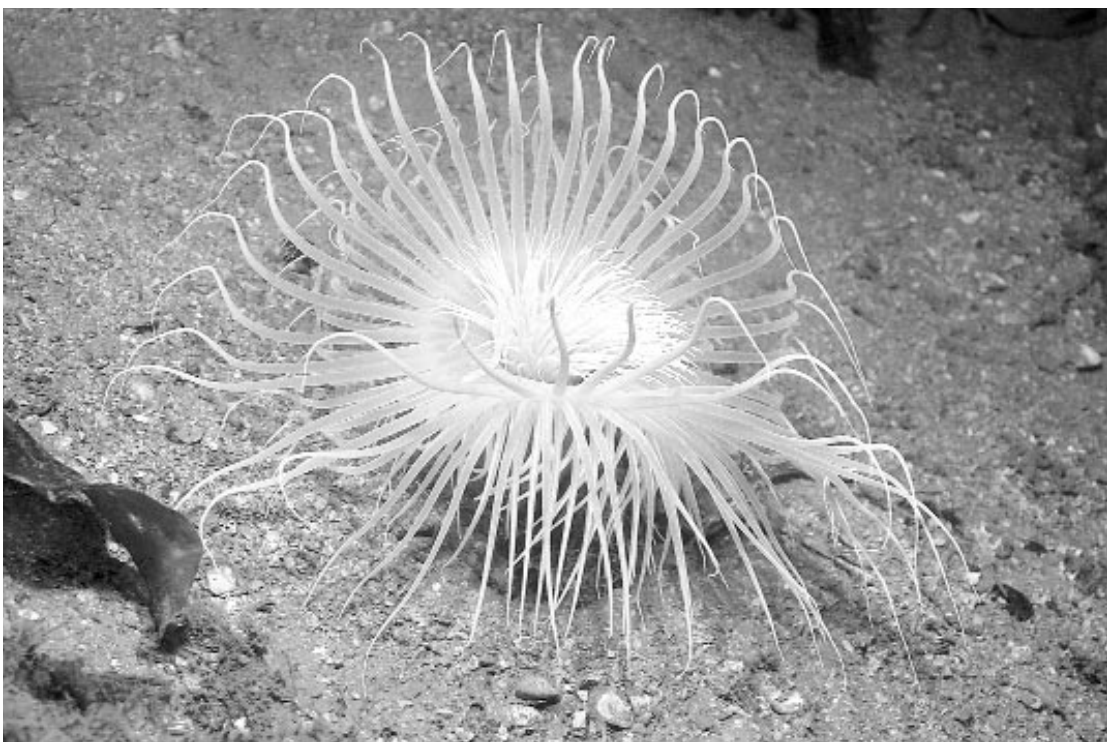
British Oceanographic Data Centre. 1992. *United Kingdom digital marine atlas. User guide. Version 2.0*. Birkenhead, Natural Environment Research Council, British Oceanographic Data Centre.

Rodwell, J.S., *ed*. In press. *British plant communities. Volume 5: maritime and weed communities.* Cambridge, Cambridge University Press.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Data from the National Saltmarsh Survey	*Data Custodian, BIS, JNCC, Peterborough, tel: 01733 62626
Statutory protected saltmarsh sites; detailed saltmarsh site information; coastal geomorphology	*Marine Conservation Officers/ Coastal Ecologist Aquatic Environments Branch, SNH, Edinburgh, tel: 0131 554 9797
Saltmarsh in Lewis and Harris	*Area Officer, SNH, Stornoway, Isle of Lewis, tel: 01851 705258
Saltmarsh in the Uists	*Area Officer, SNH, South Uist, Western Isles, tel: 01870 620238
Saltmarsh in Region 16	*Area Officer, SNH, NW Region HQ, Inverness, tel: 01463 239431

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



Loch Seaforth, North Harris, is a Marine Consultation Area - a site of particular importance for the quality and sensitivity of its marine environment. The creatures on its bed include the beautiful and very rare fireworks anemone *Pachycerianthus multiplicatus,* which outside the UK is known only from Scandinavia. Photo: Marine Nature Conservation Review, 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 were 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 Regions 15 (Western Isles) and 16 (west Highland); for further details of habitats, species and human uses and influences refer to relevant sections in Chapters 3, 5 and 9 respectively.

In this post-glacial coastline of north-west Scotland of predominantly rocky coasts and islands, deep-water fjords and exposed sandy beaches there are only a few places where a combination of shelter, shallow water and availability of sediments has created broad intertidal mud and sand flats that function as estuaries. There are nine such estuaries in Region 15, seven of them on the west coast; in Region 16 there are only two estuaries. Most estuaries in the regions are strongly marine-influenced and receive only small freshwater inflows from rivers and streams. Eight are fjards: shallow glacially-scoured systems (skerry landscapes) where shelter has permitted large sandflats to develop. One (Traigh Luskentyre) is a fjord (a drowned glacial valley) that has become secondarily sediment-filled. Parts of this estuary and the embayment of the Laxdale Estuary have subsequently gained further shelter behind sand and shingle spits.

Saltmarsh is widely distributed throughout the regions' coastline (see also section 3.6), and, unlike in most other parts of the UK where almost all the saltmarsh is estuarine, that present within the regions' estuaries forms only about one third of the total regional saltmarsh extent. Important areas of sand dunes and machair grassland are associated with many of the Region 15 estuaries.

The contribution of Region 15 and 16 estuaries to the wider resource is summarised in Table 4.1.1. In total, estuarine shores comprise almost 500 km (around 10%) of the long and indented coastline of both regions. 90% of the regions' estuarine area lies in Region 15, this region having 4% of the (British) West Coast resource and 2% of the UK resource. Region 16 estuaries form a further 0.4% and 0.2% respectively of the West Coast and UK resource. Many of the regions' estuaries drain substantially at low tide, exposing mostly coarse sandflats, with mudflats in some of the most sheltered parts such as the inner Laxdale Estuary in Region 15. Tidal ranges (3.7 - 4.3 m) are similar throughout the two regions and are greater than those further south (e.g. Strathclyde 2-4 m). Tidal ranges are highest in the two Region 16 estuaries (Kentra Bay and Loch Moidart), and smallest on Traigh Mhor in the south of Region 15.

The largest estuaries in the regions, each exceeding 1,000 ha, are four fjards on South Uist, Benbecula and North Uist in Region 15, with Oitir Mhor (over 5,500 ha) the largest. The other seven estuaries in the regions are small, and five are each less than 500 ha in total area. Large intertidal areas are likewise restricted to the four large fjards, Oitir Mhor again forming the largest area (over 4,000 ha).

Most of the estuaries are of substantial geological, wildlife and nature conservation importance. At least part of all the regions' estuaries except Bagh nam Faoilean and Camus Uig is within a Site of Special Scientific Interest, many designated for a combination of geomorphological

Table 4.1.1 Contributions of Regions 15 and 16 estuaries to the national resource[a]

	Intertidal area			*Saltmarsh area*			*Total estuarine area*			*Shoreline length*			*Longest channel length*		
	ha	*%*		*ha*	*%*		*ha*	*%*		*km*	*%*		*km*	*%*	
		15	*16*		*15*	*16*		*15*	*16*		*15*	*16*		*15*	*16*
Region 15	8,390	-	-	380	-	-	11,930	-	-	439	-	-	52	-	-
Region 16	780	-	-	70	-	-	1,220	-	-	48	-	-	15	-	-
Region 15/16	9,170	-	-	450	-	-	13,150	-	-	487	-	-	67	-	-
West Coast	195,770	4.3	0.4	20,710	1.8	0.3	323,180	3.7	0.4	14,546	3.0	0.3	1,335	3.9	1.1
GB	321,050	2.6	0.2	41,360	0.9	0.2	531,110	2.2	0.2	19,518	2.2	0.2	2,640	2.0	0.6
UK	332,350	2.5	0.2	n/a*	n/a*	n/a*	581,290	2.1	0.2	20,191	2.2	0.2	2,819	1.8	0.5

Sources: Buck (1993); Davidson & Buck (in prep). Key: n/a = not available; *areas of saltmarsh were not available for Northern Ireland; [a]to the nearest 10 ha/1 km.

and wildlife importance. Machair grasslands adjacent to the estuaries are of particular importance for the large numbers and high densities of breeding waterfowl, especially waders (see also sections 5.10, 5.11 and 5.12).

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.

The Laxdale Estuary, in the east of Lewis, close to Stornoway, has in its inner parts one of the muddier areas of tidal flats and larger estuarine saltmarshes in the region. These have formed in the shelter of two spits, the southwards-pointing shingle and blown sand Teanga Tunga and the northwards-pointing sandy Traigh Mhealaboist, seaward of which is a sandy beach.

In the south of Region 15 the broad sandflats of the Traigh Mhor embayment have formed on the sheltered east coast of Barra. Further north, the sounds between South Uist and Benbecula (Bagh nam Faoilean) and Benbecula and North Uist (Oitir Mhor) are shallow, fjardic systems with large areas of tidal flats, mostly of sand and muddy sand with fringing rocky shores. Some of the larger areas of saltmarsh in the region are scattered along the shores of the estuaries, and in the north-west part of Oitir Mhor the islands of Baleshare and Kirkibost have one of the largest sand dune systems in western Scotland (see also section 3.2). The machair supports internationally important numbers of breeding ringed plovers *Charadrius hiaticula*.

On the northern shore of North Uist lie the adjacent fjardic embayments of Traigh Vallay and Oronsay, separated by the dune and machair system of Machair Leathann. Traigh Vallay is predominantly intertidal sandflats deposited in the shelter of the island of Vallay. On both Traigh Vallay and Oronsay there are only small strips of saltmarsh and shingle shorelines. Like Traigh Vallay, Oronsay is mostly sandflats, deposited in the shelter of the island of Oronsay and a narrow sand dune spit. On the eastern side of Oronsay, Machair Robach is the most

Map 4.1.1 Estuaries. Source: JNCC Coastal Database.

dynamic and representative dune and machair area in the Uists. It has an important range of dune slack, wet machair and species-rich uncultivated dry machair. These areas, like those around Traigh Vallay, support important breeding waders populations, including internationally important numbers of ringed plovers. The mature high machair plateau experiences severe wind erosion, including deep blow-outs.

On the western shores of South Harris, two sheltered inlets have developed extensive intertidal soft shores. Scarista, in the shelter of Toe Head, is a large intertidal shell

Table 4.1.2 Physical characteristics of Region 15 & 16 estuaries

Estuary	*Centre grid ref.*	*Geomorph-ological 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 %*
Region 15									
65. Laxdale Estuary	NB4434	Fjard	559	390	96	12.8	4.7	4.1	30.2
57. Traigh Mhor	NF7005	Embayment	242	210	0	6.5	n/a	3.7	13.2
58. Bagh nam Faoilean	NF7948	Fjard	2,144	1,264	35	37.5	10.9	4.1	41.0
59. Oitir Mhor	NF8158	Fjard	5,519	4,028	144	292.4	13.3	4.1	27.0
60. Traigh Vallay	NF7875	Fjard	1,113	823	15	22.9	6.9	4.1	26.1
61. Oronsay	NF8575	Fjard	1,278	825	6	29.9	6.3	4.1	35.4
62. Scarista	NF9992	Embayment	290	290	40	7.5	n/a	3.8	0
63. Traigh Luskentyre	NG0798	Fjord	344	344	32	11.5	4.1	3.8	0
64. Camus Uig	NB0433	Fjard	438	214	10	18	5.5	3.6	51.1
Region 16									
55. Kentra Bay	NM6469	Fjard	338	313	41	13.4	4.9	4.3	7.4
56. Loch Moidart	NM6873	Fjard	881	469	24	34.9	10.1	4.3	46.8

Sources: Buck (1993); JNCC Integrated Coastal Database. Key: *to the nearest whole hectare; n/a = not applicable. Notes: 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). 'Spring tidal ranges' are for the monitoring station closest to the mouth of the estuary.

sand beach grading into saltmarsh, with brackish-water fen transitions in its inner parts. An unusual wet and dry calcareous machair landward of the saltmarsh supports a diverse flora, with sand dunes in the eastern part of the bay grading from dry machair to acid moorland. Traigh Luskentyre, with shell sand beaches and sandflats partly sheltered by the island of Taransay offshore, has tidal flats grading through mid-upper saltmarsh, dunes and machair to rough pasture. The inner bay is further sheltered by the dynamic, north-pointing dune and machair spit of Corran Seilebost.

Camus Uig is the only sediment-filled fjard on the otherwise rocky west coast of Lewis. The outer part is subtidal with rocky shores, whilst the inner half of the inlet is sediment filled, with a substantial river that drains Loch Suainaval close inland flowing along the northern shore of the estuary. In the inner part of the estuary there are areas of blown sand supporting machair vegetation.

On the coast of Region 16 there are only two sediment-filled fjards in the otherwise deep-water, rocky and fjordic coastline: Kentra Bay and Loch Moidart. Kentra Bay has several freshwater inflows discharging through a narrow mouth. The bay has mudflats and saltmarshes in its inner parts with, to the north-east, a landward transition to the peatland of Kentra Moss. Steep wooded slopes fringe western parts of the shore. To the north, Loch Moidart is fed by two rivers and discharges through two narrow mouths, on either site of the island of Eilean Shona. Much of the shore is surrounded by steep, wooded slopes. There are well-developed saltmarshes around the head of the loch, and about half the loch contains intertidal flats of mud and muddy sand.

4.1.3 Human activities

Estuaries throughout the regions are predominantly rural (Table 4.1.3), lie in some of the most unspoilt landscapes in the UK and are amongst the most natural in the country. There are small settlements close to most estuaries; only the Laxdale Estuary has a substantial settlement, Stornoway, nearby. There has been very little land claim on these estuaries, although roads cross Bagh nam Faoilean, Oitir Mhor and Traigh Luskentyre in Region 15 and some tidal flats on the Laxdale Estuary have been lost to airport extension. In addition, the broad sandflats of Traigh Mhor, Barra are used as the only beach landing strip for scheduled passenger flights in the UK. Part of the shoreline is embanked to maintain suitable drainage conditions for landing. Otherwise human development is limited to small piers and jetties. Some natural resource exploitation takes place on most estuaries, most commonly grazing on sand dunes and saltmarshes. Small-scale sand and gravel extraction has occurred in Loch Moidart and Traigh Mhor, Barra, where there is also mollusc cultivation and collection. Sediment extraction takes place also from Scarista, Traigh Luskentyre, the Laxdale Estuary, Bagh nam Faoilean and Oitir Mhor, this latter site also supporting salmon farms, mollusc cultivation and collection of algae for the alginate industry. Throughout both regions there is low-intensity recreation and tourist use of the estuarine shores, much being informal recreation - walking, bird-watching, and angling. There is also some wildfowling and there is sailing in Bagh nam Faoilean, Oitir Mhor and Kentra Bay.

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 Regions 15 and 16 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 1993 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 are available for some but not all of the 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.

Table 4.1.3 Human uses of Region 15 and 16 estuaries

Estuary	*Centre grid ref.*	*Human use type*			
		urban	*industrial*	*rural**	*recreational*
Region 15					
65. Laxdale Estuary	NB4434	○		●	○
57. Traigh Mhor	NF7005			●	○
58. Bagh nam Faoilean	NF7948			●	○
59. Oitir Mhor	NF8158			●	○
60. Traigh Vallay	NF7875			●	○
61. Oronsay	NF8575			●	○
62. Scarista	NF9992			●	○
63. Traigh Luskentyre	NG0798			●	○
64. Camus Uig	NB0433			●	○
Region 16					
55. Kentra Bay	NM6469			●	○
56. Loch Moidart	NM6873			●	○

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

4.1.5 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. 13. North 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.

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

B. Further reading

Further details of estuaries are in the *Coastal & marine UKDMAP datasets* module (Barne *et al.* 1994), available from JNCC Coastal Conservation Branch, Peterborough. A list of selected further reading for each estuary discussed in section 4.1 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.* Plymouth, Plymouth Marine Laboratory and Marine Biological Association. (Annual bibliography of recent scientific papers. No. 19.)

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 Development Department. 1987. *Water quality survey of Scotland 1985.* 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. Summary data available also in Coastal Directories UKDMAP display version.	*Coastal Data Custodian, JNCC, Peterborough, tel: 01733 62626
Statutory protected sites; detailed wildlife site information; coastal geomorphology. Firths Initiative & estuary management plans. Numerical and some digitised data.	*Marine Conservation Officers/ Coastal Ecologist, Aquatic Environments Branch, RASD, Scottish Natural Heritage, Edinburgh, tel: 0131 554 9797
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.

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 littoral (shore) and sublittoral (below low water mark) habitat types in a national context is not yet available.

Islands in Region 15 are subject to some of the most severe and frequent storms to affect the British Isles. The islands' west coasts are fully exposed to the prevailing westerly winds and have no protection from the full force of the Atlantic. However, the large Atlantic swells are dampened somewhat as the sea bed shelves gradually along the west side of the islands, with the 50 m depth contour some 12-16 km offshore (Connor & Little in prep. a). Much deeper water is present close inshore around St. Kilda, which is constantly subjected to severe Atlantic swells and has probably the most wave-exposed coast in the British Isles. The islands in Region 15 are highly indented by a series of sea lochs, providing areas of extreme shelter from wave action and a wide range of tidal stream strengths through the many narrow channels and rapids (Connor & Little in prep. a). Conditions within the lochs range from fully marine to brackish and freshwater, with most opening to the east. Earll & Pagett (1984) noted that there is a predominance of fjards (shallow complexes of small basins separated by sills), as opposed to the deeper fjords found more commonly on the mainland. There are also several open sea lochs. The islands lie in the path of the Gulf Stream, which helps to keep winter sea temperatures above those on the mainland and encourages the growth of warm-water species at a higher latitude than further east around the mainland (Connor & Little in prep. a). More survey work has been carried out in the intertidal areas, and more recently in the sea lochs and small brackish lochs, or obs, than on the open coasts.

In Region 16, the mainland coast is the most remote and rugged coastline on mainland Britain; it is dissected by a number of sea lochs, which are partially protected from the full force of the Atlantic by the Inner and Outer Hebrides. However, much of the open outer coast is exposed to wave action. The northern and southern approaches to the Minch are subject to considerable swell; many of the sea lochs, by contrast, are protected by sills or narrows and are very sheltered from wave action. This leads to a wide range of intertidal and subtidal habitats. The narrows and some of the tidal sounds, such as the Sound of Sleat, generate strong tidal currents, reaching 3-4 m/s in places, providing further diversity of habitats.

Southern species, such as the anemone *Bunodactis verrucosa*, the brown alga *Cystoseira tamariscifolia* and the red alga *Meredithia microphylla*, extend further north along the coasts of Region 15 than they do along the coasts of Region 16 (Harvey *et al*. 1980; Maggs 1986). This may be due to the influence of the Gulf Stream. The fauna and flora of the northern coast of Region 16 show a slight decrease in species richness compared with more southern parts of the Scottish west coast, as some of the warm-water species find their most northerly limits on or south of this stretch of coast (Connor & Little in prep. b). For instance, the algal flora of north-west Scotland is reduced by 25 species compared to waters south of the Firth of Lorne (Region 14) (Maggs 1986). On the shores, the abundance of *Chthamalus* spp. is very much reduced as *Semibalanus balanoides* becomes the dominant barnacle, while northern algae such as *Odontothalia dentata* and *Ptilota plumosa* become more abundant in appropriate habitats compared with further south (Harvey *et al*. 1980). In the sublittoral, urchin grazing is suggested as a major factor in reducing species richness in rocky areas (Dipper 1981a; Davies 1989), particularly to the north of the Ardnamurchan Peninsula on the mainland coast.

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

Seven Marine Consultation Areas (MCAs) occur in Region 15 and a further seven in Region 16: Loch Seaforth, The Obbe, Loch Roag, Loch Maddy, Loch Eynort, Loch Obe and the St. Kilda group (Region 15); and Loch Sunart, Loch Duich, Loch Long, Loch Carron, Dunvegan Head (Skye), Loch Torridon and Loch Laxford (Region 16). These are non-statutory designated areas identified by Scottish Natural Heritage (and previously by the Nature Conservancy Council (NCC 1990)) as of particular importance on account of the quality and sensitivity of the marine environment within them (see also section 7.4.3). There are also a number of areas proposed as Special Areas of Conservation (SACs) that contain sea-bed communities of interest. These include four sites in Region 15 and two in Region 16 (see section 7.2.4).

4.2.2 Important locations and communities

Table 4.2.1 lists locations of marine biological importance mentioned in the text (Map 4.2.1). However, there remain large stretches of mainland coast, particularly in the near-shore and offshore sublittoral zones, for which little is known of the flora and fauna.

Region 15

Lewis and Harris (east coast)

Lewis and Harris are quite highly indented on both coasts and have a very wide range of habitats. The Butt of Lewis is exposed to considerable wave action, reflected in its marine communities, which tend to feature large populations of relatively few species. In the subtidal, steep and vertical bedrock drops to 20 m, forming overhangs, caves and gullies. These are dominated by barnacles, encrusting sponges, hydroids and bryozoan turf (Gubbay 1988). Bishop & Holme (1980) highlighted the large, open Broad Bay as

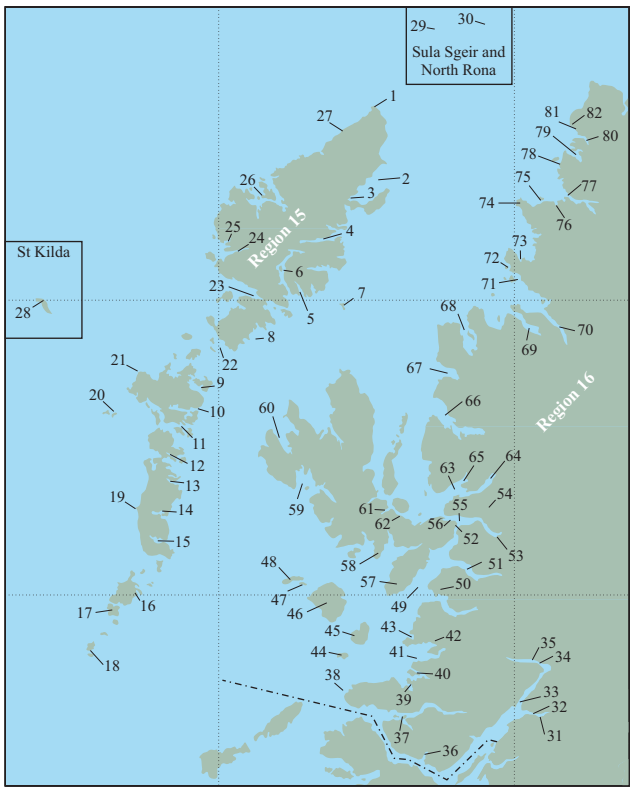
Table 4.2.1 Sites of marine interest mentioned in the text

No. on Map 4.2.1	*Location*	*Grid ref.*
	Region 15	
1	Butt of Lewis	NB5266
2	Broad Bay	NB5143-NB5738
3	Laxdale Estuary	NB4434
4	Loch Erisort	NB3521
5	Loch Claidh	NB2702
6	Loch Seaforth	NB2107
7	Shiant Islands	NG4298
8	Ob Leasaid	NG1189
9	Loch Maddy	NF9370
10	Loch Eport	NF9263
11	Grimsay	NF8757
12	Bagh nam Faoilean	NF8245
13	Loch Skipport	NF8338
14	Loch Eynort	NF8028
15	Loch Boisdale	NF7918
16	Barra	NF7000
17	Vatersay	NL6195
18	Mingulay, Berneray	NL5581
19	Rubha Ardvule	NF7129
20	Monach Islands	NF6462
21	Griminish Point	NF7276
22	The Obbe, Leverburgh	NG0186
23	Luskentyre Inlet	NG0698
24	Loch Resort	NB0617
25	Loch Tamanavay	NB0320
26	Loch Roag	NB1434
27	Arnol to the Butt of Lewis	NB3150-NB5266
28	St. Kilda	NA1000
29	Sula Sgeir	HW6230
30	North Rona	HW8132
Not shown	Rockall	-
	Region 16	
31	Loch Leven	NN0959
32	Ballachulish Narrows	NN0559
33	Corran Narrows	NN0163
34	Annat Narrows	NN0776
35	Loch Eil	NN0577
36	Loch Aline	NM6845
37	Loch Sunart	NM5960
38	Ardnamurchan Point	NM4167
39	Kentra Bay	NM6469
40	Loch Moidart	NM6773

No. on Map 4.2.1	*Location*	*Grid ref.*
	Region 16 (continued)	
41	Sound of Arisaig	NM6680
42	Loch nan Uamh	NM7083
43	Loch nan Ceall	NM6386
44	Muck	NM4179
45	Eigg	NM4685
46	Rubha na Roinne, Rum	NM4099
47	Sgeir a' Phuirt, Sanday	NG2704
48	Canna	NG2405
49	Loch Nevis	NM7794
50	Sound of Sleat	NG6703
51	Loch Hourn	NG8407
52	Kyle Rhea	NG7922
53	Loch Duich	NG9220
54	Loch Long	NG9029
55	Loch Alsh	NG8225
56	Kyle Akin	NG7626
57	Sleat Peninsula	NG5802
58	Elgol	NG5113
59	Loch Bracadale	NG2839
60	Loch Dunvegan	NG2152
61	Loch Ainort	NG5528
62	Strollamus	NG6026
63	Plockton	NG7934
64	Strome Narrows	NG8635
65	Achintraid, Loch Kishorn	NG8338
66	Loch Torridon	NG7956
67	Loch Gairloch	NG7975
68	Loch Ewe	NG8486
69	Little Loch Broom	NH0194
70	Loch Broom	NH1095
71	Summer Isles	NB9605
72	Isle Ristol	NB9711
73	Achnahaird Bay	NC0114
74	Point of Stoer	NC0235
75	Oldany Island	NC0934
76	Duart Lochan	NC1333
77	Loch a'Chairn Bhain	NC2133
78	Scourie Bay	NC1445
79	Loch Laxford	NC2148
80	Loch Inchard	NC2355
81	Lochan nam Meallan	NC1957
82	Sheigra	NC1860

being of national importance on account of its moderately exposed sandy beaches, which are some of the richest and most varied for marine communities in Lewis and Harris. The three dominant communities are characterised by the tellin *Angulus* (*Tellina*) *tenuis,* the lugworm *Arenicola marina* and the heart urchin *Echinocardium cordatum*, together with the razor shell *Ensis siliqua*. At the head of Broad Bay is the Laxdale Estuary, which has one of the largest areas of tidal flats in Region 15 (Buck 1993).

The shores at the entrance to Loch Erisort are representative of the east coast of Lewis and Harris (Powell *et al*. 1979). The presence of the non-native barnacle *Elminius modestus* (a New Zealand introduction) is notable. Loch Erisort is a fjordic sea loch with several fjardic features. It has a wide range of habitats within a relatively small area (Powell *et al*. 1979); these included vertical rock faces in tidal channels, boulders and gravel and an unusually large expanse of mud at the head of the loch, featuring the unusual unattached brown alga *Ascophyllum nodosum* in its environmentally-modified form (ecad) *mackaii*. The flat topshell *Gibbula umbilicalis*, a species generally scarce on the west coast, is abundant on rocky shores here. In the subtidal, a particularly wide range of sediment communities is present (Holt 1991a), including undisturbed sediment with the sea pen *Virgularia mirabilis* and the opisthobranch mollusc *Philine aperta*. Of particular note was the discovery of a dense bed of the small sea cucumber *Ocnus planci* amongst stones and shells on muddy sediment. Loch Seaforth, a little further south, is the longest (23 km) and deepest (98 m) fjord in Region 15 (Edwards & Sharples 1986). *Ascophyllum nodosum* ecad *mackaii* was also found here, on extremely sheltered intertidal areas at the head of the loch. In the subtidal, typical fjordic communities (generally rare in Region 15) occur, such as the *Protanthea simplex/Neocrania anomala* association of sheltered bedrock (Howson 1989). In Loch Seaforth and Loch Claidh deep muds have populations of the tall sea pen *Funiculina quadrangularis*. On bedrock areas below the kelp *Laminaria*



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

hyperborea zone at the entrances to the east coast sea lochs there are frequent records of such species as the featherstar *Leptometra celtica* (known in British waters only from off the west coast of Scotland), the sea fan *Swiftia pallida* and the football sea squirt *Diazona violacea* (Holt 1991a).

The Shiant Islands lie about 8 km off the east coast of North Harris. There is a lack of information for the sublittoral from here; the shore at Sgeirean a'Bhaigh, at the north of the main island, is of columnar cliffs, boulders and large pools (Powell *et al*. 1980). At Ob Leasaid, on South Harris, to the south of Loch Stockinish, there is a small brackish marine basin with a sill. This site has the largest tidal rapids of their type on Lewis and Harris and has a profusion of sponges, hydroids and anemones (Gubbay 1988).

North Uist, Benbecula, South Uist and Barra (east coast)

The Uists have been noted for their marine biological interest for well over a hundred years. North Uist in particular contains a large number of brackish lochs, or obs (see also section 3.4).

Loch Maddy, covering approximately 24 km^2, is the most complex fjardic sea loch in the British Isles. It contains innumerable small rocks and islands and over 22 sills and basins (Howson 1991a). Conditions range from an exposed fully marine entrance to extremely sheltered brackish basins in the inner parts. These basins connect to freshwater lochans inland. The loch is considered to be one of the richest and most interesting sea loch systems in the British Isles, both for littoral interest (Lewis 1957; Powell *et al*. 1979) and for sublittoral interest (Connor 1994). The great variety of habitats gives rise to a high diversity of species. There are excellent examples of intertidal wave-sheltered, tide-swept communities, such as dense cover of knotted wrack *Ascophyllum nodosum* and toothed wrack *Fucus serratus*, with accompanying sponges and ascidians. Of particular note are two areas of tidal rapids, at Sponish and Leiravay. These support a very rich fauna, with underboulder communities dominated by several species of sponge (particularly *Halichondria panicea*) and encrusting ascidians (including *Botryllus schlosseri* and *Dendrodoa grossularia*). Cover is by dense fucoids, particularly long thongweed *Himanthalia elongata* and kelps (mostly *Laminaria digitata* and *L. hyperborea*), with some species of red algae normally restricted to below low water. Elsewhere in the subtidal there are channels of tide-swept stones and gravel with 'hedgehog' rhodoliths (spiked pebbles) formed by unusual calcareous algae: maerl *Lithothamnion glaciale* and *Phymatolithon calcareum*. Shallow, muddy basins support large populations of the rarely recorded sea cucumber *Labidoplax media* (Howson 1991a). At the entrance to the loch, deep bedrock and boulders support a rich fauna featuring the sea fan *Swiftia pallida*, large erect sponges (such as *Axinella infundibuliformis*), erect bryozoans including *Porella compressa*, and a variety of hydroids including *Agalophenia tubulifera* and *Nemertesia ramosa*.

Loch Eport, to the south of Loch Maddy, has a deep channel (up to 30 m), giving it certain fjordic characteristics (Howson *et al*. 1994). Upper Loch Eport has a series of basins ranging from fully marine to brackish to freshwater, connected by shallow rapids. Along the shores of the loch are tide-swept species-rich communities similar to those found in Loch Maddy (Howson 1991a). In the subtidal, the deep narrows at the entrance to the loch were dominated by hydroids such as *Abietinaria abietina* and *Sertularia argentea* and the soft coral *Alcyonium digitatum*. According to Howson *et al*. (1994), only the narrows at Loch Moidart and Kylesku are comparable to these at Loch Eport. Opening into the southern side of the loch, over a narrow sill that is only over-topped with seawater at high spring tides, is the brackish Loch Obisary (see also section 3.4). This is a most unusual loch, probably unique in the British Isles, as it has a permanent halocline at 4-5 m depth, separating deeper saline water from shallower brackish water. The fully marine area has a moderately rich flora and fauna but there is poor diversity in the brackish areas (Mitchell *et al*. 1980).

Further south, between North Uist and Benbecula, the open flats on the north side of the island of Grimsay are considered to be of primary marine biological importance (Powell *et al*. 1979), owing to the range of sediment types and associated communities. These include exposed sand (characterised by a sandmason worm *Lanice conchilega* community); sand/muddy sand (a heart urchin *Echinocardium cordatum* - razor shell *Ensis siliqua* community); sheltered muddy sand (a lugworm *Arenicola marina* community); and sheltered mud (a peppery furrow shell *Scrobicularia plana* community). While the western side of the channel separating the two main islands is primarily of sand, the eastern shores are predominantly rocky, with both exposed and sheltered communities. A similar area of sand flats (to the west) and rocky islets (to the east) exists at Bagh nam Faoilean, which separates Benbecula from South Uist. The wide range of habitat types and differing wave exposures have led to a rich variety of intertidal communities being present here. In particular, the sand flats at Oitir Bheag have a rich infauna (Bishop & Holme 1980), and the tidal rapids at Leiravagh have luxuriant growths of sponges and an

unusually rich assemblage of mollusc species (Smith 1978a).

Loch Skipport, like Loch Eport, has both fjordic (deep water) and fjardic (shallow) features. The moderately-exposed mid-shore zone is dominated by a cover of the brown seaweed *Fucus vesiculosus* and the barnacle *Semibalanus balanoides*, with the limpet *Patella vulgata* and the periwinkle *Littorina littorea* common. On more sheltered shores further away from the entrance the wrack *Ascophyllum nodosum* was more frequent. Below low water there is a mix of steep cliffs, boulder slopes, bedrock reefs, gullies and areas of sand (Howson 1991a). The richest sediment communities were in muddy shell sands near the middle of the loch, where the sea pen *Virgularia mirabilis*, the brittlestars *Ophiura albida* and *O. ophiura* and the scallop *Pecten maximus* occurred. The narrow channel that connects the loch to the shallow, brackish Loch Bee, which is open to the coast at its north end, is controlled by sluices. To the south, Loch Eynort has a deep outer basin and a shallower inner basin, separated by a current-swept narrows, and has a series of waterfalls, sills and passes. The intertidal communities in these areas are characteristic of areas of strong tidal flow, with local areas of species richness. There is a wide range of habitats in the sublittoral, ranging from bedrock reefs, cliffs and slopes, to cobble, maerl, coarse sand, shell sand and mud. The soft mud in the outer basin supports beds of the burrowing sea cucumber *Thyone roscovita*, with ascidians dominating many areas of vertical rock. There is a gradation in type and extent of kelp forest with increasing exposure, and very sheltered shallow rock communities are well represented, although deep sheltered rock is absent (Dipper 1985). The rapids at Sruthan Beag have rich communities as a result of their high-energy environment. Loch Sheilavaig in South Uist is known to contain maerl beds (P. Tyler pers. comm.).

The shores of Loch Boisdale, apart from at the entrance, are sheltered or very sheltered from wave action, with boulders and cobbles having a dense cover of wrack *Ascophyllum nodosum* on the mid-shore and the toothed wrack *Fucus serratus* on the lower shore. Associated with these are a rich variety of sponges and ascidians, particularly in tide-swept areas (Howson 1991a). Below low water, there is a dense kelp *Laminaria hyperborea* forest with a variety of foliose red algae, such as *Plocamium cartilagineum*, *Cryptopleura ramosa* and *Delesseria sanguinea*, with the kelp *Laminaria saccharina* becoming more frequent in sheltered areas. A dense bed of the burrowing sea cucumber *Leptosynapta bergensis* is present in deep muddy sand, as well as the sea pen *Virgularia mirabilis*. Deep exposed bedrock cliffs near the entrance have an extensive cover of jewel anemones *Corynactis viridis*, together with the sea fan *Swiftia pallida*, erect sponges and hydroids (Howson 1991a).

Barra and surrounding islands

Barra and its surrounding islands are characterised by a wide variety of different habitat types, ranging from the steep and very wave exposed westerly-facing coast to the more sheltered embayments in the north and east (Dalkin in prep.). Around north-east Barra and Eriskay the highly indented coastline has a wide range of biotope types, ranging from the barnacle-dominated wave-exposed shores on the east-facing coasts of Hellisay and Gighay to the very sheltered fucoid-dominated rocky shores around Bay Hirivagh and North Bay. Loch Obe, on the east coast of Barra, is a small sea loch that presents an environment unique in this region, with its long, narrow, shallow, rocky gorge-like entrance channel and unusual tidal regime, with water in the loch often higher than outside because of the constriction of the channel. Sand is present where the narrows open out into the loch. There is strong water movement through the narrows, and the channel has a rich flora and fauna, characteristic of fast-flowing narrows (Powell *et al*. 1979). Maerl beds are present on the sea bed off the east coast of Barra (P. Tyler pers. comm.).

The west-facing coast around Barra and Vatersay is likewise characterised by steep barnacle-dominated rocky shores, with kelp forest and park (less dense vegetation) in the sublittoral zone. The kelp extends for several kilometres offshore on the flat bedrock plain that characterises this area. Surge gullies, caves and arches occur in several places around the islands, particularly on the west coast. Although the exact species composition of each cave and gully varies with local water movement, the walls of each are characterised by a robust fauna of sponge crusts, anemones and colonial ascidians (Dalkin in prep.). The floors of these wave-surged caves are generally scoured bare or dominated by scour-tolerant coralline algal crusts, barnacles or spirorbid worms. At the northern tip of Barra, the Eoligarry peninsula has exposed (on the west) and sheltered (on the east) sandy beaches at Traigh Eais, Traigh Scurrival and Traigh Mhor. On Traigh Mhor there is a rich burrowing fauna, in particular a well-developed lugworm *Arenicola marina* community, including large numbers of the common cockle *Cerastoderma edule*, which are commercially harvested (Powell *et al*. 1979). The subtidal muddy sand off this beach contains a variety of bivalves and polychaete worms (T. Hill pers. comm.). The intertidal area is considered to be a site of national importance (Powell *et al*. 1979).

The Sound of Sandray between Vatersay and Sandray is one of several areas around the islands that receive increased tidal water movement. In this sound, shallow subtidal rocky areas are characterised by kelp forests, heavily laden with sponges, colonial ascidians, anemones and brittlestars (Dalkin in prep.).

The southernmost islands of Berneray and Mingulay have deep water close inshore and so receive the full force of the Atlantic swells. The very steep bedrock shores are characterised by very wide bands of lichens above typical wave-exposed communities of mussels, barnacles and red algae (Dalkin in prep.). The kelp *Alaria esculenta* dominates the sublittoral fringe, below which there is a very rich forest of *Laminaria hyperborea* with dense red algae, sponges and a turf of bryozoans.

South Uist (west coast), Benbecula, North Uist

Much of South Uist's west coast comprises long sandy beaches and shingle ridges backed by machair. The richest rocky site is at Rubha Ardvule, where there is a sizeable area of hard intertidal rock. Offshore shallows provide a measure of protection from wave action, giving rise to exposed rather than very exposed habitats, and the site was proposed as a site of national marine biological importance by Harvey *et al*. (1980).

The Monach Islands lie about 10 km due west of North Uist. There are three main islands, linked by sandy tombolos (spits connecting the islands), backed by dunes and machair. The intertidal communities are characteristic

of exposed broken rocky shores, and the islands appear to be the northern limit of the alga *Cystoseira tamariscifolia* (Powell *et al*. 1979). There is an extensive area of flat broken bedrock with small boulders and pebbles offshore. Kelp *Laminaria hyperborea* forest covers this area and is particularly dense off the southern margin of Ceann Ear. The islands were proposed by Powell *et al*. (1979) as a site of primary marine biological importance.

Griminish Point, on the north-west coast of North Uist, is the most exposed shore in this sector and amongst the most exposed in Scotland. Powell *et al*. (1979) described fine examples of exposed rocky shore communities here and proposed it as a site of national marine biological importance.

Lewis and Harris (west coast)

The wide, relatively shallow Sound of Harris is swept by strong tides and contains extensive beds of eelgrass *Zostera* spp. However, no detailed sea bed surveys have been carried out in this area (P. Tyler pers. comm.). On the northern shore of the Sound of Harris, the small tidal inlet of the Obbe at Leverburgh has a range of sheltered habitats subject to strong currents at the sill and to freshwater influence in the inner parts (Powell *et al*. 1979). There is a rich underboulder fauna, together with species typical of areas of strong water movement.

The Luskentyre inlet, proposed by Powell *et al*. (1979) as a site of national marine biological importance, supports the richest and most varied sedimentary shores on the west coast of Harris and Lewis. There are exposed and more sheltered sandy beaches and sheltered flats of muddy sand, and a corresponding range of burrowing communities, including a crustacean-polychaete community (typical of exposed sand), a tellin *Angulus* (*Tellina*) *tenuis* community (moderately sheltered sand), a lugworm *Arenicola marina* community (sheltered muddy sand), and a peppery furrow shell *Scrobicularia plana* community (sheltered mud). Howson (1989) noted that shell gravel often occurred at the exposed mouths of several of the west coast sea lochs, including Lochs Resort and Tamanavay on North Harris. This substrate is colonised by the large and uncommon ascidian *Molgula occulta*. In the same vicinity, areas of coarse sand were colonised by the burrowing sea cucumber *Neopentadactyla mixta*. The soft muddy sea bed at the centre of these lochs supported large numbers of the echiuran *Maxmuelleria lankasteri*, a species found in only a few other sea lochs (Howson *et al*. 1994).

Loch Roag, on the central west coast of Lewis, covers an area of over 50 km^2 and is the largest loch system in the Hebrides (Earll & Pagett 1984). A wide variety of littoral habitats are present, with sandy beaches, steep cliffs, and mud in the inner reaches, the shores having every grade of wave exposure; Powell *et al*. (1979) considered the loch system to be of outstanding interest because of its wide range of littoral communities. The sublittoral also has a wide diversity of habitats, though the number and variety of species is not exceptionally high. Species diversity appears to be highest around the outer isles, particularly on the lee sides of islands, where wave action is slightly moderated. Eelgrass *Zostera marina* beds and beds of the horse mussel *Modiolous modiolus* occur within the loch (Dipper 1983). Of particular interest are a number of tidal narrows and rapids, for example those at Valasay on Great Bernera in the centre of the loch system. Here there are small boulders and cobbles with patches of coarse clean sand and maerl in between. Dense growths of the kelp *Laminaria hyperborea* and the podweed *Halidrys siliqua* have various species attached to them, including anemones, ascidians and lush growths of the breadcrumb sponge *Halichondria panicea*. Further up the west coast of Lewis, Uig Sands is a sheltered bay with extensive sand flats. The sediment communities found here are typical of exposed, clean sand and sheltered muddy sand (Buck 1993).

The 35 km stretch of coast along the north-west coast of Lewis, between Arnol and the Butt of Lewis, was described by Powell *et al*. (1979) as a good example of fully exposed shelving rocky shore in north-west Britain, with deep water close inshore.

St. Kilda, North Rona and Rockall

The St. Kilda island group lies some 66 km west of the Sound of Harris and comprises the main island of Hirta, together with Soay, Dun, Levenish and Boreray. The shores are predominantly very exposed and near-vertical, featuring numerous sea caves, which Hiscock (1992) considered to be of special interest and the best developed in Britain. Gauld *et al*. (1953) found the shores to be remarkably uniform, with three distinct zones: a supralittoral fringe of bare rock with limpets *Patella vulgata* and the red alga *Porphyra umbilicalis*; a mid-shore zone dominated by barnacles, and a sublittoral fringe with the kelp *Alaria esculenta* and calcareous algae. The only sedimentary beach, in Village Bay, is a sandy beach which is completely washed away in winter, leaving a storm beach of boulders. The extreme exposure to wave action has brought about records of marine species very high above the waterline: Bagenal (1957) noted the rough periwinkle *Littorina saxatilis* and the green alga *Enteromorpha* spp. at 29 m above sea level, and the amphipod *Orchestia gammarellus* at 107 m!

In the sublittoral, St. Kilda is renowned for its clear oceanic waters, extensive vertical rock faces and complex systems of gullies, arches, caves and tunnels, these last features being probably the best-developed in Britain. The combination of high wave exposure and constant surge produces a rich marine life which comprises mainly encrusting or low-growing species, such as sponges, anemones, bryozoans and polyclinid ascidians (Howson & Picton 1985). The exceptional water clarity enables the kelp *Laminaria hyperborea* to grow as deep as 35 m. The influence of the North Atlantic Drift is considered to be greater here than at inshore Scottish sites, and many species of predominantly southern and western distribution in the British Isles are present. Howson & Picton (1985) did not find the usual surge gulley association of *Dendrodoa grossularia* and *Clathrina coriacea* in the tunnels and caves of St. Kilda, although C. coriacea was abundant in shallow water. The dominant species in areas of highest water movement was the sponge *Myxilla incrustans*, which formed a blanket cover on the walls of tunnels and surge gullies.

North Rona lies about 70 km NNE of the Butt of Lewis and Sula Sgeir 65 km north of the Butt of Lewis. Gilbert *et al*. (1973) found the shore communities at both of these islands to be similar to those on Fair Isle, Lewis and northern Scotland, ranging from exposed to very exposed. The shore flora included *Alaria esculenta*, *Mastocarpus stellatus*, *Palmaria palmata*, *Polysiphonia urceolata*, *Porphyra umbilicalis* and *Fucus spiralis* in its *nana* form. Another

fucoid, the northern *Fucus distichus edentatus,* has its southern limit on North Rona, and another subspecies, *anceps,* is found on the extremely exposed shores at the north end of Lewis, North Rona, Sula Sgeir, the Flannan Isles and St. Kilda (Powell 1957, 1958). The sublittoral habitat and communities are comparable to those around St. Kilda (Brown 1985), with two cold-water species, the wolf fish *Anarhichas lupus* and the anemone *Phellia gausapata* being recorded from both islands.

Rockall is the most remote rock in the British Isles, lying some 360 km west of the Western Isles, and because of its isolation and extreme exposure it is of considerable scientific importance. Very few species with planktonic larvae are found in the littoral zone, and it has been suggested that mussels are absent from the rock, although Laffoley & Hiscock (1988) discovered a species of barnacle *Verruca stroemia* and a limpet *Tectura virginea*. The kelp *Laminaria hyperborea* is apparently absent too, with the shallow sublittoral being dominated by *Alaria esculenta*. Beneath this canopy there is a rich mosaic of sponges, hydroids, anemones and red algae, predominantly encrusting and low-growing species. Although the bedrock is richly colonised, species diversity is not as high as might be expected in such an extreme environment and remote location.

Region 16

Upper Loch Linnhe to Mallaig (including the Small Isles)

The shores of Loch Leven are strongly influenced by freshwater run-off, leading to impoverishment of the littoral communities present (Davies 1991). The head of the loch supports dense stands of the brown alga *Fucus ceranoides*, a species characteristic of brackish conditions. The tide-swept narrows at the entrance to the loch, at Ballachulish, as well as those of the Corran Narrows, which separate the upper and lower sections of Loch Linnhe, and those at Annat at the mouth of Loch Eil, have specialised communities which grow on cobbles in the fast-flowing tidal streams. They have rich horse mussel *Modiolus modiolus* beds, covered by dense stands of hydroids, particularly *Tubularia indivisa* (Connor 1990). The Ballachulish Narrows communities feature certain bivalves rarely encountered above low water mark and a rich assortment of sponges, hydroids and sea squirts under fronds of the toothed wrack *Fucus serratus*. Loch Eil, which forms the upper part of Loch Linnhe, has been found to contain water that is more saline than that of Loch Linnhe itself, despite being further from the sea (Smith 1981b). This is because denser, more saline water flows into the loch beneath the layer of fresh water. The limited rocky shores of upper Loch Linnhe and Loch Eil are dominated by fucoids (particularly the knotted wrack *Ascophyllum nodosum*), with muddy gravel areas featuring the cockle *Cerastoderma edule* and the bivalves *Dosinia exoleta* and *Venerupis senegalensis* (Smith 1981b). The sublittoral communities within Loch Eil appear to be poorly developed, with subtidal bedrock featuring the anemone *Protanthea simplex* and the brachiopod *Neocrania anomala*.

The Sound of Mull is notorious for its rock-strewn, current-swept waters, and a large number of ships have foundered here, many now supporting rich and varied biological communities. It also features a number of spectacular underwater vertical cliffs, which have high densities of sponges, hydroids, anemones and erect bryozoans (Bishop 1984). One such cliff can be found at the jetty at the entrance to Loch Aline, on the north side of the Sound of Mull, where a vertical wall of rock drops to a depth of over 90 m. The encrusting sponge *Hymedesmia paupertas*, unusual for its bright blue colour, has been recorded from here. The loch itself is very sheltered, with boulder slopes leading to a muddy bottom. The communities present are relatively impoverished when compared with those in the Sound of Mull. Sea squirts *Ciona intestinalis* and *Ascidia mentula* are present on subtidal bedrock below the kelp *Laminaria hyperborea* zone, while on the shallow fine mud, dense populations of the sea pen *Virgularia mirabilis* and the opisthobranch mollusc *Philine aperta* are noteworthy (Connor 1990).

Loch Sunart is a narrow fjordic sea loch and at 31 km in length is the second longest sea loch in Scotland, after Loch Fyne (Region 14). It has a complex bathymetry with numerous islands and rocks and a series of sills, which divide the loch into six basins. This, combined with a maximum depth of 124 m, means there is a very wide range of habitats, particularly in the sublittoral, and an exceptionally rich fauna and flora. There is a clear transition from exposed shores at the mouth of the loch to extremely sheltered sites towards the head, with shores gradually becoming more dominated by fucoid algae to the east. In addition, Davies & Connor (1993) reported the barnacles *Chthamalus montagui* and *Semibalanus balanoides* becoming less frequent and the kelps in the sublittoral fringe changing from *Alaria esculenta* and *Laminaria digitata* to predominantly *L. saccharina*. Smith (1978b) highlighted the shore at Camaschoirk as being particularly rich in both habitat and species diversity. Sediment shores towards the outer part of the loch held moderately exposed habitats, with crustaceans, polychaetes and the lugworm *Arenicola marina*. The sediments become progressively finer and muddier towards the head of Loch Sunart and in Loch Teacuis, which branches off the main loch (Howson *et al.* 1994). Some of the small sediment-filled embayments, such as at Salen Harbour, were covered by the brackish brown alga *Fucus ceranoides* and the unusual free-living *Ascophyllum nodosum* ecad *mackaii*. Dense growths of *Ascophyllum nodosum* with a rich understorey fauna were found in the divided tide-swept entrance channels leading into Loch Teacuis (Davies & Connor 1993). Patches of dwarf eelgrass *Zostera noltii* (amongst saltmarsh on the upper shore) and eelgrass *Z. marina* (on shallow subtidal sand and gravel) have also been reported from Loch Sunart (Cleator 1993).

Several of the best examples in all the Scottish sea lochs of subtidal, sheltered bedrock biotopes have been found in Loch Sunart (Howson *et al*. 1994). Muddy gravels in weak tidal streams support some of the best and most extensive beds in Britain of the gaping file shell *Limaria hians*. This unusual bivalve forms nests or galleries just beneath the surface of the gravel and thus remains largely hidden from view. Rich communities are present on deep, furrowed mud, with notable populations of the tall sea pen *Funiculina quadrangularis*, the fireworks anemone *Pachycerianthus multiplicatus*, the burrowing crab *Goneplax rhomboides* and the snake blenny *Lumpenus lampretaeformis* (Davies 1990). In addition, populations of the deep-water featherstars *Leptometra celtica* and *Antedon petasus* are found in shallow, near-shore areas of the loch. The rock and island complex at

the entrance to the loch supports an exceptionally rich variety of fauna and flora, with rich kelp *Laminaria hyperborea* forests (Davies 1990). Below the kelp, populations of the soft coral *Alcyonium glomeratum* are present, a south-western species found elsewhere on the west coast of Scotland only in the Sound of Mull and Firth of Lorne, together with the sea fan *Swiftia pallida*, a northern species, and the imperial anemone *Aureliania heterocera*. Sheltered rock here features a very diverse association of hydroids, ascidians and sponges, including a number of rare species (see also section 5.4).

The Ardnamurchan Peninsula is the westernmost part of the Scottish mainland, with Ardnamurchan Point being the only very exposed mainland site between Kintyre and the Minch (Holt in prep.). It was regarded by Harvey *et al.* as being of national marine biological importance. The coastline mainly comprises a series of very exposed steep rocky headlands characterised by barnacle and limpet-dominated biotopes with *Alaria esculenta* in the sublittoral fringe. There are also a few locally sheltered bays in which the rock is covered by dense fucoid algae and where white sandy beaches support burrowing crustacean and polychaete communities. Shallow sublittoral surge gully communities, with hydroid, bryozoan and anthozoan turfs, occur in the gullies between stacks on the sea cliffs. Offshore there are a number of charted pinnacles and reefs, including Bo Faskadale and Elizabeth Rock. The shallowest parts of these pinnacles are very exposed, with dense stands of (often very large) *Laminaria hyperborea*, together with dense foliose red algae, sponges and colonial ascidians. At greater depths, these faces are dominated by dense dead man's fingers *Alcyonium digitatum*, large colonies of the sulphur yellow sponge *Cliona celata* and other sponges including large *Pachymatisma johnstonia, Haliclona viscosa* and the cup sponge *Axinella infundibuliformis*. Anemones, cup corals and hydroids formed a turf over much of the rock surface. Overhangs and cave roofs support the zoanthid anemone *Parazoanthus anguicomus* (Holt in prep.).

Mingary, 2 km east of Kilchoan on the Ardnamurchan Peninsula, has a range of semi-exposed and sheltered habitats with a rich fauna and flora (including species rarely seen intertidally), which Harvey *et al*. (1980) considered to be of national marine biological importance. Kentra Bay (also known as Loch Ceall Traigh) is one of the largest areas of intertidal flats in western Scotland, and the faunal communities found here are considered to be particularly rich (Powell *et al*. 1980). Rocky shores at the mouth of the bay have examples of *Ascophyllum nodosum*-dominated communities, with sheltered tide-swept communities below low water mark (Howson *et al*. 1994).

Loch Moidart is unusual in that it has two rivers flowing into its head, and therefore considerable freshwater influence in its upper reaches, and two entrance channels connecting it to the sea. The southern entrance to the loch (where most water exchange takes place) is highly tide-scoured. The shallow rapids were described as being "particularly unusual" by Howson *et al*. (1994), as they feature a unique combination of fast tides, an exposed entrance and some freshwater influence. Maerl - predominantly *Phymatolithon calcareum* but sometimes *Lithothamnion corallioides* - is present in the northern entrance, together with a rich bryozoan fauna (Powell *et al*. 1980). In the subtidal in the northern arm of the loch there is soft mud with *Arenicola marina*, *Philine aperta* and *Virgularia mirabilis*. Elsewhere, boulder slopes are heavily grazed by urchins *Echinus esculentus*, with populations of the sabellid worm *Bispira volutacornis* and the ascidian *Pyura microcosmus* (Howson *et al*. 1994). Rocky areas have dense populations of the soft coral *Alcyonium digitatum* and a diversity of hydroids. In addition, Loch Moidart contains one of the largest expanses of intertidal fine sediment in western Scotland (Howson *et al*. 1994). The muddy sand flats have extensive populations of lugworm *Arenicola marina* and cockle *Cerastoderma edule* and patches of eelgrass *Zostera marina*.

In the Sound of Arisaig, the communities are more typical of the open coast than of sea lochs because of the greater exposure to wave action, with the sea cucumber *Neopentadactyla mixta* common in coarse sediments in shallow water (Howson 1990). The small sheltered sandy shore at Samalaman, on the southern side of the Sound of Arisaig, and the muddy gravel shore at Eilean nan Trom, within Loch Ailort, were regarded by Bishop & Holme (1980) as being of national marine biological importance on account of their rich intertidal burrowing communities. Loch Ailort itself is a long, narrow fjord with an exposed entrance in the Sound of Arisaig. Of particular note are the extensive and very rich sublittoral maerl beds in the outer section of the loch (Howson 1990). Associated with these were rich mixed sediment shores which also had some live maerl and populations of the sipunculid *Golfingia vulgaris*. An extensive bed of eelgrass *Zostera marina* is present at the loch's shallow entrance (and also in neighbouring Loch nan Uamh), and beds of the fucoid alga *Ascophyllum nodosum* ecad *mackaii* occur in sheltered areas. Below the kelp zone, moderately exposed rock is dominated by encrusting species such as the bryozoan *Parasmittina trispinosa* and numerous echinoderm species such as the starfishes *Porania pulvillus* and *Crossaster papposus*. More sheltered bedrock featured a community characterised by the anemone *Protanthea simplex* and the brachiopod *Neocrania anomala* (Howson 1990).

The shore at Eilean Ceann Feidh, at the head of the open sea loch of Loch nan Uamh, slopes steeply to a sandy channel with an excellent zonation of fucoids and red algae, particularly *Palmaria palmata* and the mat-forming *Audouinella floridula* on sand-scoured rocky areas. Powell *et al*. (1980) rated this area as being of national marine biological importance. The small island of Eilaen nan Cabar, on the northern side of the loch, also has steep slopes, with many of the boulders coated with silt. The rare green alga *Codium adhaerens* can be found here, at what is probably its northern limit (Powell *et al*. 1980).

Further north, Loch nan Ceall is a fjardic loch (one of only two such on the region's mainland, the other being Loch Laxford), with a typically irregular outline and series of shallow basins separated by shallow, often intertidal sills. This loch is unusual in that it has a group of skerries (rocky islets) protecting the entrance, with extensive intertidal fucal cover, which serve to create a narrow and shallow entrance channel with strong tidal flows. The channel is dominated by the kelps *Laminaria hyperborea* and *L. saccharina*, with maerl also present. Howson (1990) also reported that the loch holds good examples of several biotopes that are more common in Region 15: sheltered areas of coarse muddy sediments hold beds of *Ascophyllum nodosum* ecad *mackaii*, and soft sediment in a shallow basin inside the loch holds the rarely recorded small holothurian *Labidoplax media*, a species previously known in the British Isles only from Loch Eynort in South Uist and from one location in Ireland (Dipper 1985).

The shores of the Small Isles - Canna, Rum, Eigg and Muck - are largely of rock or boulders, backed by cliffs. Small eelgrass *Zostera marina* beds have been recorded off the east coast of Rum and the south-east coast of Eigg (Dipper 1981b). In the subtidal, Dipper (1981b) considered the marine life around Canna, Sanday and Muck to be very much more diverse than that around Rum, with Eigg appearing moderately diverse. A wide range of habitats are present, including tide-swept rock (particularly off the west coast of Muck), steep and vertical cliffs, reefs, sand and gravels. Heavy grazing by the sea urchin *Echinus esculentus* is common throughout the area. The sea pens *Pennatula phosphorea* and *Funiculina quadrangularis*, both species more characteristic of sheltered sea lochs, are found in muddy sediments off Rubha na Roinne on the north-east of Rum. The sea fan *Swiftia pallida,* a northern species, is common on deep reefs off the east coast of Rum and in the Sound of Eigg. At Sgeir a' Phuirt, off Sanday, a shallow vertical cliff face has a rich diversity of species, including several southern species, such as the anemones *Hormathia coronata* and *Actinothoë sphyrodeta*, and the rarely recorded sea cucumber *Parastichopus tremulus* (Dipper 1981b).

Mallaig to Loch Alsh

The Sound of Sleat, between Skye and the mainland, is a deep, tide-swept sound which gradually narrows to the north, resulting in strong tidal streams at Kyle Rhea where it joins Loch Alsh. A well-developed kelp forest of *Laminaria hyperborea* and *L. saccharina* is present along the northern shore, with the anemone *Sagartia elegans* and the starfish species *Asterias rubens*, *Marthasterias glacialis* and *Astropecten irregularis* all being common (Dipper 1981c). Two sea lochs open into the Sound from the mainland: Lochs Nevis and Hourn. Smith (1978b) considered the north coast of the entrance to Loch Nevis, between Sandaig and Inverie, to be of high interest for its molluscan fauna. The brackish upper reaches of both lochs support dense populations of the urchin *Psammechinus miliaris,* with the anemone *Protanthea simplex* and the brachipod *Neocrania anomala* typically present on sheltered subtidal bedrock. Forests of the impressive sea pen *Funiculina quadrangularis*, which can stand one metre tall, are commonly found in sediments below 25 m in both lochs. Near to the entrance of Loch Nevis, sheltered bedrock has rich communities of hydroids and ascidians (Howson *et al*. 1994).

Further to the north, the Duich system comprises a group of three fjords, Lochs Duich, Long and Alsh. Loch Duich is a long, narrow loch with sides that shelve steeply to form a basin over 100 m deep, with strong tidal currents at its mouth. The rocky shores extend beyond low water in the form of cliffs and boulder slopes, eventually becoming muddy sediments. The loch receives a significant input of freshwater, creating a distinct halocline and reducing water clarity, thereby limiting the depth at which algae are found (Connor 1989). Harvey *et al*. (1980) reported that the muddy gravel shore at the head of Loch Duich supports the most extensive bed (covering about 1 ha) of the free-living brown alga *Ascophyllum nodosum* ecad *mackaii* known in Scotland; in the same locality the brackish alga *Fucus ceranoides* is found on rocky areas towards the top of the shore. The effects of variable salinity conditions can be seen in some impoverished lower shore communities in the most sheltered parts, often dominated by large beds of mussels *Mytilus edulis*. By contrast, rich tide-swept rocky shore communities are present closer to the entrance. The narrows here feature cobble rapids dominated by brittlestars (particularly *Ophiopholis aculeata*), but beds of the horse mussel *Modiolus modiolus* and the gaping file shell *Limaria hians* are also present. Intense grazing by urchins *Psammechinus miliaris* and limpets *Tectura* spp. limit the diversity of erect algae and animal species. The cape form of the kelp *Laminaria digitata* is abundant in the shallows of this loch, although it appears absent from neighbouring Loch Long (Connor 1989). The best represented biotope in the Loch Duich system, and one particularly common within this loch, is very sheltered bedrock with *Protanthea simplex* and *Neocrania anomala* (Howson *et al*. 1994). Sublittoral cliffs more exposed to water movement feature communities rich in hydroids, such as *Abietinaria abietina* and *Sertularia argentea*. Towards the head of the loch, high densities of the spectacular fireworks anemone *Pachycerianthus multiplicatus*, comparable with those seen in Loch Fyne (Region 14), were present on areas of mud at 25 m depth, together with dense populations of the sea pen *Funiculina quadrangularis* (Connor 1989).

Loch Long comprises two basins over 30 m deep, separated by a shallow narrows. It is the second least saline sea loch in Scotland, with only Loch Etive having a greater freshwater input (Edwards & Sharples 1986). The entire water body tends to have a peaty colour, and in August/September 1988 a distinct halocline was reported at 3-4 m depth (Connor 1989). As with Loch Duich, this limits the depth to which sublittoral algae are found. In the most sheltered parts, the lower shore communities are generally impoverished, with sparse cover of the brown alga *Fucus serratus* and clumps of mussels *Mytilus edulis*. In the fine sediment at the head of the loch, high numbers of the blunt gaper shell *Mya truncata* occur, together with populations of the lugworm *Arenicola marina* (Connor 1989). In the subtidal, *Laminaria saccharina* is the dominant kelp species, though intense grazing by the urchin *Psammechinus miliaris* limits other algae. At the northern end of the outer narrows, steep rock exposed to moderately strong tidal streams supports a rich and unusual fauna, considerably altered by the brackish conditions. The large solitary ascidian *Ascidia virginea* is particularly common, whilst the smaller ascidians *Boltenia echinata* and *Pyura squamulosa* are present in unusually high numbers. Where bedrock gives way to boulder and cobble slopes on muddy sediments, the squat lobster *Munida rugosa*, the hydroid *Nemertesia antennina* and the starfish *Crossaster papposus* are commonly found (Connor 1989).

The main basin of Loch Alsh is 114 m deep at its deepest point (Edwards & Sharples 1986) and is surrounded by several shallower basins. The loch opens to the Sound of Sleat via Kyle Rhea and to the open coast via Kyle Akin, both subject to very strong tidal streams. Dense fucoid cover, sheltering rich tide-swept rock communities, dominates the shores of these narrows. Below a zone of kelp *Laminaria hyperborea* at Kyle Rhea, dabberlocks *Alaria esculenta,* an alga typical of more exposed conditions, is present on scoured bedrock (Scott 1991). Tide-swept communities on cobbles are rich in hydroids such as *Tubularia indivisa* and *Sertularia argentea*, as well as the barnacle *Balanus crenatus*, anemones and sponges. Unusual populations of the brittlestar *Ophiopholis aculeata* are also present here (Howson *et al*. 1994). At Kyle Akin, patchy beds of the unusual calcareous alga maerl are present

amongst a mixture of gravel, dead maerl, pebbles and shells. These beds support a variety of foliose algae including *Trailliella* spp., *Pterosiphonia parasitica*, *Halarchnion ligulatum* and *Porphyropsis coccinea*. In areas where maerl is absent, the anemones *Aureliana heterocera* and *Halcampa chrysanthellum* are found in patches of clean coarse gravel (Connor 1989). The wreck of the *Fort Napier* in Loch na Béist, which is exposed at low water, supports a rich fauna and flora, with the vertical sides colonised by the soft coral *Alcyonium digitatum*, the ascidians *Ciona intestinalis* and *Ascidia mentula* and a number of sponges (Dipper 1981b).

Isle of Skye

The island of Skye has until the last fifteen years or so been remarkably little studied in terms of its marine ecosystems. The island's long and sinuous coastline displays a wide range of exposed and sheltered rocky and sediment shores. There are a range of marine inlets, including fjords and open sea lochs and several large sounds with strong tides. Most of the lochs have exposed, open entrances (Howson *et al*. 1994). Around the south of Skye, deep water is present fairly close inshore, with rock slopes (usually of boulders) quickly giving way, by about 15 m depth, to shelving sediment (Dipper 1981c). Steep bedrock slopes are present to a depth of about 15 m around the southern half of the Sleat Peninsula, and very steep scree slopes are present at the northern end of the Sound of Sleat. Rock surfaces below the kelp forest are heavily grazed by large numbers of the urchin *Echinus esculentus* (Dipper 1981c). Extensive beds of thick dead maerl gravel (with some live *Phymatolithon calcareum*) are present around the Elgol and Sleat peninsulas, characterised by the burrowing sea cucumber *Neopentadactyla mixta* and the burrowing anemone *Peachia cylindrica*. In the sheltered headwaters of Loch Eishort, the surface of a sea bed of soft mud with occasional small boulders is dominated by the red alga *Phyllophora crispa,* to which many ascidians, mainly *Ascidiella aspersa* with some *Ascidia mentula*, are attached.

The shore at Vatten, at the western head of Loch Bracadale, has been described as the best intertidal rapids site on Skye (Gubbay 1988), with brackish water flowing over coarse black sand formed from eroded lava. A little further north, rich assemblages of small mollusc species have been reported from the sand and boulder shore at Claigan on the northern side of Loch Dunvegan (Gubbay 1988). In the sublittoral here, Hiscock & Covey (1991) reported a coarse sandy plain supporting an unusually rich and stable community, including solitary ascidians and the colonial anemone *Epizoanthus couchii* in large numbers. At the western entrance to this loch, at Dunvegan Head, is the smallest Marine Consultation Area in Scotland (Nature Conservancy Council 1990), highlighting the presence of a wide range of algae and animals in tide-swept gravels here. At several open coast sites, Hiscock & Covey (1991) found species characteristic of moderately exposed conditions, such as the branching calcareous bryozoan *Porella compressa*, the sea fan *Swiftia pallida* and the cup sponge *Axinella infundibuliformis*. In addition, very dense populations of the anemone *Hormathia coronata*, an uncommon species in Scotland, were present off Neist Point, further west. The eelgrass *Zostera marina* occurs locally on shallow sediments below kelp forests in some areas, for example in the Sound of Scalpay and Loch Slapin.

A number of maerl beds are known, including one in Loch Ainort, opposite Scalpay, which is composed of live *Lithothamnion corallioides* overlying thick mud (Dipper 1981c). Large numbers of the small urchin *Psammechinus miliaris* occur here, as well as the polychaete *Myxicola infundibulum* and various bivalves. The muddy gravel shore at Strollamus, just south of Loch Ainort, is rich in molluscs, with the small snail *Odostomia plicata* and the bivalves *Modiolus modiolus* and *Chlamys* spp. common (Gubbay 1988).

Loch Carron to Loch Torridon

Towards the mouth of Loch Carron, the boulder, gravel and muddy sand shore at Bagh an t-Strathaidh (near Duirinish) is of outstanding interest, particularly for the large biomass of bivalve molluscs (Smith 1978c). Further to the east, off Camas Dubh-ard, close to the small sheltered embayment at Plockton, there is a tombolo composed of living maerl (Powell *et al*. 1980). This is exceptionally rich in burrowing bivalves, such as *Dosinia exoleta*, *Venerupis pullastra*, *Venus striatula* and *Mya truncata* (Smith & Hiscock 1985). A small bed of eelgrass *Zostera marina* occurrs to the north. Strome Narrows have rich and diverse tide-swept bedrock communities, with a dense bed of the horse mussel *Modiolus modiolus* and abundant brittlestars (Smith & Hiscock 1985). The area also supports a 'nursery' of small urchins *Echinus esculentus* and *Psammechinus miliaris*. Loch Carron is notable for having a number of sublittoral communities that extend onto the shores, in particular beds of horse mussels *Modiolus modiolus* and of maerl *Lithothamnion coralliodes* (Connor & Little in prep. c). Smith (1978c) described the shore at Achintraid, Loch Kishorn, as "outstanding", particularly on account of its molluscan fauna.

Little information is available for the open coast between Loch Kishorn and the mouth of Loch Torridon. Loch Torridon itself stretches inland for 22 km and reaches 145 m at its deepest, and incorporates Loch Shieldaig within its central section. Of particular note is the shallow Ob Mheallaidh on the southern side of Upper Loch Torridon. It comprises an area of sand and gravel separated by a rock sill from the rest of the loch and supports a rich assortment of species, including hydroids, bryozoans, molluscs, maerl and eelgrass *Zostera marina* (Smith & Hiscock 1985). Elsewhere, the boulder areas on muddy gravel are dominated by fucoids, with a rich underboulder fauna. Dense areas of the free-living alga *Ascophyllum nodosum* ecad *mackaii* have also been recorded (Powell *et al*. 1980). In the deeper parts of the loch there are communities of brittlestars, sea pens and other burrowing megafauna. The Loch Torridon Narrows have dense stands of hydroids, and the rare northern starfish *Hippasteria phrygiana* has been recorded from within the loch (Connor & Little in prep. c). The rockpools present on the boulder shore at Loch Diabaig, on the northern side of Loch Torridon, have a rich and diverse flora and fauna (Smith 1978c).

Loch Gairloch to Cape Wrath

Howson *et al*. (1994) reported that the effects of grazing, primarily by the urchin *Echinus esculentus*, seem to be more pronounced in this section than further south, and this trend is also seen on deeper rock within sea lochs, from where most records of the bryozoan *Parasmittina trispinosa* and coralline algal-dominated rock on this part of the coast come.

Loch Gairloch is a large open loch, 64 m at its deepest, with an exposed entrance. The fucoid-covered rock on the lower part of rocky shores is subject to sand abrasion (Howson 1991b); there are also several beaches of fine sand with the thin tellin *Angulus tenuis* (Howson 1991b). In the subtidal, the typically exposed sediment biotope of gravel and coarse sand, characterised by the burrowing sea cucumber *Neopentadactyla mixta*, was found some distance into the loch. Further in, clean sand with the heart urchin *Echinocardium cordatum* and the lugworm *Arenicola marina* occur. Mixed sandy, shelly mud, with the sea pen *Virgularia mirabilis* and the scallop *Pecten maximus,* is present in some areas, while deep sheltered parts feature soft burrowed mud. The eelgrass *Zostera marina* also occurs locally on shallow sediments within the loch (Cleator 1993). Loch Ewe to the north is slightly more sheltered, although featuring similar sublittoral communities (Howson 1991b). It has a mix of rocky and sedimentary shores, the latter being of greatest interest. The moderately exposed, fine sandy beaches possess a thin tellin *Angulus tenuis* community, a crustacean-polychaete community and some development of a heart urchin *Echinocardium siliqua* community at low water, which Bishop & Holme (1980) regarded as being of national marine biological importance.

In general, the marine communities of Loch Broom and Little Loch Broom show many similarities (Holt 1991b). The gaping file shell *Limaria hians* has been recorded at the entrance to Little Loch Broom, where it was associated with maerl, and also from the sills within Loch Broom. The sublittoral fringe is dominated by forests of the kelp *Laminaria saccharina*, typical of sheltered situations, with the urchin *Echinus esculentus* or the brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra* also present. Below this, mixed sandy, shelly mud features the sea pen *Virgularia mirabilis* and the scallop *Pecten maximus*, with deeper parts having soft burrowed mud.

The Summer Isles as a whole do not exhibit as wide a diversity of sublittoral habitats and communities as other islands or island groups in the Hebrides (Dipper 1981c). The richest habitats within the Summer Isles, in terms of numbers of species and biomass, appear to be sea caves and the shallow sand and maerl areas rich in bivalves and algae. Off the northern tip of Priest Island, lying to the south-west of the main group of islands, a natural tunnel at 14 m depth provides a very good example of a habitat typical of heavy surge conditions, with abundant growths of the sponges *Halichondria panicea* and *Pachymatisma johnstonia* (Dipper 1981c). Off the south-west of Tanera Beg, a sea cave at 9 m depth, approximately 100 m long, with vertical sides and large boulders near the entrance, has a typical surge gully fauna with patches of the ascidian *Dendrodoa grossularia* and the sponges *Clathrina coriacea* and *Myxilla incrustans*, together with the anthozoans *Corynactis viridis*, *Sagartia elegans* and *Metridium senile* (Dipper 1981c). A thick live maerl bed occurs in the small bay of Mol Mor on Tanera Mhor, the maerl lying mainly on the tops of sand ridges and extending to about 20 m depth (Dipper 1981c). The red alga *Plocamium cartilagineum* covers much of the area, the commonest bivalves being *Ensis* spp., *Mya* spp. and *Lutraria* spp. (Dipper 1981c).

Around Isle Ristol and within Achnahaird Bay, Bishop & Holme (1980) described a variety of intertidal sediment types supporting communities characterised by a variety of species: thin tellin *Angulus* (*Tellina*) *tenuis*, lugworm *Arenicola marina*, sandmason worm *Lanice conchilega*, the bivalve *Venerupis pullastra*, and a community characterised by heart urchin *Echinocardium cordatum* and razor shell *Ensis siliqua*. The variety of communities in such a small area, compared with other sediment shores within this coastal sector, led Bishop & Holme (1980) to grade these sites as nationally important. These two sheltered areas are separated by the steep exposed rocky shores around the headland at Rubha Coigeach. Further to the north, Powell *et al*. (1980) noted good examples of exposed rocky and boulder shores around the Stoer Peninsula and sheltered shores on the east side of Oldany Island. The latter shores have a sufficiently wide range of habitats within a small area to merit national importance.

In Eddrachillis Bay, particularly well-developed examples of shallow surge-tolerant communities on subtidal gullies and on walls occur (Howson *et al*. 1994). On the south side of Eddrachillis Bay, Smith (1981b) noted the importance of the molluscan fauna in brackish Duart Lochan. The Loch a' Chairn Bhain complex, which includes Lochs Glencoul and Glendhu, has communities reflecting a variety of exposures to both wave-action and tidal streams (Davies 1989). In the outer part of Loch a' Chairn Bhain, coarse sediments have populations of the heart urchin *Spatangus purpureus* and the brittlestar *Amphiura securigera*; within the loch, increasing shelter produces finer sediments supporting populations of the echiuran worm *Amalosoma eddystonense* and the large bivalve *Arctica islandica,* together with more typical and widespread sheltered loch species. Upward-facing rocky areas are dominated by ascidians, particularly *Ciona intestinalis*, while boulders on sediment in the sheltered part of the loch support ascidians and brittlestars (Howson *et al*. 1994). The sills in Loch Glencoul feature nests of the gaping file shell *Limaria hians* in areas of muddy gravel. In deeper waters, areas of mixed sandy, shelly mud occur, with the sea pen *Virgularia mirabilis* and the scallop *Pecten maximus*. In addition there are rocks on muddy sediment, a typical sheltered habitat, and deep soft burrowed mud. At Kylesku Narrows, there are excellent examples of tide-swept biotopes, very rich in species, with bedrock being dominated by hydroids and the soft coral *Alcyonium digitatum* (Davies 1989).

Scourie Bay, to the south of Handa Island, is the only clean, moderately sheltered sediment shore on the west coast of Sutherland (Powell *et al*. 1980). It supports a tellin *Angulus* (*Tellina*) *tenuis* community, and though the infaunal invertebrate density is not high, it is still considered a site of marine biological importance. Close by, at Rudha Shios, there are numerous small rockpools colonised by the anemones *Metridium senile* and *Sagartia elegans*, both species more commonly found in the subtidal (Smith 1985).

Loch Laxford is one of two mainland fjardic sea lochs in Region 16 (the other being Loch nan Ceall). It has an exposed entrance and several very sheltered areas. In the innermost part of the loch, there is a large sheltered sediment-filled inlet, Traigh Bad na Baighe, with burrowing communities featuring the lugworm *Arenicola marina* and the peppery furrow shell *Scrobicularia plana*. This is the only extensive sheltered sediment shore of its kind in the area and is of national importance (Bishop & Holme 1980). Within the wide exposure range in the sublittoral, a good range of biotopes is represented, including exposed cliffs with jewel anemones *Corynactis viridis*; bedrock areas with the encrusting bryozoan *Parasmittina trispinosa* and coralline

crustose algae; and bedrock and boulders dominated by ascidians and hydroids. In shallower areas there are tide-swept cobble rapids with lush growths of the breadcrumb sponge *Halichondria panicea* on the kelp *Laminaria hyperborea*; and rapids which feature the 'hedgehog' rhodoliths (spiked pebbles) of maerl *Lithothamnion glaciale* (Holt 1991b). In more sheltered parts of the loch, plains of mixed muddy sands with shell gravel occur, with the sea pen *Virgularia mirabilis* and the scallop *Pecten maximus*. In deeper water, numerous burrowing animals were found on and in soft mud, including the Norwegian lobster *Nephrops norvegicus*, the angular crab *Goneplax rhomboides* and the sea pens *Virgularia mirabilis* and *Pennatula phosphorea* (Holt 1991b).

Howson *et al*. (1994) considered Loch Inchard to have a greater range of biotopes than any other loch within this sector of the coast. At the head of the loch there are beds of the free-living alga *Ascophyllum nodosum* ecad *mackaii*. Sheltered subtidal bedrock walls feature the anemone *Protanthea simplex* and the brachiopod *Neocrania anomala*. Sediment areas are similar to those in Loch Laxford, with mixed sandy, shelly mud and deep soft burrowed mud (Holt 1991b). To the north of Loch Inchard, Lochan nam Meallan at Oldshore has an extremely rich molluscan fauna (Smith (1981b). The shore at Sheigra is a good example of a fully exposed rocky site, with a zone of the kelp *Alaria esculenta* on the lower shore and the red alga *Porphyra umbilicalis* and the small periwinkle *Littorina neritoides* on the upper shore (Powell *et al*. 1980). The brown alga *Fucus vesiculosus* in its *linearis* form is also found here.

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

Little information is available on the sea bed from offshore locations in Regions 15 & 16, other than that shown on Admiralty charts and British Geological Survey maps.

4.2.3 Human activities

A number of human activities that affect sea-bed habitats and communities take place in these regions, many of which are described in Chapter 9. Of particular note is fin-fish and molluscan mariculture, as these activities take place in most of the sea lochs discussed in this section and have an impact on benthic communities in the vicinity of farm sites. Mariculture is discussed in section 9.2.

Additional activities specific to Region 15 included, until recently, the commercial harvesting of knotted wrack *Ascophyllum nodosum* from the sheltered shores of sea lochs on the east coast of the Western Isles and the collection of tangle (drift kelp plants, mostly *Laminaria hyperborea)* (Norton & Powell 1979). This weed was transferred to the mainland for processing into alginates. Walker (1947) estimated that 70% of Scotland's fucoid biomass (mostly *A. nodosum)* occurs in the Western Isles, the bulk of it in the Uists and Benbecula. However, one of only two Scottish alginate factories has recently closed down, and the future of this industry seems uncertain (J. Baxter pers. comm.). Drift kelp plants *Laminaria* spp. are also traditionally collected for fertilising crofts, particularly in the Hebrides. Throughout the Minch area cockle harvesting and periwinkle gathering by hand occurs, though this is thought to have little effect on existing populations and habitats at current levels (Bryan 1994).

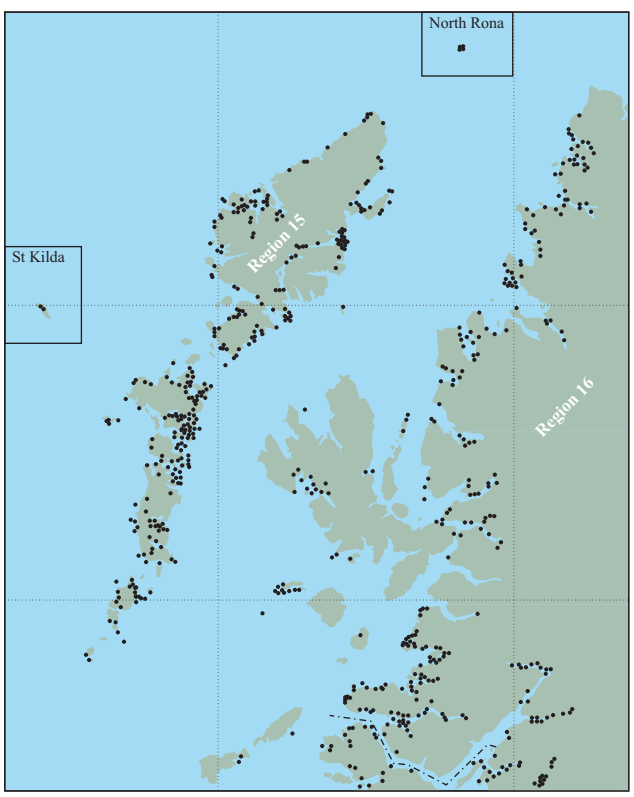
4.2.4 Information sources used

The JNCC's Marine Nature Conservation Review (MNCR) team has surveyed all the sea lochs within this region, as part of their major programme to investigate Scotland's sea lochs, undertaken between 1988 and 1992. 21 Area Reports were produced (see Howson *et al*. (1994) for a summary). In addition the MNCR team have carried out littoral and sublittoral surveys of the Ardnamurchan Peninsula (1994) and Barra and its surrounding islands (1996). 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 (see Connor & Hiscock 1996). Survey information from other sources may vary considerably in its methodology and coverage. Table 4.2.2 shows the number of sites with marine benthic habitat and species information held on the MNCR database, and Maps 4.2.2 and 4.2.3 show,

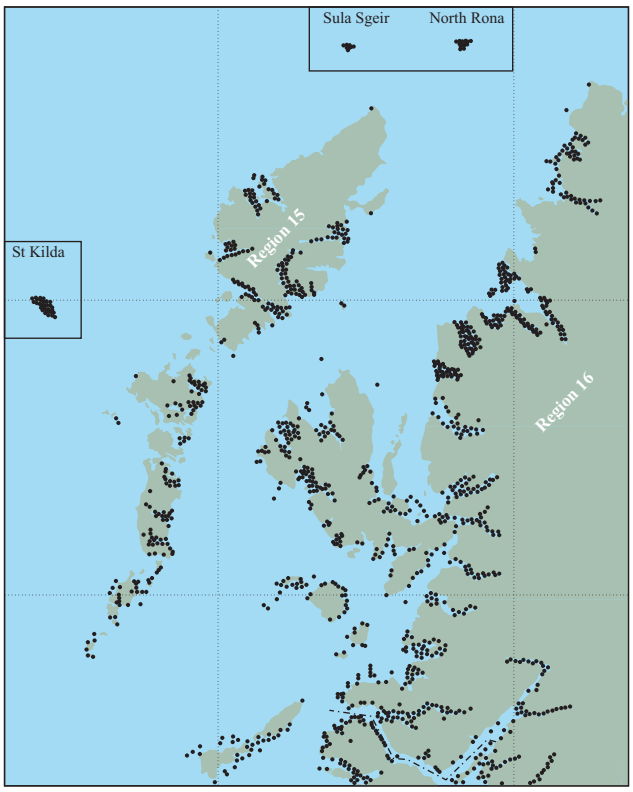
Table 4.2.2 Number of sites with marine benthic habitat and species information held on the MNCR database

	Littoral	*Near-shore sublittoral*	*Offshore*	*Total*
Region 15	238	504	0	742
Region 16	322	991	0	1,286
Regions 15 & 16	***560***	***1,495***	***0***	***2,028***

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



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.

respectively, littoral and near-shore sublittoral surveys recorded on the JNCC's MNCR database.

The only centres for marine biological research in the regions are the SOAEFD field stations at Ardtoe (Moidart) and Poolewe (Loch Ewe). Their work is primarily oriented towards inshore fisheries research, including shellfish and fish-farming. The Scottish Association for Marine Science (SAMS - formerally the Scottish Marine Biological Association), based at Dunstaffnage near Oban, 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). Smith (1978a, b, c, 1981a, b, 1983, 1985) undertook a number of surveys of shores (with particular emphasis on the molluscan fauna) for NCC throughout the west of Scotland and the Western Isles. Though there are no marine biological research stations in the Western Isles, the area has attracted much attention because of its remoteness, its natural beauty and its wide variety of marine habitats. Consequently, the islands' marine communities are perhaps better known than those on the less remote coast of north-west Scotland.

Bishop (1984) described dive sites within the Sound of Mull, and Dipper (1981b) reported on a diving survey of the Small Isles (Rum, Canna, Eigg and Muck). The southern part of Skye was surveyed by a Marine Conservation Society diving team (Dipper 1981c), while the northern part of the island was surveyed by Holt (1988) and Hiscock & Covey (1991). The shallower parts of Loch Nevis and Loch Hourn were surveyed by Breen *et al*. (1986), with Loch Nevis receiving more detailed attention by MNCR teams in 1988 and 1990.

The shores of the Summer Isles were surveyed by Heriot-Watt University expeditions in 1978 and 1979 (Anon. 1978-79), providing extensive species lists, and Jones (1980) and Dipper (1981a) investigated sublittoral habitats around the islands. Several Seasearch Phase 1 surveys have been carried out at a number of locations within the area, e.g. Canna (MacKinnon 1989); Skye sea lochs (Holt 1988); Gruinard Bay, Lochs Ewe and Gairloch (Gubbay 1990); and Loch Broom and Little Loch Broom (Gubbay & Nunn 1988). A Phase 1 survey of Lochs Sunnart and Teacuis was carried out in 1994 (Fuller *et al*. 1995).

A compilation of studies relating to the environment of the Western Isles, including a number covering marine aspects, was brought together by Boyd (1979). Powell *et al*. (1979) gave a description of the main shore communities in the Western Isles, selecting seventeen areas as being of particular marine biological interest. Norton & Powell (1979) gave a checklist of marine algae for the islands of the Western Isles. Cadman *et al*. (1993) reported on an expedition to survey the marine fauna of the St. Kilda archipelago.

For offshore areas, work is currently under way on a number of projects based at the marine laboratories of Dunstaffnage and Aberdeen, although little information has been published so far. In particular, the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD), Aberdeen, have been undertaking extensive broad-scale mapping of sea-bed substrata in the north and south Minch. In 1997 it is intended to extend the geographical scope of the study to include offshore areas to the south of the Minch (Malin Sea) and to the west of the Western Isles to a depth of 200 m (D. Murison pers. comm.).

4.2.5 Acknowledgements

The author acknowledges the help of JNCC's Marine Nature Conservation Review team (particularly Dr Tim Hill and Kate Northen) in compiling and presenting the information given here. The MNCR literature reviews by David Connor & Mike Little (in prep. a, b, c) have been widely consulted. John Baxter (SNH) and Derek Murison (SOAEFD) kindly gave additional information. Thanks are also due to Paul Tyler for commenting on the text.

4.2.6 Further sources of information

A. References cited

Anon. 1978-79. *Distribution of littoral species on the Summer Isles from student fieldwork, 1978 & 1979*. Edinburgh, Heriot-Watt University. (Unpublished.)

Bagenal, T.B. 1957. The vertical range of some littoral animals on St. Kilda. *Scottish Naturalist, 69:* 50-51.

Bishop, G.M. 1984. Report of the Mull expedition, June 4-18, 1983. *Nature Conservancy Council*, *CSD Report*, No. 528.

Bishop, G.M., & Holme, N.A. 1980. Survey of the littoral zone of the coast of Great Britain. Final report - part 1: the sediment shores: an assessment of their conservation value. *Nature Conservancy Council*, *CSD Report*, No. 326.

Boyd, J.M., *ed*. 1979. The natural environment of the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh*. *Series B*: *Biological Sciences*, *77B*, 3-19.

Breen, J.P., Connor, D.W., & McKenzie, J.D. 1986. A marine survey of Loch Nevis and Loch Hourn, western Scotland. *Glasgow Naturalist*, *21*: 153-172.

Brown, G. 1985. *British Sub-Aqua Club expedition to Rona, Sula Sgeir and Stack Skerry*. Ellesmere Port, British Sub-Aqua Club. (Unpublished.)

Bryan, A. 1994. *The Minch Review*. Inverness, Scottish Natural Heritage and Western Isles Island Council.

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

Cadman, P., Ellis, J., Geiger, D., & Piertney, S. 1993. *A survey of the marine fauna of the St. Kilda archipelago*. Swansea, University College of Swansea. (Unpublished.)

Cleator, B. 1993. *The status of the genus* Zostera *in Scottish coastal waters*. Edinburgh, Scottish Natural Heritage. (Scottish Natural Heritage Review, No. 22.)

Connor, D.W. 1989. Survey of Loch Duich, Loch Long and Loch Alsh. *Nature Conservancy Council*, *CSD Report*, No. 977.

Connor, D.W. 1990. Survey of Lochs Linnhe, Eil, Creran and Aline. *Nature Conservancy Council*, *CSD Report*, No. 1,073.

Connor, D.W. 1994. The sublittoral ecology of Scotland's islands. *In: The islands of Scotland. A living marine heritage*, ed. by J.M. Baxter & M.B. Usher. Edinburgh, HMSO.

Connor, D.W., & Hiscock, K. 1996. Data collection methods. *In: Marine Nature Conservation Review: rationale and methods*, ed. by K. Hiscock, 51-65 & Appendices 5-10. Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR Series.)

Connor, D.W., & Little, M. In prep. a. *Benthic marine ecosystems in Great Britain: a review of current knowledge. Chapter 14, West Scotland (MNCR Sector 13).* Peterborough, Joint Nature Conservation Committee.

Connor, D.W., & Little, M. In prep. b. *Benthic marine ecosystems in Great Britain: a review of current knowledge. Chapter 15, Outer Hebrides (MNCR Sector 14).* Peterborough, Joint Nature Conservation Committee.

Connor, D.W., & Little, M. In prep. c. *Benthic marine ecosystems in Great Britain: a review of current knowledge. Chapter 16, North-west Scotland (MNCR Sector 15).* Peterborough, Joint Nature Conservation Committee.

Dalkin, M.J. In prep. *Marine Nature Conservation Review: Sector 14. Barra and surrounding islands: area summary.* Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR Series.)

Davies, J. 1990. Sublittoral survey of Loch Sunart and Loch Teacuis. *Nature Conservancy Council*, *CSD Report*, No. 1,075.

Davies, J. 1991. Marine biological survey of Loch Leven. *Nature Conservancy Council*, *CSD Report*, No. 1,191.

Davies, L.M. 1989. Surveys of Scottish sea lochs: Lochs a'Chairn Bhain, Glendhu and Glencoul. *Nature Conservancy Council*, *CSD Report*, No. 983.

Davies, L.M., & Connor, D.W. 1993. Littoral survey and sublittoral sampling in Loch Sunart. *Joint Nature Conservation Committee Report*, No. 121.

Dipper, F. 1981a. Sublittoral survey in the Small Isles, Inner Hebrides. *Nature Conservancy Council*, *CSD Report*, No. 314.

Dipper, F. 1981b. Report of a sublittoral survey of south Skye, Inner Hebrides. *Nature Conservancy Council*, *CSD Report*, No. 342.

Dipper, F. 1981c. Sublittoral survey of the Summer Isles, Ross and Cromarty. *Nature Conservancy Council*, *CSD Report*, No. 365.

Dipper, F. 1983. Sublittoral survey of habitats and species in and around Loch Roag, Lewis, Outer Hebrides. *Nature Conservancy Council, CSD Report*, No. 505.

Dipper, F. 1985. Sublittoral survey of Loch Eynort, South Uist, Outer Hebrides, July 14-28 1984. *Nature Conservancy Council, CSD Report*, No. 611.

Earll, R.C., & Pagett, R.M. 1984. A classification and catalogue of the sea lochs of the Western Isles. *Nature Conservancy Council*, *CSD Report*, No. 525.

Edwards, A., & Sharples, F. 1986. *Scottish sea lochs: a catalogue*. Oban, Scottish Marine Biological Association and Nature Conservancy Council.

Fuller I., Cleator, B., & Irvine, M. 1995. *Loch Sunart and Loch Teacuis littoral biotope survey and seaweed resource assessment*. Edinburgh, Scottish Natural Heritage. (Unpublished.)

Gauld, D.T., Bagenal, T.B., & Connell, J.H. 1953. The marine fauna and flora of St. Kilda. *Scottish Naturalist*, *65*: 29-49.

Gilbert, O.L., Holligan, P.M., & Holligan, M.S. 1973. The flora of North Rona, 1972. *Transactions and Proceedings of the Botanical Society of Edinburgh*, *42*: 43-68.

Gubbay, S. 1988. *Coastal directory for marine nature conservation*. Ross-on-Wye, Marine Conservation Society.

Gubbay, S. 1990. Seasearch survey of Gruinard Bay, Loch Ewe and Loch Gairloch. *Nature Conservancy Council*, *CSD Report*, No. 1,082.

Gubbay, S., & Nunn, J. 1988. Seasearch survey of Loch Broom and Little Loch Broom. *Nature Conservancy Council*, *CSD Report*, No. 898.

Harvey, R., Knight, S.J.T., Powell, H.T., & Bartrop, J. 1980. Survey of the littoral zone of the coast of Great Britain. Final report - part 2: the rocky shores: an assessment of their conservation value. *Nature Conservancy Council*, *CSD Report*, No. 326.

Hiscock, K. 1992. The ecology and conservation of sublittoral hard substratum ecosystems in Scotland. *In*: *Marine conservation in Scotland*, ed. by J.M. Baxter & A.D. McIntyre. *Proceedings of the Royal Society of Edinburgh*. *Series B*: *Biological Sciences*, *100*: 95-112.

Hiscock, S., & Covey, R. 1991. Marine biological surveys around Skye. *Nature Conservancy Council*, *CSD Report*, No. 1,076. (Marine Nature Conservation Review Report, No. MNCR/SR/3.)

Holt, R.H.F. 1988. Seasearch: Skye sea lochs. *Nature Conservancy Council*, *CSD Report*, No. 897.

Holt, R.H.F. 1991a. Surveys of Scottish sea lochs. Sea lochs on the Isle of Harris and Lewis. Part II. *Joint Nature Conservation Committee Report*, No. 4.

Holt, R.H.F. 1991b. Surveys of Scottish sea lochs. Lochs Laxford, Inchard, Broom and Little Loch Broom. *Joint Nature Conservation Committee Report*, No. 16.

Holt, R.H.F. In prep. *Marine Nature Conservation Review: Sectors 13-15. Ardnamurchan Peninsula: area summary.* Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR series.)

Howson, C.M. 1989. Surveys of Scottish sea lochs. Sea lochs on the Isle of Harris and Lewis. *Nature Conservancy Council*, *CSD Report*, No. 982.

Howson, C.M. 1990. Survey of Scottish sea lochs. Sea lochs of Arisaig and Moidart. *Nature Conservancy Council*, *CSD Report*, No. 1,086.

Howson, C.M. 1991a. Surveys of Scottish sea lochs. The sea lochs of North and South Uist and Benbecula. *Joint Nature Conservation Committee Report*, No. 3.

Howson, C.M. 1991b. Surveys of Scottish sea lochs. Loch Gairloch and Loch Ewe. *Joint Nature Conservation Committee Report*, No. 15.

Howson, C.M., Connor, D.W., & Holt, R.H.F. 1994. The Scottish sea lochs - an account of surveys undertaken for the Marine Nature Conservation Review. *Joint Nature Conservation Committee Report*, No. 164. (Marine Nature Conservation Review Report, No. MNCR/SR/27.)

Howson, C.M., & Picton, B.E. 1985. A sublittoral survey of St. Kilda. *Nature Conservancy Council*, *CSD Report*, No. 595.

Jones, D. 1980. *A marine survey of the Summer Isles*. Huntingdon, Nature Conservancy Council. (Unpublished.)

Laffoley, D.d'A., & Hiscock, K. 1988. *Marine biological survey of Rockall, 28 & 29 June 1988. Field report*. Peterborough Nature Conservancy Council. (Unpublished report.)

Lewis, J.R. 1957. An introduction to the intertidal ecology of the rocky shores of a Hebridean island. *Oikos, 8:* 130-160.

MacKinnon, M.C. 1989. Seasearch: Canna expedition. *Nature Conservancy Council*, *CSD Report*, No. 899.

Maggs, C.A. 1986. Scottish marine macroalgae: a distributional checklist, biogeographical analysis and literature abstract. *Nature Conservancy Council*, *CSD Report*, No. 635.

Mitchell, R., Dipper, F.A., Earll, R., & Rowe, S. 1980. A preliminary study of Loch Obisary: a brackish Hebridean loch. *Progress in Underwater Science. New Series, 5*: 99-118.

Nature Conservancy Council. 1990. *Marine Consultation Areas: Scotland*. Edinburgh, Nature Conservancy Council. (Unpublished report.)

Norton, T.A., & Powell, H.T. 1979. Seaweeds and rocky shores of the Outer Hebrides. *In*: *The natural environment of the Outer Hebrides*, ed. by J.M. Boyd. *Proceedings of the Royal Society of Edinburgh. Series B: Biological Sciences*, *77B*: 141-153.

Powell, H.T. 1957. Studies in the genus *Fucus* L. II. Distribution and ecology of forms of *Fucus distichus* L. emend. Powell in Britain and Ireland. *Journal of the Marine Biological Association of the United Kingdom*, *36*: 663-693.

Powell, H.T. 1958. Occurrence of forms of *Fucus distichus* L. emend. Powell on North Rona and Sula Sgeir. *Nature*, *182*: 1246.

Powell, H.T., Holme, N.A., Knight, S.J.T., Harvey, R., Bishop, G., & Bartrop, J. 1979. Survey of the littoral zone of the coast of Great Britain: 3. Shores of the Outer Hebrides. *Nature Conservancy Council*, *CSD Report*, No. 272.

Powell, H.T., Holme, N.A., Knight, S.J.T., Harvey, R., Bishop, G., & Bartrop, J. 1980. Survey of the littoral zone of the coast of Great Britain: 6. Report on the shores of north-west Scotland. *Nature Conservancy Council*, *CSD Report*, No. 289.

Scott, S. 1991. *Marine biological survey of the proposed Skye bridge route.* Unpublished report to Miller Construction.

Smith, S.M. 1978a. Mollusca of rocky shores: North Uist, Benbecula and South Uist, Outer Hebrides. *Nature Conservancy Council*, *CSD Report*, No. 210.

Smith, S.M. 1978b. Shores of west Inverness-shire and north Argyll, with emphasis on the Mollusca. *Nature Conservancy Council*, *CSD Report*, No. 226.

Smith, S.M. 1978c. Shores of Wester Ross, with emphasis on the Mollusca of rocky shores. *Nature Conservancy Council*, *CSD Report*, No. 227.

Smith, S.M. 1981a. Littoral Mollusca of west Sutherland and Coigach. *Nature Conservancy Council*, *CSD Report*, No. 358.

Smith, S.M. 1981b. Littoral Mollusca of west Inverness-shire and north Argyll (II). *Nature Conservancy Council*, *CSD Report*, No. 358.

Smith, S.M. 1983. The shores of Lewis: marine flora and fauna. *Nature Conservancy Council*, *CSD Report*, No. 470.

Smith, S.M. 1985. *A survey of the shores and shallow sublittoral of west Sutherland*. Unpublished report to the Nature Conservancy Council.

Smith, S.M., & Hiscock, S. 1985. A survey of the shores and shallow sublittoral of Loch Torridon and Loch Carron (including Loch Kishorn) 1985. *Nature Conservancy Council*, *CSD Report*, No. 610.

Walker, F.T. 1947. A seaweed survey of Scotland. Fucaceae. *Proceedings of the Linnean Society of London*, *159*: 90-99.

B. Further reading

Further details of sea-bed communities in the region are in the *Coastal & marine UKDMAP datasets* module (Barne *et al.* 1994), available from JNCC Coastal Conservation Branch, Peterborough.

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.

Dipper, F. 1981. *Gordon Ridley's underwater photographs of north-west Scotland; an analysis*. Peterborough, unpublished report to the Nature Conservancy Council.

Eleftheriou, A., & McIntyre, A.D. 1976. *The intertidal fauna of sandy beaches - a survey of the Scottish coast*. Aberdeen, Department of Agriculture & Fisheries for Scotland. (Scottish Fisheries Research Report, No. 6.)

Eno, N.C., *ed.* 1991. *Marine conservation handbook.* 2nd ed. Peterborough, English Nature.

Hiscock, K., *ed*. 1996. *Marine Nature Conservation Review of Great Britain. Volume 1: rationale and methods*. Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR series.)

Lewis, J.R. 1957. Intertidal communities of the northern and western coasts of Scotland. *Transactions of the Royal Society of Edinburgh, 63*: 185-220.

Mills, D.J.L., Hill, T.O., Thorpe, K., and Connor, D.W. 1993. Atlas of marine biological surveys in Britain. *Joint Nature Conservation Committee Report*, No. 167. (Marine Nature Conservation Review Report MNCR/OR/17).

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

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Marine nature conservation issues in Scotland	*Aquatic Environments Branch, RASD, SNH, Edinburgh, tel: 0131 554 9797
MNCR database	*MNCR Team, JNCC, Peterborough, tel: 01733 62626
Offshore benthic studies relating to fisheries	*SOAEFD, Marine Laboratory, Aberdeen, tel: 01224 876544
General marine science information	Scottish Association for Marine Science (formerly Scottish Marine Biological Association), Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244
Shellfish collection (as curios)	Association of Scottish Shellfish Growers, 'Mountview', Ardvasar, Isle of Skye IV45 8RU, tel: 0147 14 324

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

4.3 Plankton

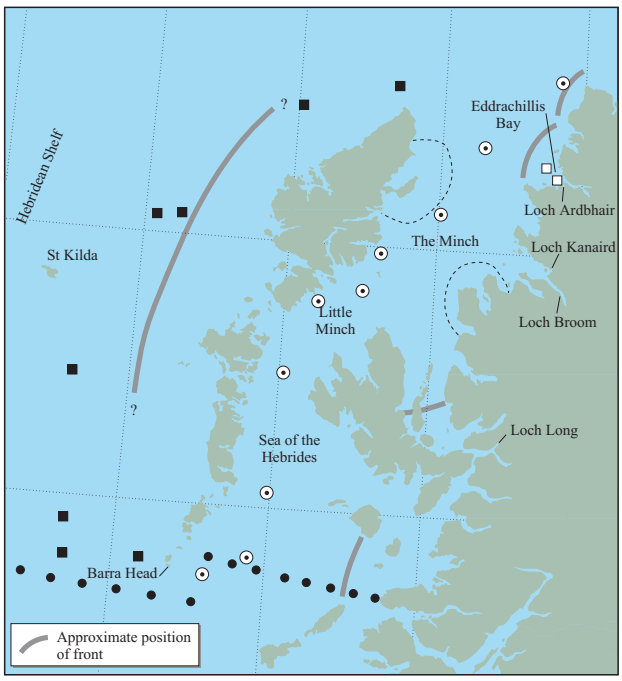
M. Edwards & A.W.G. John

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 also section 2.3), as well as by the presence of local benthic (bottom-dwelling) and littoral (shoreline) communities (see also 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 Regions 15 and 16 (Map 4.3.1) 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 discolouration 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 Regions 15 and 16, 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.

The waters off the Hebridean Shelf are well mixed during the winter, and Atlantic water is able to penetrate to the west of the Western Isles (Region 15) (Ellett 1979). By summer most of this area is stratified, with less dense coastal water spreading westward from coastal areas. Hughes (1976) suggested the possibility of a frontal boundary existing between mixed water circulating west of the Western Isles and Atlantic water over the shelf (Map 4.3.1). In Region 16, infra-red satellite photographs have indicated the possible presence of four frontal boundaries, at the entrances to the major firths and sounds (Map 4.3.1) (Gowen 1987). Because of the numerous sea lochs in the region, inshore coastal waters there are less saline and generally flow northward through the Little Minch (Ellett 1979).



Map 4.3.1 Locations of surveys and approximate (or conjectured: ?) positions of frontal boundaries. Source: after Hughes (1976) and Gowen (1987). See Table 4.3.2 for key to symbols.

The timing of the spring bloom offshore in Regions 15 and 16 is earlier than in the northern North Sea, but overall abundance and duration of total phytoplankton numbers is quite low compared with the central and southern North Sea. Studies by Simpson & Tett (1986) found that surface layer chlorophyll in Region 15 increased around the islands of St. Kilda and Barra Head, possibly due to enhanced mixing. Over most of Region 16 chlorophyll *a* concentrations range between 1-2 µg/l, except during exceptionally large blooms, which can occur in certain sea lochs (Salvidge & Lennon 1987). Sea lochs have a constant exchange of water between loch and sea, which has important implications for the growth of phytoplankton populations. Studies by Nellen & Schadt (1992) found that fairly large fluctuations in zooplankton taxa occur in Regions 15 and 16, indicating that environmental conditions differ from year to year. However, overall variability in the zooplankton biomass is low, indicating a relatively stable ecosystem.

4.3.2 Important locations and species

In Region 15 (Western Isles) survey evidence suggests that the phytoplankton is dominated by northern intermediate (mixed water) and north-east Atlantic species. Studies by Salvidge & Lennon (1987) found that diatoms are the main component of the phytoplankton over the Hebridean Shelf during spring and early summer, with initial growth being dominated by *Nitzschia* spp. and then by *Chaetoceros* spp. During the summer there is a decrease in diatom numbers, followed by a substantial increase in microflagellates and dinoflagellates, especially *Prorocentrum balticum*.

Copepods are the group with the highest diversity in the zooplankton, with overall zooplankton biodiversity increasing towards the open sea. The zooplankton is dominated by copepods *Acartia clausi* and *Pseudocalanus elongatus*. The larger copepod *Calanus finmarchicus* and euphausiids, especially *Thysanoessa* spp., can also be very common at times. The *Calanus* spp. start to increase earlier in the year than the smaller copepods, which are most dominant over the shelf but start to decline in numbers in July, when they migrate to deeper waters (off the shelf edge). Other commonly found zooplankton include the chaetognath (arrow worm) *Sagitta elegans* (a species indicative of mixed oceanic and coastal water masses), small hydromedusae, amphipods and meroplanktonic larval forms of echinoderms, polychaetes, decapods, molluscs and cirripedes. The overall abundance of copepods in Region 15 is quite high compared with other areas.

Region 15 is an important spawning area for herring, and consequently herring larvae make up a sizeable percentage of the zooplankton biomass at certain times of the year. Studies by Nellen & Schadt (1992) found that herring larvae exceeded 800 larvae per m^2 in September 1982 and their survival was very much dependent on the availability of small copepods, particularly *Paracalanus* spp. and *Pseudocalanus* spp. The adult herring in this region are also dependent on the abundance of copepods for food. Herring abundance can sometimes be correlated with numbers of *Calanus finmarchicus*.

Evidence from surveys in Region 16 indicate that diatoms are the main component of the phytoplankton during spring, which is typically dominated by *Thalassiosira* spp. and *Skeletonema costatum*. In June and July, small flagellates and dinoflagellates are an important component of the biomass. Unusually for summer stratified waters of the British Isles (where dinoflagellates normally dominate), diatoms were still found to be the dominant group in August (Salvidge & Lennon 1987; Gowen *et al*. 1983).

As in Region 15, the zooplankton of Region 16 is typically dominated by the intermediate copepods *A. clausi, P. elongatus* and *Temora longicornis*, although northern oceanic species can sometimes be found. The overall abundance and seasonal duration of copepods in Region 16 is similar to Region 15. Other commonly found zooplankton include euphausiids, decapod larvae, echinoderm larvae, fish larvae and the chaetognath *Sagitta elegans*. As in Region 15, in Region 16 the zooplankton are critical to the survival of commercially important fish species (e.g. herring), which spawn in this region or migrate through the area as larvae and pelagic adults.

4.3.3 Human activities

Dinoflagellates are of particular importance to the coastal manager because certain species can have toxic effects on other marine life. They can become the dominant taxa in sea lochs during the summer, if the loch becomes thermally stratified (Gowen 1987). For the purposes of management and insurance, Gowen (1987) distinguished two types of area in which the likelihood of toxic blooms is increased: areas near the frontal boundaries that exist at the entrance to most firths and sounds (Map 4.3.1), and sea lochs with high levels of dissolved inorganic nitrate and a long flushing time. In Region 16, 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 *Dinophysis acuminata* has been associated with Diarrhetic Shellfish Poisoning (DSP) in humans. The occurrence of DSP has been associated with low salinity in coastal water and calm weather.

Table 4.3.1. Distribution of toxic species and occurrence of blooms in Region 16

Species	*Date*	*Location*	*Maximum no. cells/ litre*
'Flagellate X'	June 1982	Loch Kanaird & Loch Broom	0.1-0.4 x 10^6
Gyrodinium aureolum	June 1977	Sea of the Hebrides & the Minches	n/a
Dinophysis acuminata	1992	Loch Long	0.946 x 10^6

Sources: after Gowen (1987) and others. Key: n/a = not available.

4.3.4 Information sources used

The marine environment of Regions 15 and 16 has been little studied compared with other coasts of the British Isles, and as a consequence little is known of the plankton of these regions. A plankton study covering Regions 15 and 16 was conducted by Salvidge & Lennon (1987), who investigated phytoplankton production in relation to hydrography. The Aberdeen Laboratory has collected data in Region 15 during occasional surveys since the 1920s (Fraser 1955), although this early work was mainly concerned with water mass indicator species. A survey by Simpson & Tett (1986) investigated the so-called 'island mass' effect around St. Kilda. Gowen *et al*. (1983) investigated the phytoplankton ecology of Loch Ardbhair in Region 16.

Since 1967 the larval herring stock (ichthyoplankton) has been investigated by various European countries. During the early 1980s these data were further analysed to reveal overall zooplankton abundance and taxonomical composition (Nellen & Schadt 1992). Unfortunately, the Continuous Plankton Recorder (CPR) survey has never sampled in Region 15 or 16, so a long-term time series of data on plankton is not available. SOAEFD is currently engaged in an oceanographic study of the Minches which will produce new data on plankton in this area. Table 4.3.2 summarises the plankton surveys in the regions (Map 4.3.1).

Table 4.3.2 Details of surveys

Identification in Map 4.3.1	*Frequency*	*Period*	*Reference*
PS (●)	Occasional	1983	Salvidge & Lennon 1987
PS (○)	Occasional	1977	Holligan *et al*. 1980
PS (■)	Occasional	1953	Fraser 1955
PS (□)	Approx. monthly	1981-1982	Gowen *et al*. 1983
_ _ _ _ _ _ (PHD)	Occasional	1930-1934	Hardy 1939
Hebridean Shelf	Approx. monthly	1936-39; 1946-50	Fraser 1952
St. Kilda	Occasional	1983; 1984	Simpson & Tett 1986
Regions 15 & 16	Occasional	1967-1989	Nellen & Schadt 1992

Key: PS: Plankton samples; PHD: Plankton herring data.

4.3.5 Further sources of information

A. References cited

Ellett, D.J. 1979. Some oceanographic features of Hebridean waters. *Proceedings of the Royal Society of Edinburgh, 77B*: 61-74.

Fraser, J.H. 1952. The Chaetognatha and other zooplankton of the Scottish area and their value as biological indicators of hydrographic conditions. *Marine Research, 2*: 1-52.

Fraser, J.H. 1955. The plankton of the waters approaching the British Isles in 1953. *Marine Research, 1*: 1-12.

Gowen, R.J. 1987. Toxic phytoplankton in Scottish coastal waters. *Rapports et Proces-verbaux des Reunions. Conseil Permanent International pour l'Exploration de la Mer, 187*: 89-93.

Gowen, R.J., Tett, P., & Jones, K.J. 1983. The hydrography and phytoplankton ecology of Loch Ardbhair: a small sea-loch on the west coast of Scotland. *Journal of Experimental Marine Biology and Ecology, 71*: 1-16.

Hardy, A.C. 1939. Ecological investigations with the Continuous Plankton Recorder: object, plan and methods. *Hull Bulletins of Marine Ecology, 1*: 1-58.

Holligan, P.M., Maddock, L., & Dodge, J.D. 1980. The distribution of dinoflagellates around the British Isles in July 1977: a multivariate analysis. *Journal of the Marine Biological Association of the United Kingdom, 60*: 851-867.

Hughes, D.G. 1976. A simple method for predicting the occurrence of seasonal stratification and fronts in the North Sea and around the British Isles. *ICES, CM (C:1):* 13.

Nellen, W., & Schadt, J. 1992. Year-to-year variability in the plankton community on the spawning ground of the Hebrides-Buchan herring. *Hydrobiological variability in the ICES area, 1980-1989, 195*: 361-387.

Salvidge, G., & Lennon, H.J. 1987. Hydrography and phytoplankton distributions in north-west Scottish waters. *Continental Shelf Research, 7*: 45-66.

Simpson, J.H., & Tett, P.B. 1986. Island stirring effects on phytoplankton growth. *In: Tidal mixing and plankton dynamics,* ed. by M.J. Bowman, C.M. Yentsch & W.T. Peterson, 41-76. New York, Springer-Verlag.

B. Further reading

Adams, J.A., & Gould, J.A. 1982. Salps in Scottish waters in 1980 and 1981. *Scottish Fisheries Bulletin, 47*: 41-43.

Aebischer, N.J., Coulson, J.C., & Colebrook, J.M. 1990. Parallel long-term trends across four marine trophic levels and weather. *Nature, London, 347*: 753-755.

Barry, B.M. 1963. Temperature, salinity and plankton in the eastern north Atlantic and coastal waters of Britain, 1957. Part III. The distribution of zooplankton in relation to water bodies. *Journal of the Fisheries Research Board of Canada, 20*: 1,519-1,548.

Barry, B.M. 1964. Temperature, salinity and plankton in the eastern north Atlantic and coastal waters of Britain, 1957. Part IV. The species relationship to the water body; its role in distribution and in selecting and using indicator species. *Journal of the Fisheries Research Board of Canada, 21*: 183-202.

Colebrook, J.M. 1982. Continuous plankton records; seasonal variations in the distribution and abundance of plankton in the north Atlantic Ocean and the North Sea. *Journal of Plankton Research, 41*: 435-462.

Colebrook, J.M. 1986. Environmental influences on the long-term variability in marine plankton. *Hydrobiologia, 142*: 309-325.

Fraser, J.H. 1950. List of rare and exotic species found in the plankton by Scottish research vessels in 1949. *Annales Biologiques, 6*: 95-99.

Fraser, J.H. 1961. The oceanic and bathypelagic plankton of the north-east Atlantic and its possible significance to fisheries. *Marine Research, 4*: 1-20.

Fraser, J.H. 1968. Overflow of oceanic plankton to the shelf waters of the north-east Atlantic. *Sarsia, 34*: 313-330.

Gowen, R.J., Tett, P., & Wood, B.J.B. 1983. Changes in the major dihydroporphyin plankton pigments during the spring bloom of phytoplankton in two Scottish sea-lochs. *Journal of the Marine Biological Association of the United Kingdom, 63*: 27-36.

Hardy, A.C., Lucas, C.E., Henderson, G.T.D., & Fraser, J.H. 1936. The ecological relations between the herring and the plankton investigated with the Plankton Indicator. *Journal of the Marine Biological Association of the United Kingdom, 21*: 147-291.

International Council for the Exploration of the Sea. 1993. Report of the working group on phytoplankton and the management of their effects. *ICES Committee Meeting Papers and Reports, ENV7*: 156.

Jones, K.J., & Gowen, R.J. 1985. The influence of advective exchange on phytoplankton in Scottish fjordic sea lochs. *In: Toxic Dinoflagellates,* ed. by D.M. Anderson, D.G. Baden & A.W White, 207-212. New York, Elsevier Science Publishing.

Jones, K.J., & Gowen, R.J. 1990. Influence of stratification and irradience regime on summer phytoplankton composition in coastal and shelf seas of the British Isles. *Estuarine, Coastal and Shelf Science, 30*: 557-567.

Pingree, R.D., Holligan, P.M., & Mardell, G.T. 1978. The effects of vertical stability on phytoplankton distributions in the summer on the north west European Shelf. *Deep-Sea Research, 25*: 1,011-1,028.

Robinson, G.A. 1965. Continuous plankton records: contribution towards a plankton atlas of the north Atlantic and the North Sea. Part IX. Seasonal cycles of phytoplankton. *Bulletins of Marine Ecology, 6*: 104-122.

Simpson, J.H., Edelsten, D.J., Edwards, A., Morris, N.C.G., & Tett, P.B. 1979. The Islay Front: physical structure and phytoplankton distribution. *Estuarine and Coastal Marine Science, 9*: 713-726.

Williamson, M.H. 1961. An ecological survey of a Scottish herring fishery. Part IV. Changes in the plankton during the period 1949 to 1959. *Bulletins of Marine Ecology, 5*: 207-229.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Continuous Plankton Recorder (CPR) survey data	Director, Sir Alister Hardy Foundation for Ocean Science, The Laboratory, Citadel Hill, Plymouth PL1 2PB, tel: 01752 633100
Plankton research	*Director, SOAEFD, Marine Laboratory, Aberdeen, tel: 01224 876544
Plankton research	Director, Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 62244

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

These regions have an outstanding range of rare and scarce species of all kinds, from centuries-old lichens to the UK's rarest native mammals, among them the wildcat and the otter. However, they are perhaps best known for the millions of seabirds that breed here, including a fifth of all the razorbills in Europe and equally important breeding populations of eight other species. Photo: Mark Tasker, JNCC.

Chapter 5 Important species

5.1 Terrestrial lower plants

N.G. Hodgetts

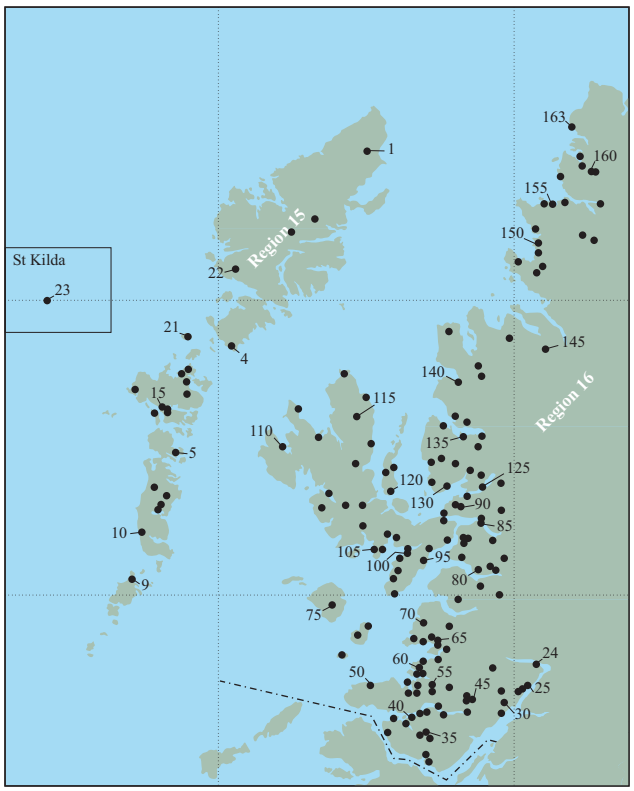
5.1.1 Introduction

This sections 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 regions' coastal 10 km squares. Along with Region 14, Regions 15 and 16 comprise one of the most important areas for lower plants in Europe, or even the world. About 63% of the British bryophyte flora and about 34% of the stonewort flora occur in this area. Precise figures are not available for other groups, but a similarly high percentage of the lichen and fungus floras may be expected because of the extremely oceanic climate. A large number of species that are considered rare or threatened in Britain or Europe as a whole are relatively abundant here. 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 biodiversity of Regions 15 and 16 is that they hold a relatively large extent of little-disturbed semi-natural habitat: much of the coastal zone is sparsely populated (although more densely so than inland) and relatively inaccessible and lower plant habitats are therefore less vulnerable to anthropogenic pressures than in many other regions.

Because of the very oceanic climate, Regions 15 and 16 (along with Region 14) are 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 List have their international centre of distribution here. Indeed, many of the 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 & Martiny 1995). Some of these threatened species are given special protection under national and international legislation.

5.1.2 Important locations and species

Table 5.1.1 lists all the sites in the two regions that are known to be important for lower plants and that have had at least some degree of survey work. Many are large, in which case the grid reference given refers to a reasonably central point. The large number of sites reflects the extreme international importance of this area for lower plants. Locations are shown on Map 5.1.1. Most of the SSSI sites in



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

Table 5.1.1 were selected for designation partly on the basis of their bryophyte and lichen interest. Many of the sites 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. Region 15 is much less sheltered than Region 16 and therefore has very little woodland. However, oceanic woodland is probably the single most important lower plant habitat in Region 16. Much ancient semi-natural oak-birch woodland remains in the more sheltered parts of the region, often in small patches confined to ravines, but also in more extensive areas. There is more woodland in the relatively sheltered south of the region than in the exposed north. 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. Fungi are important as wood decomposers and as mycorrhizal associates (depending on a

Table 5.1.1 Lower plant sites in coastal 10 km squares

Site no. on Map 5.1.1	*Location*	*Grid ref.*	*Protected status*
	Region 15		
1	Loch Scarrasdale Bog, Lewis	NB4950	SSSI
2	Achmore Bog, Lewis	NB3127	SSSI
3	Loch nan Eilean Valley Bog, Lewis	NB2323	SSSI
4	Roineabhal, Harris	NG0485	Not protected
5	Loch ba Alisdair, Benbecula	NF8549	Not protected
6	Hecla, South Uist	NF8234	Not protected
7	Beinn Mhor, South Uist	NF8031	Not protected
8	Allt Volagir, South Uist	NF7929	SSSI
9	Eoligarry, Barra	NF7006	SSSI
10	Loch Hallan, South Uist	NF7322	SSSI
11	Loch Druidibeg, South Uist	NF7837	NNR
12	Baleshare & Kirkibost, North Uist	NF7862	SSSI
13	Oban nam Fiadh, North Uist	NF8262	Not protected
14	Oban na Curra, North Uist	NF8263	Not protected
15	Lochs at Clachan, North Uist	NF8164	SSSI
16	Balranald Bog & Loch nam Feithean, North Uist	NF7170	SSSI
17	Machairs Robach & Newton, North Uist	NF8776	SSSI
18	Loch an Sticir, North Uist	NF8977	Not protected
19	Loch an Duin, North Uist	NF8973	SSSI
20	Loch an Strumore, North Uist	NF8969	Not protected
21	Pabbay	NF8988	Not protected
22	North Harris	NB0611	SSSI
23	St. Kilda	NF0999	NNR
	Region 16		
24	Achaphubuil	NN0776	Not protected
25	Doire Donn	NN0469	SSSI
26	Inverscaddle Bay	NN0268	Not protected
27	Aryhoulan	NN0167	Not protected
28	Doire Mor	NM9275	Not protected
29	Glen Scaddle	NM9567	Not protected
30	Leitir Dhubh	NM9663	Not protected
31	Rubha Ruadh	NM9560	Not protected
32	Inninmore Bay	NM7043	SSSI
33	Ardtornish	NM6945	SSSI
34	Gleann Gheal	NM7051	Not protected
35	Durinemast	NM6752	SSSI
36	Drimnin to Killundine Woods	NM5653	SSSI
37	Poll Luachrain & Druimbuidhe	NM5858	SSSI
38	Rahoy Woodlands	NM6256	SSSI
39	Beinn Iadain & Beinn na h-Uamha	NM6953	SSSI
40	Camas Glas	NM6458	Not protected
41	Glen Cripesdale	NM6760	SSSI
42	Camas Salach	NM6960	SSSI
43	Laudale Wood	NM7559	SSSI
44	A'Chreag	NM8360	Not protected
45	Coille Dubh	NM8564	Not protected
46	Ariundle	NM8364	SSSI, part NNR
47	Belsgrove Lead Mines	NM8365	Not protected
48	Salen to Woodend	NM7362	SSSI
49	Ben Hiant & Ardnamurchan Coast	NM5961	SSSI
50	Allt Fascadale	NM5069	Not protected
51	Kentra Bay & Moss	NM6366	SSSI
52	Ardtoe	NM6270	Not protected
53	Cliff	NM6669	Not protected
54	Allt an Ruighe Bhric	NM6666	Not protected

Site no. on Map 5.1.1	*Location*	*Grid ref.*	*Protected status*
	Region 16 (continued)		
55	Austinscroft	NM7169	Not protected
56	Loch Shiel (south side)	NM7768	SSSI
57	Claish Moss	NM7167	SSSI, part NNR
58	Loch Moidart	NM6873	SSSI
59	Invermoidart	NM6673	SSSI
60	Glen Uig	NM6775	part SSSI
61	Forsay	NM6877	Not protected
62	Roshven	NM7378	Not protected
63	Inverailort	NM7681	Not protected
64	Polnish	NM7383	SSSI
65	Gleann Màma	NM7384	SSSI
66	Glen Beasdale	NM7185	SSSI
67	Coille Poll Losgannan	NM7789	Not protected
68	Coille Ropach	NM6884	Part SSSI
69	Strath of Arisaig	NM6585	Not protected
70	Druim Dubh, Blàr na Caillich Buidhe & Kinsade/Lochan a'Chleirich	NM6890	part SSSI
71	Sgurr nam Feadan	NM8098	Not protected
72	Muck	NM4079	Part SSSI
73	An Sgurr & Gleann Charadail, Eigg	NM4586	SSSI
74	Laig to Kildonnan, Eigg	NM4989	SSSI
75	Rum	NM3595	NNR
76	Druim Chòsaidh	NG9400	Not protected
77	Torr a' Choit	NG9308	Not protected
78	Gleann Dubh Lochain	NG9109	Not protected
79	Glen Barrisdale	NG8803	SSSI
80	Glen Arnisdale (south side)	NG8708	Not protected
81	Coille Mhialairigh	NG8112	SSSI
82	Gleann Beag	NG8217	Not protected
83	Còsag sallow carr	NG8219	SSSI
84	Torr na h-Iolaire	NG8319	Not protected
85	Letterfearn	NG8824	Not protected
86	Allt Mhalagain	NG9612	Not protected
87	Shiel Bridge & head of Loch Duich	NG9218	Not protected
88	Camas-luinie	NG9528	Not protected
89	Dornie	NG8825	Not protected
90	Coille Mhor	NG8129	SSSI
91	Plock of Kyle	NG7527	Not protected
92	Loch na Béiste, Skye	NG7525	Not protected
93	Port Aslaig, Skye	NG7618	Not protected
94	Loch na Dal Woods, Skye	NG7015	part SSSI
95	Camus Croise, Skye	NG6811	Not protected
96	Aird of Sleat, Skye	NG5800	Not protected
97	Coille Dalavil, Skye	NG5805	SSSI
98	Achnacloich/Gillean Burn, Skye	NG5908	Not protected
99	Coille Thogabhaig, Skye	NG6012	SSSI
100	Coille a'Ghasgain, Skye	NG6312	Not protected
101	Loch Eishort, Skye	NG6314	Not protected
102	Strath, Skye	NG5919	SSSI
103	Loch Slapin, Skye	NG5620	Not protected
104	Drinan, Skye	NG5415	Not protected
105	Elgol Coast, Skye	NG5115	SSSI
106	Cuillins, Skye	NG4723	SSSI
107	Talisker, Skye	NG3329	SSSI
108	Loch Harport, Skye	NG3534	Not protected
109	Allt Grillan Gorge, Skye	NG4130	SSSI
110	Leinish Bay Woods, Skye	NG2050	Not protected
111	Geary Ravine, Skye	NG2663	SSSI
112	Greshornish, Skye	NG3253	Not protected

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

Site no. on Map 5.1.1	Location	Grid ref.	Protected status
	Region 16 (continued)		
113	Rubha Hunish, Skye	NG4175	SSSI
114	Rubha Garbhaig Wood, Skye	NG4967	Not protected
115	Trotternish Ridge, Skye	NG4560	SSSI
116	Rigg-Bile, Skye	NG5151	SSSI
117	Glen Grasco Carr, Skye	NG4544	Not protected
118	Raasay (east), Skye	NG5843	Not protected
119	Raasay (west), Skye	NG5541	Not protected
120	Raasay (south), Skye	NG5734	part SSSI
121	Lochs at Sligachan	NG4730	SSSI
122	Strollamus, Skye	NG6126	Not protected
123	Duirinish	NG7930	Not protected
124	Creag an Duilisg	NG8333	Not protected
125	Ardnarff	NG8936	Not protected
126	Eas Ban	NG9537	Not protected
127	Lochcarron (west side)	NG8840	Not protected
128	Rassal	NG8442	SSSI, part NNR
129	Beinn Bhan	NG7944	SSSI
130	Airigh-drishaig	NG7636	Not protected
131	Toscaig Woods	NG7138	Not protected
132	Applecross Coast	NG7145	Not protected
133	Allt Mor	NG7446	Not protected
134	Kenmore	NG7557	Not protected
135	Ob Mheallaidh	NG8253	SSSI
136	Doire Damh	NG8750	SSSI
137	Allt Coire Roill	NG8853	Not protected
138	Abhainn Alligin	NG8358	SSSI
139	Lower Diabaig	NG7960	Not protected
140	Shieldaig Woods	NG8072	Part SSSI
141	An Doire	NG8874	Not protected
142	Tollie Bay	NG8777	Not protected
143	Inverasdale	NG7789	Not protected
144	Gruinard (south-east)	NG9887	Not protected
145	Dundonnel (west)	NH1083	Not protected
146	Achnahaird Bay	NC0113	Not protected
147	Loch Lurgainn	NC0709	Not protected
148	Stac Pollaidh	NC0911	NNR
149	Rhegreanoch	NC0816	NNR
150	Kirkaig	NC0819	NNR
151	Feadan	NC0724	Not protected
152	Ben More Assynt	NC2720	SSSI, part NNR
153	Loch Assynt (east)	NC2322	Not protected
154	Pollachapuil	NC1032	Not protected
155	Nedd	NC1332	Not protected
156	Ardvar Woodlands	NC1733	SSSI
157	Gleann Dhubh	NC2932	Not protected
158	Loch a'Mhuilinn Wood	NC1639	NNR
159	Stack Woods	NC2743	SSSI
160	Loch Stack	NC2643	SSSI
161	Cnoc nam Cro	NC2446	Not protected
162	Laxford Bridge Rock Coast	NC2248	Not protected
163	Sheigra-Oldshoremore	NC1958	SSSI

Souces: references listed in section 5.1.5 and JNCC's protected sites database. Key: SSSI = Site of Special Scientific Interest; NNR = National Nature Reserve.

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, as on the island of Eigg.

The extensive coastal hard rock cliffs of the two regions support characteristic lichen assemblages, the species composition of which varies according to geology. However, the coastal cliffs of Region 15 are as yet inadequately surveyed. Basalt cliffs are good lower plant habitats, with mosses such as *Glyphomitrium daviesii* sometimes locally abundant. Exposures of Durness limestone, as on Skye and a number of localities on the mainland, are particularly rich in lichens. Species usually encountered as epiphytes often grow on coastal rocks in the favourable oceanic climate, such as *Lobaria* spp., *Ulota phyllantha* etc. Raised beaches are usually good areas for lower plants, as the habitats are many and varied, with dripping cliff vegetation, former sea caves, rocks, small wetlands, streams and grassland. The scarce moss *Myurium hochstetteri* is a distinctive feature of these areas and has its national centre of distribution in Region 15. It is otherwise known only from Macaronesia (Azores, Madeira and Canary Islands).

In Region 15, the upland and montane areas of Harris and South Uist support their own distinctive lower plant communities, although their diversity is limited by the acidic and unvaried geology. In the extremely oceanic climate of the Western Isles the mixed hepatic mat community is found at lower altitudes than it usually is on the mainland. Region 16 contains some important montane areas, most notably Ben Nevis and its outliers, the Cuillin and Trotternish ranges in Skye, Knoydart and the northern part of Ben More Assynt in Sutherland. North-east-facing corries support bryophyte and lichen assemblages that include species found only in these extreme conditions. Summit ridges, cliffs and rock ledges, high level flushes and other montane habitats all support their own distinctive lower plant communities. Areas of wet heath at medium altitude may support the 'northern Atlantic mixed hepatic mat' community (Ratcliffe 1968). This community is virtually confined to the west coasts of Scotland and Ireland and consists of a number of species of large oceanic liverworts.

Machair, one of the most characteristic habitats in Region 15, occurs principally on the islands of North and South Uist and Barra. Machair areas are relatively fertile and have been subjected to a long history of cultivation, unlike much of western Scotland. Undisturbed calcareous grassland found on the shell sand of these islands can support a distinctive bryophyte community, with a number of scarce mosses present. In addition, there are often characteristic fungus assemblages present. Rocks within the machair are often rich in lichens, and machair lochs are notable for their stonewort communities. Areas of wet grassland and fen also occur, rich in mosses that are scarce elsewhere. Region 16 has smaller areas of sand dune in sheltered bays, with bryophyte-rich damp dune slacks, notably at Achnahaird Bay, the northernmost locality in the world for the liverwort *Petalophyllum ralfsii*.

Much of the lowland to mid-altitude moorland in the regions is interesting for lower plants, and coastal wetlands such as small valley mires, raised bogs and areas of wet

heathland occur in abundance. These are usually rich in bryophytes and fungi, particularly where there is some base-rich influence. Because of the oceanic climate wet heath predominates in the moorland, with *Sphagnum* bogs and extensive occurrences of oceanic mosses such as *Campylopus shawii* ('bog gold') and *C. setifolius*. Small oceanic liverworts of the family Lejeuneaceae can be found on stems of heather and at the base of rocks, where conditions are humid and sheltered. The liverwort *Colura calyptrifolia* has been found growing on the fronds of hard fern *Blechnum spicant* near Lingerabay in south Harris (Averis 1994), a phenomenon that is rare in the British flora though widespread in the tropics.

In Region 15 the island of St. Kilda has important populations of several rare and scarce lower plant species. The Small Isles (Rum, Eigg, Muck and Canna) in Region 16 have many lower plant-rich areas, particularly on coastal cliffs, raised beaches and maritime-influenced heath and moorland.

Table 5.1.2 lists the Red Data Book species found in the regions (out of a total of 139 bryophytes, eleven stoneworts and 177 lichens on the British Red Lists, as at December 1996), excluding extinct species. For fungi there is insufficient information for a comprehensive count. In addition, the regions contain 165 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 regional lists of nationally scarce lichens and fungi.

Internationally protected species in the regions include the liverwort *Petalophyllum ralfsii*, which occurs on wet dune grassland in Region 16 and is protected under Annex II of the EC Habitats & Species Directive and Appendix I of the Bern Convention. Species protected under Schedule 8 of the Wildlife and Countryside Act 1981 and occurring in the regions are *Geocalyx graveolens* (liverwort) (Region 15); plus *G. graveolens, P. ralfsii* (liverworts)04 and *Caloplaca luteoalba, Pannaria ignobilis, Parmentaria chilensis, Pseudocyphellaria lacerata* (lichens) (Region 16).

Examples of species that are considered threatened in Europe as a whole but which are not rare enough to qualify for the British Red List and which have their international centres of distribution here include the liverworts *A. wilsonii* and *Radula carringtonii*, the mosses *C. shawii* and *Myurium hochstetteri* and lichens in the genera *Leptogium*, *Lobaria*, *Pseudocyphellaria* and *Pannaria*. Many of these species are large and spectacular, often forming conspicuous masses hanging off trees. The moss *Tortella fragilis* is present in some abundance on the machair of South Uist. St. Kilda has important populations of the liverwort *G. graveolens*, the moss *Sanionia orthothecioides* and the lichens *Anaptychia ciliaris* ssp. *mamillata*, *Lecanora straminea* and *Porina mammillosa*.

Table 5.1.2 Red Data Book lower plants in Region 15 & 16

Species	*Locations/habitat*
Liverworts	
Geocalyx graveolens	On peaty ground, near Ardtoe (Lochaber), Ord (Skye), Plock of Kyle (Lochalsh), Rhegreanoch (Ross & Cromarty) and St. Kilda (Western Isles)
Lejeunea mandonii	On rocks in humid ravines, by Loch Sunart (Lochaber) and on the Elgol Peninsula (Skye); not seen since 1967
Petalophyllum ralfsii	Wet dune grassland, Achnahaird Bay (Ross & Cromarty)
Mosses	
Bryum knowltonii	Wet dune grassland, Achnahaird Bay (Ross & Cromarty)
Bryum warneum	Wet dune grassland, Achnahaird Bay (Ross & Cromarty)
Daltonia splachnoides	On wet peaty ground or rotting wood, Loch Duich (Ross & Cromarty) and Inverscaddle Bay (Lochaber)
Eurhynchium pulchellum	Basalt rocks, The Storr (Skye)
Lichens	
Arthothelium macounii (A. reagens)	On hazel, Coille Thogabhaig and Rubha Ghail (Skye)
Bactrospora dryina	On oak, Loch Sunart (Lochaber)
Caloplaca luteoalba	On elm, Flowerdale House (Ross & Cromarty); not seen since 1963
Catolechia wahlenbergii	Montane rocks, Druim Chosaidh (Lochaber) and Sgurr Alisdair (Skye)
Chromatochlamys larbalestieri	On granite in stream, Loch Moidart (Lochaber)
Gyalidea roseola	Entrance to old lead mine, Belsgrove (Lochaber)
Ionaspis melanocarpa	On limestone by stream, Inchnadamph (Sutherland)
Lecanactis amylacea	Base of oak tree, Coille Thogabhaig (Skye)
Lecanora frustulosa	Basalt rock, The Storr (Skye)
Leptogium saturninum	On ash tree, Rassal Ashwood (Ross & Cromarty)
Pannaria ignobilis	On tree trunk, head of Loch Duich (Ross & Cromarty)
Parmentaria chilensis	On hazel in Resipole Ravine, Loch Sunart (Lochaber)
Peltigera venosa	Mossy ledges on basalt cliffs, Ben na h-Uamha (Lochaber)
Polychidium dendriscum	On oak and alder, Loch Sunart and north of Luinne Bheinn (Lochaber)
Pseudocyphellaria lacerata	Unlocalised records, Morvern and Knoydart (Lochaber)
Pyrenula coryli	Unlocalised record, Morvern (Lochaber)
Pyrenula dermatodes	On rowan in Glen Barrisdale (Lochaber)
Sticta canariensi	On rocks and trees at a number of sites from Lochaber to Sutherland
Vestergrenopsis elaein	Basalt rocks on the Trotternish ridge (Skye)

Source: JNCC Lower Plants Database.

5.1.3 Human activities

Current issues that may have a bearing on the lower plant flora of these regions include road and bridge 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. Pollution in the form of acid rain is a general problem that may be exacerbated in some areas by the atmospheric effects of oil spills. Nutrient enrichment by drift from fish farms can locally affect epiphytic communities. Over-exploitation of mountain slopes by skiing developments is an important factor in influencing fragile alpine lower plant communities, and erosion is a general problem on popular walking routes in the Highlands. The issue of the 'superquarry' at Lingerabay on Harris remains controversial.

Some sites are National Nature Reserves (NNR) and are therefore managed for nature conservation. Many more are Sites of Special Scientific Interest (SSSI). 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 woods become more senescent (dominated by older trees). The spread of rhododendron *Rhododendron ponticum* has altered the character of some sites and should be kept under control 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

Sites in Region 15 are relatively poorly known compared with those in Region 16. Data for bryophytes and the larger lichens are generally good but are 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 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) and some sites of international importance for bryophytes are listed by Hodgetts (1995). 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. Data collation for fungi is still at a relatively early stage. 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. Monitoring of the condition and management regimes of Sites of Special Scientific Interest (SSSIs) and National Nature Reserves in the regions is conducted by Scottish Natural Heritage (SNH).

5.1.5 Further sources of information

A. References cited

Averis, A.B.G. 1991. *A survey of the bryophytes of 448 woods in the Scottish Highlands.* Edinburgh, Nature Conservancy Council. (Scottish Field Survey Unit Report, No. S54.)

Averis, A.B.G. 1994. *The vegetation of Roineabhal, Bleaval and Chaipaval, South Harris, Outer Hebrides, Scotland.* Edinburgh, Scottish Natural Heritage. (SNH Contract Report, No. W0155.)

Fletcher, A., *ed.* 1984. *Survey and assessment of lowland heath lichen habitats. Nature Conservancy Council, CSD Report,* No. 522.

Hodgetts, N.G. 1992. *Guidelines for selection of biological SSSIs: non-vascular plants.* Peterborough, Joint Nature Conservation Committee.

Hodgetts, N.G. 1995. Bryophyte site register for Europe including Macaronesia. *In: Red Data Book of European bryophytes*, ed. by The European Committee for the Conservation of Bryophytes, 195-291. Trondheim, ECCB.

James, P.W., & Wolseley, P.A. 1991. *A preliminary report of coastal lichen sites in England, Wales and Scotland.* Peterborough, Nature Conservancy Council. (Unpublished report.)

Ratcliffe, D.A. 1968. An ecological account of Atlantic bryophytes in the British Isles. *New Phytologist, 67*: 365-439.

Schumacker, R., & Martiny, P. 1995. Threatened bryophytes in Europe including Macaronesia. *In: Red Data Book of European bryophytes*, ed. by The European Committee for the Conservation of Bryophytes, 29-193. Trondheim, ECCB.

B. Further reading

Belcher, H., & Swale, E. 1976. *A beginner's guide to freshwater algae.* London, Institute of Terrestrial Ecology, HMSO.

Bellinger, E.G. 1980. *A key to common British algae.* London, The Institution of Water Engineers and Scientists.

Bon, M. 1987. *The mushrooms and toadstools of Britain and north-western Europe.* London, Hodder & Stoughton.

British Lichen Society Woodland Lichens Working Party. 1993. Revised assessment of epiphytic lichen habitats - 1993. *Joint Nature Conservation Committee Report*, No. 170.

Buczacki, S. 1989. *Fungi of Britain and Europe.* London, Collins. (Collins New Generation Guide.)

Daniels, R.E., & Eddy, A. 1990. *Handbook of European Sphagna.* 2nd ed. London, Institute of Terrestrial Ecology/HMSO.

Fletcher, A., *ed.* 1982. Survey and assessment of epiphytic lichen habitats. *Nature Conservancy Council, CSD Report,* No. 384.

Hill, M.O., Preston, C.D., & Smith, A.J.E. 1991. *Atlas of the bryophytes of Britain and Ireland. Volume 1. Liverworts.* Colchester, Harley Books.

Hill, M.O., Preston, C.D., & Smith, A.J.E. 1992. *Atlas of the bryophytes of Britain and Ireland. Volume 2. Mosses (except Diplolepideae).* Colchester, Harley Books.

Hill, M.O., Preston, C.D., & Smith, A.J.E. 1994. *Atlas of the bryophytes of Britain and Ireland. Volume 3. Mosses (Diplolepideae).* Colchester, Harley Books.

Ing, B. 1992. A provisional Red Data list of British fungi. *The Mycologist, 6*. (British Mycological Society.)

Moore, J.A. 1986. *Charophytes of Britain and Ireland.* London, Botanical Society of the British Isles. (BSBI Handbook, No. 5.)

Phillips, R. 1981. *Mushrooms and other fungi of Great Britain and Europe.* London, Pan Books.

Purvis, O.W., Coppins, B.J., Hawksworth, D.L., James, P.W., & Moore, D.M. 1992. *The lichen flora of Great Britain and Ireland.* London, Natural History Museum Publications.

Ratcliffe, D.A., *ed.* 1977. *A nature conservation review.* Cambridge, Cambridge University Press.

Smith, A.J.E. 1978. *The moss flora of Britain and Ireland.* Cambridge, Cambridge University Press.

Smith, A.J.E. 1990. *The liverworts of Britain and Ireland.* Cambridge, Cambridge University Press.

Stewart, N.F., & Church, J.M. 1992. *Red Data Books of Britain and Ireland: stoneworts.* Peterborough, Joint Nature Conservation Committee.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
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 9389123
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, 110 Eastbourne Road, Darlington, Co. Durham DL1 4ER, tel: 01325 484595
Fungi (general and sand dune)	M. Rotheroe, Conservation Officer, British Mycological Society, Fern Cottage, Falcondale, Lampeter, Dyfed SA48 7RX, tel: 01570 422041
Fungi (general Scottish)	Dr R. Watling, Royal Botanic Garden, Inverleith Row, Edinburgh EH3 5LR, tel: 0131 5527171
Fungi (British Mycological Society database)	Dr P. Cannon, International Institute of Mycology, Bakeham Lane, Englefield Green, Egham, Surrey TW20 9TY, tel: 01784 470111

Type of information	*Contact address and telephone no.*
Bryophytes (general Scottish)	D.G. Long, Royal Botanic Garden, Inverleith Row, Edinburgh EH3 5LR, tel: 0131 5527171
Bryophytes (Scottish lowland)	A.B.G. Averis, 2 Traprain Cottages, Traprain, Haddington, East Lothian EH41 4PY, tel: 01620 860029
Bryophytes (Scottish upland)	G.P. Rothero, Stronlonag, Glenmassan, Dunoon, Argyll PA23 8RA, tel: 01369 706281
Bryophytes (British Bryological Society herbarium)	A.R. Perry, Department of Botany, National Museum of Wales, Cardiff CF1 3NP, tel: 01222 397951
Bryophytes (BRC database)	*C.D. Preston, Biological Records Centre, ITE, Monks Wood, Huntingdon, tel: 01487 773381
Lower plants (species status; Red Data Book Database; site register etc.)	*N.G. Hodgetts, JNCC, Peterborough, tel: 01733 62626
Freshwater algae	Freshwater Biological Association, the Ferry House, Far Sawry, Ambleside LA22 0LP, tel: 015394 42468

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

The extensive rocky coastline of the two regions supports characteristic lichen assemblages whose species composition varies according to the geology. Several species that are usually epiphytic (found on trees) often grow on coastal rocks in the relatively mild, moist oceanic climate. Photo: Pat Doody, JNCC.

5.2 Flowering plants and ferns

V.M. Morgan

5.2.1 Introduction

This section describes the importance of Regions 15 (Western Isles) and 16 (west Highland) for vascular plants (i.e. flowering plants and ferns), particularly species that are rare or scarce in Great Britain. Species occurring in the regions' coastal 10 km squares are normally included, whether or not they are regarded as 'coastal'. However, mountain sites on the mainland of Region 16, which are at most indirectly affected by the coastal environment, are omitted, although because of their great international importance they are briefly discussed in the introduction to Chapter 3. Numbers of rare and scarce species occurring in the regions are shown in Table 5.2.1.

Table 5.2.1 Numbers* of rare and scarce coastal higher plant species in Regions 15 & 16

	Protected species	*Other Red Data Book species*	*Scarce species*
Region 15	***2***	***4***	***23***
Region 16	***6***	***3***	***71***
Lochaber	4	2	55
Skye & Lochalsh	2	2	46
Ross & Cromarty	1	0	31
Sutherland	2	0	29

Sources: JNCC rare plants database; Stewart *et al.* (1994); BRC database. Key: *excluding known introductions and records from before 1970.

The special conditions that support centres of plant biodiversity are a combination of elements, including climate and geology. Much of Regions 15 and 16 is exposed to strong, often salt-laden westerly and south-westerly winds (see section 2.3). The degree of exposure depends on altitude and shelter, with the sea lochs, sounds and glens being generally less exposed (Green & Harding 1983). Temperatures in Regions 15 and 16 are influenced by relatively warm Atlantic currents, with the seasonal temperature range reduced compared with in inland areas. In Region 15, the period from April to December is typically frost-free and the region has an annual temperature range of only 8.8 °C, resulting in a long but slow growing season (Angus 1991; Manley 1979). Region 16 has a low incidence of frost, although the peaks of the more mountainous islands - Skye in particular - are both colder and wetter than the rest of the region, with more than 200 wet days per year. Much of the region has an excess of rainfall over evaporation, drainage and transpiration (i.e. uptake of water by plants) and thus blanket bog has developed in places.

As a result of these factors, a number of different elements are found in the regions' flora (Matthews 1955; Currie 1979). For example, a small but significant element consists of species that are widespread in North America but which extend no further east into Europe than the British Isles. These species include American pondweed *Potamogeton epihydrus* (Region 15), which is known from nowhere else in Europe, while Irish lady's-tresses *Spiranthes romanzoffiana* (Regions 15 and 16) and pipewort (Region 16) are confined in Europe to western Scotland and Ireland. Another significant element in the flora is the Lusitanian or oceanic western element. Characteristic species include hay-scented buckler-fern *Dryopteris aemula,* Wilson's filmy-fern *Hymenophyllum wilsonii,* Tunbridge filmy-fern *Hymenophyllum tunbrigense* and pale butterwort *Pinguicula lusitanica*. None of these is rare, but all are characteristic of this extremely oceanic area. Species at the northern limits of their British distribution in Region 15 include hay-scented buckler-fern, marsh St. John's-wort *Hypericum elodes,* strawberry clover *Trifolium fragiferum* and pyramidal orchid *Anacamptis pyramidalis*.

Rare and scarce species grow in a wide range of habitats. In these regions, the relatively intact, extensive suites of habitats and vegetation in their natural pattern, with little pollution and few alien species, are of great rarity and interest. Most significant are the transitions from sea shores to machair, blacklands and moorland with brackish, acidic and neutral lochs. Some of the regions' characteristic aquatic species, such as slender naiad *Najas flexilis* (Regions 15 & 16), many pondweeds *Potamogeton* spp. (Region 15) and pipewort *Eriocaulon aquaticum* (Region 16), rely on unpolluted water. The geographic position of the regions, together with the prevailing winds from the Atlantic, have protected the sites from air pollution compared with the rest of the UK, although acid deposition can be a serious problem on less well-buffered acidic rocks. A number of the key localities in the regions are on limestone and base-rich Tertiary igneous rocks (e.g. Rum, Trotternish, Ardnamurchan), which are often associated with rare and scarce species.

Region 15 has a restricted flora compared with the mainland, possibly as a result of the poor, thin soils (R. Pankhurst pers. comm.) and because the islands' isolation is a barrier to westward colonisation (Currie 1979). The only 'classic' British plant locality in the region is the Uists, which are well-known for their internationally significant concentrations of aquatic species. The archipelago holds more than two thirds of the British pondweed species *Potamogeton* spp. (Pankhurst & Mullin 1991). Bog orchid *Hammarbya paludosa* (nationally scarce) and Shetland pondweed *Potamogeton rutilus* (nationally rare) are present; although not protected they are considered vulnerable in Europe (Morgan & Leon 1990). In Region 16, rocky uplands and lochs are of particular importance. The two 'classic' British plant localities that are known for their nationally significant concentrations of rare and scarce species in Region 16 are Ardnamurchan and the Cuillins in the Isle of Skye.

In Region 15 the salt-laden winds enable some species that are usually strictly maritime to grow at higher altitudes; for example, sea-milkwort *Glaux maritima* grows at 200 m on Mingulay (Angus 1991). There are also a large number of arctic or arctic-alpine species that are more typically upland species but grow at lower levels in the regions (Currie & Murray 1983), although this 'altitudinal descent' is less marked in Region 15 than in Region 16. Species include moss campion *Silene acaulis* and purple saxifrage *Saxifraga*

oppositifolia (Regions 15 and 16) and mountain avens *Dryas octopetala* (Region 16). The occurrence of montane vegetation at sea level is a characteristic feature of the northern coasts of Britain. On extremely exposed stretches another characteristic feature is waved heaths, in which dwarf shrubs, such as heather *Calluna vulgaris*, juniper *Juniperus communis* and bearberry *Arctostaphyllos uva-ursi*, have been shaped by the strong winds into a 'wave form'. Examples of both features are to be seen just to the south of Cape Wrath, in Region 16.

5.2.2 Important locations and species

Key localities that support two or more rare and/or five or more scarce species in Region 15 and two or more rare species in Region 16 are shown on Map 5.2.1 and listed in Table 5.2.2. Scarce species may occur near to, rather than within, some localities. In addition to these key localities, a number of other sites are moderately species-rich.

There are a number of endemic (i.e. confined to Great Britain) species present in these regions, all from taxonomically difficult groups. Scottish scurvygrass *Cochlearia scotica* (which may be a subspecies of common scurvygrass *Cochlearia officinalis*) is found in both regions, but is particularly common in Region 15. The eyebrights *Euphrasia marshallii*, *E. heslop-harrisonii* and the rare *E. rotundifolia* are endemic to the regions, although in Region 15 the true identity of populations of the latter is uncertain (R. Pankhurst pers. comm.). Isolated records of the

Map 5.2.1 Key localities for rare and scarce higher plants, and locations mentioned in the text. Sites are listed in Table 5.2.2. Source: JNCC rare plants database.

Table 5.2.2 Key localities for rare and scarce plants (records post 1970)

Locality	*Status*	*Species*
Region 15		
West coast of South Uist	Part NNR, part SSSI, part undesignated	Red Data Book species: American pondweed *Potamogeton epihydrus*, holy-grass *Hierochloe odorata*, slender naiad *Najas flexilis* Scarce species: eight scarce species
West coasts of Benbecula and North Uist	Part SSSI, part undesignated	Red Data Book species: holy-grass, Shetland pondweed *Potamogeton rutilus*, slender naiad Scarce species: Irish lady's-tresses *Spiranthes romanzoffiana*, plus six other scarce species
West coast of South Harris	Part SSSI, part undesignated	Red Data Book species: Lapland marsh-orchid *Dactylorhiza lapponica* Scarce species: Scottish scurvygrass *Cochlearia scotica*, plus five other scarce species
Uig to Butt of Lewis	Part SSSI, part undesignated	Red Data Book species: the eyebright *Euphrasia campbelliae* Scarce species: thread rush *Juncus filiformis*, Scottish scurvygrass, plus four other scarce species
Region 16		
Morvern to Ardnamurchan	Part SSSI, part undesignated	Red Data Book species: Arctic sandwort *Arenaria norvegica* subsp. *norvegica*, Lapland marsh-orchid, pigmyweed *Crassula aquatica*, pipewort *Eriocaulon aquaticum* Scarce species: brown beak-sedge *Rhynchospora fusca*, forked spleenwort *Asplenium septentrionale*, Irish lady's-tresses, Scottish scurvygrass, plus twelve other scarce species
Isle of Rum	NNR	Red Data Book species: Arctic sandwort, Lapland marsh-orchid Scarce species: brown beak-sedge, mossy cyphel *Minuartia sedoides*, two-flowered rush, plus eight other scarce species
Cuillin Hills area	Part SSSI, part undesignated	Red Data Book species: Alpine rock-cress *Arabis alpina*, pipewort Scarce species: Arctic mouse-ear *Cerastium arcticum*, brown beak-sedge, rock whitlowgrass *Draba norvegica*, Scottish scurvygrass, plus ten other scarce species
Trotternish to Kilmaluag	Part SSSI, part undesignated	Red Data Book species: Iceland-purslane *Koenigia islandica*, pipewort Scarce species: Alpine pearlwort *Sagina saginoides*, Arctic mouse-ear, the eyebrights *Euphrasia ostenfeldii* and *E. marshallii*, lady's-mantle *Alchemilla wichurae*, mossy cyphel, Scottish scurvygrass, two-flowered rush, plus fifteen other scarce species

Sources: JNCC rare plants database; Biological Records Centre (BRC) database; Stewart *et al.* (1994); SSSI citation sheets. Key: SSSI = Site of Special Scientific Interest; NNR = National Nature Reserve. Note: key localities are those with important populations of rare species and/or six or more scarce species. Scarce species may occur near to rather than within some localities. Only those scarce species known from up to 60 ten km squares are listed by name.

eyebright *E. campbelliae* have been found in Region 15; this species is known from nowhere else in Great Britain. In Region 16 the eyebrights *E. eurycarpa* and *E. rhumica* and some hawkweeds *Hieracium* spp. are endemic, with nineteen species of hawkweed known from Skye alone (Currie & Murray 1983). In the British Isles, alpine rock-cress *Arabis alpina* is found only in Region 16.

The recorded occurrence of rare species in Regions 15 and 16 is listed in Table 5.2.3. There are six nationally rare (Red Data Book) species in Region 15 and nine in Region 16, of the 317 rare species listed for Great Britain in the *British Red Data Book of vascular plants* (Perring & Farrell 1983). Of the 254 scarce species (i.e. known from 16-100 ten kilometre grid squares) in Great Britain, 23 occur in Region 15 and 71 in Region 16. Three species are protected under international law and eight are amongst the 107 listed on Schedule 8 of the Wildlife & Countryside Act (1981).

5.2.3 Human activities

On the machair areas of Region 15, traditional crofting agriculture is largely beneficial to the conservation of higher plants because of its non-intensive nature; areas are left fallow as part of the rotational cycle. Much of the machair is now an Environmentally Sensitive Area (ESA), in which land managers are encouraged to maintain and enhance the wildlife and landscape value of their land (see also section 7.3). In other areas of both regions higher plants may be affected by overgrazing by sheep, removal of native woodland, heather burning, afforestation of peatland and drainage of wetland habitats, and the maintenance of high numbers of deer for sport (Ball 1983; Kerr & Boyd 1983; Murray 1980). These factors have led to widespread habitat degradation, particularly on acid soils.

5.2.4 Information sources used

A number of the species and sites in this section have been surveyed by Scottish Natural Heritage (SNH) and the Royal Botanic Garden, Edinburgh. Monitoring of certain Sites of Scientific Interest (SSSIs) and National Nature Reserves (NNRs) is conducted by SNH, who hold reports. The JNCC maintains a database of nationally rare plant species, which includes site records. Members of the Botanical Society of

Table 5.2.3 Recorded occurrence of nationally rare (RDB) and/or protected species

Species	*Recorded occurrence in: total no. of 10 km squares in GB*	*no. of coastal 10 km squares in region*[2]	*no. of sites in region (approx.)*	*Key localities*	*Habitat*
Region 15					
American pondweed *Potamogeton epihydrus*	1	1	4	West coast of South Uist	Lochs
The eyebright *Euphrasia campbelliae*	4	4	4	Near Melbost; near Brenish; Uig to Butt of Lewis	Grassy heathland
Holy-grass *Hierochloë odorata*	14	2	2	West coast of South Uist; West coast of Benbecula	Damp grassland
Lapland marsh-orchid *Dactylorhiza lapponica*[1, 3, 5]	9	1	1	Harris	
Shetland pondweed *Potamogeton rutilus*	10	2	4	West coasts of Benbecula and North Uist	Lochs
Slender naiad *Najas flexilis*[3, 4]	15	5	13	West coast of South Uist; west coasts of Benbecula and North Uist	Clean lochs
Region 16					
Alpine rock-cress *Arabis alpina*[3]	1	1	1	Cuillin Hills area	Rock ledges
Arctic sandwort *Arenaria norvegica* subsp. *norvegica*[3]	11	6	5	Morvern to Ardnamurchan; Isle of Eigg; Isle of Rum	Base-rich screes and river shingle
Club sedge *Carex buxbaumii*	4	1	1	Arisaig	Loch margins
Iceland-purslane *Koenigia islandica*	5	3	6	Trotternish	Bare, stony mountains
Killarney fern *Trichomanes speciosum*[2, 3, 4]	80+	7	7	-	Damp, sheltered rock faces
Lapland marsh-orchid *Dactylorhiza lapponica*[1, 3, 5]	10	5	11	Morvern to Ardnamurchan; Isle of Rum; Raasay	Heaths and bogs
Pigmyweed *Crassula aquatica*[3]	1	1	1	Morvern to Ardnamurchan	Wet mud
Pipewort *Eriocaulon aquaticum*	9	7	15	Morvern to Ardnamurchan; Cuillin Hills area; Trotternish to Kilmaluag; Lochain Dubha	Acid lochs
Slender naiad *Najas flexilis*[3, 4]	15	1	1	North Morar	Clean lochs

Sources: JNCC rare plants database and rare plant survey reports. Key: [1]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 species is not universally accepted; [2]Killarney fern is present only in its gametophyte (non-vascular form), which is more widespread than the sporophyte form; numbers of sites and localities are provisional and localities are not included in this table; [3]listed on Schedule 8 of the Wildlife & Countryside Act (1981); [4]protected under Annex II of the EC Habitats & Species Directive; [5]all orchids are protected under the CITES Convention.

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). The BSBI's vice-county recorders (five covering Regions 15 and 16) also hold more detailed local records on vascular plant distribution.

5.2.5 Acknowledgements

Thanks are due to J.H. Barne, A. Currie, R. Pankhurst, C.D. Preston, R. Scott, C. Sydes, M. Wigginton, G. Yoxon and staff at the Biological Records Centre.

5.2.6 Further sources of information

A. References cited

Angus, I.S. 1991. Climate and vegetation of the Outer Hebrides. *In: Flora of the Outer Hebrides,* ed. by R.J. Pankhurst & J.M. Mullin. London, Natural History Museum Publications.

Ball, M.E. 1983. Native woodlands of the Inner Hebrides. *In: The natural environment of the Inner Hebrides*, ed. by J.M. Boyd & D.R. Bowes. *Proceedings of the Royal Society of Edinburgh,* 83B.

Currie, A. 1979. The vegetation of the Outer Hebrides. *In: The natural environment of the Outer Hebrides,* ed. by J.M. Boyd. *Proceedings of the Royal Society of Edinburgh, 77B:* 219-265.

Currie, A., & Murray, C.W. 1983. Flora and vegetation of the Inner Hebrides. *In: The natural environment of the Inner Hebrides*, ed. by J.M. Boyd & D.R. Bowes. *Proceedings of the Royal Society of Edinburgh, 83B*: 293-318.

Green, F.H.W., & Harding, R.J. 1983. Climate of the Inner Hebrides. *In: The natural environment of the Inner Hebrides*, ed. by J.M. Boyd & D.R. Bowes. *Proceedings of the Royal Society of Edinburgh, 83B:* 121-140.

Kerr, A.J., & Boyd, J.M. 1983. Nature conservation in the Inner Hebrides. *In: The natural environment of the Inner Hebrides*, ed. by J.M. Boyd & D.R. Bowes. *Proceedings of the Royal Society of Edinburgh, 83B:* 627-648.

Manley, G. 1979. The climatic environment of the Outer Hebrides. *In: The natural environment of the Inner Hebrides*, ed. by J.M. Boyd. *Proceedings of the Royal Society of Edinburgh, 83B*: 47-59.

Matthews, J.R. 1955. *Origin and distribution of the British flora*. London, Hutchinson's University Library.

Morgan, V., & Leon, C. 1990. *Bern Convention: revision of Appendix I (Flora).* Unpublished report for World Conservation Monitoring Centre and the Council of Europe, September 1990.

Murray, C.W. 1980. *The botanist in Skye.* Portree, Portree High School/Botanical Society of the British Isles.

Pankhurst, R.J., & Mullin, J.J. 1991. *Flora of the Outer Hebrides*. London, Natural History Museum Publications.

Perring, F.H., & Farrell, L. 1983. *British Red Data books: 1. Vascular plants.* 2nd ed. Nettleham, Royal Society for Nature Conservation.

Stewart, A., Pearman, D.A., & Preston, C.D. 1994. *Scarce plants in Britain.* Peterborough, Joint Nature Conservation Committee/ Institute of Terrestrial Ecology/Botanical Society of the British Isles.

B. Further reading

Allan, B., & Woods, P. 1993. *Wild orchids of Scotland*. Edinburgh, HMSO.

Ball, M.E. 1987. Botany, woodland and forestry. *In: Rhum: the natural history of an island*, ed. by T.H. Clutton-Brock & M.E. Ball. Edinburgh, Edinburgh University Press.

Biagi, J.A., Chamberlain, D.F., Hollands, R.C., King, R.A., & McKean, D.R. 1985. *Freshwater macrophyte survey of selected lochs in Lewis and Harris*. Edinburgh, Royal Botanic Garden. (Unpublished report)

Chamberlain, D.F., King, R.A., McKean, D.R., Miller, A.G., & Nyberg, J.A. 1984. *Freshwater macrophyte survey of selected lochs in the Uists*. Edinburgh, Royal Botanic Garden. (Unpublished report.)

Cowie, N.R., & Sydes, C. 1995. S*tatus, distribution, ecology and management of Lapland marsh-orchid* Dactylorhiza lapponica. Edinburgh, Scottish Natural Heritage. (Scottish Natural Heritage Review, No. 42.)

Dobson, R.H. 1983. The vascular plants of Northern Ardnamurchan. *The Glasgow Naturalist, 20*: 313-331.

Dobson, R.H., & Dobson, R.M. 1985. The natural history of the Muck Islands, North Ebudes: 1. Introduction and vegetation with a list of vascular plants. *The Glasgow Naturalist 21*(1)*:* 13-38.

Hadley, G., *ed*. 1985. *A map flora of mainland Inverness-shire*. Edinburgh/London, Botanical Society of Edinburgh and Botanical Society of the British Isles.

Henderson, D.M. 1992. *Annotated checklist of the flora of Wester Ross*. 2nd ed. Wester Ross, Inverewe House.

Kenworthy, J.B. 1976. *John Anthony's flora of Sutherland.* Edinburgh, Botanical Society of Edinburgh.

Perring, F.H., & Walters, S.M. 1990. *Atlas of the British flora*. London, Botanical Society of the British Isles.

Perring, F.H., & Walters, S.M. 1990. *New flora of the British Isles. Distribution maps*. Cambridge, Cambridge University Press.

Raven, J.E. 1980 The flora of Morvern and Ardnamurchan compared with that of Mull. *Watsonia, 13*(1): 1-10.

Royal Botanic Garden, Edinburgh. 1983. *Survey of aquatic vegetation on South Uist and Benbecula - 25 July - 5 August 1983.* (Unpublished report.)

Scouller, C. 1988. *An introduction to the flowering plants and ferns of Lochbroom and Assynt*. Lochbroom, Lochbroom Field Club.

Small, A., *ed.* 1979. *A St. Kilda handbook*. Dundee, University of Dundee/National Trust for Scotland. (Department of Geography Occasional Paper, No. 5.)

Stace, C. 1991. *New flora of the British Isles*. Cambridge, Cambridge University Press.

C. Contact names and addresses

Type of information	Contact address and telephone no.
Ross & Cromarty - species on SSSIs and NNRs, other protected areas, data on distribution of rare and scarce species, rare plant surveys, licensing and protected species	*Area Officer, Ross & Cromarty Office, SNH, Kinlochewe, tel: 01445 760254
Sutherland - species on SSSIs and NNRs, other protected areas, data on distribution of rare and scarce species, rare plant surveys, licensing and protected species	*Area Officer, Sutherland Office, SNH, Elphin, tel: 01854 666234
Lochaber - species on SSSIs and NNRs, other protected areas, data on distribution of rare and scarce species, rare plant surveys, licensing and protected species	*Area Officer, Lochaber & Lochalsh Office, SNH, Fort William, tel: 01397 704716
Isle of Skye - species on SSSIs and NNRs, other protected areas, data on distribution of rare and scarce species, rare plant surveys, licensing and protected species	*Area Officer, Isle of Skye Office, SNH, Portree, tel: 01478 613329
Western Isles - species on SSSIs and NNRs, other protected areas, data on distribution of rare and scarce species, rare plant surveys, licensing and protected species	*Area Officer, Stornoway Office, SNH, Stornoway, tel: 01851 705258
Biological Records Centres and herbaria:	
Highland Region (and Highland Biological Recording Group)	Assistant Curator (Natural Sciences), Inverness Museums & Art Galleries, Castle Wynd, Inverness IV2 3ED, tel: 01463 237114
Isle of Skye	The Director, Skye Environmental Centre, Broadford, Isle of Skye IV49 9AQ, tel: 01471 822487
Local BSBI vice-county records	c/o Dr P. Macpherson, Hon. Secretary, Scotland Committee, Botanical Society of the British Isles, 15 Lubnaig Road, Glasgow G43 2RY, tel: 0141 632 0723

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

5.3 Land and freshwater invertebrates

M.S. Parsons & A.P. Foster

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 Regions 15 (Western Isles) and 16 (west Highland).

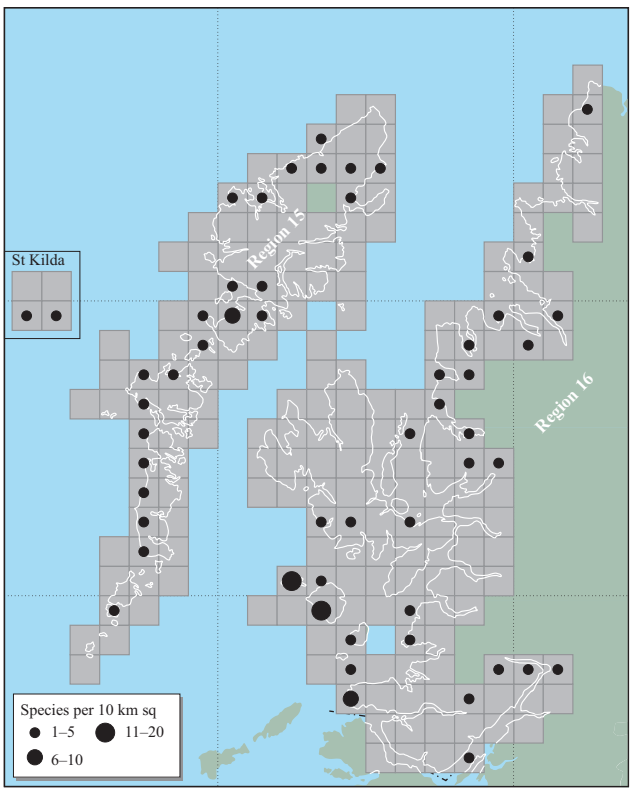
Regions 15 and 16 are nationally and internationally important for the conservation of several invertebrate species, with several species having a significant part of their British distribution along these coastlines (including one species, the weevil *Ceutorhynchus insularis*, which in Britain has been found only in Region 15). Of 358 coastal nationally rare (Red Data Book - RDB) and 455 coastal nationally scarce species listed by Kirby (1994a, b), six and fourteen respectively have been recorded in Region 15 and six and 25 respectively in Region 16, according to JNCC's Invertebrate Site Register (ISR). Several other scarce and threatened species not treated as coastal by Kirby (1994a, b) have been recorded from coastal localities in Regions 15 and 16. Map 5.3.1 shows the numbers of all RDB invertebrate species (including Kirby's 'coastal' species) recorded in coastal 10 km squares in the regions; Map 5.3.2 shows the recorded distribution of all nationally scarce invertebrates in the regions, 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 regions, so actual occurrence may differ from recorded distributions.

Table 5.3.1 lists the three species of invertebrate recorded in Region 16 that are on international Directives, Conventions or the Wildlife & Countryside Act (1981). None of these species has been recorded in Region 15.

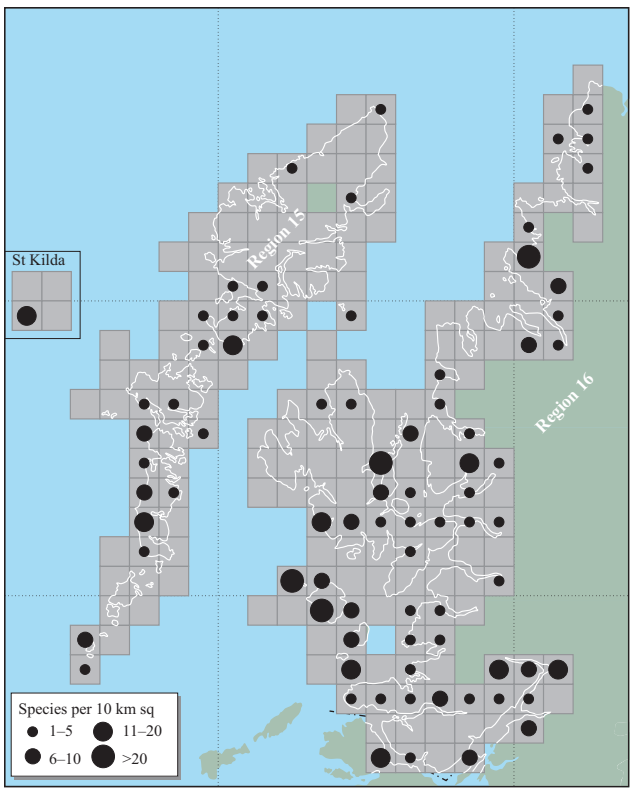
Table 5.3.1 Protected invertebrate species in Region 16

Species	*Protected status*	*Locations†*
Freshwater pearl mussel *Margaritifera margaritifera*	1, 2, 3**	North Ebudes
Medicinal leech *Hirudo medicinalis*	1, 2, 3*, 4	West Sutherland (last available records 1956)
Marsh fritillary butterfly *Eurodryas aurinia*	1, 2	Argyll Main; North Ebudes (last available records 1957)

Key: Protected status codes: 1 = EC Habitats and Species Directive; 2 = Bern Convention; 3 = Schedule 5, Wildlife & Countryside Act 1981 (excluding Schedule 5 section 9(5): sale only); 4 = CITES is the Convention on International Trade in Endangered Species of Wild Fauna and Flora; *Variation of Schedules Order 1988; **Variation of Schedules Order 1991; †Watsonian vice-counties, areas commonly used in biological recording: Argyll Main = Argyll & Bute excluding Bute, Kintyre and the offshore islands; North Ebudes = Eigg, Rum and Skye and their smaller neighbours.



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.

5.3.2 Important locations and species

Coastal nationally rare species as defined by Kirby (1994a, b) are listed in Table 5.3.2.

The ISR has records for over 80 sites in Region 15 and more than 150 in Region 16. Some of these are imprecisely defined and others are subsites of larger areas. Several sites support RDB species and many are the habitats of nationally scarce species. Table 5.3.3 lists the sites that are considered to be particularly important for invertebrate conservation, mainly on the basis of data on the ISR. Site selection was based on the range and/or scarcity of species present, the species/habitat associations and the amount of available habitat.

The dune and machair sites of the regions have a variety of microhabitats, all of which support a range of invertebrates. In Region 15 in particular the dunes and machair often grade through marshy areas to open water, which typically has fringing vegetation. All these habitats are exploited by a range of invertebrates. Strandline litter is a microhabitat used by many species, including a number of Staphylinidae (rove beetles). The ground beetle *Bembidion pallidipenne*, a species found on beaches with damp sand, is known from a very few sites in Regions 15 and 16. The micro-moth *Scrobipalpa clintoni* frequents sandy and shingle beaches, the larva feeding in the stems of curled dock *Rumex crispus*. Several species of scarce and threatened moth occur in more vegetated areas of dunes. These include the rare belted beauty *Lycia zonaria*, which frequents areas where plants such as bird's-foot-trefoil *Lotus* spp. occur, and the pretty pinion *Perizoma blandiata*, which has been recorded from several sites in the region where its foodplants, eyebrights *Euphrasia* spp., are found. As with many bees and wasps, the northern colletes *Colletes floralis*, recorded in Region 15, is associated with areas of bare sand in sunny situations amongst dune grassland. The coast dart moth *Euxoa cursoria* (recorded recently in Region 16) is confined to coastal dunes and is most frequently found behind the foredunes. Its larvae feed on a variety of sand dune plants.

A range of moth species are associated with sea cliffs. In Regions 15 and 16 the Scotch annulet moth *Gnophos obfuscatus* often frequents rocky situations, where the larvae feed on heather *Calluna vulgaris* and other low-growing plants. Where juniper *Juniperus communis* scrub occurs, moths such as the chestnut-coloured carpet *Thera cognata* and the juniper carpet *T. juniperata* can be found. The steep south-facing herb-rich slopes at Ardnamurchan are known to support a rare moth, the grey *Hadena caesia*. This moth seems to be found mainly within 50 m of high water-mark (Heath & Emmet 1979). The transparent burnet *Zygaena*

Table 5.3.2 Coastal Red Data Book (RDB) species in Regions 15 & 16

Species	*Description and notes on recorded occurrence in the region*
Region 15	
RDB1	
Ceutorhynchus insularis	Small (2-3 mm) weevil feeding on scurvygrass *Cochlearia* spp. In Britain recorded only from St. Kilda; otherwise known from only a few islands off the coast of Iceland.
RDB3	
Colletes floralis	Mining bee confined to the west coast of Scotland, where it is typically found on coastal dunes on the mainland and on machair grassland at its island colonies. Loch Druidibeg NNR.
Belted beauty moth *Lycia zonaria*	Coastal sandhills, where the larvae feed on bird's-foot-trefoil *Lotus* spp., burnet rose *Rosa pimpinellifolia* and other low-growing plants. Caernarvonshire, Cheshire, Argyllshire and the Hebrides (many records).
pRDBK	
Aleochara verna	Rove beetle recorded on the coast under rotting seaweed above the high tide mark. Inner and Outer Hebrides: Tarbet, Harris.
Ceutorhynchus cakilis	Littoral weevil associated with sea rocket *Cakile maritima* and sea kale *Crambe maritima*. North Uist.
Omalium rugulipenne	Rove beetle, found under dead seaweed. Local in England; also known from Scotland but probably rarer in the north of its range. Luskentyre Banks and Saltings SSSI, Tolsta Dunes, Coll Sands and Gress Saltings.
Region 16	
RDB3	
Grey moth *Hadena caesia mananii*	Cliffs and rocky places by the sea. Larvae feed on sea campion *Silene maritima*. Local, western Argyllshire, Ardnamurchan and several of the Hebridean islands (Rum, Canna and Talisker Bay on Skye).
Belted beauty moth *Lycia zonaria*	Coastal sandhills, where the larvae feed on bird's-foot-trefoil *Lotus* spp., burnet rose *Rosa pimpinellifolia* and other low-growing plants. Ardnamurchan, Rum, Muck and Canna.
pRDB3	
Narrow-bordered five-spot burnet moth *Zygaena lonicerae jocelynae*	Associated with a variety of maritime grassland flowers. Talisker Bay, Skye.
pRDBK	
Arena tabida	Very rare rove beetle of coastal habitats. In sand, under stones embedded in sand and in dead birds. Rum.
Omalium rugulipenne	Rove beetle, found under dead seaweed. Local in England; also known from Scotland but probably rarer in the north of its range. Loch Gairloch Coast, Ardnamurchan SSSI, Achnahaird, Mellangaun, Morar Bay, Camusdarach Bay, Mungasdale, Rum.
Trichohydnobius suturalis	Small beetle; sandy beaches on the coast. Very local with a scattered distribution from southern England north to Wester Ross. Redpoint (Loch Torridon).

Source: JNCC (Invertebrate Site Register). Key: Red Data Book categories: RDB1 = endangered; RDB2 = vulnerable; RDB3 = rare; RDBI = indeterminate; RDBK = insufficiently known; pRDB = proposed species as categorised in e.g. Hyman & Parsons (1992); pRDBK = 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 in Regions 15 & 16

Site	*Grid ref.*	*Status*
Region 15		
Askernish Coast	NF7222	SSSI
Ormiclate Dunes	NF7332	SSSI
Howmore Estuary, Loch Roag	NF7535	SSSI
Liniclate Dunes	NF7749	Undesignated
Baleshare & Kirkibost	NF7862	SSSI
Paible	NF7266	Undesignated
Balranald Bog & Loch Nam Feithean (includes machair)	NF7170	SSSI
Hosta	NF7172	Undesignated
Leathann	NF8176	Undesignated
St. Kilda	NF0999	NNR, SPA, NTS,
Biosphere Reserve, World Heritage Site Northton Bay	NF9990	SSSI
Luskentyre Banks and Saltings	NG0897	SSSI
Camas Uig	NB0432	Undesignated
Valtos Dunes	NB1035	Undesignated
Barvas Dunes	NB3451	Undesignated

Site	*Grid ref.*	*Status*
Region 16		
Carnach Wood	NN0958	SSSI
Doire Donn	NN0570	SSSI
Doire Mor	NM9276	Undesignated
Ariundle/Loch Sunart Woodlands	NM8464	NNR
Salen to Woodend	NM7362	SSSI
Ardnamurchan	NM4867	SSSI
Muck	NM4179	SSSI (in part)
Rum	NM3798	NNR, SPA,
Biosphere Reserve		
Canna & Sanday	NG2506	SSSI, NTS (in part)
Talisker Bay, Talisker	NG3129	SSSI
River Kilmartin, Staffin	NG4865	Undesignated
Raasay	NG5738	SSSI (in part)
Carn Mor, Strathcarron	NG9643	Undesignated
Rassal	NG8442	SSSI, NNR (in part)
Shieldaig Woods	NG8252	SSSI
Loch Gairloch Coast (including Redpoint and Cille Dubh)	NG7579	SSSI (in part)
Inverpolly	NC0713	NNR

Key: NNR - National Nature Reserve; NTS - National Trust for Scotland; SPA - Special Protection Area; SSSI - Site of Special Scientific Interest.

purpuralis subsp. *caledonensis* inhabits dry, steep, south-facing slopes or undercliffs, the larvae feeding on wild thyme *Thymus drucei*. The belted beauty moth *Lycia zonaria* subsp. *britannica* is primarily thought of as a moth of machair and dunes, but in Region 16 it has also been found inhabiting dry, herb-rich coastal grassland below basalt cliffs.

Coastal woodlands in Region 16 have a wide range of habitats exploited by invertebrates. The larvae of the click beetle *Ampedus pomorum* develop mainly in decaying and rotten birch wood, although they have also been found in other wood. The net-winged beetle *Dictyoptera aurora* is thought to be associated with dead Scots pine wood, and the darkling beetle *Bolitophagus reticulatus* is associated with the bracket fungus *Fomes fomentarius* on birch. The chafer (a beetle) *Cetonia cuprea*, whose larvae develop in the nests of wood ants *Formica* spp., has been recorded at Doire Mor. The dotted carpet moth *Alcis jubata*, which has been recorded from a few sites in the region, inhabits ancient woodland, the larvae feeding on various lichens. The chequered skipper *Carterocephalus palaemon* has been found at several sites, where it frequents woodland margins and sheltered ground; it is particularly fond of south-facing dips in undulating terrain.

The moorland, mire and wetland habitats of Regions 15 and 16 support a range of species with restricted distributions. Damp moorland and mosses are the habitat of the pyralid moth *Crambus uliginosellus* and the Manchester treble-bar *Carsia sororiata*. The larvae of the latter moth feed on the flowers of various *Vaccinium* species (crowberry etc). The northern emerald *Somatochlora arctica* is a scarce damselfly usually associated with peaty bogs. The beetle *Cyphon konigsbergensis* occurs mainly in open bogs and has been found on a few sites within the regions. The banks of streams support a range of species such as the nationally scarce cranefly *Limnophila apicata*. Lilljeborg's whorl snail *Vertigo lilljeborgi* is a boreo-alpine relict that is declining nationally. It is associated with saturated, decaying vegetation in swampy situations. Pools and larger water-bodies within machair can support a range of water beetles, including *Dytiscus lapponicus, Gyrinus minutus* and, in some locations, *Potamonectes griseostriatus*. Vegetation in these water-bodies can provide suitable foodplants for some invertebrates, for example the weevil *Litodactylus leucogaster*, that are thought to be associated with water-milfoils *Myriophyllum* spp. Brackish and tidal marshes are home to species such as the hoverfly *Lejogaster splendida*.

In Great Britain the weevil *Ceutorhynchus insularis* is known only from old records from St. Kilda, in Region 15. The northern colletes *Colletes floralis*, a mining bee, is confined to coastal localities in the west of Scotland. The small autumnal moth *Epirrita filigrammaria* (also found in Region 16) is not known outside the British Isles. Perhaps the best known inhabitant of the machair dunes is the belted beauty *Lycia zonaria*, which has been recorded from several sites along the west coast of Region 15, where the local subspecies of this moth was described as *atlantica* by Harrison & Heslop (1940). Greatorex-Davies (1980) suggests that the "species probably occurs continuously on the machair, which extends all the way along the west coast of these islands," although there is evidence to suggest that the moth becomes less frequent to the north of the islands.

In Region 16 there are several species with a restricted national distribution. For example, a large part of the British populations of the moths *Scrobipalpa clintoni* and the transparent burnet *Zygaena purpuralis* are found along this stretch of coast. The British distribution of the chequered skipper *Carterocephalus palaemon* is now largely centred on this part of the country and the majority of populations of the moth the grey *Hadena caesia* are within this region. The dew moth *Setina irrorella* has been recorded at a few sites in the region; it is a scarce species with a disjunct distribution in this country. A number of distinct subspecies have been described from the Inner Hebrides and there are indications that island forms exist that have not yet been described (Wormell 1983). One example is the subspecies *jocelynae* of the narrow-bordered five-spot burnet moth *Zygaena*

lonicerae, which is found only on Skye. A large area of land around Beinn Eighe and Loch Maree Islands is known to support an outstanding assemblage of Odonata (dragonflies and damselflies) in the national context. Amongst those species found is the northern emerald *Somatochlora arctica*, a scarce damselfly that is confined to northern Scotland.

5.3.3 Human activities

Appropriate site management may be vital for maintaining invertebrate interest, since invertebrates occur in the full range of coastal habitats and many require particular microhabitats, often using subtle features of vegetation structure or areas of bare ground. As most invertebrates have annual life cycles, the habitat features they utilise must be present in the right condition in each and every year. Many of the rarest species have poor powers of dispersal and are thus unable to colonise suitable habitat from afar, so it is vital that suitable breeding conditions are retained at sites year after year. Site management often overlooks many features that are of importance to invertebrates, many species surviving by default. The management of coastal habitats for invertebrates is covered by Kirby (1992). Management of sites for the chequered skipper *Carterocephalus palaemon* is discussed by Young & Ravenscroft (1991) and Ravenscroft (1996).

5.3.4 Information sources used

Many of the data referred to here come from the Invertebrate Site Register (ISR), a computerised GB-wide database that, although not comprehensive, includes information from many sources, specialists and surveys, as well as from the literature (such as entomological journals and local biological record centres). It is the most complete data set available on the scarcer species occurring in the regions. Additional information was gleaned from a range of other reports and reviews, e.g. Wormell (1983).

As with most regions in Great Britain, the level of invertebrate recording varies over these sections of coast as well as between the various invertebrate groups. Most of the major invertebrate groups have been studied, but to varying degrees. Although there are local residents who study some groups of invertebrates, much of the recording activity on the coasts of the regions has been the result of visiting specialists.

In Region 15 there has been a long history of interest in the invertebrate fauna of the islands. For example, the first insects recorded from St. Kilda were found in the mid 19th century (Waterston 1981). Since then, many invertebrate zoologists have visited the islands of Region 15. Perhaps the majority of recent recording effort has been on the machair sites on the west coasts of the more easily accessible islands, although there are records (many comparatively old) for several sites on east coasts, for example Stornoway Castle Woodlands. In Region 15 the Coleoptera and Lepidoptera have received the greatest recording effort over the years. This is illustrated by the fact that over 600 species of Coleoptera and over 360 species of Lepidoptera have been recorded from the islands (Waterston 1981). New discoveries are frequently made, even amongst the better known groups. However, as the faunas are comparatively under-recorded, more work on invertebrates is needed, particularly along relatively under-studied stretches of the coastline.

In Region 16 a few sites are particularly well known for certain species and are consequently regularly studied, although usually at specific times of year. Recording effort along under-worked stretches of coast, including those where there does not appear to have been any invertebrate recording, would probably result in the location of further sites of importance for invertebrate conservation. The Lepidoptera are probably the best known invertebrate order in the region. On some sites in the islands a range of other orders have been comparatively well-recorded; for example, over 530 species of Coleoptera (beetles) have been found on Rum (Welch 1983).

In 1976 the Institute of Terrestrial Ecology was commissioned by the Nature Conservancy to undertake an invertebrate survey of dune and machair sites, which included sites in Regions 15 & 16. The Rothamsted Invertebrate Survey have operated light traps at two sites in Region 15 and three sites in Region 16, and the Butterfly Monitoring Scheme has undertaken a transect on one site in Region 16 (Pollard *et al*. 1986). There are a few regional journals that include occasional notes and papers on the invertebrate faunas of the coasts of Regions 15 and 16, for instance the *Hebridean Naturalist*, the *Glasgow Naturalist* and the *Proceedings of the Royal Society of Edinburgh*. Recent volumes of the *Glasgow Naturalist* include a summary of records for each year from the west of Scotland, including many records from Region 16. There have also been several local lists published, usually covering one or more of the islands of Region 16: for instance, Campbell (1970, 1971) covers Canna, Wormell (1983) covers the Inner Hebrides, and aspects of the invertebrate fauna of the Muck Islands have recently been covered in several papers (Dobson 1986, 1987, 1990, 1991, 1993). The Highland Biological Recording Group also cover the coast of Region 16.

National recording schemes for a wide range of invertebrate groups contain records from the coasts of Regions 15 and16. Most of these are co-ordinated by specialists with assistance from the Biological Records Centre (Institute of Terrestrial Ecology).

Provisional distribution maps have been published for a wide range of invertebrates, including many for which Regions 15 and 16 are important. For example, Young & Ravenscroft (1991) map the distribution of the chequered skipper butterfly *Carterocephalus palaemon* in Scotland, and Heath & Emmet (1979, 1983, 1990) map many Lepidoptera species found in the regions.

5.3.5 Acknowledgements

Thanks are due to D. Procter (JNCC) and Dr S. Ball (JNCC) for providing the raw data from the ISR and for assistance in producing the maps and Table 5.3.1. Thanks are also due to D. Procter and J. Barne (JNCC) for their comments.

5.3.6 Further sources of information

A. References cited

Bratton, J.H., *ed*. 1991. *British Red Data Books: 3. Invertebrates other than insects*. Peterborough, Joint Nature Conservation Committee.

Campbell, J.L. 1970. Macro-lepidoptera Cannae. The butterflies and moths of Canna. *Entomologist's Record and Journal of Variation*, *82***:** 211-214, 235-242, 292-299.

Campbell, J.L. 1971. Macro-lepidoptera Cannae. The butterflies and moths of Canna. *Entomologist's Record and Journal of Variation*, *83*: 6-12.

Dobson, R.M. 1986. The natural history of the Muck Islands, North Ebudes. 2. Spiders, harvestmen and pseudoscorpions. *Glasgow Naturalist*, *21*(2)*:* 173-181.

Dobson, R.M. 1987. The natural history of the Muck Islands, North Ebudes. 4. Beetles. *Glasgow Naturalist*, *21*(3)*:* 335-349.

Dobson, R.M. 1990. The natural history of the Muck Islands, North Ebudes. 6. Moths and butterflies. *Glasgow Naturalist*, *21*(5)*:* 585-597.

Dobson, R.M. 1991. The natural history of the Muck Islands, North Ebudes. 7. Insecta: Apterygota and Exopterygota. *Glasgow Naturalist*, *22*(1)*:* 31-40.

Dobson, R.M. 1993. The natural history of the Muck Islands, North Ebudes. 9. Insecta: Neuroptera, Trichoptera, Siphonaptera and Hymenoptera-Symphyta and Aculeata. *Glasgow Naturalist*, *22*(3): 255-258.

Greatorex-Davies, J.N. 1980. Recent records of *Agrotis ripae* (Hübner) (Noctuidae) and other sand-dune Lepidoptera from Scotland. *Entomologist's Gazette*, *31*: 19-22.

Harrison, J.W., & Heslop J.W. 1940. A new subspecies of *Nyssia zonaria* Schiff and a new aberration of *Poecilopsis lapponaria* B. *Entomologist's Record and Journal of Variation*, *52:* 33-35.

Heath, J., & Emmet, A.M., *eds*. 1979. *The moths and butterflies of Great Britain and Ireland*. *Volume 9.* London, Curwen Press.

Heath, J., & Emmet, A.M., *eds*. 1983. *The moths and butterflies of Great Britain and Ireland. Volume 10.* Colchester, Harley Books.

Heath, J., & Emmet, A.M., *eds*. 1990. The butterflies of Great Britain and Ireland. *The moths and butterflies of Great Britain and Ireland. Volume 7, Part 1.* Colchester, Harley Books.

Hyman, P.S., & Parsons, M.S. 1992. *A review of the scarce and threatened Coleoptera of Great Britain*. *Part 1.* Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No. 3.)

Hyman, P.S., & Parsons, M.S. 1994. *A review of the scarce and threatened Coleoptera of Great Britain*. *Part 2*. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No. 12.)

Kirby, P. 1992. *Habitat management for invertebrates: a practical handbook*. Sandy, Royal Society for the Protection of Birds, the Joint Nature Conservation Committee and National Power.

Kirby, P. 1994a. *Habitat fragmentation; species at risk*. Peterborough, English Nature. (English Nature Research Reports, No. 89.)

Kirby, P. 1994b. *Habitat tabulations for rare and scarce invertebrates: Coleoptera (part); Dolichopodidae & Empididae; macro-moths; Ethmiinae, Stathmopodinae and Gelechiidae.* Peterborough, Joint Nature Conservation Committee (unpublished report).

Pollard, E., Hall, M.L., & Bibby, T.J. 1986. *Monitoring the abundance of butterflies 1976-1985.* Peterborough, Nature Conservancy Council. (Research & survey in nature conservation, No. 2.)

Ravenscroft, N. 1996. *The chequered skipper.* Colchester, Butterfly Conservation.

Shirt, D.B., *ed*. 1987. *British Red Data Books: 2. Insects*. Peterborough, Nature Conservancy Council.

Waterston, A.R. 1981. Present knowledge of the non-marine invertebrate fauna of the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh*, *79B*: 215-321.

Welch, R.C. 1983. Coleoptera in the Inner Hebrides. *Proceedings of the Royal Society of Edinburgh*, *83B*: 505-529.

Wormell, P. 1983. Lepidoptera in the Inner Hebrides. *Proceedings of the Royal Society of Edinburgh*, *83B*: 531-546.

Young, M.R., & Ravenscroft, N.O.M. 1991. Conservation of the chequered skipper butterfly (*Carterocephalus palaemon* Pallas) in Scotland. *Nature Conservancy Council, CSD Report,* No. 1,272.

B. Further reading

Bland, K.P. 1993. Records of Lepidoptera on North Uist, Outer Hebrides. *Glasgow Naturalist, 22*(3): 247-250.

Chalmers-Hunt, J.M. 1989. *Local lists of Lepidoptera*. Uffington, Hedera Press.

Collier, R. 1986. *The conservation of the chequered skipper in Britain*. Peterborough, Nature Conservancy Council. (Focus on nature conservation, No. 16.)

Colvin, M., & Reavey, D. 1993. *A directory for entomologists*. 2nd ed. Middlesex, Amateur Entomologist's Society. (Pamphlet No. 14.)

Falk, S. 1991. *A review of the scarce and threatened bees, wasps and ants of Great Britain*. Peterborough, Nature Conservancy Council. (Research & survey in nature conservation, No. 35.)

Falk, S. 1991. *A review of the scarce and threatened flies of Great Britain (part 1).* Peterborough, Nature Conservancy Council. (Research & survey in nature conservation, No. 39.)

Foster, A.P. 1983. National review of non-marine Molluscs. *Nature Conservancy Council, CSD Report,* No. 449.

Foster, G.N. 1983. Atlas of British water beetles. Preliminary edition - part 2. *Balfour-Browne Club Newsletter, 27*: 1-23.

Foster, G.N. 1985. Atlas of British water beetles. Preliminary edition - part 4. *Balfour-Browne Club Newsletter, 35:* 1-22.

Hammond, C.O. (Revised by Merritt, R.) 1983. *The dragonflies of Great Britain and Ireland.* 2nd ed. Colchester, Harley Books.

Heath, J., & Emmet, A.M., *eds*. 1985. *The moths and butterflies of Great Britain and Ireland. Volume 2.* Colchester, Harley Books.

Mendel, H. 1990. *Provisional atlas of the click beetles (Coleoptera: Elateroidea) of the British Isles*. Huntingdon, Biological Records Centre.

Merrett, P. 1990. *A review of the nationally notable spiders of Great Britain*. Peterborough, Nature Conservancy Council. (Contract surveys, No. 127.)

Parsons, M.S. 1993. *A review of the scarce and threatened pyralid moths of Great Britain*. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No. 11.)

Parsons, M.S. 1995. *A review of the scarce and threatened ethmiid, stathmopodid and gelechiid moths of Great Britain*. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No. 16.)

Ravenscroft, N.O.M. 1995. The conservation of *Carterocephalus palaemon* in Scotland. *In*: *Ecology and conservation of butterflies*, ed. by A.S. Pullin, 165-179. London, Chapman & Hall.

Smith, K., & Smith, V. 1983. *A bibliography of the entomology of the smaller British offshore islands*. Faringdon, E.W. Classey.

Stubbs, A.E. 1992. *Provisional atlas of the long-palped craneflies (Diptera: Tipulinae) of Britain and Ireland*. Huntingdon, Biological Records Centre.

Thomas, J., & Lewington, R. 1991. *The butterflies of Britain and Ireland*. London, National Trust/Dorling Kindersley.

Thomson, G. 1980. *The butterflies of Scotland. A natural history*. London, Croom Helm.

Trevor, J. 1994. Butterflies of the Outer Hebrides. *Butterfly Conservation News, 58:* 30-31.

Waring, P. In prep. *A review of the scarce and threatened macrolepidoptera of Great Britain*. Peterborough, Joint Nature Conservation Committee.

Welch, R.C. 1979. Survey of the invertebrate fauna of sand dune and machair sites in the Outer Hebrides during 1976. *Proceedings of the Royal Society of Edinburgh*, *77B*: 395-404.

Wormell, P. 1987. Invertebrates of Rhum. *In*: *Rhum. The natural history of an island*, ed. by T.H. Clutton-Brock & M.E. Hall, 63-77. Edinburgh, Edinburgh University Press.

C. Contact names and addresses

Type of information	Contact address and telephone no.
Invertebrate site and species information	*Dr D. Phillips, SNH Headquarters, Edinburgh, tel: 0131 447 4784
Occurrence of invertebrates in the regions	*Biological Records Centre, Institute of Terrestrial Ecology, Monks Wood, tel: 01487 77338
Invertebrate Site Register (ISR): a computerised national inventory of sites of significance to invertebrate conservation; contains records of local, scarce and threatened species of all groups of invertebrates	*Invertebrate Site Register, JNCC Peterborough, tel: 01733 62626
Literature-based entomological records	Scottish Insect Records Index, c/o Dr M.R. Shaw, National Museums of Scotland, Chambers Street, Edinburgh EH1 1JF, tel: 0131 225 7534
Conservation of butterflies and moths	British Butterfly Conservation Society, Glasgow, Art Gallery & Museum, Kelvingrove, Glasgow G3 8AG, tel: 0141 305 2660
Highland regional biological records centre	Stephen Moran, Highland Biological Recording Group, Inverness Museum and Art Gallery, Castle Wynd, Inverness IV2 3ED, tel: 01436 237114
National recording database for aquatic Coleoptera, and specific survey information on scarce species	Balfour-Browne Club/ Dr G.N. Foster, 3 Eglinton Terrace, Ayr KA7 1JJ, tel: 01292 525294

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

5.4 Rare sea-bed species

J. Plaza & Dr W.G. Sanderson

5.4.1 Introduction

This section considers rare and scarce marine benthic (sea-bed) species, excluding fish. The occurrence and distribution of benthic communities is discussed in section 4.2. 'Nationally rare' marine benthic 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 survey 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 may occur more commonly towards the centre of their biogeographic range. Of the eighteen species listed from Region 15, for example, four are southern species occurring near or at the northern margins of their distribution, while three are northern (i.e. North Atlantic/subarctic) species approaching their southern margins. A species described here as 'nationally rare' or 'nationally scarce' is therefore not 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 more data become available or populations change, the status of species listed in this chapter will require re-evaluation.

Four rare marine benthic species and fourteen scarce species have been recorded from Region 15 (Western Isles), while four rare and 20 scarce species have been recorded within Region 16 (west Highland). Loch Maddy (on North Uist), the Island of St. Kilda, and Loch Seaforth (on Lewis) appear to harbour more rare and scarce species than other areas in the Region 15. In Region 16, the area around Ardnamurchan and Loch Sunart appears to contain the highest numbers of rare and scarce species. Notable concentrations of rare and scarce species in this region also occur around the easternmost part or Skye (Loch Alsh and Loch Duich) and further north, at Loch Ewe and Little Loch Broom. These observations should, however, be regarded with caution, since survey effort has been uneven. As has been mentioned in section 4.2, the marine flora and fauna of north-west Scotland show a slight decrease in species richness compared with more southern parts of the Scottish west coast, as some of the warm-water species find their most northerly limits on or south of this stretch of coast. This may go some way to explaining the relative paucity of rare and scarce species in these regions, compared with Region 14.

Only two marine benthic species known to occur in the region are protected by statute: the foxtail stonewort *Lamprothamnium papulosum* and the northern hatchet-shell *Thyasira gouldi* are both protected under the Wildlife & Countryside Act 1981. Rare and scarce species of maerl (calcareous red seaweed) that are listed in the EC Habitats & Species Directive have been excluded from this chapter because of taxonomic doubt over records of the species in the region.

5.4.2 Important locations and species

Table 5.4.1 lists the rare and scarce marine benthic species that have been recorded in the regions, 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). Maps 5.4.1 and 5.4.2 summarise the known distribution of important locations for rare and scarce species in recent times. Note that in Map 5.4.2 some of the 10 km squares straddle the border between Region 16 and Region 14: in these squares only the records that occur in Region 16 have been included, so some of these squares actually contain more rare and scarce species in total than are mentioned here.

Some nationally rare and scarce species described here, such as *Lamprothamnium papulosum*, are restricted to very specific habitat types in Great Britain that themselves are rare, scarce or (in some cases) threatened. Such species may therefore be of nature conservation importance. Species confined to saline lagoons, maerl or seagrass beds have been so considered (see e.g. Anon 1995). Region 15 and Region 16 each contain four species that are thought to 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 replace their numbers slowly at the margins of their global distribution. This renders them particularly vulnerable to even minor, infrequent impacts. As a result, communities of southern species have been considered important as reference sites for monitoring the marine environment in the UK (Fowler & Laffoley 1993). A similar argument may apply to northern species approaching the southern limit of their biogeographical range; two such species occur in Region 15 and another two in Region 16. Genetic, 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 importance of genetic, species and habitat biodiversity in the UK has recently been the focus of *Biodiversity: the Steering Group report* (Anon 1995). 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 species, however, will occur to some extent in the waters of Great Britain outside the coastal zone.

Table 5.4.1 'Nationally rare' and 'nationally scarce' marine benthic species found in Regions 15 & 16

Species	*Region* 15	16	*Area(s) of occurrence*	*Habitat/associations*	*Comments*	*Useful reference*
A sponge *Phakellia ventilabrum*	✓	✓	15: East Loch Tarbert, Loch Maddy 16: Loch Sunart	Slightly sheltered locations near to deep water.	Possibly an offshore species. May be habitat specific.	Ackers *et al.* (1992)
A sponge *Tethyspira spinosa*	✓		15: St. Kilda	On wave exposed subtidal rock to *c.* 60 m.	Southern species.	Ackers *et al.* (1992)
A sponge *Mycale lingua*	✓	✓	15: Loch Maddy, Loch Seaforth 16: Loch Duich, Loch a' Chairn Bhain, Loch Sunart	Generally on deep (40 m+), sheltered rock.	A very conspicuous species.	Ackers *et al.* (1992)
A sponge *Clathria barleei*		✓	16: Loch Sunart	Subtidal, on rocks, stones and sometimes on *Lophelia pertusa*. Usually at more than 40 m depth.	Possibly a deeper water species, scarce in nearshore waters.	Ackers *et al.* (1992)
A sponge *Plocamilla coriacea*	✓	✓	15: St. Kilda 16: Loch Sunart	Often on vertical or overhanging subtidal bedrock in areas of flowing water. Often has other sponges attached.	Southern species. distribution includes Mediterranean.	Ackers *et al.* (1992)
A hydroid *Hartlaubella gelatinosa*		✓	16: Loch Nevis, Loch Hourn	Intertidal to 15 m or deeper, often in gentle current.	From Denmark to the Mediterranean and Black Sea. Tolerant of silt and brackish water.	Hayward & Ryland (1990)
A soft coral *Parerythropodium coralloides*	✓		15: St. Kilda, Loch Claidh	Overhangs & crevices out of light. Sheltered from strong wave action. 0-25 m.	Southern. More common in SW Europe and the Mediterranean. Somewhat cryptic but still probably scarce.	Manuel (1988)
Fireworks anemone *Pachycerianthus multiplicatus*	✓	✓	15: Loch Seaforth, Loch Resort 16: Loch Pooltiel, Loch Alsh, Upper Loch Linnhe, Loch Duich, Loch Eil	Partially buried in muddy substratum from 10-130 m depth.	Elsewhere known only from Scandinavia and Ireland.	Manuel (1988)
A sea anemone *Arachnanthus sarsi*	✓		15: St. Kilda, Loch Seaforth	Found in a mixture of shell sand, from 15-36 m.	Discovered in several localities in west Scotland. Otherwise known only from Norway (140 m depth) and Ireland.	Picton & Manuel (1985)
A sea anemone *Parazoanthus anguicomus*	✓	✓	15: St. Kilda, Loch Eynort 16: Small Isles, Loch a' Chairn Bhain, Loch Eynort, Skye, Loch Sunart	Subtidal rock.	Deep water species occasionally in shallow water.	Manuel (1988)
A sea anemone *Phellia gausapata*	✓	✓	15: North Rona 16: Kyle Rhea, Skye	On rocks in kelp zone, usually in small aggregations, lower shore to 30 m.	Known only from Scotland and Ireland.	Manuel (1988)
An echiuran worm *Amalosoma eddystonense*		✓	16: Raasay, Loch Duich, Loch Sligachan, Loch Alsh, Loch Nevis, Loch a' Chairn Bhain, Loch Glencoul, Loch Ailort, Little Loch Broom, Loch Ewe	Buried quite deep in sublittoral muddy gravels.	Difficult to sample, but still probably scarce.	Hayward & Ryland (1990)
An amphipod *Austrosyrrhoe fimbriatus**		✓	16: Loch Gairloch	Habitat poorly known. May be characteristic of maerl substrata in SW Britain.	Known only from a few British localities (Lincoln 1979).	Moore (1984)

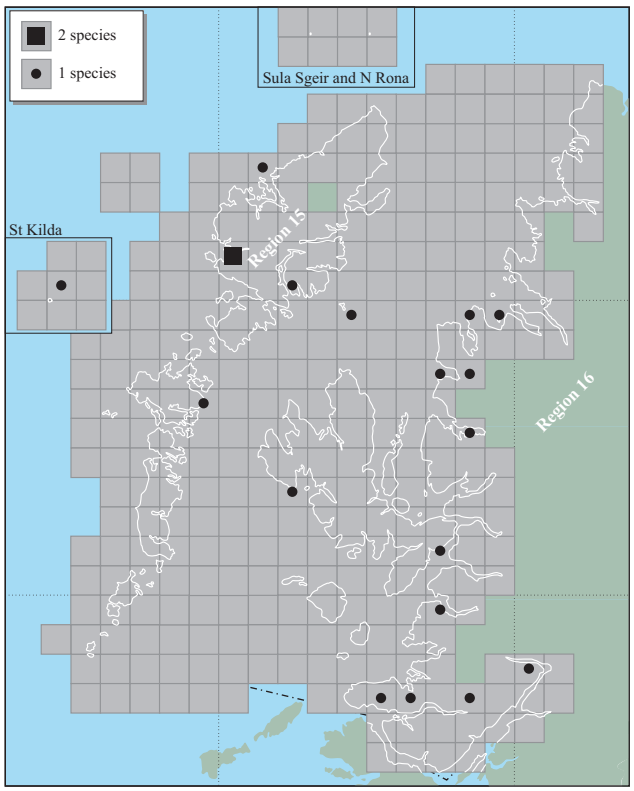
Table 5.4.1 'Nationally rare' and 'nationally scarce' marine benthic species found in Regions 15 & 16 (continued)

Species	*Region* 15	16	*Area(s) of occurrence*	*Habitat/associations*	*Comments*	*Useful reference*
Lagoon snail *Hydrobia neglecta*	✓		15: North Uist	In hyposaline lagoons, salinity usually above 10 g/kg. Seems to favour *Potamogeton* spp. and *Zostera* spp.	Only recently distinguished from other *Hydrobia* spp. so may be under-recorded.	Cherril & James (1985)
A crab *Ebalia granulosa*		✓	16: Loch nan Uamh	Sublittoral sediment/ mixed gravel.	Range extends to Mediterranean, may be more common offshore.	Hayward & Ryland (1990)
A sea slug *Stiliger bellulus*		✓	16: Loch Nevis	Mud and muddy sand sea beds, possibly feeds on hydroids.	Inconspicuous but probably genuinely scarce.	Graham (1988)
A sea slug *Okenia leachii* *		✓	16: Shiant Islands & Talisker Bay, Skye	Muddy sand sea beds, usually in deep water beyond 25 m. Feeds on sea squirts.	Also occurs in Shetland and the Celtic Sea.	Picton & Morrow (1994)
A sea slug *Trapania pallida*		✓	16: Little Loch Broom, Loch Sunart	Amongst hydroids, bryozoans and sponges on rocky sublittoral cliffs and outcrops.	Occurs in NE Atlantic to the coasts of Spain and France.	Picton & Morrow (1994)
A sea slug *Proctonotus mucroniferus**		✓	16: Loch Torridon	Unknown; found spawning on hydroids.	Recorded only once in the last 50 years. May have been overlooked and confused with *Janolus hyalinus.*	Thompson & Brown (1984)
A sea slug *Aeolidiella alderi*		✓	16: Loch Sunart	Intertidal, feeding on a variety of sea anemones.	Southern species. Single record in this region could be a northern outlier.	Picton & Morrow (1994)
A sea squirt *Synoicum incrustatum**	✓		15: Loch Maddy	Encrusting upper, near-horizontal surfaces subject to sand scour. Depth ranges from 8-35 m.	Easy to overlook but single record from the British Isles suggests it is genuinely rare.	Connor (1989)
A fan mussel *Atrina fragilis*		✓	16: Loch Duich	Point of shell down in mud, sand and gravel. Shallow subtidal to considerable depths. Sometimes gregarious.	Widely distributed in GB but rarely encountered. North Scotland to Iberian Peninsula. May have declined owing to sea-bed disturbance and collection (Holme 1995).	Tebble (1976)
Northern hatchet shell *Thyasira gouldi* #*		✓	16: Loch Sunart, Upper Loch Linnhe, Loch Eil	In organic-rich soft mud or sand to considerable depths.	Wide geographic range from north Norway to Cape Cod.	Blacknell & Ansell (1975)
A bryozoan *Bugula purpurotincta**	✓		15: East Loch Roag	Low water to shallow sublittoral on shells and rock.	A northern species. Occurs north to Spitzbergen, including Norway.	Hayward & Ryland (1990)
A brittle star *Asteronyx loveni*		✓	16: Loch Torridon, Loch Hourn	Found clinging high above the sediment generally to gorgonids and slender sea pens in deep water.	In Britain, recorded sporadically from around Scotland. Also from SW Ireland. May be more common offshore.	Mortensen (1977)
A brittle star *Ophiopsila annulosa*		✓	16: Loch Nevis	Subtidal coarse gravel only, buried.	More common in south Britain; habitat may be under-recorded but still probably scarce.	Picton (1993)
A red seaweed *Gelidiella calcicola* ##		✓	16: South coast of Skye, Loch Ailort	Normally confined to maerl.	Localised in restricted habitat.	Maggs & Guiry (1987)
A red seaweed *Dermocorynus montagnei**	✓		15: Loch Resort	Epilithic on small stones, sublittoral 3-9 m.	Inconspicuous, but thought to be rare.	Irvine (1983)

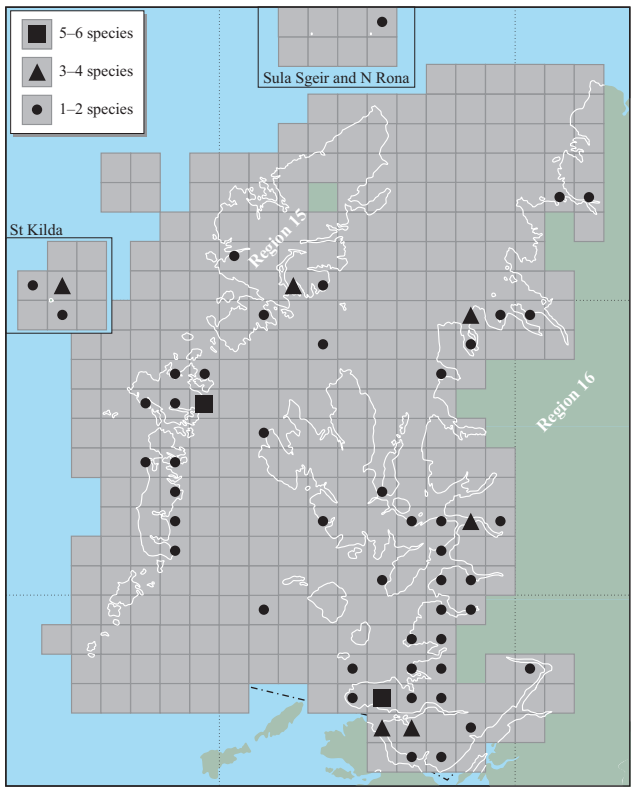
Table 5.4.1 'Nationally rare' and 'nationally scarce' marine benthic species found in Regions 15 & 16 (continued)

Species	*Region* 15	16	*Area(s) of occurrence*	*Habitat/associations*	*Comments*	*Useful reference*
A red seaweed *Callophyllis cristata*	✓	✓	15: Loch Maddy, Loch Boisdale 16: Loch Ewe, Loch Sunart, Loch Moidart	Sublittoral to 30 m. Epiphytic on holdfasts of *Laminaria* spp. and on rock.	Northern species. May be confused with *Sphaerococcus* spp. and *Plocamium* spp. Cautiously regarded as scarce.	Irvine (1983)
A red seaweed *Tsengia (=Platoma) bairdii**	✓		15: Loch Resort	Pebbles at 15 m.	Extremely rare; this record is the only one from this century in the British Isles.	Maggs (in prep.)
A red seaweed *Schmitzia hiscockiana*	✓	✓	15: Loch Resort 16: Loch Ewe	Sublittoral on tide swept cobbles.	Scattered distribution in GB. Restricted habitat. Common at few sites of occurrence. Recorded only in the British Isles and in Sweden.	Maggs & Guiry (1985)
A brown seaweed *Carpomitra costata*	✓		15: Loch Bhrollum, Loch Skipport, St. Kilda	Epilithic on bedrock and boulders to a depth of 37 m.	Well known in the Mediterranean. Most British records are from the south coast.	Fletcher (1987)
A brown seaweed *Desmarestia dresnayi*		✓	16: Loch Nevis, Loch Dunvegan	Epilithic on small stones and shells embedded in gravel in sublittoral in areas of moderate to strong water current.	Easily overlooked but probably still scarce.	Fletcher (1987)
Foxtail stonewort *Lamprothamnium papulosum#*	✓		15: Several sites on North Uist and Benbecula	In brackish lagoons in a range of salinities from 10-30 g/kg growing to a depth of 2 m.	Thought to occur from Norway to Tunisia, and possibly further south.	Stewart & Church (1992)

Source: species names after Howson (1987); in the absence of a specific common name the nearest available group name has been used. Key: * = nationally rare; # = protected under the Wildlife & Countryside Act 1981; ## = species associated with maerl. Note: many of the scarce species listed here are only a little more common than the rare species listed.



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

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. Survey effort in Regions 15 and 16 has not been uniform and assertions made as to the distribution of rare and scarce species may be somewhat artificial. This is particularly true for areas around the open coast, which remain poorly studied. Species that are likely to be very under-recorded or overlooked on a national scale have been avoided in the present work. Every effort has been made to obtain biogeographic data for rarity assessment, but data have not been used from reports prior to 1965 in the present study.

Historically, Regions 15 and 16 have not been subject to as much survey effort as other regions further south, although the presence of Scottish Office Agriculture Environment and Fisheries Department field stations at Loch Ewe and at Ardtoe, Moidart, have contributed to marine biological knowledge about the region. In order to fill the substantial gaps that then existed in the knowledge of the marine biology of western Scotland, the Nature Conservancy Council (NCC) commissioned a large body of littoral work in the 1970s and 1980s. More recently, a systematic survey of the Scottish sea lochs was undertaken as part of the Marine Nature Conservation Review (MNCR) between 1988 to 1992 (Howson *et al.* 1994), and the resulting reports have been an important source of data for this section. Additional records have been gathered following personal communications with experts in many taxonomic fields. It has not been possible in this section 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.

MNCR survey work uses a consistent methodology to record conspicuous species (Connor & Hiscock 1996). The MNCR of Great Britain is at present incomplete but, nevertheless, will substantially increase the quality and evenness of distribution of the available data. Combined with other surveys, this will almost certainly expand our knowledge of the 'nationally rare' and 'scarce' species in Region 15 and Region 16. Consequently, the nationally rare and scarce status of the organisms presented here may require re-evaluation and in future 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.

The nationally scarce brown alga *Fucus distichus* is a northern species at the southern limit of its range in the UK. However, owing to taxonomic changes, the identities of records from St. Kilda are unclear (Powell 1957; Rice & Chapman 1985). It would be valuable to reconfirm some of these records.

5.4.4 Acknowledgements

The author is grateful for the assistance of the JNCC's Marine Nature Conservation Review Team and Coastal Conservation Branch, as well as the expert advice of Dr R.N. Bamber, Dr J.M. Baxter, Dr J. Brodie, P.F. Clark, D.W. Connor, Dr M.J. Costello, 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 T.O. Hill, Dr K. Hiscock, I.J. Killeen, Dr G. Könnecker, J.M. Light, Dr C.A. Maggs, Dr J.D. McKenzie, Prof. P.G. 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, S.M. Turk and Dr R.B. Williams. The author is grateful to R. Covey, C. Duncan, C.M. Howson, Dr J. Hunter, Dr S. Mathieson, D. Murison and Dr D.G. Raffaelli for taking time to read and comment on drafts. Access to the Marine Nature Conservation Review Database at the Joint Nature Conservation Committee, the NIBESRC Database at the Ulster Museum and the ERICA database run by the Cornish Biological Records Unit has been invaluable for the overall analysis.

5.4.5 Further sources of information

A. References cited

Ackers, R.G., Moss, D., & Picton, B.E. 1992. *Sponges of the British Isles ('Sponge V') - a colour guide and working document*. 5th ed. Ross-on-Wye, Marine Conservation Society.

Anon. 1995. *Biodiversity: the UK Steering Group Report*. London, HMSO, for Department of the Environment.

Blacknell, W.M., & Ansell, A.D. 1975. Features of the reproductive cycle of an arctic bivalve from a Scottish sea loch. *Pubblicazioni della Stazione Zoologica di Napoli*, *39*: 26-52.

Bratton, J.H., *ed*. 1991. *British Red Data Books: 3. Invertebrates other than insects*. Peterborough, Joint Nature Conservation Committee.

Cherrill, A.J., & James, R. 1985. The distribution and habitat preferences of four species of Hydrobiidae in East Anglia. *Journal of Conchology*, *32*: 123-133.

Connor, D.W. 1989. *Synoicum incrustatum* (Sars 1851), an ascidian new to the British Isles. *Irish Naturalists' Journal*, *23*: 37-80.

Connor, D.W. & Hiscock, K. 1996. Data collection methods. *In: Marine Nature Conservation Review of Great Britain. Volume 1: rationale and methods*, ed. by K. Hiscock. Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR series.)

Fletcher, R.L. 1987. *Seaweeds of the British Isles. Vol. 3: Fucophyceae (Phaeophyceae)*. London, British Museum (Natural History).

Fowler, S., & Laffoley, D. 1993. Stability in Mediterranean-Atlantic sessile epifaunal communities at the northern limits of their range. *Journal of Experimental Marine Biology & Ecology*, *172*: 109-127.

Graham, A. 1988. *Molluscs: Prosobranch and pyramidellid gastropods*. 2nd ed. Leiden, Linnean Society of London/Estuarine and Brackish Water Sciences Association.

Hayward, P.J., & Ryland, J.S., *eds*. 1990. *The marine fauna of the British Isles and north-west Europe*. 2 vols. Oxford, Clarendon Press.

Holme, N.A. 1995. Conservation of marine molluscs in the British Isles. *In*: *The conservation biology of molluscs*, ed. by E.A. Kay. Gland, Switzerland, IUCN.

Howson, C.M., *ed*. 1987. *Directory of the British marine fauna and flora. A coded checklist of the marine fauna and flora of the British Isles and its surrounding seas*. 1st ed. Ross-on-Wye, Marine Conservation Society.

Howson, C.M., Connor, D.W., & Holt, R.H.F. 1994. The Scottish sea lochs. An account of surveys undertaken for the Marine Nature Conservation Review. *Joint Nature Conservation Committee Report*, No. 164. (Marine Nature Conservation Review Report, No. MNCR/SR/27.)

Hunter, M.L., & Hutchinson, A. 1994. The virtues and shortcomings of parochialism: conserving species that are locally rare, but are globally common. *Conservation Biology*, *8*: 1,163-1,165.

Irvine, L.M. 1983. *Seaweeds of the British Isles. Vol. 1. Rhodophyta. Part 2A. Cryptonemiales (*sensu stricto*), Palmariales, Rhodymeniales*. London, British Museum (Natural History).
IUCN Species Survival Commission. 1995. *IUCN Red List Categories*. Gland, Switzerland, & Cambridge, UK, IUCN.
Lincoln, R.J. 1979. *British marine Amphipoda: Gammaridea*. London, British Museum (Natural History).
Maggs, C.A. In prep. *Tsengia* (=*Platoma*) *bairdii* (Farlow) K. Fan et Y. Fan (Nemastomataceae, Rhodophyta) from Scotland.
Maggs, C.A., & Guiry, M.D. 1985. Life history and reproduction of *Schmitzia hiscockiana* sp. nov. (Rhodophyta, Gigartinales) from the British Isles. *Phycologia*, *24*: 297-310.
Maggs, C.A., & Guiry, M.D. 1987. *Gelidiella calcicola* sp. nov. (Rhodophyta) from the British Isles and northern France. *British Phycological Journal*, *22*: 417-434.
Manuel, R.L. 1988. *British Anthozoa (Coelenterata: Octocorallia and Hexacorallia); keys and notes for the identification of the species*. 2nd ed. Leiden, Linnean Society of London/Estuarine and Brackish Water Sciences Association.
Moore, P.G. 1984. *The fauna of the Clyde Sea Area. Crustacea: Amphipoda*. Millport, University Marine Biological Station. (Occasional publication, No. 2.)
Mortensen, T. 1977. *Handbook of the echinoderms of the British Isles*. Rotterdam, Dr W. Backhuys, Uitgever.
Picton, B.E. 1993. *A field guide to the shallow-water echinoderms of the British Isles*. London, IMMEL Publishing, for Marine Conservation Society.
Picton, B.E., & Manuel, R.L. 1985. *Arachnanthus sarsi* Carlgren, 1912, a redescription of a cerianthid anemone new to the British Isles. *Zoological Journal of the Linnean Society, 83*: 343-349.
Picton, B.E., & Morrow, C.C. 1994. *A field guide to the nudibranchs of the British Isles.* London, Immel Publishing.
Powell, H.T. 1957. Studies in the genus *Fucus* L. II. Distribution and ecology of forms of *Fucus distichus* L. emend Powell in Britain and Ireland. *Journal of the Marine Biological Association of the United Kingdom*, *36:* 663-693.
Rice, E.L., & Chapman, A.R.O. 1985. A numerical taxonomic study of *Fucus distichus* (Phaeophyta). *Journal of the Marine Biological Association of the United Kingdom*, *65:* 433-459.
Sanderson, W.G. 1996. Rare marine benthic flora and fauna in Great Britain: the development of criteria for assessment. *Joint Nature Conservation Committee Report*, No. 240.
Stewart, N.F., & Church, J.M. 1992. *Red data books of Britain and Ireland: stoneworts*. Peterborough, Joint Nature Conservation Committee.
Tebble, N. 1976. *British bivalve seashells. A handbook for identification*. 2nd ed. Edinburgh, HMSO for Royal Scottish Museum.
Thompson, T.E., & Brown, G.H. 1984. *Biology of opisthobranch molluscs.* Vol. 2. London, The Ray Society. (The Ray Society Series, No. 156.)

B. Further reading

Connor, D.W. 1991. Marine benthic ecosystems in Great Britain: a review of current knowledge. Clyde Sea, west Scotland, Outer Hebrides and north-west Scotland (MNCR coastal sectors 12-15). *Nature Conservancy Council, CSD Report*, No. 1175.
Dixon, P.S., & Irvine, L.M. 1977. Seaweeds of the British Isles. Vol. 1. Rhodophyta. Part 1. Introduction, *Nemaliales, Gigartinales*. London, British Museum (Natural History).
Fauvel, P. 1923. *Polychètes sédentaires*. Paris, Libraire de la Faculté des Sciences, for Fédération Française des Sociétés de Sciences Naturelles, Office Central de Faunistique. (Faune de France, No. 16.)
Fowler, S. 1990. Why so much fuss about islands? *Porcupine Newsletter*, *4*: 171.
Graham, A. 1988. *Molluscs: Prosobranch and pyramidellid gastropods. Keys and notes for the identification of the species*. 2nd ed. Leiden, E.J. Brill/Dr W. Backhuys, for Linnean Society of London/ Estuarine and Brackish-water Sciences Association. (Synopses of the British Fauna (New Series), No. 2.)
Ingle, R. 1993. *Hermit crabs of the north-eastern Atlantic Ocean and Mediterranean Sea. An illustrated key*. London, Chapman & Hall, for Natural History Museum Publications.
Jones, A.M., & Baxter, J.M. 1987. *Molluscs: Caudofoveata, Solenogastres, Polyplacophora and Scaphopoda. Keys and notes for the identification of the species*. London, E.J. Brill/Dr W. Backhuys, for Linnean Society of London/Estuarine and Brackish-Water Sciences Association. (Synopses of the British Fauna (New Series), No. 37.)
Maggs, C.A 1986. Scottish marine macroalgae: a distributional checklist, biogeographical analysis and literature abstract. *Nature Conservancy Council*, *CSD Report*, No. 635.
Maggs, C.A., & Hommersand, M.H. 1993. *Seaweeds of the British Isles. Volume 1: Rhodophyta. Part 3A: Ceramiales*. London, HMSO, for Natural History Museum.
Smith, B.P., & Laffoley, D. 1992. *Saline lagoons and lagoon-like habitats in England*. 1st ed. Peterborough, English Nature. (English Nature Science, No. 6.)

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Sponges, sea slugs, hydroids	B.E. Picton, BioMar, Environmental Science Unit, University of Dublin, Trinity College, Dublin 2, Republic of Ireland, tel: 00353 16772941
Amphipods	Prof. P.G. Moore, University Marine Biological Station, Millport, Isle of Cumbrae KA28 0EG, tel: 01475 350581
Crabs	P.F. Clark, Department of Zoology, Natural History Museum, Cromwell Road, London SW7 5BD, tel: 0171 938 9123
Molluscs	Dr. S. Smith, Woodleigh, Townhead, Hayton, Carlisle, Cumbria, CA4 9HJ
Sea squirts	*D.W. Connor, Marine Nature Conservation Review, JNCC, tel: 01733 62626
Bryozoans	Dr P.J. Hayward, School of Biological Sciences, University College Swansea, Singleton Park, Swansea, West Glamorgan SA2 8PP, tel: 01792 205678
Red seaweeds	Dr C.A. Maggs, School of Biology & Biochemistry, Queen's University of Belfast, Belfast BT7 1NN, tel: 01232 245133
Brown seaweeds	Dr R.L. Fletcher, University of Portsmouth, Marine Laboratory, Ferry Road, Hayling Island, Hants. PO11 0DG, tel: 01705 876 543

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

5.5 Exploited sea-bed species

C.F. Robson

5.5.1 Introduction

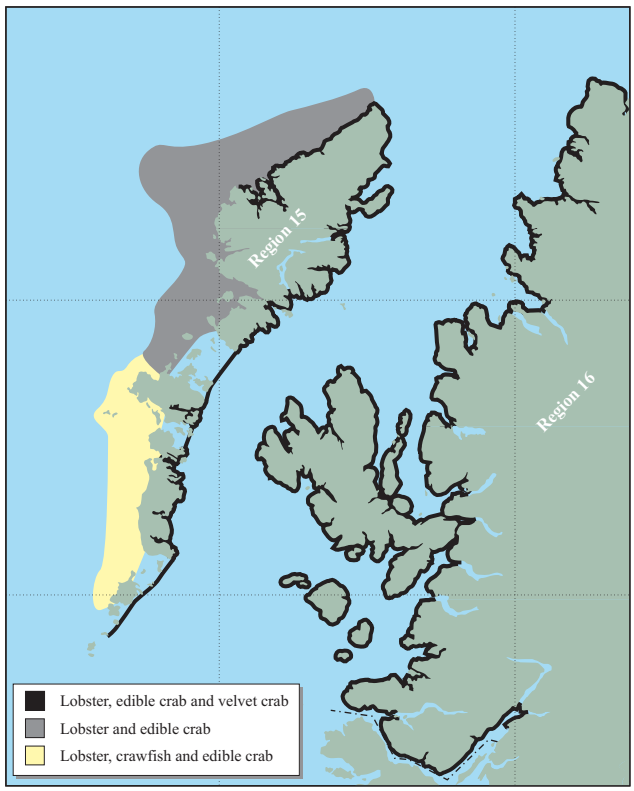
This section describes the distribution of large populations of species that live on, near, or in the bottom sediments of the sea bed (collectively called 'the benthos') and that are routinely exploited, mainly for human food. The exploitation itself is described in sections 9.1 and 9.2. Many of these 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 regions, 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.

Regions 15 and 16 are characterised by (generally inshore) distributions of exploited species such as lobster, edible crab, velvet crab, squat lobster, crawfish and large offshore populations of *Nephrops*, whip prawn and scallops. Compared with other areas in Britain there are no known exploitable quantities of brown shrimp, deep-water prawn, pink prawn, native oyster or queen scallops in these regions.

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*
Brown shrimp	*Crangon crangon*
Spider crab	*Maja squinado*
Crawfish, spiny lobster	*Palinurus elephas*
Deep-water prawn (or shrimp - referred to as both)	*Pandalus borealis*
Pink prawn (or shrimp - referred to as both)	*Pandalus montagui*
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.
Cephalopods (octopus and squid)	*Eledone cirrhosa* & *Loligo forbesii*
Lugworm	*Arenicola marina*
Ragworm/king ragworm	*Neanthes virens* & *Hediste diversicolor*
Algae, e.g. knotted wrack & kelp	*Ascophyllum nodosum* & *Laminaria* spp.



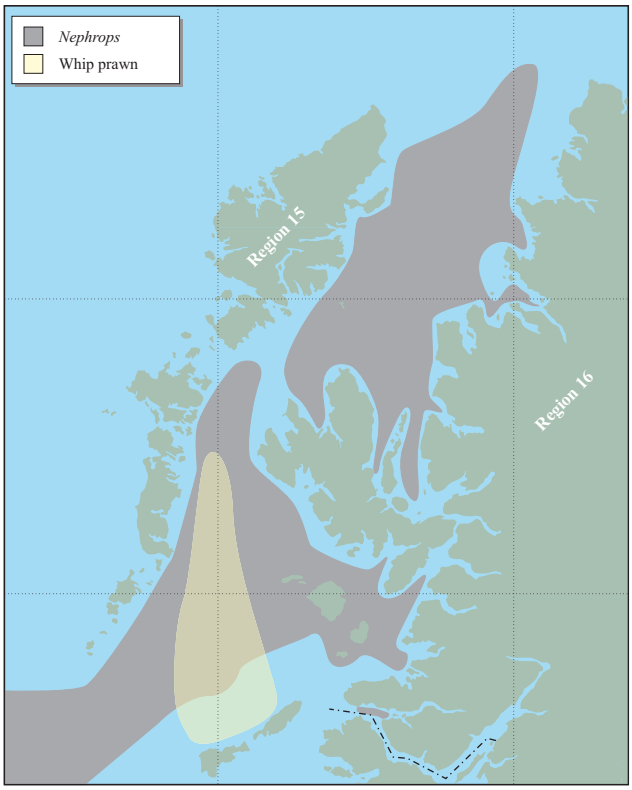
Map 5.5.1 Distribution of crustacea: lobster, edible crab, velvet crab and crawfish. © SOAEFD.

5.5.2 Important locations and species

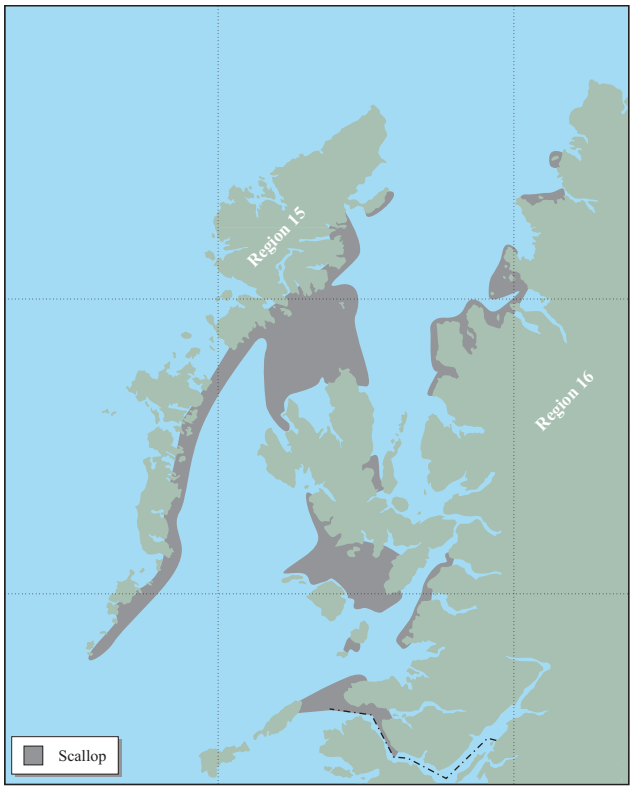
Crustacea

The broad-scale distributions of lobster, edible crab, velvet crab and crawfish in Regions 15 and 16 are shown in Map 5.5.1. Lobster, edible crab and velvet crabs are distributed around most of the coast of Region 16 (west Highland). Lobster and edible crab are also present around the west of the Western Isles and north of North Uist (Region 15). The species are also found south of this area, with crawfish. Edible crabs are often found on softer substrates - ranging from sand/gravel to rock - than lobsters. Juveniles tend to be found inshore and adults further offshore (Rees & Dare 1993). Squat lobsters have a wide distribution within the region but are more common on coarser substrates.

The distribution of *Nephrops* is determined by its preference for a sea bed of mud and muddy sand, into which it burrows; in Regions 15 and 16 it has a widespread distribution (Map 5.5.2). The majority of west coast sea lochs also support populations of *Nephrops* (not shown on Map 5.5.2 because of its small scale). *Nephrops* spawn from August to November and eggs hatch late in the following spring (Bryan 1994). The whip prawn *Dichelopandalus* - a pandalid prawn similar in size to the deep-water prawn - is present in an area of deep water that stretches south from Benbecula to Coll and Tiree. It is common in the UK only in north-west Scotland, although in the Atlantic it is distributed from Iceland to the Bay of Biscay. Females begin egg-laying in the autumn and the eggs hatch by the following April.



Map 5.5.2 Distribution of crustacea: *Nephrops* and whip prawn. Sources: Lee & Ramster (1981), SOAEFD. © Crown copyright.



Map 5.5.3 Main locations of scallops. © SOAEFD.

Molluscs

Cockles are found in the intertidal mud and sandflats of sheltered sites in the regions. The main locations of significance are in the Uists and Barra in Region 15 and Kentra Bay on the Ardnamurchan Peninsula in Region 16. Mussels are found in most sea lochs in Regions 15 and 16, 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 (thus more exploitable) mussels are mainly confined to sheltered inlets. 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. Periwinkles are found on rocky shorelines throughout the regions, wherever suitable habitat is present.

Scallops live on sandy/gravelly areas of sea bed. The broad-scale distribution of scallops in the regions is shown on Map 5.5.3. There are no exploitable quantities of queen scallops in Regions 15 and 16. Whelks are widely distributed throughout the regions, with *Neptunea* being rather more common than *Buccinum* in the more offshore areas (McKay pers. comm.). Concentrations of squid and octopus occur seasonally. Razor shells occur in inshore areas where the sea bed is clean sand. McKay (1992) reports on a survey of potentially exploitable burrowing bivalve molluscs, such as razor shells, and identifies their presence at various sites.

Polychaetes

The intertidal and subtidal zones in the estuaries of Regions 15 and 16 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).

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 these regions 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. It is subject to catch quota management by the setting of a precautionary annual Total Allowable Catch (TAC), which limits landings (see section 9.1.3). The TAC for *Nephrops* effective in Regions 15 and 16 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. This was issued under the Inshore Fishing (Scotland) Act 1984 and is applicable in thirteen areas in Regions 15 and 16 (Map 9.1.3); the prohibitions and their exceptions are listed in Tables 9.1.8

and 9.1.9. Lobster, edible and velvet crabs, *Nephrops* and scallops all have minimum landing sizes (see section 9.1.3).

The exploitation of cockles has led to concern about sustainable exploitation and impacts on wildlife. During 1994 an amendment was made to the Inshore Fishing (Scotland) Act 1984 to allow the use of tractor dredgers to be controlled by the Act. An order was subsequently issued that prohibits the use of tractor dredging for cockles on all foreshores in Scotland. Scottish Natural Heritage considered that some areas of high natural heritage interest were still vulnerable to vessel-based cockle fishing, and Nature Conservation Orders (NCOs), made under the Wildlife & Countryside Act 1981, have been obtained for some areas, although none in these regions. These NCOs prohibit all commercial collection of invertebrates (molluscs, crustacea and annelid bait species), including dredging for cockles, but they may be revoked if the areas concerned become subject under fisheries legislation to prohibition of vessel-based dredging as well as tractor-based dredging.

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 regions is described in section 9.1.2.

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 5.5.6B.

The knotted wrack has traditionally been harvested from the sheltered shores of sea lochs on the east coast of the Western Isles. It is used for the sodium and potash industry (Howson *et al.* 1994) and in the production of alginates. Stranded kelp plants *Laminaria* spp. are also traditionally collected for fertilising crofts and as animal feed, particularly in the Western Isles. The impact of kelp harvesting is detailed in Wilkinson (1995).

5.5.4 Information sources used

The three maps in this section show schematically the known broad-scale distributions of the main species of interest, based on information from the SOAEFD Marine Laboratory on the locations of the species and their fisheries. There is supporting information in the form of commercial landing statistics, samples and surveys (see sections 9.1 and 9.2). 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 regions, especially in the sea lochs.

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 around Scotland of potentially exploitable burrowing bivalve molluscs, including razor shells. The Minch Review (Bryan 1994) includes information on exploited shellfish species.

5.5.5 Acknowledgements

The author thanks David McKay (SOAEFD Marine Laboratory, Aberdeen), who provided maps and information for this section. Thanks also go to J. Kinnear (SOAEFD Marine Laboratory) and Andrew Currie (independent) for comments on a draft.

5.5.6 Further sources of information

A. References cited

Bryan, A. 1994. *The Minch review*. Inverness, Scottish Natural Heritage.

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.

Howson, C.M., Connor, D.W., & Holt, R.H.F. 1994. The Scottish sea lochs: an account of the surveys undertaken for the Marine Nature Conservation Review. *Joint Nature Conservation Committee Report*, No. 164. (Marine Nature Conservation Review Report MNCR/SR/27.)

Lee, A.J., & Ramster, J.W. 1981. *Atlas of the seas around the British Isles*. Lowestoft, MAFF.

Maggs, C.A. 1986. Scottish marine macroalgae: a distributional checklist, biogeographical analysis and literature abstract. *Nature Conservancy Council, CSD Report*, No. 635.

McKay, D.W. 1992. *Report on a survey around Scotland of potentially exploitable burrowing bivalve molluscs*. Aberdeen, SOAFD Marine Laboratory. (Fisheries Research Services Report, No. 1/92.)

Pawson, M.G. 1995. *Biogeographical identification of English Channel fish and shellfish stocks*. Lowestoft, Ministry of Agriculture, Fisheries & Food, Fisheries Laboratory. (Fisheries Research Technical Report, No. 99.)

Rees, H.L., & Dare, P.J. 1993. *Sources of mortality and associated life-cycle traits of selected benthic species: a review*. Lowestoft, MAFF Directorate of Fisheries Research. (MAFF Fisheries Research Data Report, No. 33.)

Wilkinson, M. 1995. *Information review on the impact of kelp harvesting*. Edinburgh, Scottish Natural Heritage. (SNH Review, No. 34.)

B. Further reading

Anon. 1995. *Report of the working group on* Nephrops *stocks*. Copenhagen, International Council for the Exploration of the Sea. (C.M. Papers and Reports, No. C.M. 1995/Assess:12.)

Bailey, R.S., Hislop, J.R.G., & Mason, J. 1979. The fish and shellfish resources in sea adjacent to the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, 77B*: 479-494.

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides: a natural history*. London, Collins.

Boyle, P.R. 1986. A descriptive ecology of *Eledone cirrhosa* (Mollusca: Cephalopda) in Scottish waters. *Journal of Biological Assessment UK, 66*: 855-865.

Brown, J.R., Gowen, R.J., & McLusky, D.S. 1987. The effect of salmon farming on the benthos of a Scottish sealoch. *Journal of Experimental Biology and Ecology, 109*: 39-51.

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

Cadman, P.S. 1989. Environmental impact of lugworm digging. *Nature Conservancy Council, CSD Report*, No. 910.

Clark, P.F. 1986. *North-east Atlantic crabs; an atlas of distribution*. Ross-on-Wye, Marine Conservation Society.

Clark, R.B., Alder, J.R., & McIntyre, A.D. 1962. The distribution of *Nephtys* on the Scottish coast. *Journal of Animal Ecology, 31*: 359-372.

Cook, W. 1991. *Studies on the effects of hydraulic dredging on cockle and other macroinvertebrate populations 1989-1990*. Lancaster, North Western and North Wales Sea Fishery Committee.

Cryer, M., Whittle, G.N., & Williams, R. 1987. The impact of bait collection by anglers on marine intertidal invertebrates. *Biological Conservation, 42:* 83-93.

Dipper, F. 1981. Report of a sublittoral survey of south Skye, Inner Hebrides. *Nature Conservancy Council, CSD Report*, No. 342.

Edwards, E. 1979. *The edible crab and its fishery in British waters.* Farnham, Fishing News Books.

Eno, N.C., *ed.* 1991. *Marine conservation handbook.* 2nd ed. Peterborough, English Nature.

Fowler, S.L. 1989. *Nature conservation implications of damage to the seabed by commercial fishing operations.* Peterborough, Nature Conservancy Council. (Contract surveys, No. 79.)

Gubbay, S. 1988. *A coastal directory for marine nature conservation*. Ross-on Wye, Marine Conservation Society.

Hall, S.J., Basford, D.J., & Robertson, M.R. 1990. The impact of hydaulic dredging for razor clams *Ensis* spp. on an infaunal community. *Netherlands Journal of Sea Research, 27*: 119-125.

Hancock, D.A. 1971. The role of predators and parasites in a fishery for the mollusc *Cardium edule* L. *In: Dynamics of populations. Proceedings of the Advanced Studies Institute, Oosterbeck, 1970*, ed. by P.J. den Boer & G.R. Gradwell. Wageningen, Centre for Agricultural Publication and Documentation.

Huggett, D. 1992. *Foreshore fishing for shellfish and bait.* Sandy, Royal Society for the Protection of Birds.

Huggett, D. Undated. *Coastal zone management and bait digging. A review of potential conflicts with nature conservation interests, legal issues and some available regulatory mechanisms.* Sandy, Royal Society for the Protection of Birds (unpublished).

Mason, J. 1967. Shrimps around Scotland. *Scottish Fisheries Bulletin, 27:* 13-16.

McLusky, D.S., Anderson, F.E., & Wolfe-Murphy, S. 1983. Distribution and population recovery of *Arenicola marina* and other benthic fauna after bait digging. *Marine Ecology Programme Series, 11:* 173-179.

Moore, J. 1991. *Studies on the impact of hydraulic cockle dredging on intertidal sediment flat communities.* Peterborough, Nature Conservancy Council. (Report by the Field Studies Council Research Centre, No. FSC/RC/4/91.)

Olive, P.J.W. 1993. Management of the exploitation of the lugworm *Arenicola marina* and the ragworm *Nereis virens* (Polychaeta) in conservation areas. *Aquatic Conservation: Marine and Freshwater Ecosytems, 3*: 1-24.

Seaward, D.R. 1990. *Distribution of the marine molluscs of north west Europe*. Peterborough, Nature Conservancy Council, for Conchological Society of Great Britain and Ireland.

Seaward, D.R. 1993. Additions and amendments to the *Distribution of the marine molluscs of north-west Europe* (1990). *Joint Nature Conservation Committee Report*, No. 165.

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, 1 Crieff Road, Aberfeldy, Perthshire PH15 2BJ tel: 01887 820449, and *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, c/o University College Scarborough, Filey Road, Scarborough YO11 3AZ, tel: 01723 362392

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

5.6 Amphibians and reptiles

Dr M.J.S. Swan

5.6.1 Introduction

Regions 15 (Western Isles) and 16 (west Highland) both support three species of amphibian: common frog *Rana temporaria*, common toad *Bufo bufo* and palmate newt *Triturus helveticus*; and two species of terrestrial reptile: slow worm *Anguis fragilis* and adder *Vipera berus* (although the presence of the adder is unconfirmed in Region 15). The common lizard *Lacerta vivipara* is found in Region 16 but not Region 15. Two species of marine turtle (leatherback turtle *Dermochelys coriacea* and loggerhead turtle *Caretta caretta*) have been recorded in both regions. Throughout Regions 15 & 16 it is likely that climatic conditions, the low productivity of the natural freshwaters and their susceptibility to acidification (Morrison 1994) act as natural checks to the abundance of amphibians. Terrestrial reptiles, also, are probably limited by natural constraints of climate, cover and prey availability.

Turtles have been recorded more frequently around Regions 15 & 16 than around any other coastal regions of the UK. Since 1970, 24 leatherback, two loggerhead and five unidentified turtles have been reported (Langton *et al*. 1996; C. McCarthy pers. comm.). Nine of the leatherbacks and one of the loggerheads were dead, entangled in fishing gear or stranded. In view of the number of reported sightings and the fact that most observations are of animals actively swimming, the leatherback turtle is thought by some to be a common visitor in Scottish waters at certain times of the year (Brongersma 1972; Langton *et al*. 1996) rather than being a vagrant species. They are apparently active in sea temperatures of 11°C or above and are most frequently observed during the summer months. The seas around the west of Scotland could therefore be part of the natural range of some populations of this globally threatened species.

The introduced populations of great crested newts on Skye are the only nationally and internationally important terrestrial herpetofaunal species in Regions 15 and 16. The great crested newt and the two 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 5.6.1 Protected status of amphibians and reptiles occurring in Regions 15 & 16

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 helvetica*	1, 2
Great crested newt *Triturus cristatus*	1, 2, 3
Reptiles	
Slow worm *Anguis fragilis*	1, 2
Common lizard *Lacerta vivipara*	1, 2
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.

Table 5.6.2 shows the numbers of post-1970 amphibian and reptile records in Region 16 in relation to survey effort; no published data are available for Region 15. Anecdotal evidence and recent survey data not reported here (S. Moran pers. comm.) suggest that all six species are widespread throughout the mainland and on many of the islands. However, the recorded diversities of both amphibians and reptiles in Region 16 are low, with only 5% of 10 km squares reported to contain all three amphibian species and 11% all three terrestrial reptiles. Maps 5.6.1 and 5.6.2 show the numbers of amphibian and reptile species recorded in coastal 10 km squares in the regions.

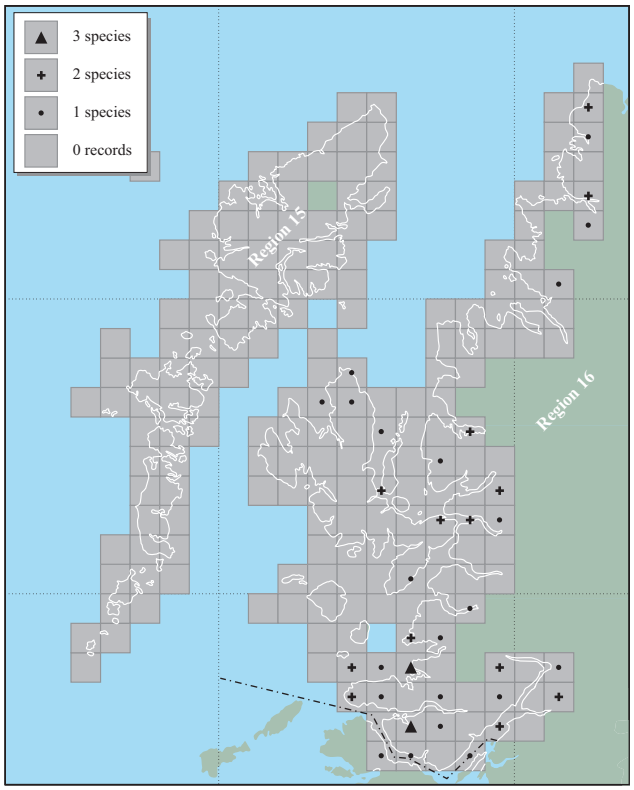
5.6.2 Important locations and species

Anecdotal evidence for the presence of amphibians in Region 15 is thought to result from sightings of recent introductions, mainly within the last decade. Frogs are thought to be localised on Harris, Lewis and North and South Uist, with few introductions having had long-term success. Toads have been introduced on several occasions but have seldom bred successfully: only one persistent toad population, at Loch Mharcoil in Bernera, Lewis, is reported, having existed for approximately ten years. Palmate newts have been observed on Grimsay, North Uist, but details of their distribution, abundance and origins are scant.

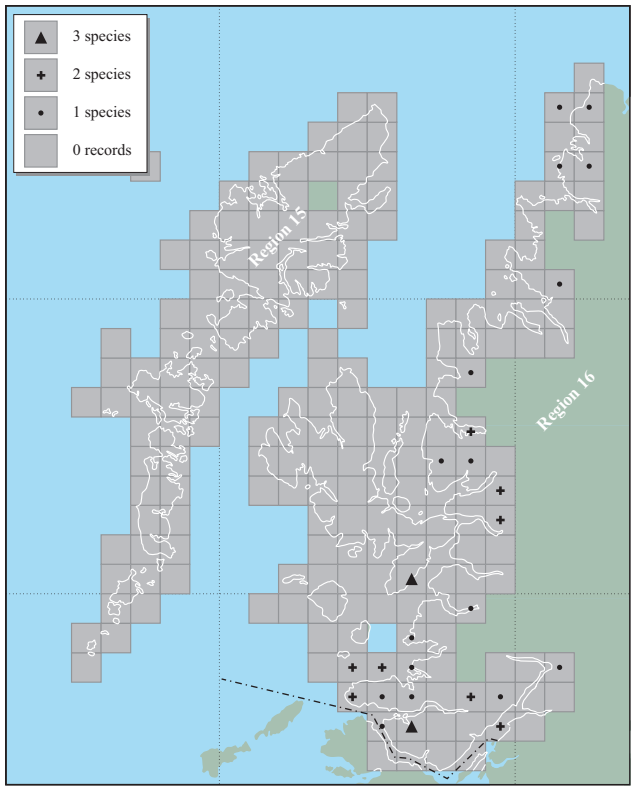
Of the reptiles, the adder has been reported (but unconfirmed) only on Lewis and is unlikely to have been introduced in the recent past; the slow worm is widespread throughout Lewis and Harris and is known to have existed on the islands for at least a hundred years. There is an uncomfirmed report of a grass snake *Natrix natrix* from Lewis (S. Angus pers. comm.) and persistent, but unconfirmed, sightings of grass snakes on Skye, including reports of eggs. Lewis and Skye are, however, well beyond the accepted north-western limit of the grass snake's UK distribution, which is Dumfries & Galloway.

Table 5.6.3 lists the amphibians and terrestrial reptiles present on some of the islands in Region 16, as reported by Campbell (cited in Berry 1979, 1983) (equivalent data for Region 15 are not available). The distribution of species and the identities of those that have been artificially introduced are, however, matters of dispute between observers.

In Region 16 most reports of the nationally rare great crested newt *T. cristatus* and smooth newts *T. vulgaris* from the mainland and several islands are thought to be the result of misidentification, but introduced populations of great crested and smooth newts are thriving in a garden on Skye. Frogs, toads and palmate newts are reported to spawn in marshes, lochs and lochans and have also been observed to breed in splash zone pools just above high water mark (which must occasionally be brackish). Toads are the only species frequently observed to breed in flowing water. The amphibians also use artificial water-bodies - ponds and ditches, reservoirs, cattle troughs and garden ponds - as breeding sites. The species are all reported to breed at a wide range of altitudes, from sea level to >300 m, and both frogs and palmate newts have been recorded at >600 m.



Map 5.6.1 Numbers of amphibian species recorded in coastal 10 km squares. There are no systematic records for Region 15. Distribution may reflect differences in recording effort. Source: Biological Records Centre, ITE Monks Wood.



Map 5.6.2 Numbers of reptile species recorded in coastal 10 km squares. There are no systematic records for Region 15. Distribution may reflect differences in recording effort. Source: Biological Records Centre, ITE Monks Wood.

Table 5.6.2 Records of amphibians and terrestrial reptiles related to survey effort in Region 16**

	*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*
Skye & Lochalsh	48	21	21	6	16	12	1.6	4.0
Lochaber	42	55	48	36	38	40	1.9	2.5
Ross & Cromarty	22	27	18	27	7	11	1.8	1.8
Sutherland	13	54	31	31	7	7	1.8	1.8
Region 16	**132**	**35**	**29**	**21**	**68**	**70**	**1.8**	**2.5**
West Coast[a]	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
Great Britain (coast and inland)	2,862	84	79	66	27,182	8,803	12.1	4.7

Sources: Biological Records Centre, Monks Wood. Key: *total includes squares that are partly in the region, but excludes squares that are exclusively marine; **there are no published data for Region 15; [a]of Britain.

The large expanses of moorland, rough grassland, woodland and conifer plantation in the region afford ample cover.

There is abundant terrestrial reptile habitat within Region 16, and as the coastal habitats are contiguous with extensive areas of heath and moorland inland the species are not restricted to a narrow coastal strip, as they are in many UK coastal regions. All three species are found on moorland and among coastal rocks and scree, with adder sightings more frequent in the more barren tracts and lizards and slow worms more common in the sheltered and more densely vegetated areas. Reading *et al.* (1994) report that the numbers of observations of adders have decreased in recent years, although this may be because of a reduction in the human population of the highlands and hence of potential observers; the range of the species does not seem to have contracted. Slow worms and lizards are reported from domestic gardens, and lizards have also been recorded at relatively high altitudes (>500 m).

5.6.3 Human activities

Few human activities are considered to threaten amphibians or terrestrial reptiles in these regions, but in Region 16 afforestation can affect both groups. As well as being directly affected by acid rainfall, waterbodies are susceptible to acidification through the accumulation and concentration of

Table 5.6.3 Distribution of species on islands in Region 16

	Common frog	*Common toad*	*Palmate newt*	*Smooth newt*	*Great crested newt*	*Slow worm*	*Common lizard*	*Adder*	*Grass snake*
Skye	✓	✓	✓	(✓)	(✓)	✓	✓	✓	(✓)
Rum			✓				✓		
Eigg		✓	✓				✓		
Canna		✓	(✓)						
Scalpay	✓	✓		(✓)			✓	✓	
Soay	✓	✓							
Raasay	✓	✓	✓	(✓)		✓	✓	✓	

Source: Berry (1979; 1983), A. Currie (pers. comm.), C. Shearer (pers. comm.). Key: ✓ = present; (✓) = records of these species may have resulted from artificial introductions or from misidentifications.

airborne acid by conifer plantation canopies. In addition, reduced light levels on the ground eliminate basking sites for reptiles. However, over much of this region the terrain is such that new plantations are relatively small and consequently their effects limited and localised. Amphibians and reptiles can also be adversely affected by infrastructure developments, but in a region with large tracts of undamaged landscape, their effects are reported to be relatively localised.

The extent to which marine turtles are threatened by human activities is largely unquantifiable. Only dead turtles - apparently stranded, injured by propellers or entangled in fishing gear - are ever examined and few carcasses are investigated by post-mortem examination to establish the exact cause of death. Elsewhere, turtles are known to have died as a result of ingesting marine debris such as plastic bags, oil or tar (Langton *et al*. 1996).

In Region 15 some of the amphibian and reptile introduction sites have proved unsuitable and further introductions into these regions are now discouraged by Scottish Natural Heritage (SNH).

5.6.4 Information sources used

Amphibian and reptile surveying in Great Britain has been extensive, with 84% of 10 km squares receiving some coverage nationally, although only 69% of coastal squares have been surveyed. However, owing to the low human population density and the inaccessibility of much of Regions 15 and 16, most of the area is very under-recorded for both amphibians and reptiles. Skye & Lochalsh and Ross & Cromarty are particularly poorly represented. The low numbers of records do not, therefore, necessarily reflect restricted distributions or low populations of the species. The shortfall in recording is now being addressed by the Highland Biological Recording Group, who are currently undertaking systematic herpetofaunal surveying in Highland Region, including the mainland of Region 16. No formal herpetofaunal recording has been undertaken on Region 15, so most of the information presented for the terrestrial species there is anecdotal.

National distribution data for 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 and include all the data collected during the National Amphibian and Reptile Surveys (NARS) undertaken by De Montfort University on behalf of English Nature. The NARS formed the focus of national amphibian and reptile recording during the 1980s and early 1990s (Oldham & Nicholson 1986; Swan & Oldham 1989, 1993a, b). More recent and extensive data for the whole of Highland Region, not yet incorporated into the BRC dataset, are held at Inverness Museum by the Highland Biological Recording Group. 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). Anecdotal evidence from Region 15 was provided by local, informed sources, including SNH local offices and the Western Isles Natural History Society.

Turtle data and information were supplied by the Natural History Museum, Southampton University and SNH. 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* (NCC 1990). Marine turtles are included in Scottish Natural Heritage's (SNH's) Species Action Plans. All sightings and strandings should be reported to SNH in Edinburgh and the Natural History Museum.

5.6.5 Acknowledgements

The author wishes to thank the following people for providing information and comments on the draft: Stewart Angus, Henry Arnold, David Blatchford, Ray Collier, Gail Churchill, Andrew Currie, Anthony Darby, Steve Gibson, David Maclennan, Colin McCarthy, Geraldine McGowan, Stephen Moran, Brian Neath, Brendan O'Hanrahan, Kenneth Porter, Catherine Shearer, Martin Smith, Mark Tasker and Grace Yoxon.

5.6.6 Further sources of information

A. References cited

Arnold, H.R., *ed*. 1983. *Distribution maps of the amphibians and reptiles of the British Isles*. Huntingdon, Biological Records Centre, Monks Wood.

Arnold, H.R., *ed*. 1995. *Atlas of amphibians and reptiles in Britain and Ireland*. Huntingdon, Biological Records Centre, Monks Wood.

Berry, R.J. 1979. The Outer Hebrides: where genes and geography meet. *Proceedings of the Royal Society of Edinburgh, 77B*: 21-43.

Berry, R.J. 1983. Evolution of animals and plants. *Proceedings of the Royal Society of Edinburgh, 83B*: 433-447.

Brongersma, L.D. 1972. *European Atlantic turtles.* Leiden, Rijksmuseum van Natuurlijke Historie.

Langton, T.E.S., Becket, C.L., King, G.L., & Gaywood, M.J. 1996. *Distribution and status of marine turtles in Scottish waters.* Edinburgh, Scottish Natural Heritage. (Research, survey and monitoring report.)

Morrison, B.R.S. 1994. Acidification. *In: The freshwaters of Scotland*, ed. by P. Boon, P. Maitland & D. McClusky. Chichester, John Wiley.
Nature Conservancy Council. 1990. *The turtle code*. Peterborough, Nature Conservancy Council. (Advice sheet.)
Oldham, R.S., & Nicholson, M. 1986. *Status and ecology of the warty newt* Triturus cristatus. *Final report*. Peterborough, Nature Conservancy Council (unpublished).
Reading, C.J., Buckland, S.T., McGowan, G.M., Gorzula, S., Jayasinghe, J., Staines, B.W., Elston, D.A., & Ahmadi, S. 1994. *Status of the adder in Scotland. Final report.* Edinburgh, Scottish Natural Heritage.
Swan, M.J.S., & Oldham, R.S. 1989. *Amphibian communities, final report*. Peterborough, Nature Conservancy Council (unpublished).
Swan, M.J.S., & Oldham, R.S. 1993a. *Herptile sites. Volume 1: national amphibian survey.* Peterborough, English Nature. (English Nature Research Reports, No. 38.)
Swan, M.J.S., & Oldham, R.S. 1993b. *Herptile sites. Volume 2: national reptile survey.* Peterborough, English Nature. (English Nature Research Reports, No. 39.)

B. Further reading

Anon. 1990. *Wildlife of Skye and Raasay.* Skye Environmental Centre.
Aston, R.J., Beattie, R.C., & Milner, A.G.P. 1987. Characteristics of spawning sites of the common frog (*Rana temporaria*) with particular reference to acidity. *Journal of Zoology, 213*: 233-242.
Beattie, R.C., Tyler-Jones, R., & Baxter, M.J. 1993. The effects of pH, aluminium concentration and temperature on the embryonic development of the European common frog, *Rana temporaria*. *Journal of Zoology, 228*: 557-570.
Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides: a natural history*. London, Collins.
British Herpetological Society. 1990. *Garden ponds as amphibian sanctuaries.* London, British Herpetological Society. (Advice sheet.)
British Herpetological Society. 1990. *Save our reptiles.* London, British Herpetological Society. (Advice sheet.)
British Herpetological Society. 1990. *Surveying for amphibians.* London, British Herpetological Society. (Advice sheet.)
Collier, R.V. 1984. Palmate newts (*Triturus helveticus*) on the Island of Rhum. *Herpetological Journal, 1*: 1-4.
Corbett, K.S. 1990. *Conservation of European reptiles and amphibians.* London, Christopher Helm.
Cummins, C.P. 1986. Effects of aluminium and low pH on growth and development in *Rana temporaria* tadpoles. *Oecologia, 69:* 248-252.
Cummins, C.P. 1988. Effect of calcium on survival times of *Rana temporaria* embryos at low pH. *Functional Ecology, 2:* 297-302.
Cummins, C.P. 1989. Interactions between the effects of pH and density on growth and development in *Rana temporaria* tadpoles. *Functional Ecology, 3:* 45-52.
Cummins, C.P. 1990. *The impact of acid conditions on the common frog* Rana temporaria *L.* PhD Thesis, Leicester Polytechnic.
Gibson, J.A. 1988. *A regional bibliography of the reptiles and amphibians of the West of Scotland.* Kilbarchan, Scottish Natural History Library.
Griffiths, R.A., de Wijer, P., & Brady, L. 1993. The effect of pH on embryonic and larval development in smooth and palmate newts, *Triturus vulgaris* and *T. helveticus. Journal of Zoology, 230*: 401-409.
Herpetofauna Consultants International. 1995. *A preliminary review of the distribution and status of great crested newts* Triturus cristatus *records in Scotland*. Edinburgh, Scottish Natural Heritage. (SNH Research Report.)
Knowlton, D. 1977. *The naturalist in the Hebrides.* Newton Abbott, David and Charles.
Mallinson, J.J. 1990. Turtle rescue. *Marine Conservation, Winter 1990/91*: 8-9.
Mallinson, J.J. 1991. Stranded juvenile loggerheads in the United Kingdom. *Marine Turtle Newsletter, 54*: 14-16.
Nature Conservancy Council. 1983. *The ecology and conservation of amphibian and reptile species endangered in Britain.* Peterborough.
Neath, B. 1993. *The wildlife of Dornie.* Dornie and District Community Enterprise Ltd.
Perrins, F. 1991. *A guide to Britain's conservation heritage.* London, Thorsons, Harper Collins.
Stephen, D. 1974. *Highland animals.* Glasgow, Collins (Highlands and Islands Development Board).
Swan, M.J.S. Cummins, C.P., & Oldham, R.S. 1994. The Amphibia. *In: The freshwaters of Scotland*, ed. by P. Boon, P. Maitland & D. McClusky. Chichester, John Wiley.
Thompson, F. 1988. *The Western Isles.* London, Batsford.
Tyler-Jones, R., Beattie, R.C., & Aston, R.J. 1989. The effects of acid water and aluminium on the embryonic development of the common frog (*Rana temporaria*). *Journal of Zoology, 219*: 355-372.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Conservation and captive breeding of amphibians and reptiles, nationally	The 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 Monk's Wood, Huntingdon, tel: 01487 773381
Designated sites - Regions 15 & 16	*Scottish Natural Heritage, North West Region, Inverness, tel: 01463 239431
Wildlife Trust sites - Scotland	*Scottish Wildlife Trust, Edinburgh, tel: 0131 312 7765
Turtles - UK	Dr C. McCarthy, Natural History Museum, Cromwell Road, London SW7 5BD, tel: 0171 938 9123
Turtles - UK	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
Reptiles and amphibians - Scotland	Co-ordinator, Scottish Adder Survey, Institute of Terrestrial Ecology, Banchory Research Station, Glassel, Banchory, Grampian Region AB31 4BY, tel: 01330 823434

Type of information	*Contact address and telephone no.*
Reptiles and amphibians - Scotland	British Herpetological Society Scottish Group, c/o 36 Newton Crescent, Dunblane, Perthshire FK15 0DZ, tel: 01786 824120
Highland Biological Recording Group	*Ray Collier, Scottish Natural Heritage, North West Region, Inverness, tel: 01463 237114, or Stephen Moran, Inverness Museum & Art Gallery, Castle Wynde, Inverness IV2 3ED, tel: 01463 237114
Reptiles and amphibians - Region 15	Western Isles Natural History Society, c/o Voluntary Action Lewis, 30 Francis Street, Stornoway HS12 2ND
Reptiles and amphibians - Region 16	South-west Ross Field Club, c/o Culag, Carr Brae, Dornie, Kyle, Ross-shire IV40 8HA, tel: 01599 555341
Reptiles and amphibians - Region 16	Skye Serpentarium, The Old Mill, Harrapool, Broadford, Isle of Skye IV49 9AQ, tel: 01471 822209
Reptiles and amphibians - Region 16	Scottish Wildlife Trust, Skye Portree Group, c/o The Secretary, Whistletop, 16 Harrapool, Broadford, Isle of Skye IV49 9AQ, tel: 01471 822845
Reptiles and amphibians - Region 16	Skye Environmental Centre, Beul-na-Mara, Lower Harrapool, Broadford, Skye IV49 9AQ, tel: 01471 822487

*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 report, 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 - 5.7.6 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.

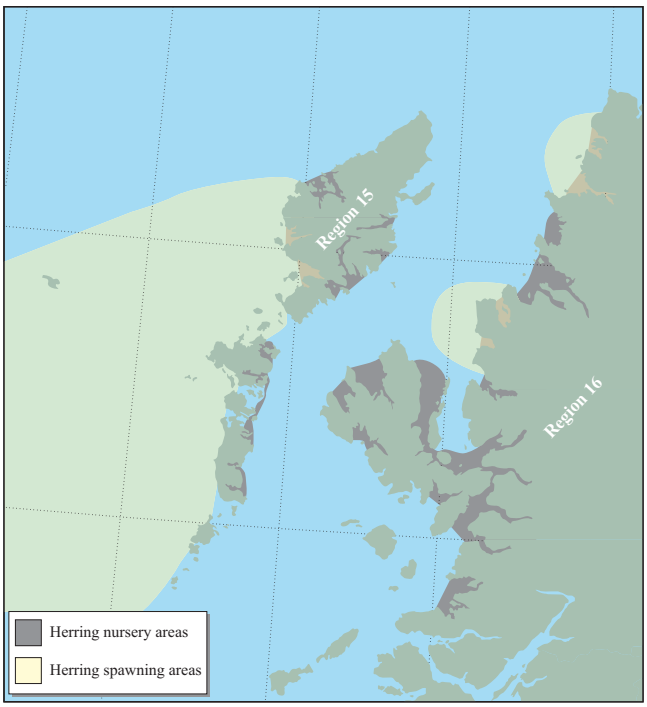
Table 5.7.1 lists the important pelagic and demersal species occurring in Regions 15 (Western Isles) and 16 (west Highland) and gives examples of protection measures in these regions.

5.7.2 Important locations and species

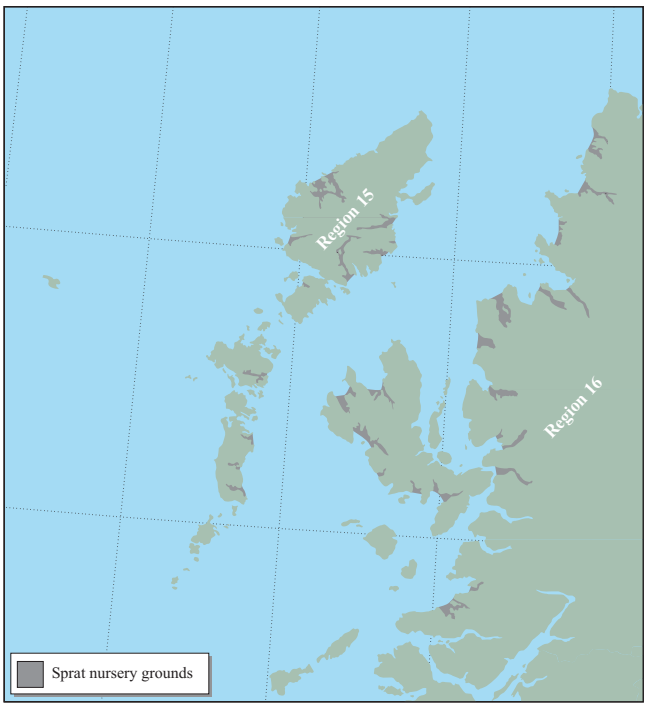
Of the pelagic species, mackerel are widely distributed around Britain and are present in the seas around the regions. Mackerel spawn throughout the shelf waters of the British Isles, but most prolifically along the edge of the continental shelf. Growing juveniles and adults migrate to coastal waters after spawning, where they remain until autumn. Overwintering concentrations of Western stock mackerel are found west of Scotland, west of Ireland and off Cornwall. The number of mackerel in the Minch is dependent on their migration route south from the Norwegian and North Seas to south-west Ireland. Since 1983 this migration has not taken them through the Minch (Bryan 1994).

Herring are abundant in the area west of the Western Isles in the summer months and migrate into the Minch in the winter. Spawning takes place in areas shown in Map 5.7.1 during the autumn and spring. Juvenile herring are found in winter in sheltered areas and sea lochs in both regions (Map 5.7.1). Studies on west coast herring larvae and juveniles indicate that they may also 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 regions in winter, especially when they migrate inshore to overwinter between September and March. Although some sprat spawning takes place in coastal waters, they mainly migrate to offshore areas, outside Regions 15 and 16, with spawning peaking between May and July. Juvenile sprat are found in sheltered sea loch nursery grounds, shown on Map 5.7.2, throughout the year.



Map 5.7.1 Herring spawning and nursery areas. Source: Bryan (1994). © Crown copyright.

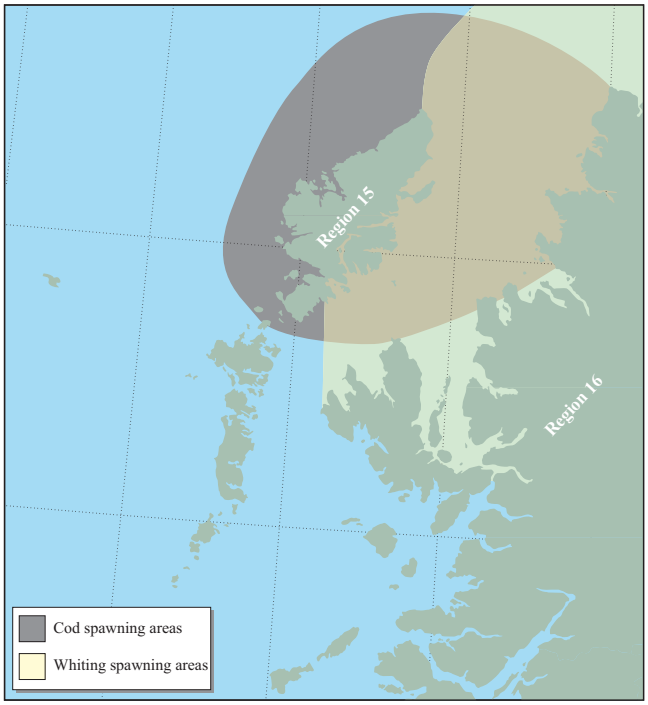


Map 5.7.2 Sprat nursery areas. Source: Bryan (1994). © Crown copyright.

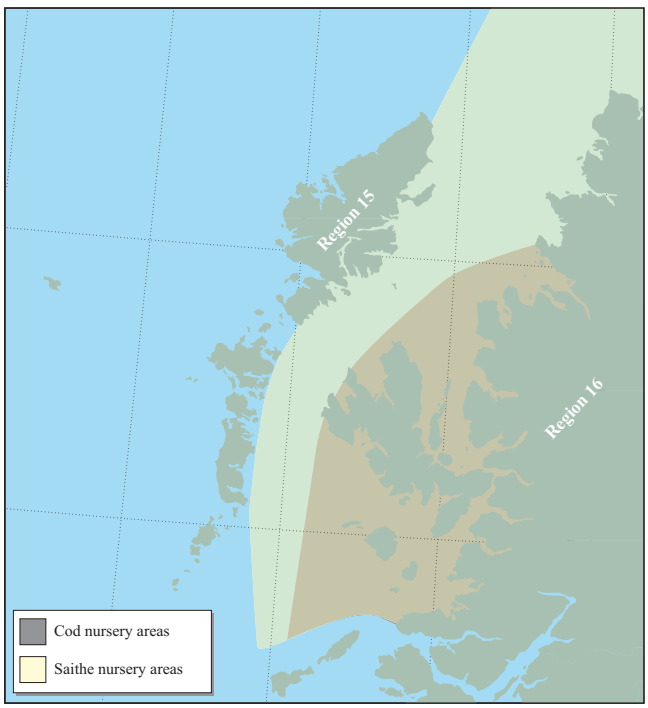
Table 5.7.1 Pelagic and demersal species and examples of measures for their protection

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
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
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.	QM

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



Map 5.7.3 Cod and whiting spawning areas. Sources: Bryan (1994); Lee & Ramster (1981). © Crown copyright.

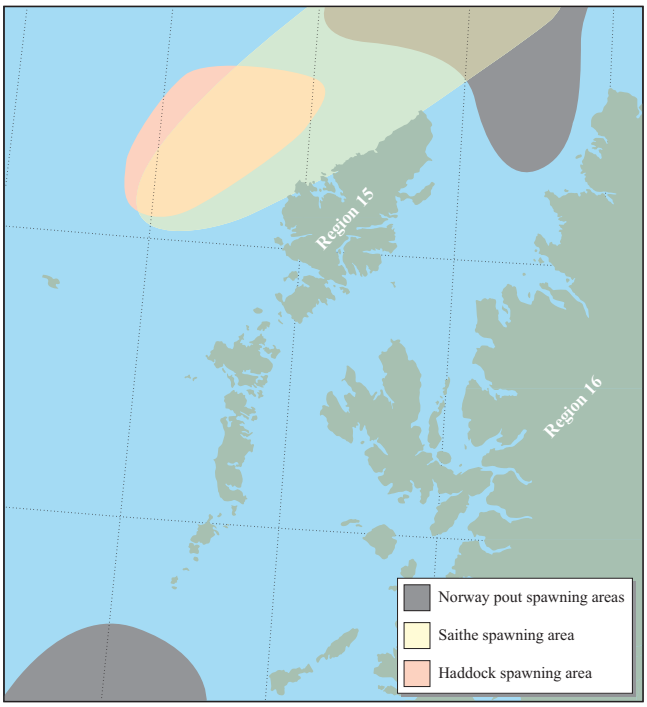


Map 5.7.4 Cod and saithe nursery areas. Source: Bryan (1994). © Crown copyright.

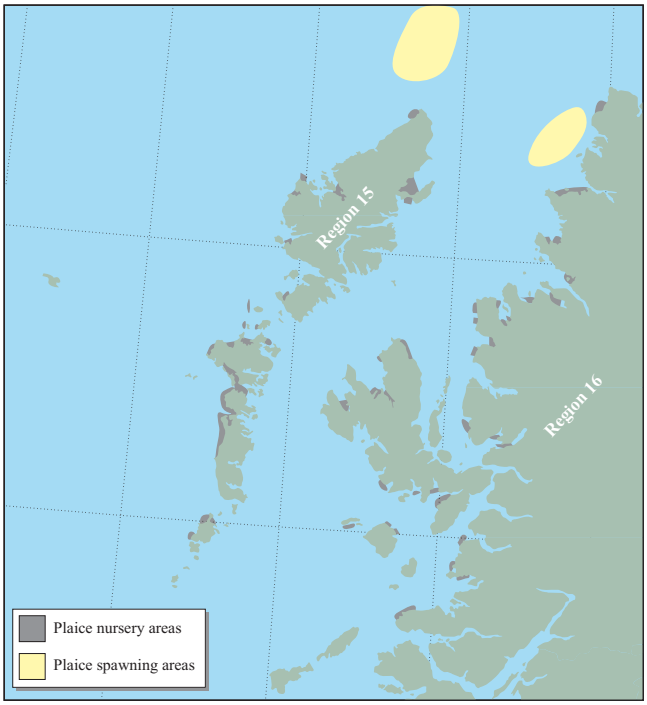
Elasmobranch species produce relatively small numbers of live young (10 -100 per year, but can be fewer in large shark species) or lay large eggs on the sea bed close to their nursery area locations. Several species of elasmobranch occur sporadically in the regions, such as the spurdog and lesser-spotted dogfish.

Of the gadoids, cod is widely distributed in the regions in the summer, but it is not as abundant as it has been in the past. Cod aggregate in a large and pronounced area in Regions 15 and 16 for spawning (Map 5.7.3), which peaks during February. Juvenile cod migrate to shallow nursery areas (Map 5.7.4). Whiting are abundant and widely distributed in the region, especially in inshore waters. The large whiting spawning area which extends from Skye north to Shetland reaches into Regions 15 and 16 (Map 5.7.3). 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. Nursery grounds for whiting are scattered throughout shallower areas of the regions.

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 in an area north-west of the Western Isles (Map 5.7.5). There are no recognised haddock nursery areas, and juveniles of the species are thought to be widely distributed. Norway pout is found in deep water offshore and is an important target species for the industrial fishery. Norway pout generally spawn for the first time at the age of two years, between January and April; there are spawning areas in the far north and to the south of these regions (Map 5.7.5). Ling, pollack and saithe are less abundant than haddock and Norway pout and more locally distributed, particularly around rocky reefs and wrecks. There is a large saithe spawning area north and west of the Western Isles (Map 5.7.5) (where spawning takes place mainly from January to March) and a



Map 5.7.5 Haddock, Norway pout and saithe spawning areas. Sources: Bryan (1994); Lee & Ramster (1981). © Crown copyright.



Map 5.7.6 Plaice spawning and nursery areas. Source: Bryan (1994). © Crown copyright.

saithe nursery area that covers all of the sea area between the Western Islands and west of Scotland (Map 5.7.4).

Plaice, dab and long rough dab are abundant in the region. They 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). Plaice spawn in two areas in the north of the regions (Map 5.7.6), and sheltered sandy coastal areas in both regions are important nursery areas for the juveniles (Map 5.7.6). 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. Dover sole have a similar lifestyle to plaice and dab but are more confined to areas with higher sea temperatures and are therefore relatively more scarce in these regions than further south. Turbot and brill have a similar lifestyle to plaice, dab and Dover sole but are much less abundant. None of the flatfish species exhibits extensive migrations, though the larvae can drift for several weeks from offshore spawning grounds to inshore nursery areas, such as Broad Bay on Lewis. There may be some interchange, either way, between spawning stocks and nursery grounds in this and adjacent regions. Lemon sole are widespread in the regions and favour deeper water than plaice with rocky or boulder-strewn sea bed alternating 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 deeper waters and there are no separate nursery or spawning areas recognised in the regions. Local concentrations of witch occur in the north and south Minches (Rae 1970). Flounders migrate in the summer between inshore, estuarine and even riverine nursery areas 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 regions. Other exploited demersal species of minor importance are conger eel and gurnards. Sandeels are present in the regions (Lee & Ramster 1981) and provide an important food source for many exploited species. Their distribution is associated with that of the coarse sand that 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.) and other prohibitions made under the Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989, in thirteen areas in the regions (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 ICES Division VIa, which covers Regions 15 and 16. 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 fish species, as well as other fish species, 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 sewage sludge dumping, dredging and dredge spoil dumping and 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 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 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. Bryan (1994) and Lee & Ramster (1981) have been used as sources 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.

European Council Regulations detailing the catch quotas for fish and shellfish species for all European countries, i.e. the Total Allowable Catches (TACs), 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 reviewed annually and the regulations for 1996 are published in European Council (1995).

5.7.5 Acknowledgements

The author thanks John Hislop (SOAEFD Marine Laboratory) and Mark Tasker (JNCC) for comments on a draft.

5.7.6 Further sources of information

A. References cited

Bryan, A. 1994. *The Minch review*. Inverness, Scottish Natural Heritage.

Doody, J.P., Johnston, C., & Smith, B. 1993. *The directory of the North Sea coastal margin*. Peterborough, JNCC.

European Council. 1986. EC Regulation No. 3094/86 (as amended). *Official Journal of the European Communities, L288* (29).

European Council. 1995. EC Regulation No. 3074/95. *Official Journal of the European Communities, L 330* (38).

Heath, M.H., & MacLachlan, P. 1986. *Studies on herring larvae off the north coast of Scotland*. Copenhagen, International Council for the Exploration of the Sea. (Council Meeting 1986/H:18.)

Lee, A.J., & Ramster, J.W. 1981. *Atlas of the seas around the British Isles*. Lowestoft, MAFF.

Pawson, M.G. 1995. *Biogeographical identification of English Channel fish and shellfish stocks*. Lowestoft, MAFF Fisheries Laboratory. (Fisheries Research Technical Report, No. 99.)

Rae, B.B. 1970. *The distribution of flatfishes in Scottish and adjacent waters*. Edinburgh, Department of Agriculture and Fisheries for Scotland. (Marine Research, No. 2.)

Turnpenny, A.W.H., & Nedwell, J.R. 1994. *The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys*. Southampton, Fawley Aquatic Research Laboratories Ltd.

B. Further reading

Bailey, R.S., Hislop, J.R.G., & Mason, J. 1979. The fish and shellfish resources in sea adjacent to the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, (B) 77*: 479-494.

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides: a natural history*. London, Collins.

Earll, R.C., *ed*. 1992. *Shark, skate and ray workshop*. Ross-on-Wye, Marine Conservation Society, for Joint Nature Conservation Committee.

Eleftheriou, A. 1979. Sandy beaches as flatfish nurseries. *Scottish Bulletin, 45:* 23-26.

Gordon, J.D.M., & Hunter, J.E. 1994. *Study of deep-water fish stocks to the west of Scotland*. Oban, Scottish Association of Marine Science.

Langham, N.P.P. 1971. The distribution and abundance of larval sandeels (*Ammodytidae*) in Scottish waters. *Journal of the Marine Biological Association of the United Kingdom, 51*: 697-707.

Lockwood, S.J. 1989. *Mackerel: its biology, assessment and management of a fishery*. Farnham, Fishing News Books.

Rae, B.B., & Devlin, S.D.E. 1972. The turbot, its fishery and biology in the Scottish area. *Marine research, 1:* 1-27.

Rae, B.B., & Shelton, R.G.J. 1982. *Notes on the food of nine species of elasmobranch (Part I) and nine species of demersal teleost (Part II) fishes from Scottish waters*. Copenhagen, International Council for the Exploration of the Sea. (C.M. Papers and Reports, No. C.M. 1982/G:56.)

Raitt, D., & Mason, J. 1968. *The distribution of Norway pout in the North Sea and adjacent waters.* Edinburgh, Department of Agriculture and Fisheries for Scotland. (Marine Research, No. 4, 19.)

Vas, P. 1995. The status and conservation of sharks in Britain. *Aquatic Conservation: Marine and Freshwater Ecosystems, 5*: 67-79.

Walsh, M., & Martin, J.H.A. 1986. *Recent changes in the distribution and migrations of the Western mackerel stock in relation to hydrographic changes.* Copenhagen, International Council for the Exploration of the Sea. (C.M. Papers and Reports, No. C.M. 1986/H:17.)

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, Aberdeen, tel: 01224 876544
UKDMAP software with maps showing distributions of selected sea fish species and spawning areas	*UKDMAP 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, SNH HQ, 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, and *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 these regions. (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 Britian. 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 and sea lochs 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 other lochs, smaller rivers and tributaries not shown on the map will also contain populations. Eels are probably found in all river systems in the regions, 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, which is relatively rare and localised in the regions, may affect the ability of fish to return to their natal rivers to spawn. Bryan (1994) discusses environmental and user interactions that influence salmon and sea trout in the Minch. 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.

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.

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

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.

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 publishes 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 (>95%) of the forms sent out are returned. Picken (1987) discusses the history of Scottish west coast sea trout catches.

5.8.5 Acknowledgements

Thanks go to Derek Murison (SOAEFD Marine Laboratory, Aberdeen), David Dunkley (SOAEFD Montrose Field Station) and Mark Tasker (JNCC) for information, advice and comments on drafts.

5.8.6 Further sources of information

A. References cited

Bryan, A. 1994. *The Minch review*. Inverness, Scottish Natural Heritage.

Gardiner, R., & Egglishaw, H. 1986. *Map of the distribution in Scottish rivers of the Atlantic salmon* Salmo salar *L.* Edinburgh, Scottish Office Agriculture, Environment and Fisheries Department. (SOAEFD Publication A.)

Gilvear, D., Hanley, N., Maitland, P., & Peterken, G. 1995. *Wild rivers: Phase 1 technical paper*. Aberfeldy, WWF Scotland.

Jones, J.W. 1959. *The salmon*. London, Collins.

MAFF/SO. 1991. *Salmon net fisheries: report of a review of salmon net fishing in the areas of the Yorkshire and Northumbria regions of the National Rivers Authority and the salmon fishery districts from the River Tweed to the River Ugie.* London, HMSO. (Report to Parliament.)

Maitland, P.S., & Campbell, R.N. 1992. *Freshwater fishes of the British Isles*. London, Harper Collins. (New Naturalist series.)

Mills, D.H. 1971. *Salmon and trout: a resource, its ecology, conservation and management*. Edinburgh, Oliver and Boyd.

Mills, D.H. 1989. *Ecology and management of Atlantic salmon*. London, Chapman and Hall.

Moriarty, C. 1978. *Eels*. Newton Abbot, David and Charles.

Picken, M.J. 1987. The history of west coast sea trout catches. *In*: *The sea trout in Scotland. Symposium held at Dunstaffnage Marine Research Laboratory, June 1987*, ed. by M.J. Picken & W. M. Shearer, 53-59. Swindon, Natural Environment Research Council, for Scottish Marine Biological Association/Department of Agriculture and Fisheries for Scotland.

Scottish Office. 1996. *Scottish salmon and sea trout catches: 1995*. Edinburgh, Scottish Office. (Scottish Office Statistical Bulletin, Fisheries Series No. Fis/1996/1.)

Scottish Office Agriculture, Fisheries Department. 1992. *Freshwater Fisheries Laboratory (Pitlochry) Annual Review 1991-1992.* Edinburgh, HMSO.

Shearer, W.M. 1992. *The Atlantic salmon: natural history, exploitation and future management*. Oxford, Blackwell Scientific.

Sinha, V.R.P., & Jones, J.W. 1975. *The European freshwater eel*. Liverpool, University of Liverpool Press.

Tesch, F.W. 1977. *The eel: biology and management of anguillid eels*. London, Chapman and Hall.

Verspoor, E., Fraser, N.H.C., & Youngson, A.F. 1991. Protein polymorphism in Atlantic salmon within a Scottish river; evidence for selection and estimates of gene flow between tributaries. *Aquaculture, 98:* 217-230.

Webb, J.H. 1991. Escaped farmed salmon and wild salmon populations. *Atlantic Salmon Trust Progress Report, December 1991*: 32-36.

Webb, J.H., Hay, D.W., Cunningham, P.D., & Youngson, A.F. 1991. The spawning behaviour of escaped farmed and wild adult Atlantic salmon (*Salmo salar* L.) in a northern Scottish river. *Aquaculture, 98:* 97-100.

B. Further reading

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides: a natural history*. London, Collins. (New Naturalist series.)

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.

Jenkins, D., & Shearer, W.M. 1986. *The status of the Atlantic salmon in Scotland*. Banchory, ITE. (NERC ITE Symposium No. 15, Banchory Research Station, 13-14 February 1985.)

Orton, D.A., *ed.* 1996. *Where to fish 1996 - 1997.* 85th ed. Beaminster, Thomas Harmsworth.

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

Out of a national total of 336, there are 67 species of exploited and unexploited fish recorded from Regions 15 (Western Isles) and 16 (west Highland), comprising five sharks and rays (elasmobranchs) and 62 bony fishes (teleosts). Some fish, including some records of gobies, gadoids and flatfishes, have not been identified to species level, and others expected to be present have not been found. Therefore the list should be considered incomplete. Region 15 has records of four of the seven British marine and estuarine species protected under national, European and international legislation (Table 5.9.1), and six such species (excluding only the lampern *Lampetra fluviatilis*) have been recorded in Region 16. The sea lamprey *Petromyzon marinus*, sturgeon *Acipenser sturio*, sand goby *Pomatoschistus minutus* and the common goby *P. microps* have been recorded from both regions, while the allis shad *Alosa alosa* and twaite shad *Alosa fallax* have been recorded only from Region 16 and the Minch area. The sea lamprey, allis and twaite shads and sturgeon are considered threatened in UK and European waters (Potts & Swaby 1993a). Map 5.9.1 shows the recorded distributions in the region of sturgeon, allis shad and twaite shad.

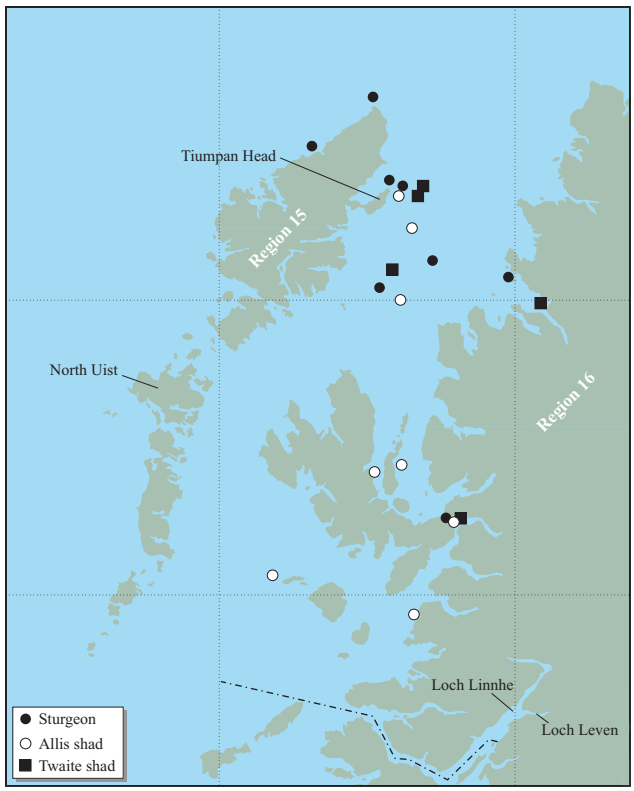
Table 5.9.1 Scheduled species and protected status

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 UK.

5.9.2 Important locations and species

Numbers and names of fish species occurring in lochs and around islands in these regions have been the subject of many surveys. In Region 15, 25 species were recorded from Loch Roag (Dipper 1984) and 30 around St. Kilda (Gauld *et al.* 1953; Howson & Picton 1985; Cadman *et al.* 1993), with the number of species recorded ranging from three in the Uists (Nichol 1936) to 35 around Harris and Lewis (Howson 1989). In Region 16 the range is from three around Canna (MacKinnon 1988) to 33 around Skye (Hiscock & Covey 1991), with 25 in Lochs Duich, Long and Alsh (Connor 1989). The fish species do not differ significantly between lochs or from island to island, and certain species have been recorded frequently, because divers, on whose sightings the numbers are based, tend to identify and report mainly common fish. In many cases fish are not identified to species.



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

Those records of sturgeon, allis shad and twaite shad held on the British Marine Fishes Database that have well-defined locations are shown on Map 5.9.1. In addition, an allis shad was recorded from 'the Outer Hebrides' in 1952, and in Region 16 the twaite shad has been recorded in Loch Linnhe (Gordon & de Silva 1980). The lampern is on the northern edge of its distribution just south of Region 16 and there are no verified records of it in either Region 15 or 16. In Region 15 sturgeon have been recorded from North Uist (Harvie-Brown & Buckley 1888). The sea lamprey has not been recorded in any inland waters (Campbell & Williamson 1979) in Region 15, although one was seen in Stornoway Harbour (Cunningham pers. comm., cited in Campbell & Williamson 1979). There is one historical report of the species in Region 16, from Loch Leven (Scott & Brown 1901).

Fish species recorded from most areas in both regions include bib *Trisopterus luscus*, ballan wrasse *Labrus bergylta*, goldsinny *Ctenolabrus rupestris* and cuckoo wrasse *Labrus mixtus*. Inshore fish such as the dragonet *Callionymus lyra*, butterfish *Pholis gunnellus*, bull rout *Myoxocephalus scorpius*, the three-spined stickleback *Gasterosteus aculeatus*, and the pogge *Agonus cataphractus* are also regularly recorded. Sharks and rays recorded from both regions include the lesser spotted dogfish *Scyliorhinus canicula* (in Region 15 recorded only from St. Kilda), the common skate *Raja batis*, the cuckoo ray *Raja naevus* and the basking shark *Cetorhinus maximus* (recorded from Skye and St. Kilda). In addition, the nursehound *Scyliorhinus stellaris* and the thornback ray *Raja clavata* have been recorded from Region 16, and the

spurdog *Squalus acanthias* from Region 15.

The Norwegian topknot *Phyrnorhombus norvegicus* is recorded from both regions but Eckstroms topknot *Phyrnorhombus regius* from Region 16 only. The latter species, recorded from the Loch Sunart and Loch Teacuis area (Davies 1990), is on the very northern edge of its distribution in Region 16. The tompot blenny *Parablennius gattorugine*, which normally inhabits the very south and west of the UK, is found from the Loch Arisaig and Moidart area in Region 16 (Howson 1990) and from Region 15. Other species on the northern edge of their distribution include the butterfly blenny *Blennius ocellaris* and the black goby *Gobius niger*, which are typically found in southern England. Two less commonly recorded gobies are well represented in Region 16. They are the leopard-spotted goby *Thorogobius ephippiatus*, recorded during six different surveys between Loch Sunart and Loch Glendhu, and Fries' goby *Leseurigobius friesii*, found during surveys between Loch Leven and Loch Torridon. Species more characteristic of cooler, northern waters are Yarrell's blenny *Chirolophis ascanii* and the snake blenny *Lumpenus lampretaeformis*. The less well known northern rockling *Ciliata septentrionalis* has also been recorded in Region 16 in Loch Gairloch (Hall *et al*. 1990). Six triggerfish *Balistes carolinensis*, normally seen further south in British waters, were recorded off Western Scotland during 1983-1984 following warmer water temperatures (1-2° above normal) (Dobson 1984).

There is no information on the associations of fish with habitats in Regions 15 and 16, apart from the feeding relationships within an assemblage of nineteen species on a sandy bottom in Loch Gairloch (Region 16), detailed in Hall *et al*. (1990). However, the associations of fish with habitats are given in Potts & Swaby (1993b). 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 types (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.

5.9.3 Human activities

Nationally, estuaries are used by up to 180 fish species for migration, spawning, feeding and as nursery grounds (Potts & Swaby 1993b). Human activities affecting estuaries and adjacent coasts in the regions are summarised in Buck (1993); these activities affect the abundance and distribution of fish. However, the remoteness of the regions and the ruggedness of much of the coastline of Region 16 means that the effects of human activities are relatively slight. Industrial development and agricultural pollution have been shown to have a detrimental effect on the estuarine environment, in particular through the discharge or run-off of heavy metals into the water (Davies 1981). Dredging can damage sensitive environments, and this activity occurs in five estuaries in Region 15. In addition, 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. Urbanisation and the discharge of untreated sewage to the sea, and particularly into estuaries, such as Kentra Bay and Loch Moidart in Region 16, result in a reduction in dissolved oxygen, to which fish are particularly sensitive. The result is that fish leave the area and do not return until treatment plants reduce the amount of sewage discharged and oxygen levels increase (Potts & Swaby 1993b). Fisheries in Region 15 are discussed in Bailey *et al.* (1979). The possible effects of fisheries on species is discussed in sections 5.7 and 9.1. The effects of cultivation of shellfish and fish species in the regions are discussed in Carss (1990) and in section 9.2. Sea angling, which occurs in many places throughout the region (Orton 1994), is also discussed in section 9.1.

5.9.4 Information sources used

There has been no detailed study of the fish species of the coasts of either region and most records have been made during littoral and sublittoral surveys of sea lochs and islands carried out by the JNCC's Marine Nature Conservation Review (MNCR) team and others. The Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD), Dunstaffnage Marine Laboratory and the Scottish Association for Marine Science hold information on marine and estuarine fishes, and some Scottish universities carry out individual research projects. Rare fish observed in Scotland are generally reported to SOAEFD.

Information of marine and estuarine fishes is stored in the British Marine Fishes Database, which covers UK fish and individual records for this area. Information is being gathered from a variety of sources including research institutes, fish biologists, anglers and fishermen. The data include published literature and unpublished reports, as well as personal communications from fish biologists.

5.9.5 Acknowledgements

The authors wish to thank Dr R. Gibson (Dunstaffnage Marine Laboratory) and Dr J.D.M. Gordon (Scottish Association for Marine Science) for providing information.

5.9.6 Further sources of information

A. References cited

Bailey, R.S., Hislop, J.R.G., & Mason, J. 1979. The fish and shellfish resources in seas adjacent to the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, 77B:* 479-494.

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

Cadman, P., Ellis, J., Geiger, D., & Piertney, S. 1993. *A survey of the marine fauna of the St. Kilda archipelago.* University of Swansea. (Unpublished report.)

Campbell, R.N., & Williamson, R.B. 1979. The fishes of inland waters in the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, 77B:* 377-393.

Carss, D.N. 1990. Concentrations of wild and escaped fishes immediately adjacent to fish farm cages. *Aquaculture, 90:* 29-40.

Connor, D.W. 1989. Survey of Loch Duich, Loch Long, and Loch Alsh. *Nature Conservancy Council, CSD Report,* No. 977. (Marine Nature Conservation Review Report MNCR/SR/010/89.)

Davies, I.M. 1981. *Survey of trace elements in fish and shellfish landed at Scottish ports 1975-76*. Aberdeen, SOAFD. (Scottish Fisheries Research Report, No. 19.)
Davies, J. 1990. Sublittoral survey of Loch Sunart and Loch Teacuis. *Nature Conservancy Council, CSD Report,* No. 1,075. (Marine Nature Conservation Review Report MNCR/SR/008.)
Dipper, F. 1984. Sublittoral survey of habitats and species in and around Loch Roag, Lewis, Outer Hebrides. *Nature Conservancy Council, CSD Report,* No. 505.
Dobson, J. 1984. Fish - Triggerfish off Western Scotland. *Glasgow Naturalist, 20*(5)*:* 486-488.
Gauld, D.T., Bagenal, T.B., & Connell, J.H. 1953. The marine fauna and flora of St. Kilda, 1952. *Scottish Naturalist, 65*(1)*:* 29-49.
Gordon, J.D.M., & De Silva, S.S. 1980. The fish populations of the west of Scotland shelf. Part I. *Oceanography and Marine Biology, London. Annual Review, 18:* 317-366.
Hall, S.J., Raffaelli, D., Basford, D.J., Roberston, M.R., & Fryer, R. 1990. The feeding relationships of the larger fish species in a Scottish sea loch. *Journal of Fish Biology, 37:* 775-791.
Harvie-Brown, J.A., & Buckley, T.E. 1888. *A vertebrate fauna of the Outer Hebrides.* Castle Street, Edinburgh, David Douglas.
Howson, C. 1989. Sea lochs on the Isles of Harris and Lewis. *Nature Conservancy Council, CSD Report,* No. 982. (Marine Nature Conservation Review. Surveys of Scottish sea lochs.)
Howson, C.M. 1990. Sea lochs of Arisaig and Moidart. *Nature Conservancy Council, CSD Report,* No. 1,086. (Marine Nature Conservation Review. Surveys of Scottish sea lochs.)
Howson, C.M., & Picton, B. 1985. A sublittoral survey of St. Kilda. *Nature Conservancy Council, CSD Report,* No. 595.
Orton, D.A., *ed*. 1994. *Where to fish 1994-1995*. 84th ed. Beaminster, Thomas Harmsmith.
Potts, G.W., & Swaby, S.E. 1993a. *Marine fishes on the EC Habitats and Species Directive.* Peterborough, Joint Nature Conservation Committee. (Confidential report.)
Potts, G.W., & Swaby, S.E. 1993b. *Marine and estuarine fishes of Wales. The development of the British Marine Fishes Database and monitoring programme for Wales*. Bangor, Countryside Council for Wales.
Scott,T., & Brown, A. 1901. The marine and fresh-water fishes. *In: Fauna, flora and geology of the Clyde area,* ed. by G.F.S. Elliot, M. Laurie & J.B. Murdoch, 173-180. Glasgow, Local Committee for the Meeting of the British Assocation.

B. Further reading

Breen, J.P., Connor, D.W., & McKenzie, J.D. 1986. A marine survey of Loch Nevis and Loch Hourn, Western Scotland. *Glasgow Naturalist, 21*(2)*:* 153-172.
Davidson, N.C., Laffoley, D.d'A., Doody, J.P., Way, L.S., Gordon, J., Key, R., Drake, C.M., Pienkowski, N.W., Mitchell, R., & Duff, K.L. 1991. *Nature conservation and estuaries in Great Britain.* Peterborough, Nature Conservancy Council.
Davies, J. 1989. Lochs A'Chairn Bhain, Glendhu and Glencoul. *Nature Conservancy Council, CSD Report,* No. 983. (Marine Nature Conservation Review. Surveys of Scottish sea lochs.)
Davies, J. 1991. Marine Nature Conservation Review. Marine biological survey of Loch Leven. *Nature Conservancy Council, CSD Report,* No. 1,191. (Marine Nature Conservation Review Report MNCR/SR/014.)
Dipper, F. 1981. Sublittoral survey of habitats and species around the Summer Isles: Ross and Cromarty. *Nature Conservancy Council, CSD Report,* No. 365.
Dipper, F. 1985. Sublittoral survey of Loch Eynort, South Uist, Outer Hebrides. *Nature Conservancy Council, CSD Report,* No. 611.
Dipper, F.A., Lumb, C.M., & Palmer, M.A. 1987. A littoral, sublittoral and limnological survey of Loch Obisary, North Uist. *Nature Conservancy Council, CSD Report,* No. 807.
Gordon, J.D.M. 1981. The fish populations of the west of Scotland shelf. Part II. *Oceanography and Marine Biology. Annual Review. London, 19:* 405-441.
Hiscock, S., & Covey, R. 1991. Marine biological surveys around Skye. *Nature Conservancy Council, CSD Report,* No. 1,076. (Marine Nature Conservation Review.)
Mackinnon, M.C. 1988. Canna expedition. *Nature Conservancy Council, CSD Report,* No. 899. (Confidential report.)
Mackinnon, M.C., & Lumb, C.M. 1987. Loch Sunart sublittoral survey. *Nature Conservancy Council, CSD Report,* No. 794.
McIntosh, W.C. 1866. Observations on the marine zoology of North Uist, Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, 5: 600-614.*
Nichol, A.T. 1936. The brackish-water lochs of North Uist. *Proceedings of the Royal Society of Edinburgh, 56:* 169-195.
Nicol, E.A.T. 1936. The fauna of Loch Bee. *Scottish Naturalist, 1936:* 31-134.
Potts, G.W., & Swaby, S.E. 1993. *Review of the status of estuarine fishes.* Peterborough, English Nature. (English Nature Research Reports, No. 34.)
Powell, H.T., Holme, N.A., Knight, S.J.T., Harvey, R., Bishop, G., & Bertrop, J. 1979. Shores of the Outer Hebrides: a geological survey of the littoral zone. *Nature Conservancy Council, CSD Report,* No. 272.
Rae, B.B. 1971. *The distribution of flatfishes in Scottish and adjacent waters.* Aberdeen, Department of Agriculture and Fisheries for Scotland. (Marine Research, No. 2.)
Smith, S. 1985. A survey of the shores and shallow sublittoral Loch Torridon and Loch Carron (including Loch Kishorn). *Nature Conservancy Council, CSD Report,* No. 610.
Smith, S.M. 1978. Shores of West Inverness-shire and North Argyll with emphasis on the Mollusca. *Nature Conservancy Council, CSD Report,* No. 226.
Treasurer, J.W. 1994. Distribution and species and length composition of wrasse (Labridae) in inshore waters of West Scotland. *Glasgow Naturalist, 22*(54)*:* 409-417.
Waterston, A.R., & Lyster, I.H.J. 1979. The macrofauna of brackish and freshwaters of the Loch Druidibeg National Nature Reserve and its neighbourhood, South Uist. *Proceedings of the Royal Society of Edinburgh, 77B:* 353-376.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
British Marine Fishes Database	Dr G.W. Potts and S.E. Swaby, Marine Biological Association UK, Citadel Hill, Plymouth PL1 2PB, tel: 01752 633100
Fisheries - Scotland	*SOAEFD Fisheries Research Services, Marine Laboratory, Aberdeen, tel: 01224 876544
Fish conservation - UK	*Marine Advisory Officer, JNCC Peterborough, tel: 01733 62626
Fish conservation - Scotland	*Aquatic Environments Branch, SNH HQ, Edinburgh, tel: 0131 554 9797
Fish research - Scotland	Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244
Fish research - Scotland	Scottish Association for Marine Science, PO Box 3, Oban, Argyll PA34 4AD, tel: 01631 562244

*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 divers, grebes and seaduck: in other words, those species reliant for an important part of their life on the marine environment. (Section 5.12 includes information on these waterfowl species where they occur close inshore, particularly within estuaries.)

Regions 15 (Western Isles) and 16 (west Highland) are of very great importance for several species of seabirds. Seventeen colonies - ten in Region 15 and seven in Region 16 - are at least nationally important, of which nine in Region 15 and three in Region 16 are internationally important. More than 1% of the European population of 21 species breed in these regions, with one further species present in nationally important numbers. The populations of nine species (fulmar, Manx shearwater, storm petrel, Leach's petrel, gannet, guillemot, razorbill, black guillemot and puffin) are present at levels above 20% of the European population.

The waters in the regions vary greatly in their nature, from extreme inshore at the heads of sea lochs, to deep oceanic water. As a consequence the seabird fauna is very diverse compared with many UK waters. The numbers and vulnerability of birds at sea in both regions are high in relation to much of the rest of the UK (Map 5.10.1), although the importance of each area varies for different species. The offshore area over the continental shelf break is important for much of the year, partly because it provides a focus for fishing vessels, which in turn can produce much edible waste. Generally, the areas near colonies are of greatest importance in summer, with the Minches and some parts of the Sea of Hebrides remaining important throughout the year.

Table 5.10.1 Overall importance of seabirds breeding in Regions 15 & 16

Species	*Total*	*%GB*	*% Europe*
Fulmar *Fulmarus glacialis*	136,907	25.5	24.1
Manx shearwater *Puffinus puffinus*	63,340	42.8	41.7
Storm petrel *Hydrobates pelagicus*	10,000s	>20	>20
Leach's petrel *Oceanodroma leucorhoa**	10,000s	>80	>80
Gannet *Morus bassanus**	72,306	36.1	29.9
Cormorant *Phalacrocorax carbo*	642	9.4	4.9
Shag *Phalacrocorax aristotelis*	9,846	27.0	18.6
Arctic skua *Stercorarius parasiticus*	84	2.6	2.6
Great skua *Stercorarius skua*	335	3.9	3.9
Black-headed gull *Larus ridibundus*	912	0.5	1.1
Common gull *Larus canus*	1,708	2.5	1.4
Lesser black-backed gull *Larus fuscus*	1,392	1.7	1.2
Herring gull *Larus argentatus*	12,212	8.1	2.0
Great black-backed gull *Larus marinus*	4,421	24.0	18.0
Kittiwake *Rissa tridactyla*	42,600	8.6	7.7
Sandwich tern *Sterna sandvicensis*	72	0.5	0.1
Roseate tern *Sterna dougallii**	1	-	-
Common tern *Sterna hirundo*	1,454	11.4	3.0
Arctic tern *Sterna paradisaea*	3,555	8.3	3.6
Little tern *Sterna albifrons*	108	4.5	0.6
Guillemot *Uria aalge*	267,574	25.6	22.2
Razorbill *Alca torda*	42,709	29.0	23.5
Black guillemot *Cepphus grylle*	10,507	28.0	25.4
Puffin *Fratercula arctica*	175,549	47.0	44.3

Sources: regional totals are compiled from the most recent available good-quality counts up to 1995; figures for Great Britain are from Thompson *et al*. (1996); those for Europe are from Lloyd *et al*. (1991). Key: *occurs in Region 15 only. Note: counts are of pairs, except for guillemot, razorbill and black guillemot, which are counted individually.

5.10.2 Important locations and species

Breeding seabirds require habitat that is free from predatory mammals; nearly all colonies in the regions are on offshore islands or cliffs. In Region 15 nine colonies are important at the European level, and one (Ardivachar Machair) is important at the Great Britain level (Table 5.10.2). Four of the islands within the St. Kilda archipelago (treated as one colony here) are of international importance in their own right. In Region 16 three colonies are important at the European level, with a further four colonies important at the Great Britain level (Table 5.10.2).

The feeding areas offshore from breeding colonies are of equivalent importance to the colonies themselves as birds require a local source of 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 ('fronts') or where tides converge around headlands or over some sea-bed features, such as the continental shelf edge (see also section 4.3). Fulmars are present in high densities over the shelf break west of Region 15 throughout the year (Stone *et al*. 1995). The area to the immediate north of the Minch is of importance to this species during summer, autumn and winter. Manx shearwaters are commonest in the Sea of the Hebrides near Rum during spring and summer, and the shelf waters to the west of the Hebrides are also important in May and June. Manx shearwaters are accompanied by sooty shearwaters *Puffinus griseus* between July and November. Storm petrels occur most commonly over the shelf waters to the west of Region 15 between May and August, while Leach's petrels occur over the shelf break and deeper water further to the west. Gannet distribution changes through the year. They are common near St. Kilda and over waters to the west in March and April, but switch to waters to the east of St. Kilda and over other parts of the shelf in summer (May to October). Through the winter, gannets are commonest over the shelf edge and to the west of St. Kilda. Cormorants and shags are found in nearshore waters, with shags being much commoner. Important areas for the latter species include the Sound of Harris, and nearshore in the Minch and Sea of Hebrides. Eiders *Somateria mollissima* breed at relatively low densities on all coasts of the regions, with the highest densities at the north end of Loch Linnhe. Red-breasted

Table 5.10.2 Seabird colonies in Regions 15 &16 of at least national importance for particular species

Site no. on Map 5.10.2	*Colony*	*Grid ref.*	*Species*	*Count date*	*Count*	*1% EU/GB population*	*Protected status*
	Region 15						
1	Tolsta Head	NB564471	Great black-backed gull	1988	258	EU	SSSI
2	Shiant Islands	NG420980	Fulmar	1986	6,816	EU	SSSI/SPA
			Shag	1986	1,776	EU	
			Guillemot	1986	18,379	EU	
			Razorbill	1986	10,947	EU	
3	Berneray	NL560800	Kittiwake	1985	5,114	GB	SSSI
			Guillemot	1985	19,881	EU	
			Razorbill	1985	11,893	EU	
4	Mingulay	NL560830	Fulmar	1985	9,000	EU	SSSI
			Shag	1985	500	GB	
			Guillemot	1985	11,000	GB	
			Razorbill	1985	5,000	EU	
5	Ardivachar Machair	NF746453	Little tern	1990	27	GB	None
6	Monach Islands	NF630620	Common tern	1985	194	GB	SSSI/SPA
			Little tern	1987	34	GB	
			Black guillemot	1987	850	EU	
7	St. Kilda	NA100000	Fulmar	1987	62,786	EU	SSSI/SPA
			Storm petrel	1987	2,000+	EU	
			Leach's petrel	1987	5,000+	EU	
			Gannet	1994	60,428	EU	
			Great skua	1994	144	EU	
			Kittiwake	1987	7,829	EU	
			Guillemot	1987	22,705	EU	
			Razorbill	1987	3,814	EU	
			Puffin	1987/9	155,000	EU	
8	Flannan Islands	NA700460	Guillemot	1988	21,926	EU	SSSI/SPA
			Razorbill	1988	3,160	EU	
9	Sula Sgeir	HW620305	Fulmar	1985	7,800	EU	SSSI
			Gannet	1994	10,440	EU	
			Guillemot	1986	25,382	EU	
10	North Rona	HW810325	Great black-backed gull	1993	851	EU	SSSI
			Guillemot	1986	17,802	EU	
			Razorbill	1986	1,519	GB	
			Puffin	1986	4,750	GB	
	Region 16						
11	Loch Sunart	NM500600	Common tern	1993	158	GB	
12	Sound of Arisaig	NM600800	Common tern	1994	240	GB	
13	Rum	NM380960	Manx shearwater	1990	62,800	EU	SSSI/SPA
14	Canna	NG250050	Shag	1995	981	GB	SSSI
15	Fladda Chuain	NG360814	Arctic tern	1988	500	GB	
16	Summer Isles	NB970050	Storm petrel	1995	10,000s	EU	SPA
			Black guillemot	1989	378	GB	
17	Handa	NC140480	Great skua	1995	115	EU	SSSI/SPA
			Kittiwake	1995	7,418	EU	
			Guillemot	1994	114,000	EU	
			Razorbill	1987	16,394	EU	

Source: JNCC/Seabird Group Seabird Colony Register. Key: GB = nationally important; EU = internationally important; SSSI = Site of Special Scientific Interest; SPA = Special Protection Area. Note: counts are of pairs, except for guillemots, razorbills and black guillemots, which are counted individually. For most species the most recent available good-quality count is presented.

mergansers *Merganser serrator* are common throughout the year in many lochs in both regions.

The seas of Regions 15 & 16 are of importance to divers. Webb *et al*. (1990) show that many of the sealochs surrounding the Minch hold relatively high densities of divers (particularly red-throated *Gavia stellata* and great northern *G. immer*) in March and April, with moderate densities between November and February. Lochs further south hold moderate densities of divers throughout the winter.

Black-headed and common gulls are predominantly inshore in their distribution at sea, and are present for most of the year. The Minch is important for lesser and great black-backed and herring gulls for much of the year. Lesser black-backed gulls move into the offshore waters in summer, in contrast to the large influx of great black-backed gulls which occurs in winter. Kittiwakes occur in high densities near their colonies in summer, are at high density in the Minch for much of the year, and use shelf edge waters to the west in winter. Both guillemots and razorbills are at highest density at sea near their colonies in the breeding season, but move to the Minch and the Sea of the Hebrides in July, with these waters becoming particularly important

in August. Many guillemots and razorbills move out of the regions in winter, but the Minch remains important for guillemots through the winter. Puffins occur in greatest numbers during the summer, relatively near their main colonies.

There are no known sites of national importance for seaduck in the regions, although this may owe as much to lack of survey work as to lack of suitable habitat (Cranswick *et al*. 1995). As described above, much of the coastline is used by low to moderate densities of divers and seaduck during the non-breeding season, so the regions overall are likely to be of importance in a British and European context for these birds.

5.10.3 Human activities

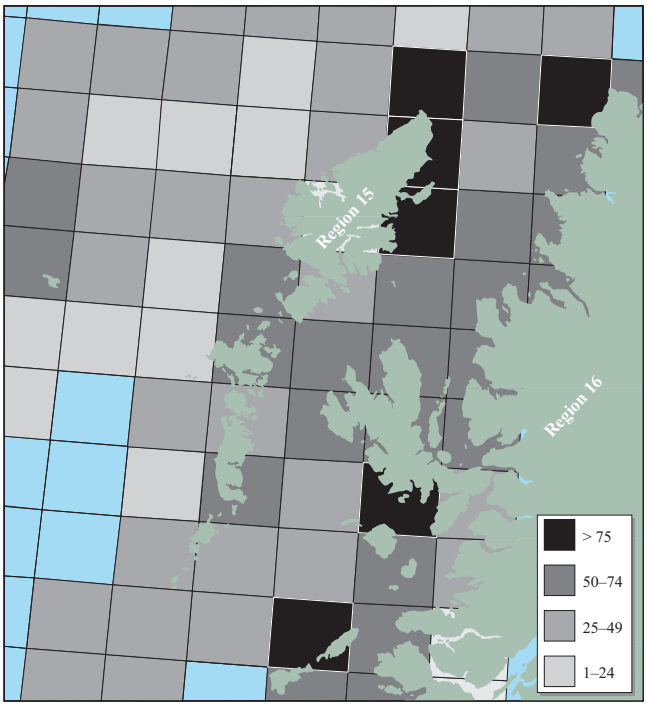
The vulnerability of seabirds at sea to the effects of human activities is calculated from the abundance of birds in the rectangles shown on Map 5.10.1 and a factor derived from the amount of time spent on the water, the overall population size and the rate at which the species recruits new individuals 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, and spills near the main colonies during the breeding season could be particularly damaging. There is no oil development in the area at present, but tankers heading south from terminals in Orkney and Shetland (Regions 1 and 2) pass either through the Minch, or to the west using the recommended deep-water channel.

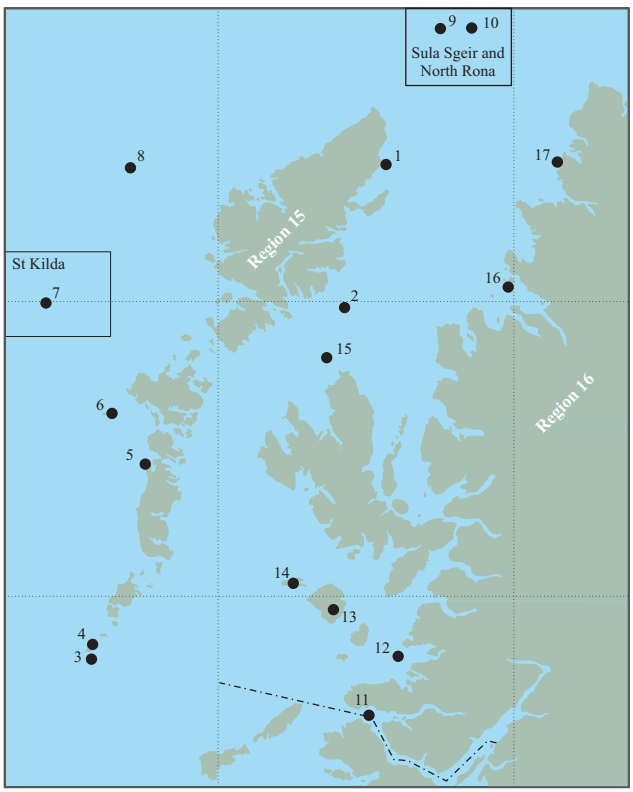
All waters in the regions are used to some extent by the fishing industry and although some birds may become entangled in fishing nets or caught on fishing lines, the scale at which this occurs is not believed to be great overall. Future changes in fishing practice, particular any increase in the use of monofilament nets, would increase the level of bycatch. Most breeding seabirds require habitat that is free from predatory mammals, hence most colonies in the regions are on offshore islands or cliffs. The damage done to tern colonies by feral North American mink *Mustela vison* has led to particular concern about its spread through mainland Scotland and Lewis/Harris. Populations of this predator have yet to become established on the Uists and Benbecula, but they would be capable of swimming across the Sound of Harris.

5.10.4 Information sources used

All seabird colonies in the regions 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 Eigg, Rum, Canna, Handa and St. Kilda (Thompson *et al*. 1996). Surveys of birds at sea in the regions have been carried out by JNCC's Seabirds at Sea Team (SAST). Coverage has generally been good in most months except November. The Minch and the Sea of the Hebrides are well surveyed in all months except November, although the inshore area near Mallaig is poorly known. The shelf seas to the west of Region 15 have been surveyed



Map 5.10.1 Relative importance of region and adjacent seas for seabirds. Shading indicates the percentage of months surveyed that show highest vulnerability rating (see text and Webb *et al.* 1995). Grid is of 15'N x 30'W rectangles. Source: JNCC Seabirds at Sea Team



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

adequately in all months except November, December, January and March. The shelf edge has inadequate coverage from September to December inclusive. 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

(Barton *et al*. 1994). Coverage, from the land, of most nearshore waters in the regions has been patchy, with SAST making a particular effort to cover systematically a sample of Region 16 sea lochs on a monthly basis over two years. The sea lochs of Region 15 are much less well studied.

5.10.5 Acknowledgements

Thanks are due to Kate Thompson (JNCC), who extracted the information on seabird numbers from the Seabird Colony Register.

5.10.6 Further sources of information

A. References cited

Barton, T.R., Barton, C., Webb, A., & Carter, I.C. 1994. Seabird distribution in inshore waters of the western United Kingdom between Wick and St. David's Head from aerial surveys in 1987-1991. *Joint Nature Conservation Committee Report,* No. 183.

Carter, I.C., Williams, J.M., Webb, A., & Tasker, M.L. 1993. *Seabird concentrations in the North Sea: an atlas of vulnerability to surface pollutants.* Aberdeen, Joint Nature Conservation Committee.

Cranswick, P.A., Waters, R.J., Evans, J., & Pollitt, M.S. 1995. *The wetland bird survey 1993-94: wildfowl and wader counts.* Slimbridge, British Trust for Ornithology/Wildfowl and Wetlands Trust/Royal Society for the Protection of Birds/ Joint Nature Conservation Committee.

Lloyd, C.S., Tasker, M.L., & Partridge, K. 1991. *The status of seabirds in Britain and Ireland.* London, Poyser.

Stone, C.J., Webb, A., Barton, C., Ratcliffe, N., Reed, T.C., Tasker, M.L., & Pienkowski, M.W. 1995. *An atlas of seabird distribution in north-west European waters.* Peterborough, Joint Nature Conservation Committee.

Thompson, K.R., Brindley, E., & Heubeck, M. 1996. *Seabird numbers and breeding success in Britain and Ireland, 1995*. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No. 20.)

Webb, A., Harrison, N.M., Leaper, G.M., Steele, R.D., Tasker, M.L., & Pienkowski, M.W. 1990. *Seabird distribution west of Britain*. Peterborough, Nature Conservancy Council.

Williams, J.M., Tasker, M.L., Carter, I.C., & Webb, A. 1994. A method of assessing seabird vulnerability to surface pollutants. *Ibis, 137:* S14-S152.

B. Further reading

Bryan, A. 1994. *The Minch review*. Stornoway, Comhairle nan Eilean/Scottish Natural Heritage.

Harrison, N.M., Webb, A., & Leaper, G.M. 1994. Patterns in seabird distribution west of Scotland. *Aquatic Conservation: Marine and Freshwater Ecosystems, 4:* 21-30.

Kirby, J.S., Evans, R.J., & Fox, A.D. 1993. Wintering seaducks in Britain and Ireland: populations, threats, conservation and research priorities. *Aquatic Conservation: Marine and Freshwater Ecosystems, 3:* 105-137.

Milne, H., & Galbraith, C.A. 1986. *Predation by eider ducks on cultivated mussels*. Aberdeen, Aberdeen University. (Final report to Department of Agriculture and Fisheries, Scotland and Highlands and Islands Development Board.)

Moser, M.E., Broad, R.A., Dennis, R.H., & Madders, M. 1986. The distribution and abundance of some coastal birds on the west and north-west coasts of Scotland in winter. *Scottish Birds, 14:* 61-67.

Owen, M., Atkinson-Willes, G.L., & Salmon, D.G. 1986. *Wildfowl in Great Britain.* 2nd ed. Cambridge, Cambridge University Press.

Prater, A.J. 1981. *Estuary birds of Britain and Ireland*. Calton, Poyser.

Rennie, F.W. 1988. The status and distribution of the great skua in the Western Isles. *Scottish Birds, 15:* 80-82.

Rose, P.M., & Scott, D.A. 1994. *Waterfowl population estimates.* Slimbridge, International Waterfowl and Wetlands Research Bureau. (IWRB publication No. 29.)

Skov, H., Durinck, J., Leopold, M.F., & Tasker, M.L. 1995. *Important bird areas for seabirds in the North Sea including the Channel and the Kattegat*. Cambridge, BirdLife International.

Tasker, M.L., Moore, P.R., & Schofield, R.A. 1988. The seabirds of St. Kilda, 1987. *Scottish Birds, 15:* 21-29.

Walsh, P.M., Brindley, E., & Heubeck, M. 1995. *Seabird numbers and breeding success in Britain and Ireland, 1994*. Peterborough, Joint Nature Conservation Committee. (UK Nature Conservation, No. 18.)

Waters, R.J., & Cranswick, P.A. 1993. *The wetland bird survey 1992-93: wildfowl and wader counts.* Slimbridge, British Trust for Ornithology/Wildfowl and Wetlands Trust/Royal Society for the Protection of Birds/Joint Nature Conservation Committee.

Webb, A., Stronach, A., Stone, C.S., & Tasker, M.L. 1995. *Vulnerable concentrations of birds to the south and west of Britain*. Peterborough, Joint Nature Conservation Committee.

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	*Birds Advisor, JNCC, Peterborough, tel 01733 62626
Information on seabirds in Scotland	*SNH, Aquatic Environments Branch, RASD, Edinburgh, tel: 0131 554 9797
Nearshore waterfowl	*Wildfowl & Wetlands Trust, Slimbridge, tel: 01453 890333

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

5.11 Other breeding birds

R.T. May & A.B. Law

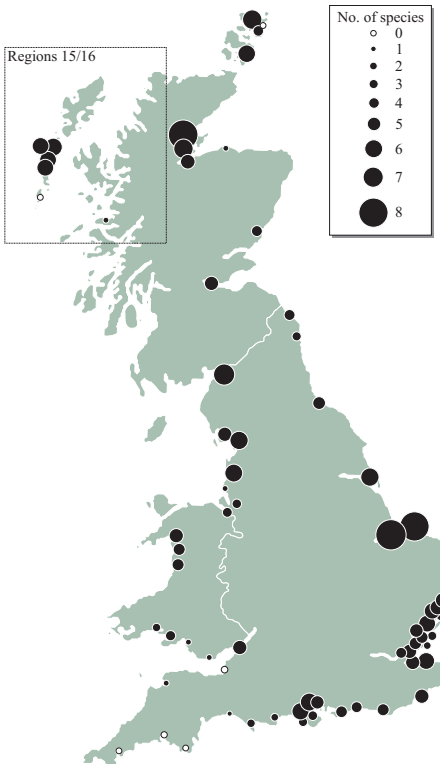
5.11.1 Introduction

This section outlines the importance of Regions 15 (Western Isles) and 16 (west Highland) to breeding birds other than seabirds. Because of their distinctive ecology and mixed-species breeding colonies, seabirds are described separately in section 5.10, although the occurrence close inshore and in sea lochs of marine waterfowl (divers, grebes, seaducks and cormorant *Phalacrocorax carbo*) is noted here, where it is of particular significance.

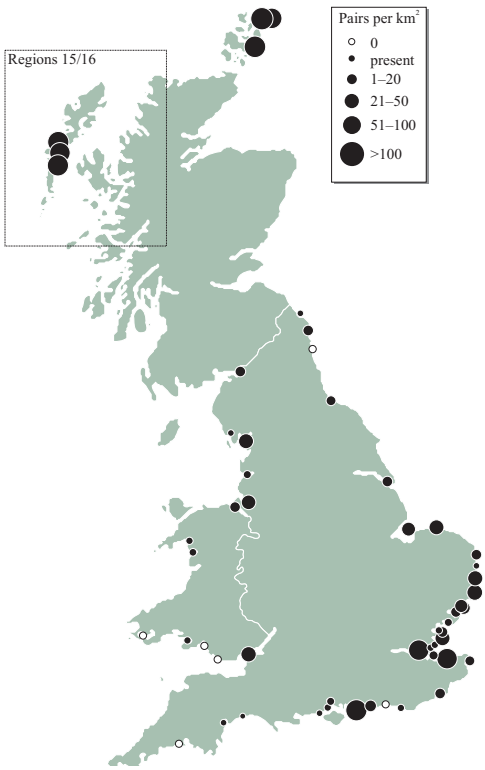
Region 15's grasslands are amongst the most important breeding grounds for waders in the north-west Palearctic, in terms of both densities and numbers (Davidson *et al.* 1991; Davidson 1991; Fuller *et al.* 1979; Fuller *et al.* 1986). The largest, consistently most diverse breeding waterfowl assemblages occur on the machair (Map 5.11.1), where densities of breeding waders are greater than anywhere else in Britain (Map 5.11.2). The exceptional importance of the machair is also emphasised by the high total numbers of breeding waders. The UK's most outstanding coastal concentration of dunlin *Calidris alpina*, of international importance, is found here (Map 5.11.3) (Fuller *et al.* 1979). Also, Region 15 supports some 30% of the national breeding population of ringed plover *Charadrius hiaticula* (Map 5.11.4) (Fuller *et al.* 1986; Prater 1989). The Southern Isles (North and South Uist and Benbecula) comprise one of the major breeding grounds for waders in western Europe (Fuller & Percival 1988). Machair grassland in Region 15 is also internationally important for breeding corncrake *Crex crex*, a globally threatened bird (Heredia *et al.* 1996), and the cultivated dry machair supports nationally important numbers of corn bunting *Miliaria calandra*, one of Britain's most rapidly declining bird species (Donald *et al.* 1996; Williams *et al.* 1986). After the machair, the most important coastal habitat for breeding waterfowl in these regions in terms of densities is the blackland, while moorland/peatland habitats have the lowest densities (Fuller *et al.* 1986; Pienkowski *et al.* 1986). In Region 16 the breeding waterfowl assemblages are fairly diverse, but individual species are not abundant. However, this region is a major stronghold in the UK of the red-throated diver *Gavia stellata* and black-throated diver *G. arctica*, which occur here in nationally important numbers.

Sites in Regions 15 and 16 play an important role in maintaining the global range of several wader species (Davidson *et al.* 1991). Numbers of lowland breeding waders, especially those associated with wet grassland areas and saltmarshes, have been declining, not only nationally but also internationally (Hötker 1991), because of habitat loss or degradation. The relative importance of the regions for these breeding birds is thus likely to increase.

Several raptor species breed in the regions, including golden eagle *Aquila chrysaetos*, which is particularly abundant on Skye, and the white-tailed eagle *Haliaeetus albicilla*, Britain's largest raptor, which has been successfully re-established on the west coast of Scotland and the Western Isles (Love 1988; Evans *et al.* 1994). In addition the regions' populations of a number of breeding bird species, such as twite *Carduelis flavirostris*, rock pipit *Anthus petrosus petrosus*,

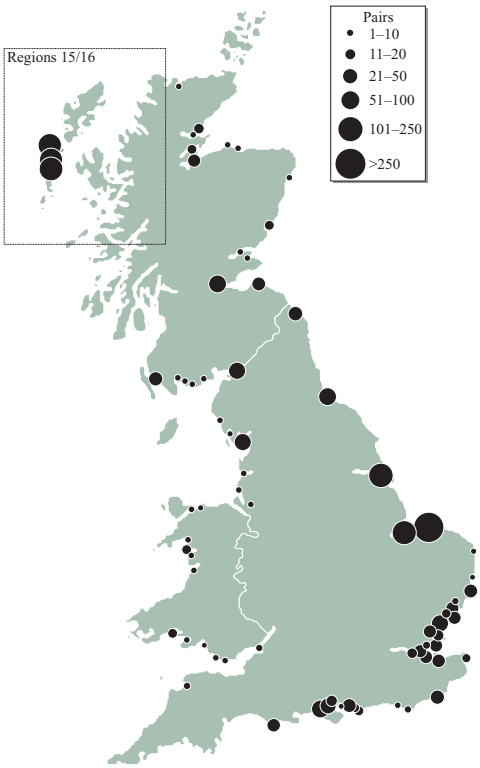


Map 5.11.1 Numbers of different breeding wader species on British estuaries (waders also breed elsewhere on the coast). Source: Davidson *et al.* (1991).



Map 5.11.2 Maximum densities of all waders breeding on wet grasslands adjacent to estuaries. Source: Davidson *et al.* (1991).

Map 5.11.3 Distribution and maximum density of dunlins breeding on saltmarshes and wet grasslands adjacent to estuaries. Source: Davidson *et al.* (1991).



Map 5.11.4 Numbers of breeding ringed plover on British estuaries (species also breeds elsewhere along the coast). Source: Davidson *et al.* (1991) from data in Prater (1989).

redwing *Turdus iliacus*, raven *Corvus corax*, golden eagle, whimbrel *Numenius phaeopus* and corncrake, are important because the species are restricted in the UK to north and west Britain.

Much of the important breeding bird habitat in the regions lies 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. In addition, the RSPB has a reserve at Balranald (Region 15) containing coastal dunes, machair and marshes, which holds internationally important numbers of dunlin and nationally important numbers of corncrake and ringed plover (Pritchard *et al.* 1992).

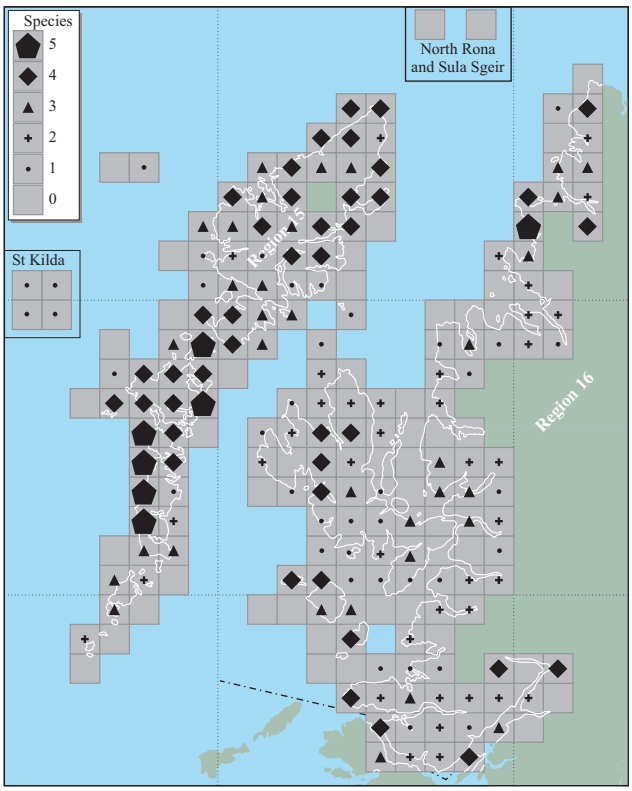
5.11.2 Important locations and species

Maps 5.11.5 and 5.11.6 show the incidence of confirmed breeding in coastal 10 km squares in the regions of selected species characteristic of two typical habitat types: wet grassland/machair (teal *Anas crecca*, lapwing *Vanellus vanellus*, redshank *Tringa totanus*, mallard *Anas platyrhynchos*, snipe *Gallinago gallinago*, pintail *Anas acuta*); and shingle, sand dune and other dry grassland (ringed plover, oystercatcher *Haematopus ostralegus*, shelduck *Tadorna tadorna*). In the wet machair areas in Region 15, especially in the Southern Isles, a very large number of wader species breed at high densities, particularly dunlin, redshank, lapwing and snipe (Table 5.11.1). Dunlin are usually moorland and montane breeding species elsewhere in the UK but in this region they breed at sea level (Fuller *et al.* 1986). Possibly a third of the British breeding population is found in the Southern Isles, the densities on the machair being exceptional (Fuller *et al*. 1986). The peatlands on Lewis, which contain scattered freshwater lochs, are nationally important for golden plover *Pluvialis apricaria*, dunlin, greenshank *Tringa nebularia*, red-throated diver, black-throated diver, golden eagle and merlin (Stroud *et al.* 1988; Pritchard *et al*. 1992).

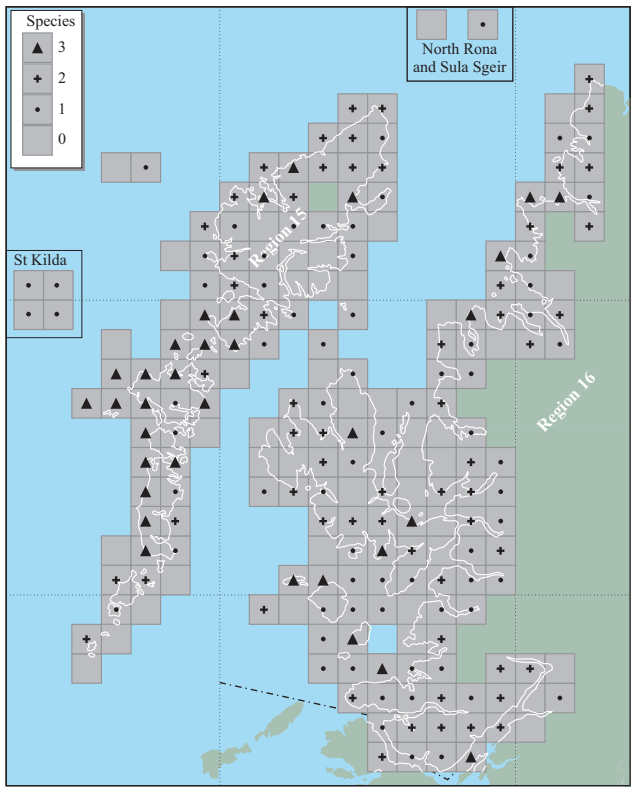
Few waders nest on the most exposed western beaches of Region 15 (Fuller *et al.* 1979; Fuller *et al*. 1986). However, these habitats provide ideal breeding habitats for oystercatcher, ringed plover and lapwing (Jackson 1988). Ringed plovers nest in sandier areas along the coast, especially on the dry, cultivated machair and young fallow of the Southern Isles and the shores of the Monach Isles, with sand dunes the second most common habitat. Detailed studies on the Uists, Benbecula and adjacent small islands showed that in 1984 nearly 31% of ringed plover in the UK bred on the dry machair of these islands (Table 5.11.2) (Prater 1989).

Shelduck are most abundant in Region 15 on Benbecula (Gibbons *et al*. 1993; Table 5.11.3), where they are found on the sandy bays and saltmarshes; some have nested in rabbit burrows in the dunes (Boyd 1979).

Region 15 is significant for a number of other breeding bird species. The corncrake has one of its main strongholds in South Uist, where it nests on wet grassland and low-intensity agricultural land (Gibbons *et al.* 1993). Amongst the region's breeding raptors are golden eagle, white-tailed eagle, peregrine *Falco peregrinus*, buzzard *Buteo buteo* and merlin *F. columbarius*, which hunt the machair and moor (Cunningham 1983). Long-eared owl *Asio otus*, osprey *Pandion haliaetus*, hen harrier *Circus cyaneus*, sparrowhawk *Accipiter nisus* and kestrel *F. tinnunculus* are occasional breeders in the region. These islands also support a number



Map 5.11.5 Numbers 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).



Map 5.11.6 Numbers 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 *et al.* (1993).

Table 5.11.1 Waders breeding on machair and blackland in the Southern Isles (Region 15) in relation to British totals (1983/4)

Species	*% British total (approx.)*
Oystercatcher	7
Ringed plover	26
Lapwing	2
Snipe	2 (<5)
Dunlin	23 (35)
Redshank	8

Source: Fuller *et al.* (1986). Note: numbers in brackets are corrected estimates to allow for the inconspicuousness of these species.

of rare species, including whimbrel and red-necked phalarope *Phalaropus lobatus*, as well as two sub-species of wren (the St. Kilda wren *Troglodytes troglodytes hirtensis* and the Outer Hebrides wren *T. t. hebridensis*).

As much of Region 16's coast is rocky, breeding waterfowl are restricted to a few localities (Bryan 1994). Abundant, regionally widespread species include red-breasted merganser *Mergus serrator* and eider *Somateria mollissima*. The breeding waterfowl of wet grassland habitats are most diverse on Rum, the Isle of Skye and near Inverpolly (Map 5.11.5). Although fragmented, the saltmarsh areas support a relatively high diversity of breeding waders (Table 5.11.4); densities of other waterfowl on these areas are not particularly high. The dry coastal habitats on Rum and the Isle of Skye have a relatively high diversity of breeding waterfowl (Map 5.11.3).

Table 5.11.2 Numbers of pairs of territorial (presumed breeding) ringed plovers in Regions 15 & 16 (1984)

	Pairs (coastal) counted in survey	*% GB total counted in survey*
Region 15		
Lewis/Harris	*100	1.4
North & South Uist/Benbecula	2,224	30.9
Region 16		
Ross & Cromarty	*205	2.8
†Sutherland	*160	2.2
†Inner Hebrides	*500+	6.9
Scotland coast	5,002	69.4
GB coast total	***7,207***	-

Source: Prater (1989). Key: *estimate; †only partly within Region 16. Note: survey coverage varied between areas, although it was generally good in the regions overall. In Region 15 there is no clear distinction between inland and coastal habitats, because farmland, maritime heathland and moorland and machair merge into sand dunes and beaches.

Table 5.11.3 Sites in Region 15 holding at least 45 shelduck (1992)

Site	*Total*	*Pairs*	*Non-breeding birds*
North Uist	52	26	0
Baleshare	57	7	43
Benbecula	80	32	16
South Uist	49	20	9

Source: WWT national shelduck survey (1992)

Table 5.11.4 Densities of breeding waders on a sample of saltmarshes in Region 16 (1985)

Site	*Oystercatcher*	*Ringed plover*	*Lapwing*	*Dunlin*	*Curlew*	*Redshank*	*Common sandpiper*	*Total wader*
	pairs/km²	*pairs/km²*	*pairs/km²*	*pairs/km²*	*pairs/km²*	*peak nests/km²**	*pairs/km²*	*pairs/km²*
Kentra Bay	-	-	-	-	-	4	-	4
Loch Duich	5	10	-	-	-	-	15	30
Loch Carron	8	2	-	-	-	1	-	11
Loch Kishorn	4	4	4	-	-	6	-	18
Little Loch Broom	3	7	-	3	-	-	-	13
Loch Broom	12	-	-	-	6	-	-	18

Source: Allport *et al.* (1986). Key: * ≃ pairs/km².

Rocky shores, especially in the Inner Hebrides, are the main habitats for breeding ringed plover and oystercatcher in Region 16 (Table 5.11.2). These areas are also favoured by breeding rock pipit, peregrine and raven. The suite of habitats associated with the numerous inland freshwater lochs and surrounding moorlands in Region 16 are particularly important areas for red-throated and black-throated divers, raptors (especially golden eagle, white-tailed eagle, merlin, peregrine and hen harrier) and greenshank. Buzzard, kestrel, sparrowhawk and redwing are also notable in these areas (Pritchard *et al*. 1992). There is some association between these areas and coastal areas: red-throated divers, for example, often travel from inland lochs to coastal waters to feed (Gibbons *et al*. 1993), and sea eagles hunt over wide areas including rocky coasts. Important sites for breeding birds in Region 16 include Loch Maree, Assynt Lochs, Inverpolly, Loch Urigill, Loch Stack and Loch nam Brac. The Summer Isles have one of the few areas in Britain that supports a native breeding population of greylag goose *Anser anser*, which is of considerable conservation significance (Bryan 1994; Gibbons *et al*. 1993). The geese are associated with the coast and machair/moorland habitats.

5.11.3 Human activities

In these regions any incremental land claim along the machair, coastal bays and sand dune systems has the potential to affect breeding waterfowl populations through loss of nesting and feeding habitat, although 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 good assessments of the scale of the problem for these regions. There have been instances of theft of eagle eggs (A. Currie pers. comm.) and other persecution of birds of prey (RSPB 1995).

Conservation priorities may be furthered through site designations and agricultural support programmes (e.g. Cadbury & Lambton 1995). Dry machair land is worked on a rotation of a few years' cultivation followed by a fallow period; this rotation provides a changing mosaic of habitats that is of crucial importance to their wader populations. Active land management for conservation in many coastal areas has increased populations of breeding waterfowl. The Scottish Crofters Union and the RSPB emphasise the importance of crofting and future crofting policy (Stowe & Campbell 1992).

Many sites in the regions are vulnerable to drainage and other agricultural change. The appropriate management (e.g. by winter flooding) of wet grasslands (see e.g. Coleshaw 1995; Scholey 1995; Thomas *et al.* 1995) is of crucial importance for wader populations (see also papers in Hötker 1991): 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. Different grazing regimes on saltmarshes can significantly alter the density and nesting success of breeding waders through effects on vegetation composition and structure (Cadbury *et al*. 1987). Any activities that affect the water levels, nutrient status and acidity of lochs will affect breeding species (Pritchard *et al*. 1992). Afforestation and peat extraction also have the potential to affect significant numbers of key bird species (Pritchard *et al*. 1992).

Breeding birds are sensitive to disturbance from introduced predators (A. Currie pers. comm.). Recent unpublished wader surveys (1993-1995) in the southern isles of the Outer Hebrides have recorded very significant declines (40-60%) in numbers of snipe, redshank, dunlin and ringed plover compared to surveys undertaken in the mid 1980s (Fuller *et al.* 1986). There have been no gross changes in habitat that might easily explain these declines, but predation of nests, especially by introduced hedgehogs *Erinaceus europaeus*, appears to be heavily implicated. RSPB are currently planning further research to investigate the causes of the declines and to implement measures to halt and reverse them (M. O'Brien & D. Jackson pers. comm).

There is potential conflict resulting from eiders concentrating around mussel farms. Methods for the environmentally sensitive protection of mussel farms from eider duck are discussed by Galbraith (1992).

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). While these data are one of the best sources for comparisons at county, regional and national scales, care should be taken with their use to assess individual sites or 10 km squares. This is because the tetrad coverage of each 10 km square was not always the same, 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 km squares should be undertaken with caution, as there may be greatly varying amounts of land within each square.

Because of its exceptional breeding bird interest there have been many studies of Region 15, including studies of particular areas or islands (e.g. the Monach Islands) and bird species (e.g. the corncrake) (see section 5.11.6B). For a number of species, extensive survey work has also been undertaken by volunteers. Usually these surveys have been organised as part of wider British surveys (e.g. for ringed plover (Prater 1989) and shelduck (S. Delany, WWT, pers. comm.)). Thom (1986) provides a general source on birds of Scotland.

5.11.5 Acknowledgements

Thanks are due to D.A. Stroud and D.M. Craddock (JNCC), D. Jackson (RSPB) and A. Currie.

5.11.6 Further sources of information

A. References cited

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

Boyd, J.M., *ed.* 1979. *Natural environment of the Outer Hebrides.* Edinburgh, The Royal Society of Edinburgh.

Bryan, A. 1994. *The Minch review.* Stornoway, Comhairle nan Eilean/Scottish Natural Heritage.

Cadbury, C.J., Green, R.E., & Allport, G. 1987. Redshanks and other breeding waders of British saltmarshes. *RSPB Conservation Review, 1:* 37-40.

Cadbury, C.J., & Lambton, S. 1995. The importance of RSPB nature reserves for Red Data birds. *RSPB Conservation Review, 9:* 20-24.

Coleshaw, T. 1995. Rising to the water levels challenge. *Enact*, *3*(1): 7-9.

Cunningham, W.A.J. 1983. Birdwatching in Lewis and Harris. *Scottish Birds 12*(5)*:* 154-157.

Davidson, N.C. 1991. Breeding waders on British estuarine wet grasslands. *Wader Study Group Bulletin, 61, Supplement:* 36-41.

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.

Donald, P.F., Hines, P., Jackson, P., Dustow, J., Hepburn, I., Albon, G.F., & Jervis, S. 1996. Numbers, distribution and habitat associations of corn buntings on the Outer Hebrides and Tiree in 1995. *Scottish Birds, 18*: 170-181.

Evans, I.M., Love, J.A., Galbraith, C.A., & Pienkowski, M.W. 1994. Population and range restoration of threatened raptors in the United Kingdom. *In: Raptor conservation today*, ed. by B. Meyburg & R.D. Chancellor, 447-457. Mountfield, Sussex, WWGBP/The Pica Press. (Proceedings of the IV World Conference on Birds of Prey and Owls, Berlin, Germany, 10-17 May 1992.)

Fuller, R.J., & Percival, S.M. 1988. Surveys of breeding waders in the Southern Isles of the Outer Hebrides, 1983 - 1987. *Nature Conservancy Council, CSD Report,* No. 904.

Fuller, R.J., Reed, T.M., Buxton, N.E., Webb, A., Williams, T.D., & Pienkowski, M.W. 1986. Populations of breeding waders Charadrii and their habitats on the crofting lands of the Outer Hebrides, Scotland. *Biological Conservation, 37*: 333-361.

Fuller, R.J., Wilson, J.R., & Coxon, P. 1979. Birds of the Outer Hebrides: the waders. *In: Natural environment of the Outer Hebrides,* ed. by J.M. Boyd, 419-430. Edinburgh, Royal Society of Edinburgh.

Galbraith, C.A. 1992. *Mussel farms. Their management alongside eider ducks.* London, HMSO

Gibbons, D.W., Reid, J.B., & Chapman, R. 1993. *The new atlas of breeding birds in Britain and Ireland 1988-1991.* London, T. & A.D. Poyser.

Heredia, B., Rose, L., & Painter, M. 1996. *Globally threatened birds in Europe. Action plans.* Strasbourg, Council of Europe.

Hötker, H., *ed.* 1991. Waders breeding on wet grassland. *Wader Study Group Bulletin, 61:* Supplement.

Jackson, D.B. 1988. *Habitat selection and breeding ecology of three species of waders in the Western Isles of Scotland*. University of Durham, PhD. thesis.

Love, J.A. 1988. *The return of the white-tailed sea eagle to Scotland: 1975-1987*. Peterborough, Nature Conservancy Council. (Research & survey in nature conservation, No. 12.)

Pienkowski, M.W. 1992. The impact of tourism on coastal breeding waders in western and southern Europe: an overview. *Wader Study Group Bulletin, 68:* 92-96.

Pienkowski, M.W., Fuller, R.J., Jackson, D.B., & Percival, S.M. 1986. Breeding waders of blackland, moorland and agriculturally improved moorland in the Uists and Benbecula. *Scottish Birds, 14:* 9-16.

Prater, A.J. 1989. Ringed plover *Charadrius hiaticula* breeding population of the United Kingdom in 1984. *Bird Study, 36:* 154-159.

Pritchard, D.E., Housden, S.D., Mudge, G.P., Galbraith, C.A., & Pienkowski, M.W., *eds.* 1992. *Important bird areas in the UK including the Channel Islands and the Isle of Man.* Sandy, RSPB.

RSPB. 1995. *Bird of prey persecution in Scotland in 1994.* Edinburgh, RSPB.

Scholey, G. 1995. Return of the "drowners". *Enact*, *3*(1)*:* 10-11.

Sharrock, J.T. 1976. *The atlas for breeding birds in Britain and Ireland*. Bath, Poyser. (British Trust for Ornithology and Irish Wildbird Conservancy.)

Stowe, T., & Campbell, G. 1992. *Crofting and the environment: a new approach.* Sandy, The Royal Society for the Protection of Birds & The Scottish Crofters Union.

Stroud, D.A., Condie, M., Holloway, S.J., Rothwell, A.J., Shepherd, K.B., Simms, J.R., & Turner, J. 1988. A survey of the moorland birds on the Isle of Lewis in 1987. *Nature Conservancy Council, CSD Report,* No. 776.

Thom, V. 1986. *Birds in Scotland.* Calton, Poyser.

Thomas, G., José, P., & Hirons, G. 1995. Wet grassland in the millenium. *Enact*, *3*(1): 4-6.

Williams, T.D., Reed, T.M., & Webb, A. 1986. Population size, distribution and habitat use of the corn bunting in the Uists and Benbecula. *Scottish Birds, 14*: 57-60.

B. Further reading

Benn, S., Murray, S., & Tasker, M.L. 1989. *The birds of North Rona and Sula Sgeir.* Peterborough, Nature Conservancy Council.

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides*. London, Collins. (New Naturalist series.)

Fuller, R.J. 1981. The breeding habitats of waders on North Uist machair. *Scottish Birds, 11*: 142-152.

Furness, R.W. 1990. Numbers and population trends of Manx shearwaters on Rhum. *Nature Conservancy Council, CSD Report,* No. 1,168.

Harris, M.P., & Murray, S. 1989. *Birds of St. Kilda.* London, HMSO.
Hepburn, I.R., Schofield, P., & Schofield, R.A. 1977. The birds of the Monach Islands, Outer Hebrides. *Bird Study, 24*: 25-43.
Hudson, A., Stowe, T.T.J., & Aspinall, S.J. 1990. Status and distribution of corncrakes in Britain in 1988. *British Birds, 83*: 173-187.
O'Brien, M. 1992. 1992/93 Survey of breeding waders on Scottish agricultural land. *Scottish Bird News,* No.28.
Reed, T.M., Currie, A., & Love. 1983. *Birds of the Inner Hebrides.* In: The natural environment of the Inner Hebrides, ed. by J.W. Boyd & D.R. Bowes. *Proceedings of the Royal Society of Edinburgh, 83B:* 449-472.
Ritchie, W. 1976. The meaning and definition of machair. *Transactions and Proceedings of the Botanical Society of Edinburgh, 42:* 431-440.
Self, M., O'Brien, M.C., & Hirons, G. 1994. Hydrological management for waterfowl on RSPB lowland wet grassland reserves. *RSPB Conservation Review, 8:* 45-56.
Stroud, D.A., Condie, M., Holloway, S.J., Rothwell, A.J., Shepherd, K.B., Simons, J.R., & Turner, J. 1988. A survey of moorland birds on the Isle of Lewis in 1987. *Nature Conservancy Council, CSD Report,* No. 776.
Tasker, M.L., Moore, P.R., & Schofield, R.A. 1988. The seabirds of St. Kilda, 1987. *Scottish Birds, 15*: 21-29.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Breeding atlas data and breeding wader data	*Development Unit, The British Trust for Ornithology, Thetford, tel: 01842 750050
Breeding bird surveys; coastal habitat management	*Regional Officer, RSPB North Scotland Office, Inverness, tel: 01463 715000
Coastal breeding wildfowl data	*Wildfowl & Wetlands Trust, Slimbridge, tel: 01453 890333
Site designations	*RASD, SNH, Edinburgh, tel: 0131 554 9797

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

5.12 Migrant and wintering waterfowl

D.M. Craddock & A.B. Law

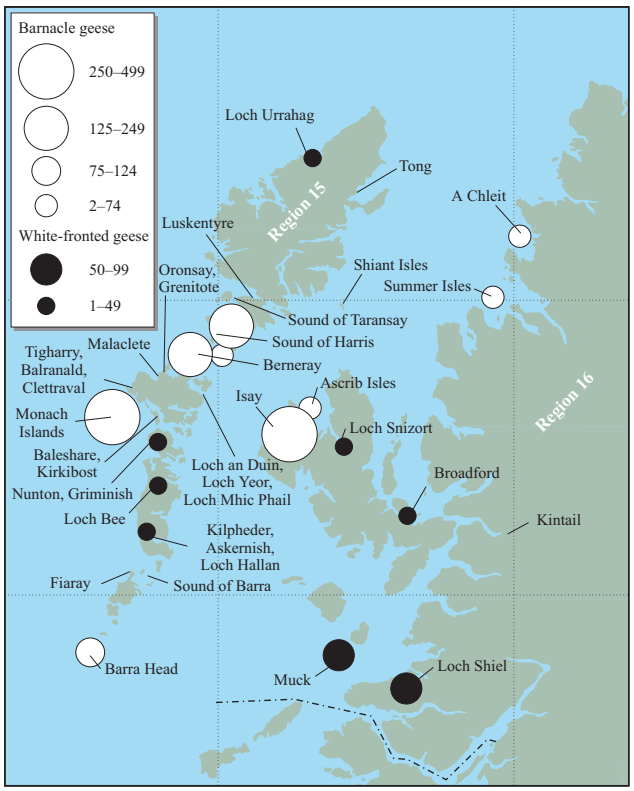
5.12.1 Introduction

This section details the importance of Regions 15 (Western Isles) and 16 (west Highland) for 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 wintering marine waterfowl and cormorant *Phalacrocorax carbo* where they occur close inshore, especially within estuaries. The importance of offshore areas for wintering divers, grebes, seaducks and cormorant is covered in section 5.10. The regions' importance for breeding waterfowl is described in section 5.11.

Owing to a lack of suitable survey data, the precise numbers of wintering waterfowl in the regions are unknown, but because of the limited shelter in these regions numbers are believed to be generally lower than on many other parts of the UK coastline. Five areas in Region 15 are each known to support internationally important populations of at least one wintering waterfowl species: The Shiant Isles, South Uist Machair and Lochs, Baleshare and Kirkibost, the Monach Islands, and the West Sound of Harris; the West Sound of Barra, Balranald and the Sound of Taransay support nationally important populations of wintering waterfowl. The region overall is also internationally important for Greenland white-fronted geese *Anser albifrons flavirostris*, which winter at several sites (Map 5.12.1). In Region 16 there are no sites known to be of international importance to wintering waterfowl. Sheltered areas of the non-estuarine coast in Region 16 support nationally important numbers of wintering grey heron *Ardea cinerea*, particularly in severe weather (Moser *et al.* 1986).

Ringing studies have shown that many species demonstrate complex patterns of interchange between sites during the course of a winter, which means that individual sites cannot be considered in isolation (Davidson *et al.* 1991; Newton & Percival 1989). Both regions can increase in importance during periods of severe weather elsewhere, when there may be influxes of waterfowl, and species such as wigeon *Anas penelope* and teal *Anas crecca* may move in from other coastal regions or inland areas (Ridgill & Fox 1990; Owen *et al.* 1986).

The non-estuarine (rocky) shores of both regions are known to support a high diversity of wintering wader species (Table 5.12.1; Figure 5.12.1) and the north of Region 15 supports some of the highest densities in the UK of waders on non-estuarine coast. Region 16 is believed, in general, to support low densities of waders on rocky shores.



Map 5.12.1. Distribution of Greenland barnacle geese and Greenland white-fronted geese wintering in Regions 15 & 16, 1993/94, and locations mentioned in the text. Sources: Delany & Ogilvie (1994); Fox *et al.* (1994).

Both regions are of importance for migrant waterfowl in spring and autumn, as they lie on the major migratory flyway of the east Atlantic, and many waterfowl, especially geese, pass through the regions as they move between southern wintering areas and Arctic breeding grounds. The South Uist Machair and Lochs are nationally important moulting sites for mute swan *Cygnus olor*.

5.12.2 Important locations and species

The west coast of Region 15 has particularly extensive areas of sandflats and machair which are favoured by wintering waders. The Atlantic coasts of the Uists and Benbecula are estimated to support over 15,000 waders, with a further 4,000 on Lewis and Harris (Buxton 1982; Summers & Buxton

Table 5.12.1 Diversity and overall densities of wintering waders on non-estuarine coasts of the regions

	No. of wader spp. recorded (out of a possible 16)	*Total no. non-estuarine waders*	*Length of non-cliff non-estuarine coast (km)*	*Length of coast surveyed (km)*	*Overall wader density (birds/km coast)*
Region 15	**15**	**32,078**	**1,116.9**	**1,026.4**	**31.2**
Lewis and Harris	15	11,053	n/a	n/a	n/a
Uists	14	21,025	n/a	n/a	n/a
Highland*	**16**	**17,647**	**2,183.3**	**1,801.2**	**9.8**

Source: Winter Shorebird Count (Moser & Summers 1987). Key: *includes part of Region 14; figures for Region 16 alone not available.

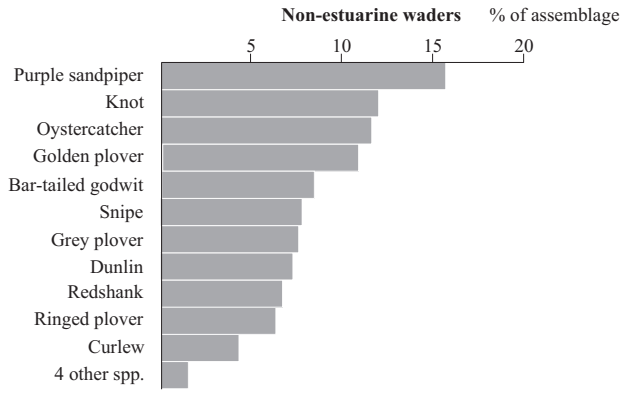


Figure 5.12.1 Relative species composition of non-breeding waterfowl assemblages on coastal areas of Region 15 (excluding geese). Sources: estuarine waterfowl data from Prater (1981), non-estuarine wader data from Moser & Summers (1987). Data for Region 16 not available.

1983). The species assemblage is determined by the type of habitat present. In Region 15 as a whole Moser & Summers (1987) found that ringed plover *Charadrius hiaticula*, sanderling *Calidris alba* and turnstone *Arenaria interpres* were the three most abundant species in the region, typically associated with rocky shorelines and sandy bays. Large numbers of purple sandpipers *Calidris maritima* are found on rocky shores in the region (Buxton 1982). Region 15 is one of the most important in the UK for numbers of wintering sanderling, which prefer sandy shores; bar-tailed godwit *Limosa lapponica* and knot *Calidris canutus* are also concentrated on sandy shores. Wildfowl such as wigeon and mallard *Anas platyrhynchos* tend to be restricted to the more sheltered sea lochs and sounds (Moser *et al.* 1986), and on the shores around Berneray and Loch an Duin there are regionally significant numbers of wigeon, and notable populations of teal on the tidal channels of Lochs Maddy, Yeor and Mhic Phail in North Uist.

Overall, internationally important numbers of nine species of wintering waterfowl species have been recorded on at least one site: ringed plover, sanderling, purple sandpiper, bar-tailed godwit, turnstone, mute swan, Greenland barnacle goose *Branta leucopsis*, dunlin *Calidris alpina* and greylag goose *Anser anser*, and a further three species have been recorded at levels of national importance: common scoter *Melanitta nigra*, oystercatcher *Haematopus ostralegus* and curlew *Numenius arquata* (Table 5.12.2).

Region 15 is particularly notable for its population of Greenland barnacle geese, both wintering and on passage. A number of localities individually support internationally significant numbers of Greenland barnacle geese, e.g. Shiant Isles, Monach Islands, West Sound of Harris (Table 5.12.2; Map 5.12.1). In addition, Baleshare and Kirkibost hold 45% of the north Scottish population of greylag geese, which also occur in notable numbers from Malaclete to Oronsay on the north coast of North Uist. There are also a number of sites in Region 15 that are notable for Greenland white-fronted geese (Fox *et al.* 1994; Map 5.12.1). Other notable wintering species in Region 15 include whooper swans *Cygnus cygnus* and twite *Carduelis flavirostris;* and ravens *Corvus corax,* which roost in woodlands on Lewis and Harris.

With the lack of consistent data there are no areas in Region 16 that are known to be of international importance to wintering waders. However, a survey in 1994 recorded internationally important numbers of wintering Greenland barnacle goose on Isay in Loch Dunvegan on Skye (Delany & Ogilvie 1994). These geese also feed and roost on many of the islands between Gairloch and Cape Wrath, notably Priest Island. Other geese are present on the islands and lochs within the region, often with considerable interchange between sites. On Skye, barnacle geese from Loch Snizort are thought to roost on either Loch Niarso or the Ascrib Islands, while on Muck, Greenland white-fronted geese feed both on their favoured feeding area at An Maol and increasingly also on improved fields throughout the island. The flock of Greenland white-fronted geese at Broadford feeds locally (Fox *et al.* 1994). Important areas for small numbers of wintering whooper swans include Loch Suardal and Kintail, where the birds alternate between Loch Shiel and Loch a' Mhuilinn (Owen *et al.* 1986).

The Winter Shorebird Survey (Moser & Summers 1987) found that mallard, wigeon and teal were the three most abundant wintering waterfowl species on the west coast of Scotland. They are found principally at the heads of the larger sea lochs and in the shallower bays (Moser *et al.* 1986; Owen *et al.* 1986). The most important area for ducks is the sheltered eastern coast of Skye, between Portree and Kyleakin and around Loch Alsh and Loch Carron (Owen *et al.* 1986). The last two sites are the most important in the region for eider (Bryan 1994). North of Skye the abundance of most species declines markedly, although goldeneye *Bucephala clangula* and long-tailed duck *Clangula hyemalis* appear to be more abundant in the north (Moser *et al.* 1986).

Table 5.12.2 Wintering waterfowl on selected sites in Region 15

Site	*International protected status*	*Species occurring at levels of national or international (*) importance*
Shiant Isles	SPA	Greenland barnacle goose*
West Sound of Barra	None	Sanderling, purple sandpiper, ringed plover, turnstone, oystercatcher, bar-tailed godwit, curlew
South Uist Machair and Lochs	SPA/Ramsar site	Ringed plover*, sanderling*, purple sandpiper*, bar-tailed godwit*, turnstone*, mute swan*
Baleshare and Kirkibost	None	Greylag goose*, dunlin*, ringed plover*, sanderling
Monach Islands	SPA	Greenland barnacle goose*
Balranald	None	Ringed plover, sanderling
West Sound of Harris	None	Greenland barnacle goose*, greylag goose, purple sandpiper, ringed plover, bar-tailed godwit, sanderling, turnstone
Sound of Taransay	None	Common scoter

Sources: data from Pritchard *et al.* (1992) and unpublished WeBS data; Greenland barnacle goose data from Delany & Ogilvy (1994). Key: SPA = Special Protection Area; Ramsar = internationally important wetland under the Ramsar Convention.

Notable passage species in Region 15 include the Iceland *schinzii* population of dunlin, bar-tailed godwit, ringed plover and oystercatcher (Bryan 1994) and in Region 16 whooper swans, Greenland white-fronted geese, pink-footed geese *A. brachyrhynchus* and barnacle geese. The area centred on the Summer Isles is used by large numbers of migrating greylag geese, as well as by whooper swans on passage to and from Iceland (Bryan 1994).

5.12.3 Human activities

Wintering waterfowl may be affected, either directly or indirectly, by a wide range of human activities. Land claim has the potential to affect waterfowl populations through loss of feeding habitat (Goss-Custard 1977; Goss-Custard & Yates 1992), and changes in management, such as reduced grazing or increased tree planting, can reduce the extent and quality of grassland available for wintering goose flocks. At important sites, SSSI designation provides a mechanism that can limit such activities. However, as flocks of species such as Greenland white-fronted goose are widely dispersed over many small islands in the regions, management needs for these birds should be addressed within the context of wider countryside conservation policies (Fox *et al*. 1994).

Bait digging and shellfish collection from intertidal sediments, as well as marine-based recreation and tourism around these regions, may lead to disturbance (Bryan 1994). 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 problem if it occurs in cold periods when wintering waterfowl need to feed almost continuously in order to survive, although as many areas of the coastline in both regions are inaccessible to humans, any disturbance is likely to be localised.

Increased fish farming, which is concentrated in the more sheltered sea lochs, may be a potential threat to wintering wildfowl (Moser *et al.* 1986). There is potential conflict with eiders which congregate around the mussel farms in the regions. Methods for the environmentally sensitive protection of mussel farms from eider duck are presented by Galbraith (1992).

Wildfowling is practised across the UK, especially in estuaries, and is a potential cause of disturbance to waterfowl, although it is generally well regulated (see also section 8.2). 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.

5.12.4 Information sources used

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 Joint Nature Conservation Committee (JNCC), is the primary source of information on wintering and migrant waterfowl in the UK. The annual summary report, e.g. Waters *et al.* (1996), summarises species trends based on counts at wetlands throughout the UK and tabulates counts of total waterfowl numbers at all counted sites. The summary is based on data available from the previous five years, which are used to determine the nationally or internationally important populations of species of waterfowl.

However, as a whole there are few WeBS data available for sites in Regions 15 and 16, owing to the inaccessibility of the coast, the incomplete coverage of sites and the fact that sites are not surveyed on a regular basis. WeBS data are available for some sites (for example Lochs Scolpaig and Olabhat in North Uist (Region 15) and Loch Torridon (Region 16)), but they are not all counted regularly, although coverage of count sites in north-west Scotland has recently improved (Waters *et al.* 1996). Detailed count data for some sites in the regions can be provided by WeBS, and inspection of these data is recommended for any planning-related activity.

The whole UK coastline was surveyed for wintering waders during the Winter Shorebird Count of 1984/85 (Moser & Summers 1987). Information on the wintering waterfowl of the non-estuarine shore is important for placing annual estuaries counts in a wider perspective. WeBS are planning a repeat national survey in 1997/98, which will be co-ordinated internationally.

For geese in Regions 15 and 16, WeBS count data are supplemented by more detailed studies of particular species. The Greenland white-fronted goose population has been the subject of a long-term national population study undertaken by the Greenland White-fronted Goose Study Group (summarised by Cunningham *et al.* 1990; Fox *et al.* 1994). Regular national surveys are also undertaken of pink-footed, north Scottish greylag and barnacle geese by the Wildfowl & Wetlands Trust on behalf of the JNCC and the country agencies.

Although now becoming slightly dated, Owen *et al.* (1986) gives a thorough and comprehensive account of the wildfowl and wetlands of the regions, summarising data available up to the mid-1980s. The volume is an invaluable source of initial information on sites and species, although this should now be supplemented by more recent count information available from WeBS, Davidson *et al.* (1991) and Buck (1993). Boyd (1979) gives an account of the physical and biological environment of the Outer Hebrides, including a detailed chapter on the area's birds. Thom (1986) provides a general source on birds of Scotland.

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 the period 1969-1975; the site accounts should be supplemented by the more recent reviews of Buck (1993). For sites of international importance (either proposed or designated), Pritchard *et al.* (1992) provides data on the important bird populations of each site, together with information on location and habitats.

5.12.5 Acknowledgements

We would like to thank David Stroud and Mark Tasker (JNCC) and Andrew Currie for their comments.

5.12.6 Further sources of information

A. References cited

Boyd, J.M. 1979. The natural environment of the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, 77B*: 3-19.

Bryan, A. 1994. *The Minch review.* Inverness, Western Isles Island Council & Scottish Natural Heritage.

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

Buxton, N.E. 1982. Wintering coastal waders of Lewis and Harris. *Scottish Birds, 12:* 38-43.

Cunningham, W.A.J., Stroud, D.A., & Fox, A.D. 1990. Greenland white-fronted geese in the Outer Hebrides. *Hebridean Naturalist, 10:* 64-68.

Davidson, N.C., & Rothwell, P.I. 1993. Disturbance to waterfowl on estuaries: the conservation and coastal management implications of current knowledge. *Wader Study Group Bulletin, 68:* 97-105.

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.

Delany, S., & Ogilvie, M. 1994. *Greenland barnacle geese in Scotland.* Peterborough, Joint Nature Conservation Committee. (Wildfowl & Wetlands Trust Report to JNCC.)

Fox, A.D., Norriss, D.W., Stroud, D.A., & Wilson, H.J. 1994. *Greenland white-fronted geese in Ireland and Britain 1982/83-1993/94: the first twelve years of international conservation monitoring.* Dublin, Greenland White-fronted Goose Study (Kalo, Denmark) & National Parks and Wildlife Service. (Greenland White-fronted Goose Study Research Report, No. 8.)

Galbraith, C.A. 1992. *Mussel farms. Their management alongside eider ducks.* Edinburgh, Scottish Natural Heritage.

Goss-Custard, J.D. 1977. The ecology of the Wash. III. Density-related behaviour and possible effects of a loss of feeding grounds on wading birds (Charadrii). *Journal of Applied Ecology, 14:* 721-739.

Goss-Custard, J.D., & Yates, M.G. 1992. Towards predicting the effect of salt-marsh reclamation on feeding bird numbers on the Wash. *Journal of Applied Ecology, 29:* 330-340.

Moser, M.E., Broad, R.A., Dennis, R.H., & Madders, M. 1986. The distribution and abundance of some coastal birds on the west and north-west coasts of Scotland in winter. *Scottish Birds, 14*: 61-67.

Moser, M., & Summers, R.W. 1987. Wader populations on the non-estuarine coasts of Britain and Northern Ireland: results of the 1984-85 Winter Shorebird Count. *Bird Study, 34*: 71-81.

Newton, S.F., & Percival, S. 1989. Barnacle geese on Coll and Tiree. *In: Birds on Coll and Tiree: status, habitats and conservation*, ed. by D.A. Stroud, 115-127. Edinburgh, Nature Conservancy Council/Scottish Ornithologists Club.

Owen, M. 1992. An analysis of permit systems and bag records on NNRs. *Joint Nature Conservation Committee Report,* No. 68.

Owen, M., Atkinson-Willes, G.L., & Salmon, D.G. 1986. *Wildfowl in Great Britain.* 2nd ed. Cambridge, Cambridge University Press.

Prater, A.J. 1981. *Estuary birds in Britain and Ireland.* Calton, Poyser.

Pritchard, D.E., Housden, S.D., Mudge, G.P., Galbraith, C.A., & Pienkowski, M.W., *eds.* 1992. *Important bird areas in the UK including the Channel Islands and the Isle of Man.* Sandy, RSPB.

Ridgill, S.C., & Fox, A.D. 1990. *Cold weather movements of waterfowl in western Europe.* Slimbridge, IWRB. (IWRB Special Publication, No. 13.)

Summers, R.W., & Buxton, N.E. 1983. Wintering wader populations on the open shores of northern Scotland. *Scottish Birds, 12:* 206-211.

Thom, V. 1986. *Birds in Scotland.* Calton, Poyser.

Waters, R.J., Cranswick, P.A., Evans, J., & Pollitt, M.S. 1996. *The Wetland Bird Survey 1994-1995: wildfowl and wader counts.* Slimbridge, BTO/WWT/RSPB/JNCC.

B. Further reading

Benn, S., Murray, S., & Tasker, M.L. 1989. *The birds of North Rona and Sula Sgeir.* Peterborough, Nature Conservancy Council.

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides*. London, Collins. (New Naturalist series.)

Cranswick, P.A., Waters, R.J., Evans, J., & Polit, M.S. 1995. *The Wetland Bird Survey 1993-1994: wildfowl and wader counts.* Slimbridge, BTO/WWT/RSPB/JNCC.

Harris, M.P., & Murray, S. 1989. *Birds of St. Kilda.* London, HMSO.

Hepburn, I.R., Schofield, P., & Schofield, R.A. 1977. The birds of the Monach Islands, Outer Hebrides. *Bird Study, 24*: 25-43.

Love, J.A. 1980. Birdwatching on Rhum. *Scottish Birds, 11*: 48-51.

Stroud, D.A., *ed.* 1989. *Birds on Coll and Tiree: status, habitats and conservation*. Edinburgh, Nature Conservancy Council/Scottish Ornithologists' Club.

Tasker, M.L., Moore, P.R., & Schofield, R.A. 1988. The seabirds of St. Kilda, 1987. *Scottish Birds, 15*: 21-29.

C. Contact names and addresses

Type of information	*Organisation*
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 wader (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	*Designated Areas and Sites Branch, Scottish Natural Heritage, Edinburgh, tel: 0131 554 9797

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

5.13 Land mammals

Dr C.E. Turtle & K.D. Meakin

5.13.1 Introduction

This section covers land mammals that occur in the coastal 10 km squares in Regions 15 (Western Isles) and 16 (west Highland), concentrating on those that are truly coastal, such as the otter *Lutra lutra*, and those that occur on the coast for reasons of shelter and foraging, such as some bat species. Other mammals - common and widespread throughout Britain, feral or recently introduced - are not discussed.

The incidence and distribution of terrestrial mammals in the regions reflect the high quality of the coastal habitat. Several nationally rare species occur in the regions. Scotland is nationally important for two of them: the otter and the wildcat *Felis silvestris*. The otter has a stronghold in Scotland and the Scottish otter population is important at the European and international level (S. Gibbons pers. comm.). In Britain the wildcat 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.). Region 15 is extremely important for otters, although the wildcat is absent; both otters and wildcats are found in Region 16.

Scotland is also of national significance for the pine marten *Martes martes*, which is declining in both distribution and numbers throughout Great Britain and is reduced to relict populations in England and Wales (Morris 1993). The main population is confined to the Scottish Highlands, including the coastal area of Region 16 (Velander 1983). The red squirrel *Sciurus vulgaris* is extinct over much of England and Wales but is still widespread in wooded parts of Scotland, including conifer plantations in the south of Region 16. Bats use the coast for foraging, where there is suitable habitat with shelter and flightlines to the feeding areas (Walsh & Harris 1996a & b). Only two of the fourteen species of British bat are recorded from these regions (Arnold 1993): the pipistrelle *Pipistrellus pipistrellus* (recorded from both regions), and the brown long-eared bat *Plecotus auritus* (recorded recently only from Region 16). These bats are classed as vulnerable in Europe (Stebbings & Griffith 1986), although they are recorded throughout Britain, where they are on the northerly edge of their range in Europe.

All British bats, the otter, pine marten, and wildcat are listed under Schedule 5 of the Wildlife and Countryside Act, and the wildcat is listed under Schedule 6 also. Otters, bats and wildcats are also protected under Annex IV of the EC Habitats & Species Directive. All British bats are listed under Appendix II of the Bern Convention. Table 5.13.1 summarises the recorded distribution of protected mammals in the regions.

Table 5.13.1 Recorded occurrence of protected mammals in the regions

Species	*Estimate of importance in region*
Region 15	
Long-eared bat	Rare, one record prior to 1959
Pipistrelle bat	Scarce and highly localised
Otter	Common
Wildcat	Absent
Region 16 (mainland)	
Pipistrelle bat	Localised
Long-eared bat	Scarce
Pine marten	Frequent
Otter	Common
Red squirrel	Rare
Wildcat	Occasional
Region 16 (islands)	
Pipistrelle bat	Localised
Long-eared bat	Recently recorded
Pine marten	Recent arrival via Skye Bridge
Otter	Common
Wildcat	No confirmed recent records

Source: Arnold (1993); A. Currie (pers. comm.).

5.13.2 Important locations and species

In general, the range of mammal species and the sizes of their populations decrease on islands in the regions with increasing distance westward from the Region 16 mainland; some islands contain endemic races of particular species.

Estimates of the numbers of otters in Regions 15 and 16 are contentious because distribution surveys have been based on signs of presence, such as spraints (faeces), and no clear relationship has been established between evidence of otter presence and otter numbers (Morris 1993). Otters are strongly marine in their distribution in Regions 15 and 16. Otters use all coastal habitats, although food is less available on long sandy beaches, saltmarshes and exposed cliff headlands than in sheltered rocky inlets (R. Green pers. comm.). It is unlikely that there is any part of the coastline of either region that is not used, at least occasionally, by otters (Green & Green 1980), but activity is concentrated where the shore is rocky and where there is an extensive seaweed zone (Bryan 1994). The Hebridean population is important because of its size and genetic diversity.

Bats are little known from Region 15, and suitable habitats are rare owing to the scarcity of trees and the prevalence of strong winds. There is one record of an unidentified long-eared bat in Region 15, from North Uist, prior to 1959 (Arnold 1993). Pipistrelles are recorded from the castle grounds at Stornoway, one of the few places in Region 15 where there are trees (J. Fergussen pers. comm.). Pipistrelle colonies are scarce and localised on the mainland of Region 16, while on Skye there are a number of small colonies, where they forage around buildings with associated tree cover. They also occur on Rum around Kinloch Castle. Brown long-eared bats are present in widely-spread locations in the south-west part of the Region 16 mainland (A. Currie pers. comm.) and have recently been confirmed on Skye (G. Yoxon pers. comm.).

Pine martens are dependent on large areas of woodland.

Young forestry plantations with coarse grassland, heather and grass moorland or grass and scrub rides are a key element, as these habitats support high numbers of field voles, the principal prey item (Gurnell *et al*. 1994). More mature plantations are less valuable (D. Balharry pers. comm.). In Region 16 the pine marten is present on the mainland but absent on the islands, except for a few that have crossed the recently completed Skye Bridge. There are no pine martens in Region 15.

Wildcats can utilise a variety of habitats, including woodland, moorland, grassland and marsh. They are known to use sheltered areas of coast (Easterbee *et al*. 1991), although their distribution in Region 16 seems to reflect the incidence of forestry plantations. Reduced persecution and an increase in woodland owing to forestry plantation have contributed to an expansion in their numbers and distribution on the mainland (Morris 1993). On Skye, Arnold (1993) records wildcat from one 10 km square, but there are no recent confirmed records.

5.13.3 Human activities

Regions 15 and 16 are among the least disturbed parts of Britain, although some human activities that occur in them may affect mammal populations. For example, the increasing use of the coast by ecotourists, cyclists and motorcyclists, horse-riders and walkers with dogs is having an unquantified but perceptible effect on wildlife, including mammals (R. Green pers. comm.).

Many Scottish sea lochs are now used for fish farming and it is not known if organic enrichment by fish food or the use of chemicals to maintain the health of fish stocks affect otter populations (Morris 1993; A. Somerville pers. comm.). Otters are at risk from pollution in the form of toxic chemicals such as PCBs and chemicals in sheep dip (Bryan 1994). Many oil tankers pass through the Minches, with the associated risk of large scale oil spills (Bryan 1994). Oil spills and accidental fuel oil spillages from other marine shipping can cause otter deaths (Jenkins 1980). The use of lobster creels and eel fyke nets causes a considerable number of otter deaths each year (Jefferies *et al.* 1984). The Vincent Wildlife Trust supplies free otter guards to fyke-netters, and these have proved successful. Mortalities resulting from creels now appear to outnumber those from fyke nets, but it has not been possible to modify creels (Green pers. comm.). Mink *Mustela vison*, an introduced species in Region 15, is thought to compete for food with otter populations.

Otter deaths on roads are increasing. In these regions many roads run through otter habitat around sea lochs and the open coast (Bryan 1994), and road improvement schemes are thought to be a greater threat to otters than most industrial development now taking place in Scotland. Pine martens are similarly being killed on the roads, with two of the first four recorded on Skye being casualties (A. Currie pers. comm.).

Wildcats, pine martens and otters are occasionally accidentally killed by predator and pest control measures. Forestry is still spreading in Region 16, although less quickly than in the past (A. Somerville pers. comm.). As plantations age they support fewer pine martens and wild cats, owing to falling numbers of small prey mammals (Gurnell *et al.* 1994).

Hybridisation of wildcats and feral cats is likely to increase as the numbers of domestic cats tend to grow in line with the human population.

5.13.4 Information sources used

The otter and wildcat are the only mammals to have been surveyed on a systematic basis, although the second otter survey of Scotland did not cover Highland Region (Green & Green 1987). There have been three otter surveys of Scotland: in 1977-1979 (Green & Green 1980), in 1984-1985 (Green & Green 1987) and 1991-1993 (Green & Green in press); these surveys have established the importance of coastal areas for the otter population. However they did not cover Region 15 and there have been no specifically coastal mammal surveys in either region. It is difficult to establish the significance of the wildcat records because of the possibility of hybridisation. The 1980-1982 survey of pine marten (Velander 1983) covered few of the coastal areas of these regions, but did demonstrate the importance of scattered coastal sites. There have been no comprehensive surveys for the bats. The National Bat Sites Register (Mitchell-Jones in press) records the most important sites for bats in Britain, but bat distribution in the region is generally little known, owing to a scarcity of recorders (A. Somerville pers. comm.). The absence of bat data makes it difficult to establish the value of the coast for bats, although any coastal sites with bat roosts will be important.

5.13.5 Acknowledgements

Thanks go to A. Currie who suggested improvements to a draft of the text, as well as to D. Balharry, J. Fergussen, S. Gibbons, R. Green, A. Somerville and G. Yoxon. The Biological Records Centre, Monks Wood, provided recent data for the area.

5.13.6 Further sources of information

A. References cited

Arnold, H.R. 1993. *Atlas of mammals in Britain*. London, HMSO. (ITE research publication No. 6.)

Berry, R.J. 1979. The Outer Hebrides: where genes and geography meet. *Proceedings of the Royal Society of Edinburgh, 77B:* 21-43.

Berry, R.J. 1983. Evolution of animals and plants. *Proceedings of the Royal Society of Edinburgh, 83B:* 433-447.

Bryan, A. 1994. *The Minch review*. Inverness, Scottish Natural Heritage & Stornoway, Western Isles Islands Council.

Easterbee, N., Hepburn, L.V., & Jefferies, D.J. 1991. *Survey of the status and distribution of the wildcat in Scotland, 1983-1987.* Edinburgh, Nature Conservancy Council.

Green, J., & Green, R. 1980. *Otter survey of Scotland 1977-79.* London, The Vincent Wildlife Trust.

Green, J., & Green, R. 1987. *Otter survey of Scotland 1984-85.* London, The Vincent Wildlife Trust.

Green, J., & Green, R. In prep. *Otter survey of Scotland 1991-94.* London, The Vincent Wildlife Trust.

Gurnell, J., Venning, T., MacCaskill, B., & MacCaskell, D. 1994. The food of pine martens *(Martes martes)* in West Scotland. *Journal of Zoology, London, 234:* 680-683.

Jefferies, D.J., Green, J., & Green, R. 1984. *Commercial fish and crustacean traps: a serious cause of otter* Lutra lutra *mortality in Britain and Europe*. London, Vincent Wildlife Trust.

Jenkins, D. 1980. *Conserving otters*. Cambridge, Institute of Terrestrial Ecology.
Mitchell-Jones, A.J. In press. The status and conservation of horseshoe bats in Britain. *Myotis, Vol. 32.*
Morris, P.A. 1993. *A red data book for British mammals*. London, The Mammal Society.
Stebbings R.E., & Griffith, F. 1986. *Distribution and status of bats in Europe.* Huntingdon, Institute of Terrestrial Ecology, Monks Wood.
Velander, K.A. 1983. *Pine marten survey of Scotland, England and Wales 1980-1982.* London, Vincent Wildlife Trust.
Walsh, A., & Harris, S. 1996a. Foraging habitat preferences of vespertilionid bats in Britain: land-use relations and conservation management priorities. *Journal of Applied Ecology, 33*: 508-518.
Walsh, A., & Harris, S. 1996b. Factors determining the abundance of vespertilionid bats in Britain: geographic, land class and local habitat relationships. *Journal of Applied Ecology, 33:* 519-529.

B. Further reading

Angus, S. 1990. Feral mink and polecat in the Western Isles, with notes on the pine marten. *Hebridean Naturalist, 10:* 69-72.
Chanin, P.R.F. 1985. *The natural history of otters*. London, Croom Helm.
Corbet, G.B., & Harris, S.H., *eds.* 1991. *The handbook of British Mammals*. 3rd ed. Oxford, Blackwell Scientific Publications.
Cresswell, P., Harris, S., & Jefferies, D.J. 1990. *The history, distribution, status and habitat requirements of the badger in Britain*. Peterborough, Nature Conservancy Council.
Harvie-Brown, J.A., & Buckley, T.E. 1888. *A vertebrate fauna of the Outer Hebrides*. Edinburgh, David Douglas.
MacDonald, S.M., & Mason, C.F. 1983. Some factors influencing the distribution of otters *Lutra lutra*. *Mammal Review, 13:* 1-10.
MacDonald, S. M. 1983. The status of the otter *Lutra lutra* in the British Isles. *Mammal Review, 13:* 11-23.
National Rivers Authority. 1933. *Otters and river management.* Bristol, NRA. (Conservation Technical Handbook, No. 3.)
Neal, E. 1986. *The natural history of badgers.* London, Croom Helm.
Schober W., & Grimmberger E. 1987. *A guide to bats of Britain and Europe*. London, Hamlyn.
Strachan, R., & Jefferies, D.J. 1990. *The water vole* Arvicola terrestris *in Britain 1989-90: its distribution and changing status.* Peterborough, Vincent Wildlife Trust/Joint Nature Conservation Committee.
Stebbings, R.E. 1988. *Conservation of European bats*. London, Christopher Helm.
Walsh, A., Harris S., & Hutson, A. 1995. Abundance and habitat selection of foraging vespertilionid bats in Britain: a landscape scale approach. *Symposium Zoological Society London, 67:* 325-344.
Walsh, A., & Harris, S. In prep. *Bat habitats survey.* Peterborough, Joint Nature Conservation Committee.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
National site and species information	*SNH HQ, Edinburgh, tel: 0131 554 9797
Local site and species information	*Scottish Wildlife Trust, Conservation Officer, Edinburgh, tel: 0131 312 7765
Mammals - Region 15	*SNH North-west Region Head Office, Inverness, tel: 01436 239431
Mammals - Region 16	*SNH Stornoway Office, Isle of Lewis, tel: 01851 705258
Bats	Scottish Bat Group, Prof P. Racey, Dept. of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB9 2TN, tel: 01224 272000
Otters	J. and R. Green, The Vincent Wildlife Trust Otter Rehabilitation Centre, Barjarg, Barr Hill, 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, tel: 0171 498 4358
General mammal information	*Institute of Terrestrial Ecology, Monks Wood, tel: 01487 773381

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

5.14 Seals

C.D. Duck

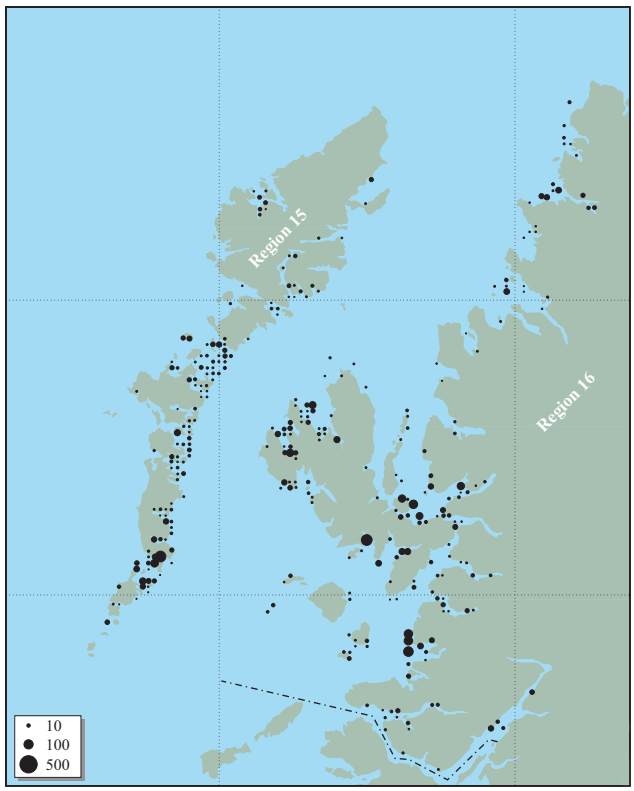
5.14.1 Introduction

Common seals *Phoca vitulina* may be found almost anywhere in the sheltered eastern waters of Region 15 (Western Isles) and in Region 16 (west Highland) throughout the year. Approximately 8% of common seals counted in Great Britain in August occur in Region 15 and approximately 10% in Region 16 (Table 5.14.1). Grey seals *Halichoerus grypus* are common and widespread in Region 15, especially along the western coasts. This region holds a number of internationally important breeding sites which collectively produce nearly 40% of the grey seal pups born in Great Britain (Table 5.14.1) and nearly 15% of pups born in the world. The region is therefore of international importance for the species. In Region 16, however, grey seals are considerably less abundant in coastal areas than common seals. The region produces only an estimated 0.1% of grey seal pups born in Great Britain and holds no major breeding sites.

5.14.2 Important locations

The numbers and distribution of common seals at haul-out sites in Regions 15 & 16 in early August is shown on Map 5.14.1 (Table 5.14.2). Approximately 35% of common seals in Region 15 occur on South Uist and 20% on Barra, most of them on the numerous small, sheltered skerries in the Sound of Barra and in North Bay, Barra. There are also important haul-out sites in the Sound of Harris and along the east coast of Benbecula, with smaller aggregations in Lochs Boisdale and Eynort (South Uist) and Lochs Seaforth and Roag (Lewis). The more distant offshore islands of St. Kilda, the Flannan Isles and North Rona were not surveyed. It is highly unlikely that common seals occur at any of these sites because of the degree of exposure, although grey seals do haul-out on all of them. In Region 16 the greatest concentrations of common seals occurred around Arisaig and Loch nam Uamh, around Skye (Lochs Einort, Scavaig and Dunvegan, the Ascrib Islands, around Broadford and Scalpay), and in the Loch Carron sector (Plock of Kyle and the Kishorn Islands). Over 45% of common seals counted in the region were on Skye and 17% around Arisaig. There were smaller aggregations in the Summer Isles, Eddrachillis Bay and Loch Laxford.

Grey seal August distribution and breeding sites in the regions are shown on Map 5.14.2 (Table 5.14.3). Some of the biggest grey seal breeding colonies in Great Britain are



Map 5.14.1 Common seal haul-out distribution in the regions in August 1992; surveys conducted by SMRU between 1988 and 1992. Circle areas are proportional to the numbers of seals at haul-out sites in each 2 km square. Source: SMRU.

situated in Region 15, including internationally important breeding sites on the Monach Isles, on islands off south-west Harris, and on North Rona, north of the Butt of Lewis. Ceann Iar, in the Monach Isles, is the second biggest grey seal breeding site in the world. Pup production on the Monachs has risen rapidly since the evacuation of the human population in the late 1940s. A small (unknown) number of grey seals breed on St. Kilda.

Although there are no major grey seal breeding sites in Region 16, small numbers of pups are born annually on Muck, Rum, Canna, the Ascrib Islands, Rona and occasionally at other sites scattered along the west coast of Skye and along the mainland, north of the Crowlin Islands.

The Monach Isles and North Rona have been proposed

Table 5.14.1 Numbers of common and grey seals in Regions 15 & 16 in relation to the rest of GB

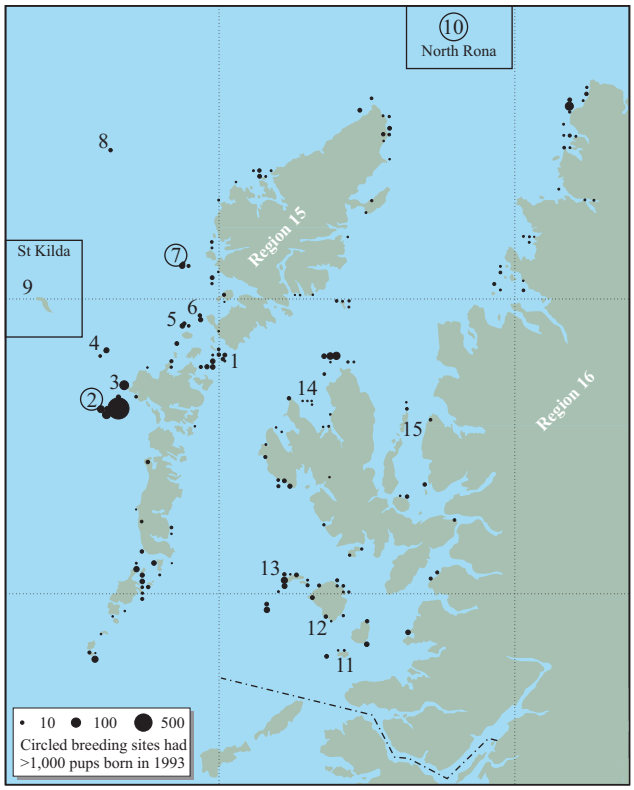
	Common seals		*Grey seals*		
	*Number of seals**	*% of GB total*	*Pup production**	*% of GB total*	*Associated population year old*
Region 15	2,300	8.1	12,800	37.8	43,500
Region 16	2,850	10.1	50-100**	0.1**	200**
Regions 15 & 16	5,150	18.2	12,900**	37.9**	43,700**
Scotland	26,400	93.1	31,000	91.6	105,300
GB total	***28,350***	-	***33,850****	-	***115,000****

Sources: Sea Mammal Research Unit (SMRU), SNH. Key: *to nearest 50; **estimate.

Table 5.14.2 Common seal numbers in areas regularly surveyed

Area surveyed	*Grid ref.*	*No. of seals*	*% of region total*
Region 15			
Lewis	NB300340	230	10.1
Harris	NG120980	287	12.6
North Uist	NF810700	306	13.4
Benbecula	NF820520	212	9.3
South Uist	NF800350	785	34.5
Barra (Barra Head to Eriskay)	NL660980	458	20.1
Monach Isles	NF620620	0	0
Region 16			
Loch Linnhe, Morvern & Ardnamurchan (Salachan Glen to Smirisary)	NM961526-NM649780	251	8.7
Muck	NM410800	105	3.7
Eigg	NM470860		
Rum	NM370000		
Canna	NG240060		
Arisaig & Morar (Smirisary to Mallaig)	NM649780-NM681976	499	17.3
Loch Nevis, Sound of Sleat & Loch Alsh (Mallaig to Kyle of Lochalsh)	NM681976-NG762271	136	4.7
Skye	NG430400	1,296	45.1
Raasay and Rona	NG570410 NG620570	24	0.8
Loch Carron (Kyle of Lochalsh to Rubha na h-Uamha)	NG762271-NG721347	158	5.5
Applecross, Torridon & Gairloch (Rubha na h-Uamha to Rubha Reidh, incl. the Crowlin Islands)	NG721347-NG739919	68	2.4
Loch Ewe, Gruinard Bay & Little Loch Broom (Rubha Reidh to the Head of Loch Broom)	NG739919-NH173864	11	0.4
Summer Isles & Enard Bay (Head of Loch Broom to Point of Stoer)	NH173864-NC021356	86	3.0
Eddrachillis Bay (Point of Stoer to Rubha Ruadh, Loch Laxford)	NC021356-NC165513	207	7.2
Kinlochbervie (Rubha Ruadh to Cape Wrath)	NC165513-NC256750	33	1.1

Source: SMRU. Survey dates: August 1992 (Region 15), August 1988-1992 (Region 16).



Map 5.14.2 Grey seal haul-out distribution in the regions in August 1993 and the locations of the main breeding sites (1993). Circle areas are proportional to the numbers of seals at haul-out sites in each 2 km square. Numbers refer to the main breeding sites in the regions (see Table 5.14.3). Source: SMRU.

as 'possible' Special Areas of Conservation (SACs) under the EC Habitats & Species Directive at least in part for their grey seal populations, and the RSPB reserve at Balranald has seal interest, as has the Small Seal Islands SSSI, which includes the islands of Flodday (Barra), Causamul and Haskeir (North Uist) and Shillay, Coppay and Gasker (Harris).

5.14.3 Human activities

There are long established inshore and offshore fisheries in Region 15 which have always been in some conflict with seals, especially greys. During the 1980s a tangle net fishery for crawfish *Palinurus vulgaris* off the west coast of Barra and South Uist resulted in a considerable by-catch of seals (estimated at some hundreds). This fishery continues but its overall effect on seals is not known. Fishing is a very important industry in Region 16 (see section 9.1). The imminent reintroduction of a demersal monofilament net fishery outside the six-mile limit may have a deleterious impact on common and grey seals, both of which are known to forage on and close to the sea floor (Bjørge *et al.* 1995; Thompson & Fedak 1993; Thompson *et al.* 1991). The extent of this fishery and its likely eventual impact on seals is not yet known. In both regions seals have been found with fishing net round their necks, although the proportion of animals affected is unknown. Seals may also occasionally become entangled in ropes and drown while playing with buoys marking lobster *Hommarus gammarus* or crab *Cancer pagurus* and *Portunus puber* creels.

Since the 1970s the numerous sheltered sea lochs along the west coast of Scotland have encouraged the development of the fin-fish farming industry. Particularly important areas include Lochs Linnhe, Sunart, Harport, Carron, Torridon, Ewe, Broom, Laxford and Inchard (see section 9.2). In recent years, improvements in anti-predation measures such as net design and construction, more efficient sonic seal-scaring devices and a general increase in human activity around fish farm cages have reduced the amount of damage caused by seals. However, some damage still occurs and seals persistently visiting fish farms are likely to be shot. In some areas it is likely that previously-used haul-out sites are no longer available to seals because of fish-farming activities.

There are no tour operators who routinely take tourists to view seal colonies in Region 15, although a number of local boatmen will provide this service on demand. The Uist Outdoor Centre operates out of Loch Maddy and the 'Lobster Fisher' operates more regularly out of Stornoway (Bryan 1994; Morrison 1995). Swimming with seals in clear water is an attraction which draws sub-aqua divers to the

Table 5.14.3 Grey seal pup production

Site no. on Map 5.14.2	*Main breeding sites*	*Grid ref.*	*No. pups born*	*Proportion of region total (%)*
	Region 15			
1	Sound of Harris islands (Langay, Gilsay, Groay, Lingay, Scaravay)	NG010790	100	0.8
2	Monach Islands (total)	NF620620	8,364	65.5
2	Stockay (Monachs)	NF660630	532	4.2
2	Ceann Ear (Monachs)	NF649627	1,103	8.6
2	Shivinish (Monachs)	NF628622	698	5.5
2	Ceann Iar (Monachs)	NF616625	5,787	45.3
2	Shillay (Monachs)	NF592627	244	1.9
3	Causamul	NF660705	167	1.3
4	Haskeir	NF614820	179	1.4
5	Shillay (Sound of Harris)	NF880910	473	3.7
6	Coppay	NF932938	381	3.0
7	Gasker	NA875115	1,651	12.9
8	Flannan Isles	NA725465	0	0
9	St. Kilda	NA100000	10-100*	0.4*
10	North Rona	HW814330	1,562	12.2
	Region 16			
11	Muck	NM396812	5-15*	14*
12	Rum	NM342933-NM360923	15-20*	18*
13	Canna	NG203050	10-25*	23*
14	Ascrib Islands	NG298648	10-50*	45*
15	Rona	NG616536	10*	9*

Sources: SMRU data (1993 breeding season), SNH. Key: *estimate from *ad hoc* single count made by SNH staff or local residents.

archipelago. Although the number of divers is fairly small, dive boats operate out of Loch Maddy and Stornoway in Region 15 and as far afield as Oban in Region 16. St. Kilda is one of the most popular dive sites. In Region 16 tourism provides an important source of income during the summer months. There are both official and unofficial seal-watching tours operating out of many small ports, e.g. Arisaig, Mallaig, Kyle of Lochalsh, Kyleakin, Broadford, Portree, Dunvegan, Ullapool and Kylestrome. Many tour operators are fishermen who use the presence of seals as an additional or alternative source of income.

In Region 15 scientific studies of the breeding biology of grey seals on North Rona have been carried out almost continuously since the 1960s (Boyd & Campbell 1971; Anderson & Fedak 1987; Pomeroy *et al.* 1994; Twiss *et al.* 1994; Amos *et al.* 1995) and less regularly on the Monach Isles (Anderson & Harwood 1985). Initiated by the Nature Conservancy, these studies have been continued by the Sea Mammal Research Unit (SMRU), the University of Cambridge and the University of Durham. In addition to estimating population size, current investigations include: estimating variation in the breeding performance of known individuals; effects of habitat preference on breeding performance; at-sea foraging ecology; and diet composition.

In Region 16, the Inner Sound between Raasay, Rona and the mainland coast at Applecross is used by the Ministry of Defence as a submarine torpedo testing range. The effects of these tests on seals in the area is unknown, although the exclusion of commercial fishing and recreational boating activities could be beneficial.

5.14.4 Information sources used

Data on the numbers and distribution of seals in Regions 15 and 16 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 Great Britain. Common seals were surveyed by SMRU in Region 15 in 1992 and in Region 16 between 1988 and 1992, using a helicopter equipped with a thermal imaging camera. Surveys were conducted in early August, during the common seal annual moult, when the greatest and most consistent numbers of seals haul out. Surveying was further restricted to within two hours of low tides occurring between 1000 and 1800 hrs BST. Since an unknown proportion of the population was at sea during the surveys, numbers represent a minimum population size. The SMRU common seal surveys also provide data on grey seal distribution in early August, but numbers at haul-out sites outside the autumn breeding season are unpredictable and can vary greatly from day to day. Grey seal pup production estimates for Region 15 are derived from counts from annual conventional aerial photographic surveys carried out at regular intervals through the breeding season (Ward *et al.* 1987; Hiby *et al.* 1988). Total population numbers are derived from pup production estimates. In Region 16 SMRU monitor grey seal pup production on Canna and the Ascrib Islands every two or three years during annual aerial surveys.

Common seals hauled out on islands in inner Loch Dunvegan (Region 15) are counted regularly throughout the year by W.A. Richmond. In Region 16 there are so few grey seal pups born in the region that no intensive surveying is carried out. SMRU monitor grey seal pup production on Canna and the Ascrib Islands every two or three years during annual aerial surveys. Grey seal pup production on Rum is monitored by SNH staff annually, although many of

the beaches used for breeding are relatively inaccessible. Additional information on grey seal breeding sites was provided by local residents. The Skye Environmental Centre monitors numbers of common seals hauled-out around Broadford.

5.14.5 Acknowledgements

Thanks go to Stewart Angus, John Love (SNH), Amanda Bryan (Ross and Cromarty Enterprise), Alison Johnston, John Angus McIntyre (Marine Harvest-McConnell) and Jane Twelves for providing information on Region 15 and for commenting on drafts. Thanks are also due to Lesley Cranna, Sarah Hutcheon (Scottish Natural Heritage), Bill Richmond and Andrew Currie for information on Region 16 and comments on drafts.

5.14.6 Further sources of information

A. References cited

Amos, W.A., Twiss, S.D., Pomeroy, P.P., & Anderson, S.S. 1995. Evidence for mate fidelity in the grey seal. *Science, 268:* 1,897-1,899.

Anderson, S.S., & Fedak, M.A. 1987. Grey seal, *Halichoerus grypus*, energetics: females invest more in male offspring. *Journal of Zoology, London, 211*: 667-679.

Anderson, S.S., & Harwood, J. 1985. Time budgets and topography: how energy reserves and terrain determine breeding behaviour of grey seals. *Animal Behaviour, 1985:* 1,343-1,348.

Bjørge, A., Thompson, D., Hammond, P., Fedak, M., Bryant, E., Aarfjord, H., Roen, R., & Olsen, M. 1995. Habitat use and diving behaviour of harbour seals in a coastal archipelago in Norway. *In: Whales, seals, fish and man*, ed. by A.S. Blix, L. Walløe & Ø. Ulltang, 211-223. Amsterdam, Elsevier. (Developments in Marine Biology No. 4. Proceedings of the International Symposium on the Biology of Marine Mammals in the North East Atlantic. Tromsø, Norway, 29 Nov - 1 Dec 1994.)

Boyd, J.M., & Campbell, R.N. 1971. The grey seal (*Halichoerus grypus*) at North Rona, 1959 to 1968. *Journal of Zoology, London, 164*: 469-512.

Bryan, A. 1994. *The Minch review*. Inverness, Scottish Natural Heritage & Western Isles Islands Council.

Hiby, A.R., Thompson, D., & Ward, A.J. 1988. Census of grey seals by aerial photography. *Photogrammetric Record, 12*: 589-594.

Morrison, D. 1995. *Wildlife tourism in the Minch. Distribution, impact and development opportunities.* Inverness, Scottish Natural Heritage & Stornoway, Western Isles Islands Council. (Report produced for the Minch Project.)

Pomeroy, P.P., Anderson, S.S., Twiss, S.D., & McConnell, B.J. 1994. Dispersion and site fidelity of breeding female grey seals (*Halichoerus grypus*) on North Rona, Scotland. *Journal of Zoology, London, 233:* 429-447.

Thompson, D., & Fedak, M.F. 1993. Circulatory responses of grey seals (*Halichoerus grypus*) during diving at sea. *Journal of Experimental Biology, 174*: 139-164.

Thompson, D., Hammond, P.S., Nicholas, K.S., & Fedak, M.F. 1991. Movements, diving and foraging behaviour of grey seals (*Halichoerus grypus*) during diving at sea. *Journal of Zoology, London, 224*: 223-232.

Twiss, S.D., Pomeroy, P.P., & Anderson, S.S. 1994. Dispersion and site fidelity of breeding male grey seals (*Halichoerus grypus*) on North Rona, Scotland. *Journal of Zoology, London, 233:* 683-693.

Ward, A.J., Thompson, D., & Hiby, A.R. 1987. Census techniques for grey seal populations. *Symposium of the Zoological Society of London, 58*: 181-191.

B. Further reading

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides*. London, Collins.

Boyd, J.M., Lockie, J.D., & Hewer, H.R. 1962. The breeding colony of grey seals on North Rona, 1959. *Proceedings of the Zoological Society of London, 138*: 257-277.

Darling, F.F. 1939. *A naturalist on Rona*. Oxford University Press.

Gubbay, S. 1988. *A coastal directory for marine nature conservation.* Ross-on-Wye, Marine Conservation Society.

Hammond, P.S., Hall, A.J., & Prime, J.H. 1994. The diet of grey seals in the Inner and Outer Hebrides. *Journal of Applied Ecology, 31*: 737-746.

Law, R.J., Fileman, C.F., Hopkins, A.D., Baker, J.R., Harwood, J., Jackson, D.B., Kennedy, S., Martin, A.R., & Morris, R.J. 1991. Concentrations of trace metals in the livers of marine mammals (seals, porpoises and dolphins) from waters around the British Isles. *Marine Pollution Bulletin, 22:* 183-191.

McGillivray, D. 1995. Seal conservation legislation in the UK: past, present and future. *International Journal of Marine and Coastal Law, 10:* 19-52.

Turnpenny, A.W.H., & Nedwell, J.R. 1994. *The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys.* Southampton, Fawley Aquatic Research Laboratories Ltd.

Vaughan, W.R. 1983. Seals in the Inner Hebrides. *Proceedings of the Royal Society of Edinburgh, 83B:* 219-228.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Seal numbers and distribution around the UK	Callan Duck, Sea Mammal Research Unit, Gatty Marine Laboratory, University of St. Andrews, Fife KY16 8LB, tel: 01334 476161
Seals in Region 15	*SNH Stornoway Office, Isle of Lewis, tel: 01851 705258
Seals around the Uists and St. Kilda	*SNH South Uist, Western Isles, tel: 01870 620 238
Seals in Region 16	*SNH, North-west Region Head Office, Inverness, tel: 01463 239431
Seals around north Skye	Skye Environmental Centre Ltd., Isle of Skye Field Centre, Broadford, Isle of Skye IV49 9AQ, tel: 01471 822487
Seals and fisheries	*SOAEFD Marine Laboratory, Aberdeen, tel: 01224 876544
Seals in Scotland	*SWT, Edinburgh, tel: 0131 312 7765

*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

Region 15 (Western Isles) is probably the richest region in the UK and one of the most important areas in north-west Europe for cetaceans (whales, dolphins and porpoises). Region 16 (west Highland) is also one of the richest regions in the UK. 20 species of cetaceans have been recorded since 1980 along the coasts or in the nearshore waters (within 60 km of the coast) of Region 15, and nineteen species in the waters of Region 16. Of these, eleven species in Region 15 (41% of the 27 UK species) and eight species in Region 16 (30% of UK species) are either present throughout the year or recorded annually as seasonal visitors. Other species were recorded only occasionally.

The commonest species in nearshore waters in both regions are the harbour porpoise *Phocoena phocoena*, common dolphin *Delphinus delphis*, white-beaked dolphin *Lagenorhynchus albirostris*, Risso's dolphin *Grampus griseus* and minke whale *Balaenoptera acutorostrata*. In addition, the killer whale *Orcinus orca* is common in the waters of Region 15. It is also a regular visitor to Region 16, along with the white-sided dolphin *Lagenorhynchus acutus* and long-finned pilot whale *Globicephala melas*. These two species also occur regularly offshore to the north, south and west of the Western Isles, along with bottlenose dolphin *Tursiops truncatus*, sperm whale *Physeter macrocephalus* and fin whale *Balaenoptera physalus*. 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 EC Habitats & Species Directive as species whose conservation requires the designation of Special Area of Conservation (see also section 7.2).

5.15.2 Important locations and species

Table 5.15.1 lists species resident or regularly occurring in Regions 15 & 16. Fin whale, sperm whale and bottlenose dolphin are occasionally encountered in the waters of Region 16 but are more likely to be seen in Region 15. Other cetacean species recorded in both regions include sei whale *Balaenoptera borealis*, humpback whale *Megaptera novaeangliae*, Sowerby's beaked whale *Mesoplodon bidens*, True's beaked whale *Mesoplodon mirus*, Cuvier's beaked whale *Ziphius cavirostris*, and northern bottlenose whale *Hyperoodon ampullatus*. In addition to these species, blue whale *Balaenoptera musculus*, northern right whale *Eubalaena glacialis* and striped dolphin *Stenella coeruleoalba* have been recorded in Region 15, while false killer *Pseudorca crassidens* and beluga *Delphinapterus leucas* have been recorded in Region 16.

In both regions, as elsewhere in western Britain, headlands and the sounds between islands, together with offshore fishing banks, are the most favoured localities for cetaceans in coastal waters. Favoured localities for cetaceans in Region 15 include the continental shelf edge and other areas with uneven bottom topography such as the Stanton and Shiant Banks, sounds (e.g. Sounds of Harris, Barra and neighbouring islands, Monachs, Flannans and St. Kilda group) and headlands (e.g. Butt of Lewis, Eye Peninsula and Barra Head) (Evans 1981, 1992; Evans *et al.* 1993a, b).

Harbour porpoises are widespread in nearshore waters of both Region 15 and Region 16 (Map 5.15.1). In the former they are encountered in the Sounds of Barra, Vatersay, Sandray, Pabbay, Mingulay and Berneray, the Sound of Harris and around the Monach, Flannan and Shiant Isles, and in large bays and sea lochs such as Loch Roag, Loch Tarbert and Loch Maddy. In Region 16 they are found particularly in the Sounds of Sleat and Raasay, around the Small Isles and in bays and lochs around Skye and the west mainland (Lochs Nevis, Hourn, Duich, Carron, Torridon, Gairloch, Ewe, Broom, Laxford and Inchard) (Evans 1992; Evans *et al*. 1993a, b; Northridge *et al.* 1995).

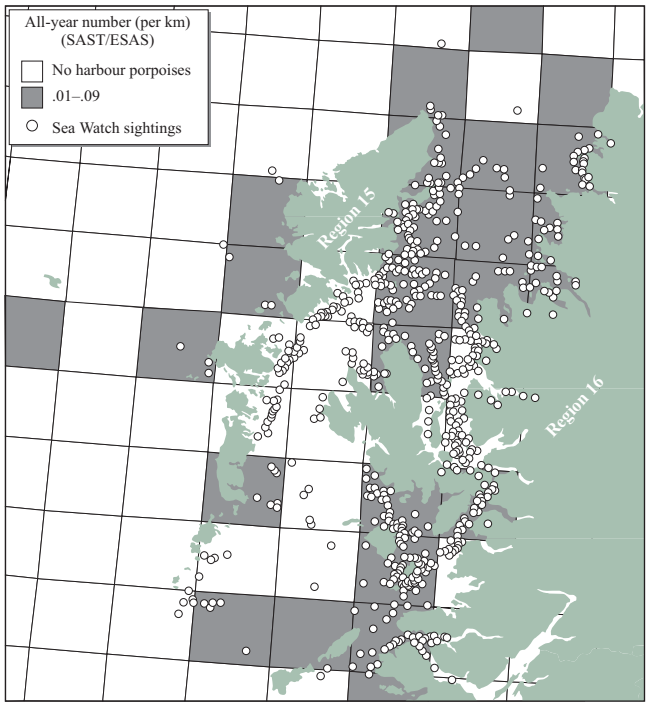
The white-beaked dolphin occurs throughout coastal waters (Map 5.15.2). It is the commonest species in the North Minch, Little Minch and western Sea of the Hebrides, occurring mainly offshore along the edge of banks. It is also found north and west of Region 15 in association with seasonal concentrations of mackerel. The common dolphin is most abundant in the first half of the summer, occurring mainly in the southern and eastern parts of Region 16 around the Inner Hebrides, particularly between Coll and Muck, Eigg and the mainland and off the Sleat Peninsula of Skye. This species is also abundant to the south-west, south and south-east of the Outer Hebridean chain, particularly around the Stanton Banks (Evans 1992; Evans *et al*. 1993a, b; Northridge *et al.* 1995).

In Region 15 Risso's dolphins are found along the Eye Peninsula, Lewis, and in nearshore waters east of Harris and the Uists (Map 5.15.3). In Region 16 they are regularly seen off Neist Point in Skye, west and north of Canna and around Eigg and Muck. Killer whales range widely over the continental shelf west of the Hebrides as well as in the north Minch, Little Minch and the Sea of the Hebrides. They are also encountered north and east of Raasay and Rona and south-west of Canna in Region 16. Long-finned pilot whales and white-sided dolphins are more pelagic species than the others and are mainly recorded west of Region 15, particularly along the continental shelf edge, where fin whales and sperm whales are also occasionally seen. They are generally recorded at those points in the waters of Region 16 which are closest to the open Atlantic, i.e. offshore in the northern portion of the North Minch and in the southern Sea of the Hebrides, south-west of Canna (Evans 1992; Evans *et al.* 1993a, b). Individuals recognised by photo-identification show strong fidelity to particular localities such as Mingulay, the Eye Peninsula, south-east Harris, north-west Mull and Neist Point, Skye (Atkinson 1995; Atkinson *et al.* 1996; Evans *et al.* 1993a, b).

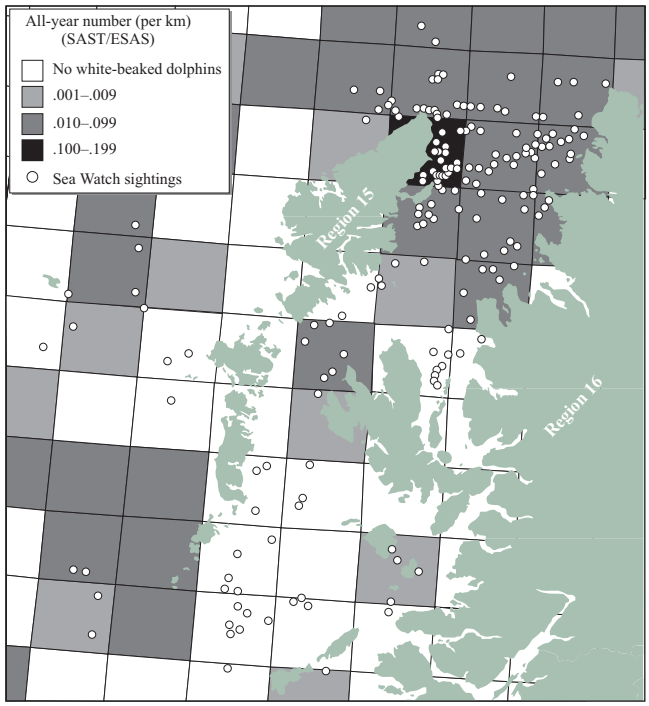
Minke whales (Map 5.15.4) are widely distributed in small numbers in Region 15, particularly around the Sound of Harris, the Shiants, the Flannan Isles and St. Kilda. They are also regularly found in Region 16 in the sounds between Skye, Canna, Rum, Muck, Eigg and entrances to the mainland sea lochs, off Neist Point in West Skye, north of Raasay, in Gairloch and offshore along the edge of banks in the Sea of the Hebrides, Little Minch and North Minch (Evans 1992; Evans *et al.* 1993a, b; Northridge *et al.* 1995). Peak

Table 5.15.1 Cetacean species regularly recorded in Regions 15 & 16

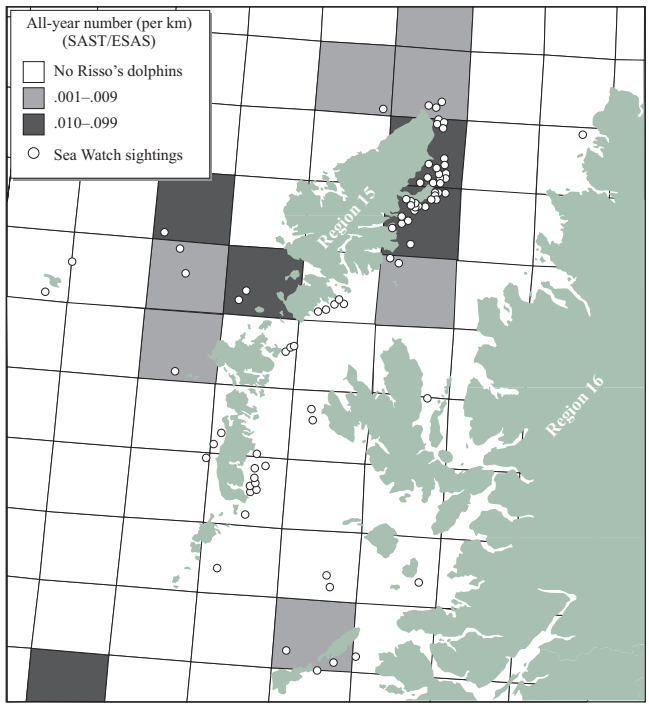
Species	*Status, distribution and seasonal occurrence*	
	Region 15	*Region 16*
Fin whale	Uncommon singly or in twos, along the continental shelf edge west of St. Kilda, occasionally coming nearshore along the west coast and into the north Minch. Sightings mainly from May to August.	Not a regular visitor.
Minke whale	Small numbers (groups of 5-10), east of the Sound of Harris, around the Shiants, Flannans and St. Kilda group, mainly between July and October.	Small numbers (groups of 5-10), around the Inner Hebrides and entrances to west mainland sea lochs, with peak sightings between July and October
Harbour porpoise	Common, particularly in the Sound of Barra and neighbouring islands, the Monachs and Harris, in large bays and sea lochs such as Loch Roag, Loch Tarbert and Loch Maddy and in the Little Minch. Peak sightings occur between July and October, when singles or family groups may form aggregations numbering 10-30 individuals.	Common, particularly in the north-eastern part of the Minch and the Sea of Hebrides, and along the mainland coast, where they may occur far up the larger lochs, such as Loch Duich and Loch Hourn. Peak numbers and frequency of sightings occur between July and October, when singles or family groups may form aggregations numbering 30-40 individuals.
Harbour porpoise	Common, particularly in the Sound of Barra and neighbouring islands, the Monachs and Harris, in large bays and sea lochs such as Loch Roag, Loch Tarbert and Loch Maddy and in the Little Minch. Peak sightings occur between July and October, when singles or family groups may form aggregations numbering 10-30 individuals.	Common, particularly in the north-eastern part of the Minch and the Sea of Hebrides, and along the mainland coast, where they may occur far up the larger lochs, such as Loch Duich and Loch Hourn. Peak numbers and frequency of sightings occur between July and October, when singles or family groups may form aggregations numbering 30-40 individuals.
Bottlenose dolphin	Uncommon but recorded regularly in the vicinity of Barra and South Uist, mainly between April and September.	Not a regular visitor.
Common dolphin	Common in early summer, especially between May and July, sometimes in large groups (up to 500 individuals) around the Stanton Banks and southern end of the Sea of the Hebrides.	Common in early summer, especially between May and July, sometimes in large groups (up to 500 individuals) in the eastern part of the Sea of the Hebrides, occasionally off the west Highland coast north of Skye.
White-beaked dolphin	Common in groups (10-100 individuals) in nearshore waters along the Outer Hebrides, west to St. Kilda and east in the North Minch, Little Minch and western half of the Sea of the Hebrides. Peak sightings between July and September.	Common in groups (up to 50 individuals) in the North Minch, Little Minch and western half of the Sea of the Hebrides, mainly between May and September.
White-sided dolphin	Uncommon, but generally in large numbers (100-1,000 individuals), mainly offshore west of the Outer Hebrides, but also at the northern end of the North Minch and southern end of the Sea of the Hebrides. Most sightings in July and August.	Uncommon, but generally in large numbers (100-1,000 individuals), mainly offshore in the southern end of the Sea of the Hebrides or northern end of the North Minch. Most sightings in July and August.
Risso's dolphin	Widely distributed in groups of 5-25, usually nearshore, occurring mainly between March and September.	Widely distributed in groups of 5-25, usually nearshore, occurring mainly between March and September.
Long-finned pilot whale	Common (groups of 10-50) in offshore waters, particularly along the edge of the continental shelf, but sometimes in nearshore waters, where mass strandings occasionally take place (e.g. April 1992). Peak sightings between April and September.	Uncommon (groups of 10-25), occurring mainly offshore in the North Minches between April and September.
Killer whale	Uncommon (singly or in groups of 2-10) but widely distributed, occurring mainly between May and September. Individuals recognised by photo-ID are seen repeatedly in particular localities (e.g. in Little Minch east of Harris and the Uists) (Evans 1996; Evans *et al.* 1993a, b).	Uncommon (singly or in groups of 2-10) but widely distributed, occurring mainly between May and September. Individuals recognised by photo-ID are seen repeatedly in particular localities (e.g. off Raasay, in Little Minch west of Skye, and south-west of Canna) (Evans 1996; Evans *et al.* 1993a, b).
Sperm whale	Uncommon in offshore waters west of the Western Isles, along the edge of the continental shelf, but occurring sometimes in nearshore waters, where mass strandings very occasionally take place (e.g. Feb-Mar 1988). No apparent seasonal pattern.	Not a regular visitor.



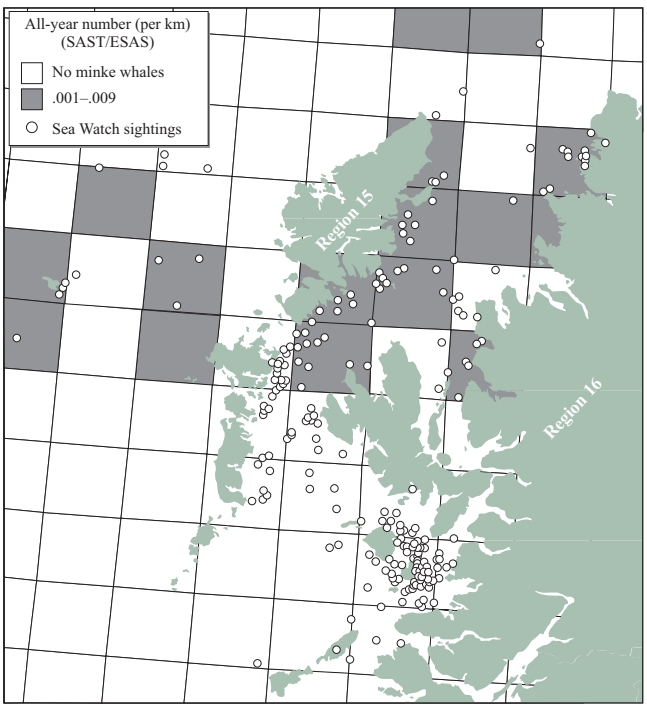
Map 5.15.1 Harbour porpoises: all-year number sighted per kilometre of Seabirds at Sea survey (source: JNCC SAST/ESAS); and sightings reported to the Sea Watch sighting system (source: Evans (1992)).



Map 5.15.2 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: Evans (1992)).



Map 5.15.3 Risso's 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: Evans (1992)).



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: Evans (1992)).

numbers and frequencies of sightings occur between July and October, when single whales and small groups may form larger aggregations. Photo-identification studies show that some individuals return to the same localities year after year (Gill & Fairbairns 1995; Evans *et al.* 1993a, b; Evans & Hoogerheide 1996). One minke whale occupied Loch Grimshader, Lewis, between November 1993 and March 1994.

5.15.3 Human activities

Cetaceans in Regions 15 and 16 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 (from underwater sounds).

The main fishing port in Region 15 is Stornoway, but other small ports exist at Berneray (North Uist), on Eriskay and South Uist, and at Castlebay (Barra). Mallaig, Lochinver, Ullapool and Kinlochbervie are the major fishing ports in Region 16 (see section 9.1). A variety of fisheries can result in the accidental capture of cetaceans, but the greatest impact in UK waters appears to come from bottom set gill nets, including tangle nets and nets set around wrecks, most frequently affecting harbour porpoises and common dolphins. Purse seine and midwater trawling can also lead to by-catches, whilst creel lines sometimes entangle minke whales. There are a few reports of small cetaceans (mostly harbour porpoise but also white-beaked dolphin and long-finned pilot whale) in Regions 15 and 16 being killed accidentally in fishing gear, although figures on catch levels are not available (Northridge 1988). A humpback whale became trapped in a salmon net in Loch Duich (August 1984) but was subsequently released (Evans 1993). In both regions minke whales occasionally become entangled in creel lines and fixed salmon gill nets (Evans 1993, 1995).

Cetacean tissues of various species have been analysed for organic contaminant levels in recent years by SOAEFD Marine Laboratory, Aberdeen (e.g. Wells *et al*. 1996). In general, contaminant levels encountered are comparable with levels from other regions around the UK.

There are no major holiday resorts in the regions, but recreational activities with the potential to disturb cetaceans (e.g. speedboats and jet skis) are based in Ullapool, Gairloch, Uig, and Raasay, and to a limited extent Mallaig, Kyle of Lochalsh and Lochinver (Region 16), and in Stornoway and Loch Maddy (Region 15). 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 and other baleen whale species than with dolphins and porpoises (Evans 1987, 1995). 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 therefore are 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 1995).

A code of conduct for boat users has been produced by the Sea Watch Foundation (SWF) and distributed around yacht clubs and marinas, and Scottish Natural Heritage has a dolphin awareness scheme for Scotland, although this currently concentrates upon 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 (SWF) (Evans 1992), and the strandings scheme organised by the Natural History Museum in London (1913-present) (Sheldrick *et al.* 1994), run within Scotland by SAC Veterinary Investigation Centre, Inverness. In addition, dedicated cruises are conducted by SWF and the Western Isles Sailing Company throughout Regions 15 & 16 (although mainly in the North Minch, Little Minches and the Sea of the Hebrides) every summer from 1992 to the present (Evans *et al.* 1993a, b). The Joint Nature Conservation Commitee Seabirds at Sea Team (SAST) also collects effort-related data on cetaceans during offshore seabird surveys.

During summer 1980, dedicated cruises were conducted west of Region 15 (Evans 1981), but apart from records provided by vessels to and from the St. Kilda group there has been little coverage on the Atlantic side of Region 15 and what there is has been almost entirely confined to the months of May - October. Sea-based coverage of Region 16 is good, although more or less confined to the months of May - October. Systematic land-based watches have been carried out from Haskeir Light in the Sea of the Hebrides, from Neist Point, Skye, and from Handa Island. Sea Life Surveys (between Mull and Eigg) (Fairbairns & Fairbairns 1995; Gill & Fairbairns 1995), MV *Shearwater* (around all the Small Isles), and Sail Gairloch (Eastern Minch and Inner Sound) all undertake cetacean surveys in Region 16. Opportunistic sightings effort has been highest between the months of April and September, when sea conditions are usually best. Photo-ID studies are currently being conducted by Sea Life Surveys, on minke whales, and by SWF on minke whales, killer whales and Risso's dolphins.

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 the summer wardens of Handa Island, and those provided by the keepers of the Haskeir Light. Thanks are also due to I. Birks, C. Clark, R. Fairbairns, J. Gordon, C. Speedie, C. Swann, M.L. Tasker, J. Twelves, A. Webb and G. Yoxon.

5.15.6 Further sources of information

A. References cited

Atkinson, T. 1995. *A pilot photo-identification study of Risso's dolphins (*Grampus griseus*) in the coastal waters of the Eye Peninsula, Isle of Lewis, Scotland*. Report to the Mammal Conservation Trust.

Atkinson, T., Evans, P.G.H., & Gill, A. 1996. *Photo-ID catalogue of Risso's dolphins in north-west Scotland*. Oxford, Sea Watch Foundation.

Baines, M.E. 1993. *Marine mammal monitoring during the seismic exploration of block 107/21 in Cardigan Bay, Autumn 1993*. Haverfordwest, Dyfed Wildlife Trust.

Evans, P.G.H. 1981. *Report of the North-east Atlantic scientific cruise, 1980*. London, Mammal Society.

Evans, P.G.H. 1987. *The natural history of whales and dolphins*. London, Christopher Helm.

Evans, P.G.H. 1990. Whales, dolphins and porpoises. The order Cetacea. *In*: *Handbook of British mammals*, ed. by G.B. Corbet & S. Harris, 299-350. Oxford, Blackwell.

Evans, P.G.H. 1992. *Status review of cetaceans in British and Irish waters.* Oxford, Sea Watch Foundation. (Report to the UK Department of the Environment, London.)

Evans, P.G.H. 1993. *Cetacean bycatches in UK & Ireland*. Oxford, Sea Watch Foundation.

Evans, P.G.H. 1995. Human disturbance of cetaceans. *In: Exploitation of mammals*, ed. by N. Dunstone & V. Taylor. London, Chapman & Hall.

Evans, P.G.H. 1996. *Photo-ID catalogue of killer whales in north-west Scotland.* Oxford, Sea Watch Foundation.

Evans, P.G.H., Canwell, P.J., & Lewis, E.J. 1992. An experimental study of the effects of pleasure craft noise upon bottle-nosed dolphins in Cardigan Bay, West Wales. *In: European research on Cetaceans, 6,* ed. by P.G.H. Evans. Cambridge, European Cetacean Society.

Evans, P.G.H., & Hoogerheide, D. 1996. *Photo-ID catalogue of minke whales in north-west Scotland.* Oxford, Sea Watch Foundation.

Evans, P.G.H., Swann, C., Lewis, E., Parsons, E., Heimlich-Boran, J.R., & Heimlich-Boran, S.L. 1993a. Survey of cetaceans in the Minches and Sea of Hebrides, Northwest Scotland. *In: European research on Cetaceans, 7,* ed. by P.G.H. Evans. Cambridge, European Cetacean Society.

Evans, P.G.H., Swann, C., Lewis, E., Parsons, E., Heimlich-Boran, J.R., & Heimlich-Boran, S.L. 1993b. *Report of survey of cetaceans in the Minches and Sea of Hebrides, Northwest Scotland.* Oxford, Sea Watch Foundation.

Evans, P.G.H., Carson, Q., Fisher, P., Jordan, W., Limer, R., & Rees, I. 1994. A study of the reactions of harbour porpoises to various boats in the coastal waters of SE Shetland. *In: European research on Cetaceans, 8,* ed. by P.G.H. Evans. Cambridge, European Cetacean Society.

Fairbairns, R.S., & Fairbairns, J. 1995. Whalewatching - ecotourism and research. A Scottish point of view. *In: European research on cetaceans, 9*, ed. by P.G.H. Evans. Cambridge, European Cetacean Society.

Gill, A., & Fairbairns, R.S. 1995. The photo-identification of the minke whale *Balaenoptera acutorostrata* off the Isle of Mull, Scotland. *In: European research on cetaceans, 9*, ed. by P.G.H. Evans. Cambridge, European Cetacean Society.

Goold, J.C. 1996. Acoustic assessment of populations of common dolphins *Delphinus delphis* in conjunction with seismic surveying. *Journal of the Marine Biological Association, 16:* 811-820.

Northridge, S. 1988. *Marine mammals and fisheries*. London, Wildlife Link (unpublished report).

Northridge, S., Tasker, M.L., Webb, A., & Williams, J.M. 1995. Seasonal distribution and relative abundance of harbour porpoises *Phocoena phocoena* (L.), white-beaked dolphins *Lagenorhynchus albirostris* (Gray) and minke whales *Balaenoptera acutorostrata* (Lacepède) in the waters around the British Isles. *ICES Journal of Marine Science*, *52*(1)*:* 55-66.

Sheldrick, M.C., Chimonides, P.J., Muir, A.I., George, J.D., Reid, R.J., Kuiken, T., Iskjaer-Ackley, C., & Kitchener, A. 1994. Stranded cetacean records for England, Scotland and Wales, 1987-1992. *Investigations on Cetacea*, *25:* 5-28.

Wells, D.E., Mackenzie, C., & Ross, H.M. 1996. *Chlorobiphenyl patterns in marine mammals from Northern European waters*. Aberdeen, SOAEFD Marine Laboratory. (SOAEFD Scottish Fisheries Working Paper 1/96.)

B. Further reading

Brady, P., *ed*. 1991. *Fisheries of Scotland*. *Yearbook of the Scottish fishing industry.* Fleetwood, Commercial Fishing Enterprises.

Bryan, A. 1994. *The Minch review*. Inverness, Scottish Natural Heritage & Western Isles Islands Council.

Evans, P.G.H. 1990. European cetaceans and seabirds in an oceanographic context. *Lutra, 33:* 95-125.

Isles, T.D., & Sinclair, M. 1982. Atlantic herring: stock discreteness and abundance. *Science*, *215:* 627-633.

Kuiken, T., Bennett, P.M., Allchin, C.R., Kirkwood, J.K., Baker, J.R., Lockyer, C.H., Walton, M.J., & Sheldrick, M.C. 1994. PCBs, cause of death and body condition in harbour porpoises *Phocoena phocoena* from British waters. *Aquatic Toxicology, 28:* 13-28.

Law, R.J., Fileman, C.F., Hopkins, A.D., Baker, J.R., Harwood, J., Jackson, D.B., Kennedy, S., Martin, A.R., & Morris, R.J. 1991. Concentrations of trace metals in the livers of marine mammals (seals, porpoises and dolphins) from waters around the British Isles. *Marine Pollution Bulletin*, *22:* 183-191.

Lee, A.J., & Ramster, J.W. 1981. *Atlas of the seas around the British Isles.* London, MAFF.

Natural History Museum. 1990-present. *Annual reports.* London, Natural History Museum.

Pingree, R.D., & Griffiths, D.K. 1978. Tidal fronts on the shelf seas around the British Isles. *Journal of Geophysical Research, 83*: 4,615-4,622.

Richardson, W.J., Greene, C.R., Jr., Malme, C.I., & Thomson, D.H. 1995. *Marine mammals and noise.* San Diego, California, USA, Academic Press.

Sea Watch Foundation & UK Mammal Society. 1992. *Dolphin code of conduct*. Oxford, Sea Watch Foundation & UK Mammal Society.

Simpson, J.H. 1981. The shelf-sea fronts: implications of their existence and behaviour. *Philosophical Transactions of the Royal Society of London, A302:* 532-546.

Turnpenny, A.W.H., & Nedwell, J.R. 1994. *The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys.* Southampton, Fawley Aquatic Research Laboratories Ltd.

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 sightings & surveys	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, JNCC Aberdeen, tel: 01224 655700
Cetacean strandings, Scotland	Scottish Strandings Coordinator, SAC Veterinary Services, Drummond Hill, Inverness, tel: 01463 243030
Cetacean organochlorine & heavy metal levels	*Dr R.J. Law, Centre for Environment, Fisheries & Aquaculture Sciences, Burnham-on-Crouch Laboratory, tel: 01621 787200
Cetacean surveys	R. Fairbairns, Sea Life Surveys, Dervaig, Isle of Mull, Strathclyde PA75 2PL, tel: 016884 223
Cetacean surveys	I. Birks, Sail Gairloch, Tigh na Bruaich, Strath, Gairloch, Highland IV21 2BT, tel: 01445 712326
Bottlenose dolphin studies	Dr P. Thompson/M. Wilson, University of Aberdeen, Department of Zoology, Lighthouse Field Station, George Street, Cromarty IV11 8YJ, tel: 01381 600548
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.

In the absence of much archaeological evidence from Neolithic settlement sites in Region 15, ritual monuments such as the stone ring at Callanish (Lewis) hint at the level of social organisation attained here 3,000 years ago. Photo: David Stroud, 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 archaeology of these regions, gives information on the provisions for safeguarding known and unknown sites, and describes the extent of survey work and how to report new discoveries. Map 6.1.1 shows archaeological locations mentioned in the text.

Regions 15 and 16 lie on the sea routes between western continental Europe, Ireland, Iceland and Scandinavia, and were, in the historic period, part of the Kingdom of Norway. This is the sphere of cultural contact that is most apparent in the archaeological record, whereas there are few if any traces of the focal documented events of southern Britain, such as the Roman occupation, the Saxon migrations or the Norman invasion.

The regions have many fine examples of standing monuments, notably standing stones and brochs (tall round towers). New studies of less visually impressive sites are producing essential information for poorly-understood Scottish periods. However, the distribution of known sites is biased by the uneven spread of survey work, and further surveys and scientific investigations of sites are vital to developing a full picture of the past.

The range of materials and quality of waterlogged remains has been demonstrated by excavation in Loch Olavat, North Uist. In Region 15 there is potential for the discovery of submerged coastal settlements and landscapes, as post-glacial sea-level rise is estimated to have drowned a 1.5 km-wide strip of land on the west coast. This opportunity does not exist in other areas of Scotland, which have experienced uplift.

As surveys progress, discoveries of post-medieval and modern shipwrecks are expected to be numerous in the sub-tidal zone. Most known sites around Britain are of 19th or 20th-century metal ships which stand proud of the sea bed and can be located by remote sensing equipment. Wooden ships can survive either as buried hulls or as scattered sites. The records of losses, which are comprehensive for the 19th century, relatively complete for the 18th, and patchy for the 14th to 17th centuries, suggest that there are many vessels which may yet be located. For earlier periods it is necessary to examine written evidence for seaborne trade and extrapolate the occurrence of ship losses. The scale of potential discoveries is clear from the Dublin-built, 30 m-long Viking warship found at Roskilde, Denmark.

Map 6.1.1 Archaeology: locations mentioned in the text.

For the prehistoric era, evidence of seaborne exchange raises the question of boat types. Unfortunately there is little evidence for the nature of traditional sea-going craft in Regions 15 and 16. Occasional discoveries of log boats, such as those from Loch Chaluim-Chille, Skye, cannot be seen as fully representative of indigenous craft: the Gaelic world has a skinboat tradition, and West Highland Galleys are depicted on grave slabs at Kiel Church, Loch Aline.

6.2 Archaeology of the region

6.2.1 Hunters, gatherers and early farmers (Palaeolithic, Mesolithic and Neolithic)

In southern Britain human activity has been traced back some 450,000 years. Scotland, despite being habitable in warmer periods, has no securely dated remains from the Palaeolithic (*c.* 850,000-10,000 BC). The earliest dated Scottish settlement is Kinloch, on Rum (Region 16). While middens on Oronsay and at the cave site of An Corran on Skye reveal the stone technologies and the foodstuffs of the Mesolithic hunter-gatherers (*c.* 10,000-4,000 BC), such sites have yet to be investigated in Region 15: they may lie on the submerged coastal plain. However peat at Tobnan-Leobag, Callanish, and at Loch Lang, South Uist, shows a decline in woodland possibly caused by hunters burning woodland to provide new grazing.

The adoption of farming divides the Mesolithic and the Neolithic (*c.* 4,000-2,500 BC). However cultivation, animal husbandry and hunter-gathering clearly co-existed, and monumental tombs and artefacts such as polished stone axes are the diagnostic features of the period. In Region 15 the Shulishader (Sulaisiadar) axe is remarkable for its surviving hawthorn haft, while its Antrim porcellanite head demonstrates maritime exchange with Ireland. The region's chambered cairns echo forms found in both Orkney (Region 2) and the Clyde Basin (Region 14), and the picture that these create of social organisation is intensified by the later ritual monuments, of which the stone ring at Callanish (Lewis) is the prime example. Generally, Neolithic settlement sites are not common but in Region 15 they have been found at Allt Chrysal (Barra), Bharpa (Barra) and Northton (Harris). Excavation of later buildings at Eilean Domhnuill (Loch Olavat) and Eilean Tighe have revealed Neolithic occupation beneath, thus suggesting a far more extensive distribution (Armit 1996). The decorated pottery of Region 15 is also distinct from that found elswhere, and Allt Chrysal provided rare and indisputable evidence for local manufacture: a pot in a partly-fired clamp. In Region 16 cairns from this period are concentrated in the south, and sea transport is apparent, with Rum being the source of stone for axes found elsewhere (Darvill 1987).

6.2.2 Metal-working peoples (Bronze Age and Iron Age)

Change is apparent through the 3rd and 2nd millennia BC. Farming intensified after 3,000 BC and chambered cairns declined. Individual burials and cremations became favoured over communal burial, though the placing of some in old chambered cairns suggests continuing traditions (Ashmore 1996). Standing stones were erected, but the spread of agriculture right to their bases in later centuries suggests that their significance lessened over time.

Debate continues over the relationship between these cultural changes and the distribution of 'beaker' pottery. In Region 15 the concentration of settlements with this type of pottery "is virtually unparalleled elsewhere in Europe" (Armit 1996). Sites at Udal (North Uist), Northton (Harris) and Dalmore (Lewis) show small units of settlement, with the dry-stone walled houses continuing Neolithic traditions. Fragile evidence for agricultural practice, the marks of a primitive plough, have been recorded at Rosinish (Benbecula).

In these regions the metal objects which the Bronze Age implies are not found in any quantity until the end of the period. The finds, predominantly jewellery and high status weapons, are important because settlement evidence becomes scarce in these regions from around 2,000 BC. In Region 16, however, a recently revealed dwelling at Coil a Ghasgain, near Ord, Skye, is from the later Bronze Age and is regarded as pre-empting the structures of the Iron Age, which began in the 6th century BC.

In Region 15 the known Iron Age buildings are concentrated on the coast. This may reflect movement from inland areas as peat growth, resulting from the deteriorating climate, marginalised formerly cultivated land. The new period is characterised more by the appearance of monumental stone buildings than by the new metal. Dun Carloway (Region 15), Dun Telve and Dun Troddan (Region 16) are outstanding examples of the brochs that characterise both regions, while some vitrified forts (stone with timber-lacing) are also found in Region 16, such as Dun Lagaidh, near Ullapool. Excavation has shown that some of the less imposing sites, previously categorised as duns or lesser structures, are either reduced brochs or share common diagnostic features with them. The generic term 'Atlantic Roundhouse' is now applied to the "confusing typological morass" of all these structures, and their large numbers and range of sizes are seen as evidence that they are individual dwellings of family groups and architectural expressions of their territoriality (Armit 1996).

The Atlantic Roundhouse Dun Bharabhat, Cnip, overlies a settlement dating back to the 8th century BC. Such sites were used, or re-used, well into the 1st millennium AD. In Region 15, as in Shetland (Region 1), new construction focuses on a new building, the wheelhouse, from about the 1st century BC. Revetted into sand dunes, they lack the imposing exteriors of Atlantic Roundhouses and are less readily identified, although their interiors may have been more impressive. In Region 16, at Tungavale, Skye, a rectilinear structure with a souterrain ('cellar') poses questions for further research into the function of Iron Age buildings. There is artefactual evidence for continuing agriculture. Surviving pottery is crude and a lathe-turned wooden bowl from Skye (Crone 1993) may better represent the domestic utensils.

6.2.3 Roman to Medieval periods

Texts linked to Roman military activity provide the first written records for Britain. Scotland was largely outside the occupied province and even the campaigning army failed to reach these regions. However, Ptolemy noted Skye and other islands and the supporting Roman fleet circumnavigated Scotland. Three named tribes can be placed in Region 16 in the 2nd century AD: the Caereni, Carnonacae and Creones. Two centuries later the mixture of tribes that harried the Roman frontier were generally referred to as Picts.

Historical sources, in broad terms, show Regions 15 and 16 occupied by Picts, and from the 6th century the regions

were subject to Christianising movements from Ireland. In the 9th century Pictland was subsumed by the Argyll-based Dal Riata, probably in response to the Viking threat. The Vikings raided and then occupied the area, and Region 15 and many islands in Region 16 remained under Norse control until the Treaty of Perth in 1266. Meanwhile the rest of Scotland had gradually united under a single monarch, and, by the 12th century, the administration, Church, aristocracy and burghs had been established on Norman lines. Even after 1266, powerful individuals, later styled the Lords of the Isles, maintained a maritime power-base on Islay (Region 14) until the lordship was forfeited to the Scottish Crown at the end of the 15th century.

The archaeological record for this period is underdeveloped. Foster (1996) observes that, for the Pictish period, documentary sources have tended to direct archaeological activity to high status sites. Branigan & Foster (1995) note that "churches, graveyards and castles apart, identified monuments of the medieval era are scarce anywhere in the Outer Hebrides"; and Armit (1996) concludes "it is too early to present an archaeological narrative of the period from the end of Norse control until the Clearances".

Contact with the Roman world is apparent from individual artefacts, including, in Region 15, a bronze brooch from South Uist and Samian pottery from Loch na Berie broch (Lewis) and, in Region 16, a terracotta model from Skye and further pottery and glass. Whether this exchange or trade was derived from Roman or indigenous shipping activity is not known.

Carved symbol stones are indicative of Pictish activity but few occur in these regions. Examples have come from Skye and Raasay in Region 16. Excavation in Region 15 has begun to show Pictish-period settlements, for example the cellular buildings found on Lewis. At Eilean Olavat excavation has revealed a metalworking shop of 550-650 AD. The finds include, ingots, brooches and pins, which would usually be associated with high status sites and which thus suggest powerful individuals employing the smith.

Remains of documented monasteries, such as Applecross (673 AD) and Eigg (618 AD), are hard to trace. In Region 15 Christian slabs and crosses have been found on North Uist, South Pabbay and Taransay. Both regions have remains of small chapels, or enclosed cashels which housed Christian communities.

The impact of Norse settlement is apparent from place names. As many as 90% of place names on Lewis are Norse in origin, while in Region 16 Skye has a high proportion of Norse place names, which can also be traced along the mainland coast. In Region 15, settlement rather than raiding can be inferred from the burials of Norse women and children at Cnip, Lewis. A Norse long house has been excavated at Drimore, South Uist (Maclaren 1974), and the famous Lewis chessmen give a glimpse of leisure activities and artistic craftsmanship.

In Region 15 recent survey has investigated two small possible farming settlements of Medieval date, one near Loch Olavat and the other on the Vhaltos Peninsula (Armit 1996). Questions remain, however, about the evolution of nucleated settlement of tenant farmers (the Baile) and the blackhouses (turf-built dwellings with open hearths), which were to characterise the later landscapes of these regions.

6.2.4 Later centuries

At the end of the Medieval period these regions remained distinct from the rest of Scotland: this is "at once apparent if medieval burghs, royal castles, monasteries, cathedrals and sheriff's seats are plotted on a map, for the Highland area is almost blank. In later times a new distinction arose, for it was in the Lowlands that industries principally developed" (Donaldson 1993). Changes in the social and economic structure of the Highlands, beginning in the 17th century and accelerating after 1760, have been attributed to "the irresistible market pressures emanating from Lowland industrialisation and urbanisation" (Devine 1994).

The processes of change are complex, varying between individual landowners, the character of the land and its market potential. For the purposes of the archaeological record they are characterised by changes in the use of land, with the reduction of the traditional township (baile), the development of large-scale sheep farming, and the creation of crofts. This involved movement of the population. Devine (1994) explains the development of crofting as a deliberate mechanism to provide a large labour force for non-agricultural rural industries. By the 1850s the land ownership of these regions had been revolutionised, with only a few areas of Region 16, such as Arnamurchan, showing continuity (Devine 1994).

Tracing the changing agricultural practices and population distribution depends on broad-based landscape survey, which can identify the abandoned settlements. Identifying the rural industries is also a challenge; kelp-burning, for example, provided high profits and was labour-intensive, but required few permanent facilities (Thomson 1983).

Sea fishing as an alternative industry was encouraged by government, philanthropic societies and individual landowners. Its history is detectable now only through shore installations or surviving ports and harbours. In Region 15 Captain Alexander MacLeod and Lord Leverhulme encouraged fishing by introducing experienced men and commercially viable boats. They worked, respectively, on Harris in the 1770s and in Stornoway and then Obbe (now Leverburgh) in the early 20th century. Leverhulme also built shore facilities such as quays and curing plants. In Region 16 the British Fisheries Society planted Ullapool, which was also made a customs port, and Lochbag near Dunvegan.

In the 19th century the harbours and waters of these regions were busy, with the thriving herring fishery, ships exporting the regions' produce and steamers carrying seasonal workers to the Clyde, as well as naval activity and passing merchant ships. The value of shipping prompted investment in navigational safety: Eilean Glas (1789), Cape Wrath (1828), Barra Head (1833), Ardnamuchan Point (1849), Butt of Lewis (1862), Haskeir (1904) and Trodday (1909) are among the many lighthouses constructed by the Northern Lighthouse Board.

The new landowners of the 19th century brought capital to improve their estates but also a change in function. Emphasis was now placed on leisure, with visitors coming for shooting and fishing. Castles were upgraded and new facilities, such as the gardens at Inverewe, were created. Passenger steamers and the arrival of the West Highland Railway at the Kyle of Lochalsh were factors in further opening these regions up to the new force of tourism.

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 RCAHMS have been linked with Scottish Natural Heritage's Focus on Firths initiative, to ensure that archaeological information is gathered within the wider sphere of management activity. At local level coastal zone management initiatives are incorporating the human heritage, with, for example, archaeological discussion papers included in the development of strategies (Highland Regional Council 1994).

6.3.2 Activities and processes affecting the archaeological resource

The archaeological resource on land, in the intertidal zone and on the sea bed is vulnerable to both natural and man-driven processes. Unfortunately there has been little study of the processes and impacts or the options for protecting intertidal and sea-bed sites. For Region 16 Groom (1994) discusses coastal activities and their effects.

Sea-bed sites can be revealed or destroyed by changes in sediment regimes and marine erosion. Organic material, such as the hulls of wooden wrecks or prehistoric timber structures, are vulnerable to erosion and decay once covering marine sediments are removed. It is clear that human activities, for example aggregate dredging, dredging for navigation, pipe and cable-laying, or fishing with gear that has contact with the sea bed, can directly damage or destroy sites. Chemical 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 serious long-term threat to the Scottish archaeological resource, particularly in the north and west (Ashmore 1994). In Region 15 erosion of the machair by sea and wind is a major factor in both the identification and the loss of sites; sediment slumping is also a concern (Branigan & Foster 1995). 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 may also have an effect.

On land, peat extraction and afforestation are of concern. In Region 16 the need to consider safeguards for archaeological sites has been highlighted (Highland Regional Council (HRC) 1992). A survey commissioned by HRC found that the majority of fishing harbours, predominantly of 18th or 19th century construction, are functioning below capacity and now serve the leisure market (Groom 1994): such changes have implications for the retention and maintenance of historic maritime facilities.

6.3.3 Protection of historic and archaeological sites

The White Paper *This common inheritance* (DoE *et al.* 1990) expressed the government's commitment to preserving and enhancing the archaeological heritage. Remains are non-renewable and "the primary policy objectives are that they should be preserved wherever feasible and that, where this proves not to be possible, procedures should be in place to ensure proper recording before destruction, and subsequent analysis and publication" (Scottish Office 1994a). The development planning system provides the main policy framework for achieving this objective (see section 6.3.5).

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). In general, works affecting a SAM require the prior written consent of Historic Scotland. The AMAA definition of a monument includes sites both on land and in UK territorial waters, including remains of vehicles, vessels and aircraft. Although wreck sites have yet to be scheduled, Historic Scotland has scheduled sites that extend across the intertidal zone. The number of SAMs in Great Britain has been increasing at the rate of 300 a year since 1993. Table 6.3.1 shows the numbers of coastal Scheduled Ancient Monuments in the regions and in Scotland and Great Britain as a whole.

Table 6.3.1 Numbers of coastal Scheduled Ancient Monuments (SAMs) in the regions

District	*No. of SAMs in region*
Region 15	**222**
Region 16	**244**
Lochaber	149
Skye & Lochalsh	79
Ross & Cromarty	4
Sutherland	12
Region 15 & 16	***466***
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.

The Town & Country Planning (Scotland) Act 1972 allows buildings that are considered of special architectural or historic importance to be Listed. Historic Scotland has published detailed guidance on the treatment of Listed Buildings, for which controls are generally exercised via the local authority. There is now a presumption against the destruction of Listed Buildings, and consent is required prior to any demolition, alteration or extension.

The Protection of Wrecks Act 1973 permits designation of Historic Wreck Sites - shipwrecks considered of archaeological, historical or artistic importance. There are no standard criteria for designation, but Historic Scotland receives guidance from the Advisory Committee on Historic Wreck. 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 that may damage or obliterate the wreck (Archaeological Diving Unit 1994). 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. There are, as yet, no designated wrecks in this region. As fewer than 45 wrecks have been designated for the whole of Britain their distribution cannot be assumed to reflect the total sea-bed resource.

In Region 15, St. Kilda has been designated a World Heritage Site (see also section 7.2.6). St. Kilda has been occupied from at least the Iron Age and has documented settlement from the 16th century; its later remains show the impact of industrialised Britain on a materially 'primitive' society (Emery 1996).

6.3.4 Key organisations and their responsibilities

Historic Scotland executes the responsibility of the Secretary of State for Scotland in respect of the protection, management and interpretation of the 'built heritage' (i.e. ancient monuments, archaeological sites and landscapes, historic buildings, parks, gardens and designed landscapes). Historic Scotland compiles and amends the Schedule of Ancient Monuments and the statutory list of buildings of special architectural and historic interest. Historic Scotland can provide financial assistance towards the upkeep of ancient monuments and towards archaeological investigations. Historic Scotland also has responsibility for wrecks designated under the Protection of Wrecks Act (1973).

The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) is the national body of survey and record, aiming to compile and make accessible a database of Scotland's archaeological sites and buildings - the National Monuments Record Scotland (NMRS). The NMRS helps support the development of local Sites and Monuments Records (SMRs). In 1992 a new Royal Warrant extended its remit to the territorial seas and the NMRS has since been enhanced by an initial maritime section.

Local authorities have "far-reaching powers, both statutory and discretionary . . . to deliver a conservation service" (Historic Scotland 1996a). The cornerstone of their work via the development control system is the SMR - an inventory of all known archaeological features in their area - which is 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). Highland Council maintains an SMR and its archaeology service performs a range of tasks to protect and promote the heritage of Region 16. An SMR has yet to be created for the Western Isles.

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

To landward of low water mark 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.

"The preservation of ancient monuments and their settings is a material consideration in determing planning applications and appeals, whether a monument is scheduled or not" (Scottish Office 1994a). 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: "the preservation *in situ* of important archaeological remains is always to be preferred" (Scottish Office 1994a), but stress is also 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 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).

In general, the safeguards for archaeological remains provided by the planning system do not extend below low water mark. Without an appropriate management structure it has been difficult to facilitate consideration of archaeology by the many authorities involved in the sectoral regulation of the marine zone. However growing awareness of marine archaeology is leading to voluntary consideration of the archaeological resource. This has been stimulated by the development of databases of sea-bed sites and by initiatives such as the *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 Ancient Monuments and Historic Wrecks should be directed to Historic Scotland. Finds from excavations funded by Historic Scotland, made casually on monuments in care, or from excavation undertaken with Scheduled Monument Consent, if not claimed by the Crown, go before the Finds Disposal Panel, which determines to which museum they should go (Historic Scotland 1994). 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 (objects of gold and silver) and *Bona Vacantia* (unclaimed goods) means that, in effect, all antiquities found on land can be claimed by the Crown (Longworth 1993). All finds should be reported 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. Should the items be sought by a museum, it also advises to which institution they should go and the reward to be made to the finder.

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 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. During the statutory year, historic items may be lodged with a museum or conservation facility with suitable storage conditions.

There is a policy of offering wreck of historic, archaeological or artistic interest to registered museums. The responsibility of the Receiver to the finder, with regard to salvage awards, remains regardless of the historic character of the wreck. Information and reporting forms are available for the Receiver of Wreck, including a form that finders may use to volunteer to RCAHMS information on the identity and condition of wreck sites.

Although restored this century, the curtain walls of Kiessimul Castle, in Castle Bay, Barra (Region 15), date originally from the late 13th century, and the central stone keep may be even older. The family seat of the Macneils, the castle's location makes it well-nigh impregnable. Behind it the Oban ferry slides into view, emphasising the difficulty of access to and within the Western Isles even today. Photo: Pat Doody, JNCC.

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 1994). This listed a number of fieldwalking surveys on Lewis and Harris in the 1970s and the Uists in the 1980s. Historic Scotland have now produced a specification for coastal zone assessment surveys that sets out a standard level for future survey (Historic Scotland 1996b). Historic Scotland support in 1996 includes survey work on Lewis (Region 15) and in Region 16 survey of the coast from Ullapool to Lochinver.

Sheffield University has undertaken survey and excavation on Barra (Branigan & Foster 1995). The University of Edinburgh has undertaken survey on Lewis, including the Vhaltos Peninsula and Loch Olavat (Armit 1994, 1996). There has been underwater survey in the Outer Hebrides, with specific reference to island settlements (Dixon & Topping 1986; Dixon 1991).

Archaeological work on the sea bed has traditionally been site-specific, for example investigating the historic wrecks designated under the Protection of Wrecks 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 (Table 6.4.1). Further sources are being used to extend this initial record. It is also intended to collate environmental data on seabed 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 15	113
Region 16	206
Scotland	***1,530***

Source: RCAHMS NMR - Maritime Record

The Highland SMR has been extended to sea-bed sites. The pilot project which developed this maritime recording included a test area in Region 16: Lochaber and the Small Isles (Groom 1994).

6.4.2 Acknowledgements

Thanks are due to the staff from all the organisations mentioned in the text who provided information and advice, especially to Deanna Groom during her work with Highland Regional Council.

6.4.3 Further sources of information

A. References cited

Archaeological Diving Unit. 1994. *Guide to historic wrecks designated under the Protection of Wrecks Act 1973*. St. Andrews, University of St. Andrews.

Armit, I. 1994. Archaeological field survey of the Vhaltos Peninsula. *Proceedings of the Society of Antiquaries of Scotland, 124:* 67-94.

Armit, I. 1996. *The archaeology of Skye and the Western Isles*. Edinburgh, Edinburgh University Press.

Ashmore, P.J. 1994. *Archaeology in the coastal erosion zone. Towards a Historic Scotland policy.* Edinburgh, Historic Scotland.

Ashmore, P. 1996. *Neolithic and Bronze-Age Scotland*. Edinburgh, Historic Scotland.

Branigan, K., & Foster, P. 1995. *Barra: archaeological research on Ben Tangaval.* Sheffield, Sheffield Academic Press.

Breeze, D.J. 1993. Ancient monuments legislation. *In*: *Archaeology resource management in the UK - an introduction,* ed. by J. Hunter & I. Ralston, 56-65. Stroud, Alan Sutton.

Crone, D. 1993. A wooden bowl from Loch a'Ghinne. *Proceedings of the Society of Antiquaries of Scotland, 123:* 269-75.

Darvill, T. 1987. *Prehistoric Britain.* London, Batsford.

Department of the Environment and others. 1990. *This common inheritance: Britain's environmental strategy.* London, HMSO. (White Paper, CM1200.)

Devine, T. 1994. *Clanship to Crofters' War. The social transformation of the Scottish Highlands.* Manchester, Manchester University Press.

Dixon, N. 1991. *Coastal survey - Western Isles.* Edinburgh Unversity Department of Archaeology Annual Report.

Dixon, T., & Topping, P. 1986. Preliminary survey of later prehistoric artificial islands on the Isle of Lewis, Outer Hebrides. *International Journal of Nautical Archaeology, 15*(3): 189-194.

Donaldson, G. 1993. *Scotland. The shaping of a nation.* Nairn, David St. John Thomas.

Emery, N. 1996. *Excavations on Hirta 1986-90. The archaeology and ethnology of St. Kilda.* Edinburgh, National Trust for Scotland/ HMSO.

Foster, S. 1996. *Picts, Gaels and Scots*. Edinburgh, Historic Scotland.

Groom, D. 1994. *Sources and methodologies for establishing a maritime monuments record for the Highland Regional Council Archaeology Section.* (Msc Dissertation. Scottish Institute of Maritime Studies.)

Highland Regional Council. 1992. *Highland region indicative forestry strategy and survey report.* Inverness, Highland Regional Council.

Highland Regional Council. 1994. *Coastal zone management pilot study: archaeology. A discussion paper.* Inverness, Highland Regional Council (internal draft paper).

Historic Scotland. 1994. *A policy statement for the allocation and disposal of finds.* Edinburgh, Historic Scotland.

Historic Scotland. 1995. *A list of ancient monuments in Scotland.* Edinburgh, Historic Scotland.

Historic Scotland. 1996a. *Circular No. HS1/96. Local government reorganisation: guidance to local authorities on the conservation of the historic environment.* Edinburgh, Historic Scotland.

Historic Scotland. 1996b. *Coastal zone assessment survey*. Edinburgh, Historic Scotland. (Archaeology Procedure Paper No. 4.)

Joint Nautical Archaeology Policy Committee. 1995. *A code of practice for seabed developers.* Swindon, National Monuments Record Centre.

Longworth, I. 1993. Portable antiquities. *In: Archaeological resource management in the UK: an introduction*, ed. by J. Hunter & I. Ralston, 56-65. Stroud, Alan Sutton Publishing Ltd.

Maclaren, A. 1974. A Norse house on Drimore machair, South Uist. *Glasgow Archaeological Journal, 3:* 9-18.

Scottish Office. 1994a. *National planning policy guidance 5. Archaeology and planning.* Edinburgh, Scottish Office.
Scottish Office. 1994b. *Archaeology - the planning process and Scheduled Ancient Monument procedures.* Edinburgh, Scottish Office. (Planning Advice Note No. 42.)
Scottish Office. 1996. *Scotland's coast: a discussion paper.* Edinburgh, Scottish Office.
Thomson, W. 1983. *Kelp-making in Orkney.* Kirkwall, Orkney Press.

B. Further reading

Breeze, D.J. 1996. *Roman Scotland*. Edinburgh, Historic Scotland.
Caldwell, D., & Ewart, G. 1993. Finlaggan & Lordship of the Isles. *Scottish Historical Review, 72*(2)*:* 146-166.
Cleere, H. 1993. British archaeology in a wider context. *In: Archaeological resource management in the UK. An introduction*, ed. by J. Hunter & I. Ralston. Stroud, Alan Sutton.
Council for British Archaeology. 1994. The hunt for the Palaeolithic in Scotland. *British Archaeological News*, 136-7. (New series.)
Cunliffe, B. 1991. *Iron Age communities in Britain.* London, Routledge.
Dunlop, J. 1978. *The British Fisheries Society.* Edinburgh, John Donaldson Publishers Ltd.
Historic Scotland. 1993. *Memorandum of guidance on Listed Buildings and Conservation Areas.* Edinburgh, Historic Scotland.
Historic Scotland. 1994. *Integrated coastal zone management. A strategy for the conservation of the built heritage.* Edinburgh, Historic Scotland.
National Museums of Scotland. Undated. *Treasure Trove in Scotland*. Edinburgh, HMSO.
Robertson, A. 1970. Roman finds from non-Roman sites in Scotland. *Britannia*, *1:* 198-226.
Roesdahl, E., & Wilson, D. 1992. *From Viking to Crusader.* Uddevalla, Nordic Council of Ministers.
Shepherd, I. 1986. *Exploring Scotland's heritage, Grampian.* Edinburgh, RCAHMS, HMSO.
Woodman, P. 1989. A review of the Scottish Mesolithic: a plea for normality! *Proceedings of the Society of Antiquaries of Scotland*, *119:* 1-32.
Yeoman, P. 1995. *Medieval Scotland.* Edinburgh, Historic Scotland.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
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
National Monuments Record of Scotland	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
Region 15 archaeology in the context of planning	*Development Control, Environmental Services, Western Isles Council, Stornoway, tel: 01851 703773
Highland SMR (Region 16)	The Old School, High Street, Clachnaharry, Inverness IV3 6RB, tel: 01463 711176
Information about, and reporting of, recovered wreck. Advice on finds; reporting point for Treasure Trove.	Archaeology Department, National Museums of Scotland, Queen Street, Edinburgh EH2 1JD, tel: 0131 225 7534
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
Reporting of recovered wreck in Britain	Receiver of Wreck, Coastguard Agency, Spring Place, 105 Commercial Road, Southampton SO15 1EG, tel: 01703 329474

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

Chapter 7 Coastal protected sites

R.G. Keddie & J. Plaza

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 Regions 15 (Western Isles) and 16 (west Highland), 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 November 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 1994), although dealing specifically with planning policy in England, also gives useful summaries of some of the existing site protection mechanisms 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 EC Birds Directive and the EC Habitats & Species Directive (including lists of important species and habitat types). The statutory framework for site protection in Scotland is set out in Scottish Office Circular 6/90/95 (Scottish Office 1995). The Scottish Office is currently working on two National Planning Policy Guidance (NPPG) notes: one on natural heritage, and one on coastal matters. Publication is planned for 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, which are discussed in sections 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. For further information, see references in section 7.1.3 A.

This chapter is divided into five sections. Regional summaries of all categories of site are 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 regions.

7.1.2 Importance of the regions

Region 15 contains the only coastal World Heritage Site in Great Britain (for nature conservation interest) and a large proportion by area of Britain's coastal National Scenic Areas (16%) and Marine Consultation Areas (25%). There is also a substantial area covered by Biosphere Reserves. Region 16 contains all of the coastal John Muir Trust sites and a large proportion by area of Britain's coastal Biosphere Reserves (39%), National Nature Reserves (25%), National Scenic

Areas (56%), Marine Consultation Areas (16%), National Trust/National Trust for Scotland sites (29%) and Wildlife Trusts (in these regions the Scottish Wildlife Trust) sites (37.%). (Marine Consultation Areas, National Scenic Areas, National Trust for Scotland and, currently, John Muir Trust sites are confined to Scotland.) There are also substantial areas of Sites of Special Scientific Interest. Table 7.1.1 summarises site protection in the regions, 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 Regions 15 & 16

	Number of protected sites					*Area* covered by site protection*				
	Region	*West Coast*	*% of West Coast total in region*	*GB coast*	*% of GB coast total in region*	*Region (ha)*	*West Coast (ha)*	*% of West Coast total in region*	*GB coast (ha)*	*% of GB coast total in region*
Region 15										
Biosphere Reserves	2	7	28.6	8	25.0	2,530	21,746	11.6	27,243	9.3
Ramsar sites	2	24	8.3	61	3.3	5,386	154,378	3.5	343,524	1.6
Special Protection Areas	5	38.5	13.0	99	5.1	2,756	163,376	1.7	363,103	0.8
Possible Special Areas of Conservation	9	63	14.3	112	8.0	n/av	n/av	n/av	n/av	n/av
Environmentally Sensitive Areas	1	10	10.0	17	5.9	18,110	1,118,067	0.0	1,397,545	1.3
World Heritage Sites	1	1	100.0	1	100.0	853	853	100.0	853	100.0
National Nature Reserves	4	37	10.8	80	5.0	3,237	52,086	6.2	87,155	3.7
Sites of Special Scientific Interest	43	651	6.6	1,212	3.5	31,155	380,941	8.2	716,701	4.3
National Scenic Areas	3	23	13.0	27	11.1	116,600	693,400	16.8	745,800	15.6
Geological Conservation Review sites	29	545	5.3	1,098	2.6	n/ap	n/ap	n/ap	n/ap	n/ap
Marine Consultation Areas	7	23	30.4	29	24.1	27,557	103,287	26.7	111,896	24.6
National Trust and National Trust for Scotland[ab]	1	262[a]	0.4	453[a]	0.2	846	45,517[a]	1.9	64,127[a]	1.3
Royal Society for the Protection of Birds reserves	1	29	3.4	82	1.2	658	14,125	4.7	38,680	1.7
Ministry of Defence sites	4	45	8.9	110	3.6	1,261	18,961	6.7	53,410	2.4
Region 16										
Biosphere Reserves	1	7	14.3	8	12.5	10,684	21,746	49.1	27,243	39.2
Special Protection Areas	3.5**	38.5	9.1	99	3.5	11,692	163,376	7.2	363,103	3.2
Possible Special Areas of Conservation	8.5**	63	13.5	112	7.6	n/av	n/av	n/av	n/av	n/av
National Nature Reserves	5	37	13.5	80	6.3	22,246	52,086	42.7	87,155	25.5
Sites of Special Scientific Interest	78	651	12.0	1,212	6.4	62,814	380,941	16.5	716,701	8.8
National Scenic Areas	9.5**	23	41.3	27	35.2	417,700**	693,400	60.2	745,800	56.0
Geological Conservation Review sites	97	545	17.8	1,098	8.8	n/ap	n/ap	n/ap	n/ap	n/ap
Marine Consultation Areas	7	23	30.4	29	24.1	17,634	103,287	17.1	111,896	15.8
Regional landscape designations	9	24	37.5	62	14.5	458	434,341	0.1	507,182	0.1
National Trust and National Trust for Scotland[ab]	6	262[a]	2.3	453[a]	1.3	18,283	45,517[a]	40.2	64,127[a]	29.0
Royal Society for the Protection of Birds reserves	3	29	10.3	82	3.7	400	14,125	2.8	38,680	1.0
The Wildlife Trusts reserves	6	96	6.3	241	2.6	9,563	14,310[b]	66.8	25,882	36.9
Ministry of Defence sites	3	45	6.7	110	2.7	47	18,961	0.2	53,410	0.1
Woodland Trust properties	1	36	2.8	71	1.4	19	480	3.75	1,590	1.2
John Muir Trust sites	4	4	100.0	4	100.0	14,173	14,173	100.0	14,173	100.0

Source: JNCC. Key: n/ap = not applicable; n/av = not available; *to the nearest hectare; **site lying partly within Region 16; half the relevant site area has been included in the total; [a]includes National Trust sites for England and Wales; [b]only sites of natural heritage interest have been counted. Notes: site types not currently found in the regions: Biogenetic Reserves, Areas of Special Protection, Country Parks, Local Nature Reserves, Marine Nature Reserves, Wildfowl and Wetland 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

A. References cited

Collis, I., & Tyldesley, M. 1993. *Natural assets: non-statutory sites of importance for nature conservation.* Newbury, Local Government Nature Conservation Initiative.

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.

Department of the Environment. 1994. *Planning Policy Guidance Note 9 - nature conservation*. London, HMSO.

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.)

B. Further reading

Gubbay, S. 1988. *A coastal directory for marine conservation.* Ross-on-Wye, Marine Conservation Society.

Scottish Natural Heritage. 1995. *Natura 2000: a guide to the 1992 EC Habitats Directive in Scotland's marine environment.* Perth, Scottish Natural Heritage.

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 represent globally significant examples of biomes for both terrestrial and coastal environments. 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 under Project No. 8 of their Man and the Biosphere (MAB) ecological programme, and were launched in 1970. Criteria and guidelines for selection of sites were produced by a UNESCO task force in 1974. Although Biosphere Reserves are not always statutory protected areas, all British sites are also National Nature Reserves (section 7.3.1). There are two coastal Biosphere Reserves (2,530 ha) in Region 15 (Western Isles) and one (10,684 ha) in Region 16 (west Highland) (Table 7.2.1; Map 7.2.1).

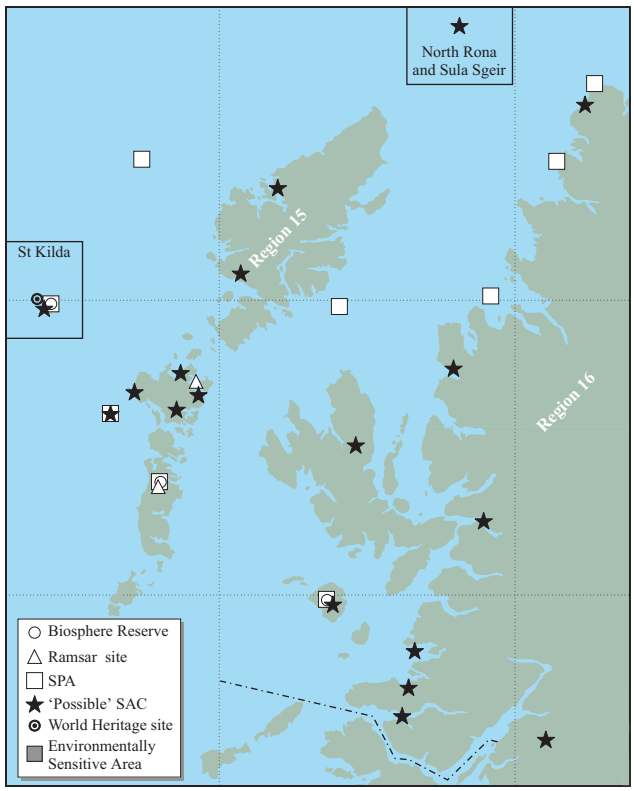
Table 7.2.1 Biosphere Reserves

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date designated*
Region 15	***2***		***2,530***	
Loch Druidibeg, South Uist		NF782378	1,677	1976
St. Kilda		NF095995	853	1976
Region 16	***1***		***10,684***	
Rum		NM370980	10,684	1976
Regions 15 & 16	***3***		***13,214***	
West Coast	7		21,746	
GB coast	8		27,243	
GB whole country	13		44,258	

Sources: JNCC, Scottish Natural Heritage. Key: *to the nearest whole 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



Map 7.2.1 Sites designated under international conventions and directives. Sources: JNCC, SNH.

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 two coastal Ramsar sites (5,386 ha) in Region 15 but none in Region 16 (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 regions' 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 Sites of Special Scientific Interest (SSSIs). There are five coastal SPAs (2,756 ha) in Region 15 and three whole and part of one coastal SPAs (11,692 ha) in Region 16 (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 7.2.2 Ramsar sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date designated*	*Selection criteria used*
Loch an Duin, North Uist		NF935740	3,606	1990	Representative wetland; regularly supports substantial numbers of individual waterfowl indicative of wetlands
Loch Druidibeg agus a' Machair, Loch Stilligary, South Uist		NF782378	1,780	1976	Representative wetland; regularly supports 1% of a waterfowl species population
Region 15	***2***		***5,386***		
West Coast	24		154,378		
GB coast	61		343,524		
GB whole country	103		357,911		

Sources: JNCC May 1996 data; SNH. Key: *to the nearest whole 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 7.2.3 Special Protection Areas (SPAs)

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date designated*	*Selection criteria used*
Region 15	**5**		**2,756**		
Shiant Isles		NG418978	202	1992	Internationally important numbers of breeding shag *Phalacrocorax aristotelis*, razorbill *Alca torda* and puffin *Fratercula arctica*, and wintering/passage Greenland barnacle geese *Branta leucopsis*; nationally important numbers of breeding fulmar *Fulmarus glacialis* and guillemot *Uria aalge*
Loch Druidibeg agus a' Machair, South Uist		NF7938	1,043	1982	Regularly supports nationally important breeding populations of corncrake *Crex crex* and little tern *Sterna albifrons*. Internationally important numbers of breeding greylag geese *Anser anser*, ringed plover *Charadrius hiaticula* and dunlin *Calidris alpina*. Internationally important wintering populations of ringed plover.
Monach Isles		NF626623 NF661630	577	1994	Internationally important numbers of wintering/passage Greenland barnacle geese; nationally important numbers of breeding guillemot, common tern *Sterna hirundo* and little tern
Flannan Isles		NA692467	81	1992	Nationally important numbers of breeding storm petrel *Hydrobates pelagicus*, Leach's petrel *Oceanodroma leucorhoa*, guillemot, razorbill, puffin, fulmar, gannet *Sula bassana* and kittiwake *Larus tridactyla*
St. Kilda		NA155050	853	1992	Internationally important numbers of breeding seabirds (exceeding 400,000 pairs), including Leach's petrel, fulmar, puffin and gannet; nationally important numbers of storm petrel, kittiwake, guillemot and razorbill; endemic sub-species of wren *Troglodytes troglodytes*
Region 16	**3.5****		**11,692**		
Rum		NM370980	10,684	1982	One of world's largest Manx shearwater *Puffinus puffinus* colonies (62,000-100,000 pairs); golden eagle *Aquila chrysaetos*, merlin *Falco columbarius* and peregrine *F. peregrinus*
Priest Island (Summer Isles)		NB925022	138	1986	Nationally important numbers of storm petrel (*c.* 10,000 pairs).
Handa Island		NC138480	363	1990	Internationally important numbers of arctic skua *Stercorarius parasiticus*; nationally important numbers of great skua *Stercorarius skua*, breeding kittiwake, guillemot and razorbill
Cape Wrath (Clo Mor)**		NC260740	507**	1996	Nationally important numbers of kittiwake, guillemot, razorbill and puffin
Regions 15 & 16	***8.5****		***14,448****		
West Coast	38.5		163,376#		
GB coast	99		363,103#		
GB whole country	136		495,843#		

Sources: JNCC June 1996 data, SNH, Pritchard *et al.* (1992). Key: *to the nearest whole hectare; **Cape Wrath overlaps boundary with Region 3; half the total area has been included here; #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 Area of Conservation (SAC) 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 in a European context. 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 is implemented through the Conservation (Natural Habitats &c.) Regulations 1994 (DoE 1994). A list of 'possible' SACs was announced by the Government on 31 March 1995. There are nine possible SACs proposed in Region 15, and eight possible SACs in Region 16, from a total of 112 sites in GB. In addition, one possible SAC falls in both Region 16 and Region 14 (Table 7.2.4; Map 7.2.1) (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 ESA (18,110 ha) in Region 15 but none in Region 16 (Table 7.2.5; Map 7.2.1).

7.2.6 World Heritage Sites (natural)

World Heritage Sites are areas of global natural and cultural significance, nominated by the state within which they are situated, the nominations then being considered by a World Heritage Committee of Party States. Sites that are accepted

Table 7.2.4 Possible Special Areas of Conservation (SACs)

Site name	*No. of sites*	*Qualifying interest*
Region 15	**9**	
Loch Maddy		Lagoons; large shallow inlets and bays
Loch Eport Lagoons		Lagoons
North Uist Machair		Machair
South Uist Machair		Slender naiad *Najas flexilis.* Hard oligo-mesotrophic waters with benthic vegetation of stonewort *Chara* formations. Machair. Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation. Oligotrophic waters containing very few minerals of Atlantic sandy plains with amphibious vegetation; *Lobelia* spp., shoreweed *Littorella uniflora* and quillwort *Isoetes* spp.
Monach Islands		Grey seal *Halichoerus grypus.* Machair.
North Harris		Northern Atlantic wet heaths with heather *Erica tetralix*
Loch Roag Lagoons		Lagoons
St. Kilda		Reefs. Submerged or partly submerged sea caves. Vegetated sea cliffs of the Atlantic and Baltic coasts.
North Rona		Grey seal *Halichoerus grypus*
Region 16	**8.5***	
Loch Etive Woods*		Old oak woods with holly *Ilex aquifolium* and hard fern *Blechnum spicant* in the British Isles.
Loch Sunart Woodlands		Otter *Lutra lutra*. Old oak woods with holly and hard fern in the British Isles.
Claish Moss and Kentra Moss		Blanket bog (active only)
Sound of Arisaig		Sandbanks which are slightly covered by seawater all the time
Rum		Dry heaths (all subtypes). Eutric scree. Northern Atlantic wet heaths with heather. Species-rich mat-grass *Nardus stricta* grassland, on siliceous substrates in mountain areas (and submountain areas in continental Europe).
Lochs Duich, Long and Alsh Reefs		Reefs
Trotternish Ridge		Chasmophytic vegetation on rocky slopes - calcareous sub-types. Eutric scree. Species-rich mat-grass grassland, on siliceous substrates in mountain areas (and submountain areas in continental Europe).
Strath		Alpine calcareous grasslands. Chasmophytic vegetation on rocky slopes - calcareous sub-types. Limestone pavements. Petrifying springs with tufa formations (Cratoneurion).
Oldshoremore and Sandwood		Machair
Regions 15 & 16	***17.5****	
West Coast	63	
GB coast	112	

Sources: JNCC March 1995 data, SNH. Key: *part of the Loch Etive Woods SAC is in 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.

Table 7.2.5 Environmentally Sensitive Areas

Site name	*No. of sites*	*Area (ha*)*	*Date designated*	*Selection criteria used*
Machair of the Uists, Benbecula, Barra and Vatersay		18,110	1988	Dry machair plain with nearby wetland important for breeding waders and corncrakes *Crex crex*; unimproved, herb-rich and coastal grasslands, dunes and maritime heath, extensive range of wild flowers, many rare; archaeologically rich with well preserved structures
Region 15	***1***	***18,110***		
West Coast	10	1,118,067		
GB coast	17	1,397,545		

Sources: MAFF, SOAEFD, SNH. Key: *to the nearest whole 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 7.2.6 World Heritage Sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date designated*	*Selection criteria used*
St. Kilda		NF095995	853	1987	Habitat where populations of rare or endangered species of plants and animals still survive. Contains unique, rare or superlative natural phenomena, formations or features or areas of exceptional natural beauty. Outstanding example representing a major stage of earth's evolutionary history.
Region 15	***1***		***853***		
West Coast	1		853		
GB coast	1		853		

Sources: JNCC, SNH. Key: *to nearest whole 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.

are placed on the World Heritage List. World Heritage Sites must have strict legal protection and any management of the site must ensure that this continues (Gubbay 1988). There is one coastal World Heritage Site of nature conservation importance in Region 15, St. Kilda (853 ha), but none in Region 16 (Table 7.2.6; Map 7.2.1). St. Kilda is the only natural World Heritage Site on the coast in Great Britain.

7.2.7 Acknowledgements

Thanks are due to Kathy Duncan (SNH), Siâron Hooper (EN), Alan Law (JNCC), MAFF and SOAEFD.

7.2.8 Further sources of information

A. References cited

Department of the Environment. 1994. *The Conservation (Natural Habitats &c.) Regulations*. London, HMSO. (Statutory Instrument No. 2716.)

Gubbay, S. 1988. *A coastal directory for marine conservation.* Ross-on-Wye, Marine Conservation Society.

Joint Nature Conservation Committee. 1995. *Council Directive on the conservation of natural habitats and wild fauna and flora (92/43/EEC) - the Habitats Directive: a list of possible Special Areas of Conservation in the UK. List for consultation (31 March 1995).* Peterborough (unpublished report to the Department of the Environment).

Pritchard, D.E., Housden, S.D., Mudge, G.P., Galbraith, C.A., & Pienkowski, M.W., *eds.* 1992. *Important bird areas in the UK including the Channel Islands and the Isle of Man.* Sandy, RSPB.

B. Further reading

DOE. 1995. *The Habitiats Directive: how it will apply in Great Britain*. London, Department of Environment, The Scottish Office and the Joint Nature Conservation Committee.

Goodier, R., & Mayne, S. 1988. United Kingdom Biosphere Reserves: opportunities and limitations. *Ecos, 9:* 33-39.

IUCN. 1979. *The Biosphere Reserve and its relationship with other protected areas*. Morges, International Union for the Conservation of Nature and Natural Resources.

IUCN. 1982. *The world's greatest natural areas. An indicative inventory of natural sites of World Heritage quality.* IUCN Commission on National Parks and Protective Areas, for World Heritage Committee.

L'Hyver-Yésou, M.-A. 1993. Biogenetic Reserves. *Naturopa, 71*: 22-23.

Ministry of Agriculture, Fisheries and Food. 1989. *Environmentally Sensitive Areas.* London, HMSO.

Nature Conservancy Council. 1988. *Internationally important wetlands and Special Protection Areas for birds.* Peterborough, Nature Conservancy Council.

Scottish Natural Heritage. 1995. *Natura 2000: a guide to the 1992 EC Habitats Directive in Scotland's marine environment*. Perth, Scottish Natural Heritage.

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.)

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, ESAs, Ramsar sites, SPAs, SACs, World Heritage Sites	*SNH, North-west Region Office, Inverness, tel: 01463 239431
Ramsar sites, SPAs	*Regional Officer, RSPB, Inverness, tel: 01463 715000
ESAs	*ESA Co-ordinator, Scottish Office Agriculture, Environment and Fisheries Department, Balivanich, tel: 01870 602346
Special Areas of Conservation	*Environment Department (Scottish Office Agriculture, Environment and Fisheries Department) Pentland House, 47 Robbs Loan, Edinburgh, tel: 0131 244 4072

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

Active blanket bog is typified by undulating spreads of *Sphagnum* mosses and other wetland plants (such as broad-leaved cottongrass *Eriophorum latifolium*, whose downy seed heads can be seen here), interspersed with small pools. In Europe this very rare habitat is a priority for conservation under the Habitats & Species Directive. All sites put forward for designation under the Directive, such as the Lewis Peatlands (pictured), must first have been notified as Sites of Special Scientific Interest (SSSIs). Photo: David Stroud, JNCC.

7.3 Sites established under national statute

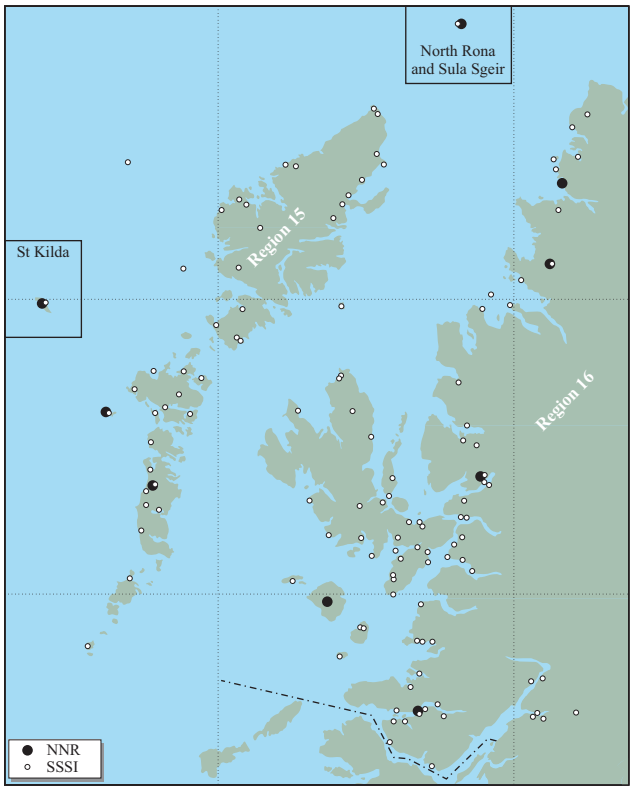
Included in this section are the types of site identification made under national legislation relating to wildlife, landscape and amenity value. Identifications are made by the statutory conservation agency (in these regions Scottish Natural Heritage), local authorities or the government acting on advice 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 & Countryside Act 1981. All NNRs are also Sites of Special Scientific Interest (SSSIs). There are four coastal NNRs (3,237 ha) in Region 15 (Western Isles) and five (22,246 ha) in Region 16 (west Highland) (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



Map 7.3.1 Coastal National Nature Reserves (NNRs) and Sites of Special Scientific Interest (SSSIs). 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*
Region 15	***4***		***3,237***		
Loch Druidibeg, South Uist		NF782378	1,677	1958	Sandy shores, islets, dunes, machair, freshwater lochs
Monach Isles		NF626623	577	1966	Islands, reefs, shell sand dunes, uncultivated machair
St. Kilda		NF095995	853	1957	Grazed coastal grassland, seabird colonies, gannetry, endemic species
North Rona & Sula Sgeir		HW810324	130	1956	Bare rock and coastal grassland islands, large breeding colony of grey seals, gannetry, other seabirds
Region 16	***5***		***22,246***		
Glencripesdale		NM700602	631	1993	Ashwood slopes
Rum		NM370980	10,684	1957	Geological interest, montane flora, breeding birds
Allt Nan Carnan		NG895405	7	1967	Wooded gorge
Inverpolly		NC135125	10,857	1961	Lochs, streams, bogs, moorland, woodland, screes, cliffs, summits and geology
Loch a'Mhuilinn		NC166394	67	1980	North-west Highland birchwood, heathland, freshwater loch, swamp, bog
Regions 15 & 16	***9***		***25,483***		
West Coast	37		52,086		
GB coast	80		87,155		
GB whole country	287		195,740		

Sources: SNH, JNCC. Key: *to the 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.

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. 8.07% of the total land mass of Britain was SSSI, as at September 1994.

There are 43 coastal SSSIs in Region 15 and 78 in Region 16, 121 (93,969 ha) in total, as at November 1996 (Table 7.3.2; Map 7.3.1). Out of this total of 121, 64% include intertidal land to Mean Low Water Mark, while 24% are purely terrestrial. 66% were selected at least partly for their biological interest and 55% at least partly for their earth science (geological or geomorphological) interest. Of the total, nearly 21% have both biological and earth science interest. Examples of a very wide range of habitats and species occur within the SSSIs in these regions, the most frequently occurring habitats being dry grassland, maritime heath, woodland and peat bog, these habitats occurring in 60% 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 coastal SSSIs may be found in the *Coastal and marine UKDMAP* datasets module disseminated by the JNCC (British Oceanographic Data Centre 1992; Barne *et al.* 1994).

Table 7.3.2 SSSIs in Regions 15 & 16

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date last notified*
Region 15	**43**		**31,155**	
Tong Saltings		NB440358	417	1984
Port of Ness		NB537636	5	1990
Stornoway Castle Woodlands		NB416330	209	1984
Shiant Isles		NG418978	202	1984
Eoligarry		NF700061	449	1990
Allt Volagir		NF798292	23	1984
Loch Hallan		NF738224	364	1988
Bornish & Ormiclate Machairs		NF753309	663	1988
Howmore Estuary & Lochs Roag and Fada		NF756356	424	1985
Loch Druidibeg		NF782378	1,677	1987
Loch Bee		NF770430	1,173	1984
West Benbecula Lochs		NF771521	116	1985
Monach Isles		NF626623	577	1983
Loch an Duin		NF935740	3,606	1985
Loch Scadavay		NF856686	527	1984
Loch Obisary		NF896620	354	1986
Lochs at Clachan		NF810640	104	1984
Baleshare & Kirkibost		NF785623	1,466	1985
Balranald Bog & Loch nam Feithean		NF712705	838	1984
Vallay		NF775765	307	1990
Machairs Robach & Newton		NF873763	758	1985
Small Seal Islands		NA875115	155	1984
Loch A'Sgurr Pegmatite		NG070865	1	1985
Loch Meurach		NG061877	2	1985
Northton Bay		NF990920	415	1984
Luskentyre Banks & Saltings		NG080973	1,172	1984
Mingulay & Berneray		NL560830	819	1983
North Harris		NB065115	12,921	1984
Loch Stiapavat		NB528643	36	1984
Loch na Cartach		NB534499	23	1984
Tolsta Head		NB557468	4	1985
Gress Saltings		NB487414	87	1984
Loch Orasay		NB387283	97	1983
Mangersta Sands		NB009309	19	1985
Glen Valtos		NB070344	53	1990
Cnoc A'Chapuill		NB090331	0	1990
Loch Dalbeg		NB227457	4	1983
Loch Tuamister		NB264456	8	1983
Little Loch Roag Valley Bog		NB140250	19	1983
Flannan Islands		NA692467	81	1983
St. Kilda		NF095995	853	1984
North Rona & Sula Sgeir		HW810324	130	1983
Rockall		-	1	1984

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date last notified*
Region 16	**78**		**62,814**	
St. John's Church		NN065587	2	1988
Carnach Wood		NN098584	85	1984
Leven Valley		NN210606	581	1990
Callert		NN074595	12	1988
Ach an Todhair		NN091717	176	1989
Doire Donn		NN054705	168	1986
Inninmore Bay		NM719423	127	1986
Drimin to Killundine Woods		NM575503	184	1988
Poll Luachrain & Druimbuidhe		NM590577	333	1988
Rahoy Woodlands		NM630580	279	1984
Glencripesdale		NM700602	631	1996
Camas Salach		NM695620	116	1987
Laudale Wood		NM760595	245	1987
Salen to Woodend		NM738633	764	1990
Ben Hiant & Ardamurchan Coast		NM600610	1,575	1989
Kentra Bay & Moss		NM650685	999	1990
Loch Moidart		NM672734	799	1986
Glen Beasdale		NM720846	510	1986
Druimindarroch		NM688842	13	1986
Loch Dubh		NM672848	6	1986
Camas Mor, Muck		NM412792	59	1986
Eigg - Laig to Kildonnan		NM495885	377	1989
Eigg - Cleadale		NM483888	93	1988
Eigg - An Sgurr & Gleann Charadail		NM482890	968	1988
Rum		NM370980	10,794	1987
Canna & Sanday		NG250060	1,356	1987
Mallaig Coast		NM684977	50	1981
Rubha Camas Na Cailnn		NG852084	27	1984
Coille Mhialairidh		NG820122	77	1984
Eilean Chlamail - Camas nan Ceann		NG773128	26	1985
Allt Cracaig Coast		NG793173	43	1985
Cosag Sallow Carr		NG824196	5	1985
Avernish		NG834262	24	1984
Ard Hill		NG818265	23	1984
Carn A'Bhealaich Mhoir		NG826324	39	1985
Attadale		NG913376	7	1989
Allt Nan Carnan		NG895405	17	1986
Slumbay Island		NG896385	8	1988
Sheildaig Woods		NG820530	224	1985
Alligin		NG838576	31	1988
Doire Damh		NG870510	310	1985
Coille Dhubh		NG811727	63	1985
Trotternish Ridge		NG455625	3,697	1990
Rigg - Bile		NG515535	516	1987
Lochs at Sligachan		NG473305	109	1985

Table 7.3.2 SSSIs in Regions 15 & 16 (continued)

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date last notified*
Region 16 (continued)				
Meall A'Mhaoil		NG555312	291	1984
Raasay		NG585400	714	1987
Eyre Point		NG577343	1	1987
Rubh'an Eireannaich		NG645248	5	1987
Ob Lusa - Ard Nis Coast		NG676245	122	1984
Loch Ashaig		NG691232	3	1990
Loch na Dal		NG703143	117	1985
Airdghunail		NG705118	41	1985
Aird Thuirinis-Port na Long		NG593004	13	1984
Coille Dalavil		NG590055	249	1986
Bagh Tharsgabhaig		NG587077	550	1984
Coille Thogabhaig		NG615128	153	1987
Ceann Loch Eishort		NG670165	43	1988
Boirearaig - Carn Dearg		NG599155	45	1984
Strath		NG607197	1,901	1986
Elgol Coast		NG517135	62	1990
Allt Geodh' A'Ghamna		NG369197	1	1984
Cuillins		NG480190	10,916	1985
Talisker		NG303317	593	1985
Geary Ravine		NG265630	3	1984
Rubha Hunish		NG410739	236	1984
Loch Cleat		NG416742	3	1990
Aultbea		NG890975	79	1988
Cailleach Head		NG985985	9	1988
Priest Island		NB925022	138	1985
Rubha Dunan		NC028070	23	1989
Inverpolly		NC135125	11,938	1986
Ardvar Woodland		NC150310	711	1986
Scourie Coast		NC143446, NC150457, NC150414	215	1989
Handa Island		NC138480	363	1986
Loch Laxford		NC217486	1,163	1963**
Sheigra - Oldshore More		NC192589	255	1987
Southern Parphe		NC250630	5,314	1990
Regions 15 & 16	***121***		***93,969***	
Scotland	1,379		859,678	
West Coast	651		380,941	
GB coast	1,212		716,701	
GB whole country	6,095		1,940,483	

Sources: SNH, JNCC. Key: *to the nearest whole 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.

7.3.3 National Scenic Areas

National Scenic Areas (NSAs) are designated by Scottish Natural Heritage as the best of Scotland's landscapes, deserving special protection in the nation's interest. This designation replaces two earlier categories of importance for scenic interest, which served to fulfil some of the approaches embodied in the National Park and Area of Outstanding Natural Beauty (AONB) designations in England and Wales. The seaward boundary of NSAs is the same as that for planning purposes in Scotland, i.e. mean low water of spring tides. Special development control measures for the 40 NSAs in Scotland were introduced by the Scottish Development Department in 1980. There are three NSAs in Region 15 (116,600 ha) and in Region 16 there are nine whole NSAs and part of one other (417,700 ha) that include areas within the coastal zone (Table 7.3.3; Map 7.3.2).

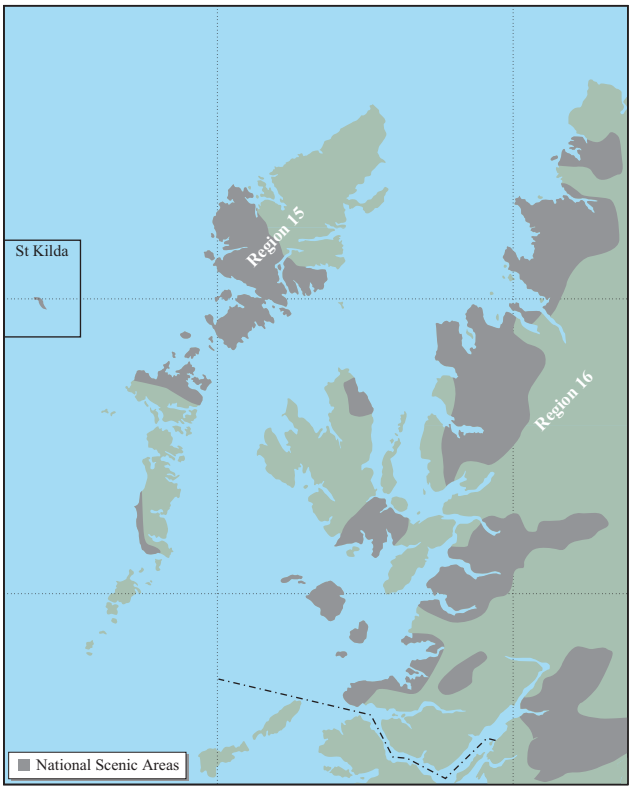
Table 7.3.3 National Scenic Areas

Site name	*No. of sites*	*Area (ha*)*	*Date designated*
Region 15	**3**	**116,600**	
South Lewis, Harris & North Uist		109,600	1980
South Uist Machair		6,100	1980
St. Kilda		900	1980
Region 16	**9.5****	**417,700****	
Ben Nevis & Glen Coe**		50,800**	1980
Morar, Moidart & Ardnamurchan		13,500	1980
Knoydart		39,500	1980
Kintail		15,500	1980
The Small Isles		15,500	1980
The Cuillin Hills		21,900	1980
Trotternish		5,000	1980
Wester Ross		145,300	1980
Assynt-Coigach		90,200	1980
North-west Sutherland		20,500	1980
Regions 15 & 16	***12.5****	***534,300****	
West Coast	23	693,400	
GB coast	27	745,800	

Sources: Countryside Commission for Scotland (1978), SNH. Key: *to the nearest whole hectare; **part of the Ben Nevis & Glen Coe NSA is in Region 14; half of the area has been included in the total for Region 16. 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 Acknowledgements

Thanks are due, in particular, to Kathy Duncan, Donald Balsillie and Natasha O'Connel (Scottish Natural Heritage), and also to Roger Bolt and Mark Tasker (JNCC), Phillip Biss (English Nature), Site Safeguards Team (Countryside Council for Wales), Neale Oliver (DoE) and Ray Woolmore (Countryside Commission).



Map 7.3.2 Coastal National Scenic Areas (NSAs). Sources: Countryside Commission for Scotland (1978), SNH.

7.3.5 Further sources of information

A. References cited

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. *UKDMAP (United Kingdom digital marine atlas).* Birkenhead, BODC. (Computer software.)

Countryside Commission for Scotland. 1978. *Scotland's scenic heritage.* Perth, Countryside Commission for Scotland.

B. Further reading

Countryside Commission. 1994. *Countryside planning file.* Cheltenham, Countryside Commission.

Countryside Commission. 1994. *United Kingdom protected environment map.* Southampton, Ordnance Survey.

Hodgetts, N.G. 1992. *Guidelines for selection of biological SSSIs: non-vascular plants*. Peterborough, Joint Nature Conservation Committee.

Joint Nature Conservation Committee. 1996. *Guidelines for selection of biological SSSIs: intertidal marine habitats and saline lagoons.* Peterborough, JNCC.

Nature Conservancy Council. 1984. *Nature conservation in Great Britain.* Peterborough, Nature Conservancy Council.

Nature Conservancy Council. 1989. *Guidelines for selection of biological SSSIs.* Peterborough, Nature Conservancy Council.

Stewart, I.S. 1996. Natural heritage conservation in the southern Outer Hebrides. *In: The Outer Hebrides. The last 14,000 years*, ed. by D. Gilbertson, M. Kent & J. Grattan, 227-251. Sheffield, Sheffield Academic Press.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
NNRs, SSSIs, NSAs	*SNH, North-west Region Office, Inverness, tel: 01463 239431
NSAs	*Highland Council, Inverness, tel: 01463 234121
Coastal and marine UKDMAP datasets	*Earth Science and Coastal Advisor, JNCC, Peterborough, tel: 01733 62626

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

7.4 Sites identified by statutory agencies

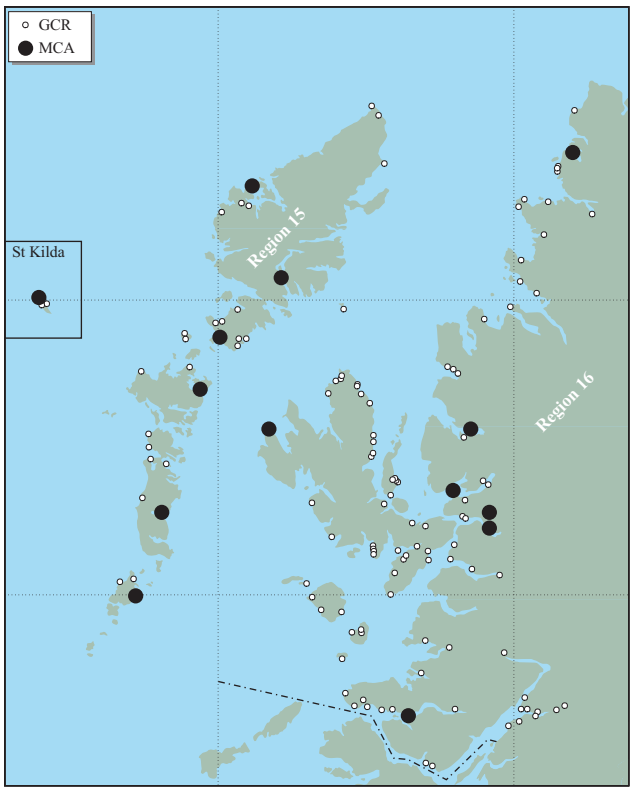
This section covers sites which, although not protected by statute, have been identified by statutory agencies as being of nature conservation or landscape importance.

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. It is therefore intended that all GCR sites will eventually be notified as SSSIs. 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. There are 29 coastal GCR sites in Region 15 and 97 sites in Region 16 (Table 7.4.1; Map 7.4.1). 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).



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).

Table 7.4.1 GCR Sites

Location	*No. of sites*
Region 15	***29***
North-west coast of Lewis	
Port of Ness	
Tolsta Head	
Shiant Islands	
Loch a Sgurr Pegmatite	
Sletteval Pegmatite Quarry	
South Harris Anorthosite	
Loch Maddy - Sound of Harris Coastline	
Rhughasinish	
Leanish	
Cnoc an Fhithich	
Eoligarry*	
Cnoca Breac	
Ardivachar to Stoneybridge	
Borve (2 sites)	
Garry A Sier to Balivanich	
North Uist Coast	
Machairs Robach and Newton, North Uist*	
Pabbay	
North Pabbay	
Chaipaval Pegmatite	
Luskentyre to Corran Seilebost*	
Mangersta Sands, Lewis*	
Cnoc a'Chapuill	
Tróigh na Berie	
St. Kilda* (2 sites)	
Gleann Mor, Hirta	
Region 16	***97***
Eyre Point	
Kildorais	
Ardsheal Hill & Peninsula	
Ardsheal Peninsula	
Kentallen	
St. John's Church, Loch Leven	
Rubh'ard Paraich	
Rubha Cladaich	
Nathrach	
Onich Dry River Gorge	
Onich Shore Section	
Rubha Cuil-cheanna	
Fassfern to Loch Ailort Road Cuttings	
Inninmore Bay	
Allt Leacach	

Table 7.4.1 GCR Sites (continued)

Location	*No. of sites*
Region 16 (continued)	
Loch Sunart	
Eilean Mor and Camas Choire Mhuilinn	
Ben Hiant	
Glas Eilean to Mingary Pier	
Glas Bheinn to Glebe Hill	
Beinn na Seilg to Beinn nan Ord	
Ardnamurchan Point to Sanna	
Loch Moidart Road Cuttings	
Lochailort	
Driumindarroch	
Kinloch Hourn	
Rubha Camas na Cailinn	
Eilean Chlamail to Camas Nan Ceann	
Totaig	
Dornie-Inverinate Road Section (A87)	
Avernish	
Ard Hill	
Carn a'Bhealaich Mhor	
Attadale	
Slumbay Point - Loch Carron	
Loch Torridon	
Flowerdale	
An Ard	
Loch Braigh to Sidhean Mor	
Gruinard Bay	
Cailleach Head	
Achduart	
Rubha Dunan	
Enard Bay	
The Laird's Pool, Lochinver	
Allt Cracaig Coast	
An Fharaid Mor - Clachtoll	
Stoer	
Loch Drumbeg	
Glencoul	
Camas nam Buth	
Scourie Mor	
Badcall	
Scourie Bay	
Sithean Mor	
Tarbet to Ruabha Ruadh	
Camas Mor, Isle of Muck	
Eigg	
South-west Eigg	
Allt Nam Bó	
Harris Bay	
Srin an t-Saighdair to Ard Nev	
East Canna and Sanday	
Ard Ghunel	
Hallaig Shore	
Kildonnan & Eilean Thuilm	
Ord	
Loch Eishort	
Boreraig to Carn Dearg	
Bearreraig River	
North Elgol Coast (2 sites)	
Loch Scavaig	
Loch na Dal	
Maol Na Gainmhich	
Allt Geodh a' Ghamhna	
Talisker	
Dun Skudiburgh	
Duntulm (Cairidh Ghlumaig & Lon Ostatoin)	
Rubha Hunish	
Loch Cleat	
Staffin Bay	
Staffin (2 sites)	
Valtos*	
Fiurnean to Rubha na h-Airde Glaise	
Elgol - Glen Scaladal	
Cadha Carnach	
Bearreraig Bay	
Prince Charles Cave to Holm	
Ard Thurinish to Port na Long	
Rubh' an Eireannaich	
Ob Lusa to Ardnish Coast	
Hallaig	
Beinn na Leac	
Rubha na' Leac	
Tarskavaig	
Regions 15 & 16	***126***
West Coast	545
GB coast	1,098
GB whole country	3,023

Sources: SNH, JNCC. Key: *site selected wholly or partly for its coastal geomorphological interest. 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.

7.4.3 Marine Consultation Areas

The non-statutory Marine Consultation Area (MCA) 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. They were originally identified to help with fish farm planning applications. Their selection encourages coastal communities and management bodies to be aware of marine conservation issues in the area. There are seven MCAs in each of Regions 15 (27,557 ha) and 16 (17,634 ha) (Table 7.4.2; Map 7.4.1).

7.4.4 Regional Landscape Designations

Regional Landscape Designations (RLDs) 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 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 15 there are no areas covered by RLDs, while in Region 16 there are nine that include areas somewhere within the coastal zone (Table 7.4.3; Map 7.4.2). There has

Table 7.4.2 Marine Consultation Areas

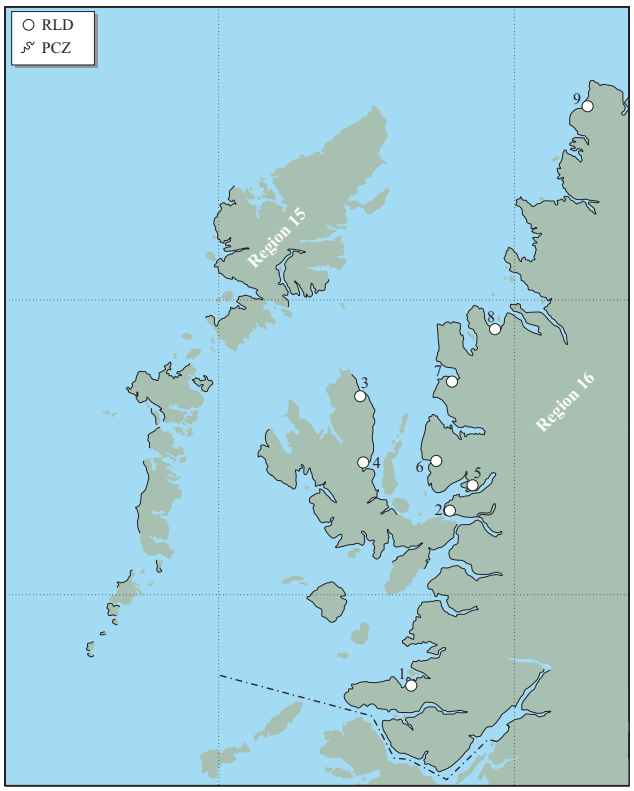
Site name	*No. of sites*	*Area (ha*)*	*Date established*
Region 15	***7***	***27,557***	
Loch Seaforth, Lewis		2,260	1990
Loch Maddy, N. Uist		2,120	1986
Loch Eynort, S. Uist		1,565	1986
The Obbe, Barra		28	1986
Loch Obe, Harris		48	1986
Loch Roag, Lewis		10,146	1986
St. Kilda		11,390	1990
Region 16	***7***	***17,634***	
Loch Sunart		5,410	1990
Loch Duich		1,200	1990
Loch Long		310	1990
Dunvegan Head		8	1990
Loch Carron		6,970	1986
Loch Torridon		2,820	1986
Loch Laxford		916	1986
Regions 15 & 16	***14***	***45,191***	
West Coast	23	103,287	
Scotland	29	111,896	

Source: NCC (1990). Key: *to the nearest hectare.

Table 7.4.3 Regional Landscape Designations (RLDs)*

Site no. on Map 7.4.2	*Site name*	*No. of sites*	*Area (ha+)*
1	Dorlin/Castle of Eilean Tioram, Moidart		<100
2	Plock of Kyle		31
3	River Leasgeary, Portree		7
4	Leth Allt Gorge, Staffin		<100
5	Strome Castle & Castle Bay		4
6	Applecross Bay, Inner Sound		10
7	Badachro Gorge and Woodland, Loch Gairloch		31
8	Gruinard Bay		75
9	Sandwood Loch, Kinlochbervie		<100
	Region 16	***9***	***458***
	West Coast	24	434,341
	Scotland coast	62	507,182
	Scotland whole country	178	1,468,000

Sources: Cobham Resource Consultants (1988), SNH. Key: *in Region 16 RLDs are all Regional Scenic Areas (RSA); +to the nearest whole 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 7.4.2 Regional Landscape Designations and Preferred Conservation Zones. Numbers refer to Table 7.4.3. Sources: Cobham Resource Consultants (1988), Scottish Development Department (1974).

been no monitoring or further comprehensive study of the number of RLDs since Cobham Resource Consultants (1988).

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 15 there is a PCZ covering a large part of the western coast of the Western Isles. In Region 16 virtually the entire mainland coastline is covered by the West Coast Dounreay-Machrihanish PCZ, which stretches from Region 3 through Region 16 to Region 14 (Map 7.4.2). This compares with 22 PCZs on the Scottish mainland and larger islands, and numerous potential PCZs around the smaller islands (only the larger islands have defined PCZs) (Scottish Development Department 1974).

7.4.6 Acknowledgements

Thanks are due to Donald Balsillie, Kathy Duncan, Alan McKirdy, Natasha O'Connel and Stuart Gardner (Scottish Natural Heritage), Roger Bolt (JNCC), Phillip Biss, Kevin Page and Marcus Polley (English Nature), and Ray Woolmore (Countryside Commission).

7.4.7 Further sources of information

A. References cited

Cobham Resource Consultants. 1988. *The effectiveness of landscape designations in Scotland. A review study.* Edinburgh, Countryside Commission for Scotland and Scottish Development Department.

Ellis, N.V. (*ed.*), Bowen, D.Q., Campbell, S., Knill, J.L., McKirdy, A.P., Prosser, C.D., Vincent, M.A., & Wilson, R.C.L. 1996. *An introduction to the Geological Conservation Review.* Peterborough, Joint Nature Conservation Committee. (Geological Conservation Review series, No. 1.)

Nature Conservancy Council. 1990. *Marine Consultation Areas: Scotland*. Edinburgh, Nature Conservancy Council.

Ratcliffe, D.A., *ed*. 1977. *A nature conservation review.* Cambridge, Cambridge University Press.

Scottish Development Department. 1974. *North Sea oil and gas - coastal planning guidelines.* Edinburgh, Scottish Development Department.

B. Further reading

Cleal, C.J., & Thomas, B.A. In prep. *British Upper Carboniferous stratigraphy*. London, Chapman & Hall. (Geological Conservation Review series, No. 14.)

Countryside Commission. 1994. *United Kingdom protected environment map.* Southampton, Ordnance Survey.

Department of the Environment and the Welsh Office. 1992. *Marine Consultation Areas. A description.* London, Department of the Environment.

Gordon, J.E., & Sutherland, D.G., *ed*. 1993. *Quaternary of Scotland*. London, Chapman and Hall. (Geological Conservation Review series, No. 6.)

Gregory, K.J., *ed.* In prep. *Fluvial geomorphology of Great Britain.* London, Chapman and Hall. (Geological Conservation Review series, No. 13.)

Scottish Development Department. 1981. *National planning guidelines - priorities for development planning.* Edinburgh, Scottish Development Department.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
NCR sites, GCR sites, MCAs (Region 15)	*SNH Western Isles Area Office, Stornoway, tel: 01851 705258
NCR sites, GCR sites, MCAs (Region 16)	*SNH North-west Region Head Office, Inverness, tel: 01463 239431
PCZs, RLDs (Region 15)	*Western Isles Council, Stornoway, tel: 01851 703773
PCZs, RLDs (Region 16)	*Highland Council, Inverness, tel: 01463 702000

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

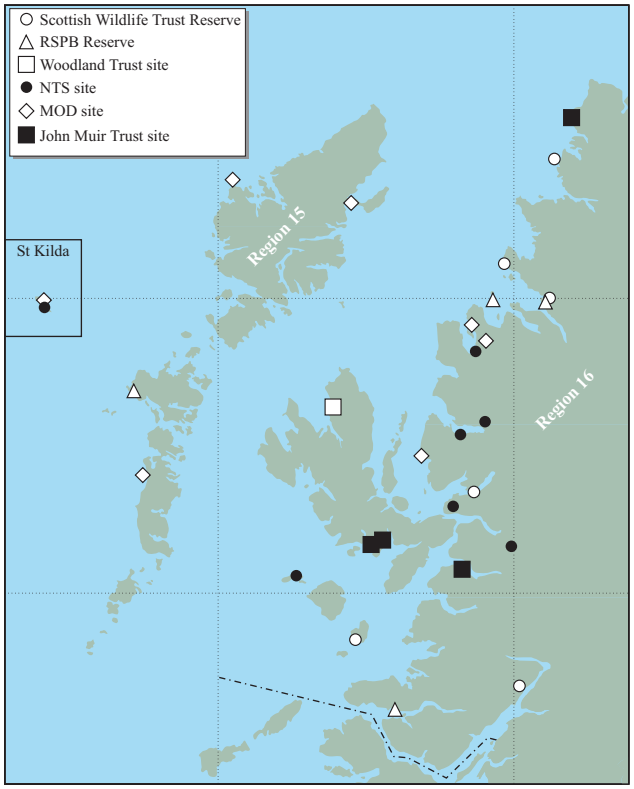
7.5 Other types of protected site

7.5.1 The National Trust for Scotland

The National Trust for Scotland (NTS) is a charitable organisation, established in 1931 (National Trust for Scotland Order Confirmation Act 1935) for the purposes 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 1996). 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 power 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 is one NTS site (846 ha) in Region 15 (Western Isles) and six (18,283 ha) in Region 16 (west Highland) that are of natural heritage interest (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 is one (658 ha) RSPB site in Region 15 and three (400 ha) in Region 16 (Table 7.5.2; Map 7.5.1).



Map 7.5.1 Coastal voluntary and privately-owned sites. Sources: National Trust for Scotland (NTS), Ministry of Defence (MoD), Scottish Wildlife Trust (SWT), RSPB, Woodland Trust, John Muir Trust.

Table 7.5.1 National Trust for Scotland sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date acquired*	*Landform*
Region 15	***1***		***846***		
St. Kilda Archipelago		NF094997	846	1957	Islands
Region 16	***6***		***18,283***		
Canna & Sanday, Small Isles		NG250060	1,514	1981	Islands
Kintail and Morvich		NG980150	7,052	1944	Coastal highland
Balmacara Estate & Kyle/Plockton Peninsula		NG780290	2,279	1946	Coastal estate
Shieldag Island		NG810543	13	1970	Forested island
Torridon		NG894580	6,516	1967	Coastal mountains
Inverewe Garden		NG860820	909	1953-93	Garden
Regions 15 & 16	***7***		***19,129***		
Scotland coast	20		25,170		
West Coast**	262		45,517		
GB coast**	453		64,127		

Sources: NTS, JNCC. Key: *to nearest whole hectare; **includes National Trust sites in England and Wales. Notes: in this table only sites of natural heritage interest have been included; 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 reserves

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date acquired*	*Interest*
Region 15	***1***		***658***		
Balranald, N. Uist		NF706707	658	1966	Sandy and rocky beaches, dunes, machair, marshland and loch; corncrakes, nesting waders, nesting and wintering waterfowl, wintering raptors; breeding otters and grey seals
Region 16	***3***		***400***		
Glenborrodale Woods		NM610610	102	1988	Loch shore, broadleaved woodland, bogs, flushes, heathland; breeding passerines, raptors
Priest Island		NB925020	138	1980	Rocky shore and island with high cliffs and mixed maritime vegetation; nesting seabirds and wintering geese
Isle Martin		NH090995	160	1980	Varied island with beaches, rocky shores and cliffs, mixed vegetation with small lochans; wide range of breeding species including seabirds
Regions 15 & 16	***4***		***1,058***		
West Coast	29		14,125		
GB coast	82		38,680		

Source: RSPB (1994; *in litt.*). Key: *to the nearest whole 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.

7.5.3 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 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 no coastal Wildlife Trust sites in Region 15 but six (8,224 ha) in Region 16 (Table 7.5.3; Map 7.5.1).

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 regions. There are four coastal MoD sites (1,261 ha) in Region 15 and three in Region 16 (47 ha) (Table 7.5.4; Map 7.5.1).

Table 7.5.3 The Wildlife Trusts sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date acquired*
Region 16				
Doire Donn		NN050703	168	1966
Isle of Eigg		NM474875	1,518	1978
Eielan Na Creige Duibhe		NG824335	1	1970
Ben More Coigach		NC075065	5,949	1988
Handa Island		NC138480	363	1991
Isle Ristol		NB970110	225	1993
Region 16**	***6***		***8,224***	
Scotland coast**	26		13,785	
West Coast	96		14,310	
GB coast	241		25,882	

Sources: Scottish Wildlife Trust (1996), JNCC. Key: *to the nearest whole hectare; **all Scottish Wildlife Trust. 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.

Table 7.5.4 MoD sites

Site name	*No. of sites*	*Area (ha)**	*Habitats*	*Protected status*
Region 15	***4***	***1,261***		
Stornoway, Lewis		326	Rock, sand	SSSI
South Uist		900	Sand dunes, grassland, machair	SSSI
Uig, Lewis		31	Rock, cliff, shingle	NSA
St. Kilda		4	Sand, rock, grassland	SPA, NSA, pSAC, SSSI, NNR, Biosphere Reserve, World Heritage Site
Region 16	***3***	***47***		
Applecross		3	Rock	No designation
Aultbea		36	Rock, shingle	SSSI
Aultbea		8	Rock, sand	No designation
Regions 15 & 16	***7***	***1,308***		
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; SSSI = Site of Special Scientific Interest; NNR = National Nature Reserve; pSAC = possible Special Area of Conservation; SPA = Special Protection Area; NSA = National Scenic Area. 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.

7.5.5 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 are no Woodland Trust sites in Region 15 but one in Region 16 (Table 7.5.5; Map 7.5.1).

Table 7.5.5 The Woodland Trust sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*
Region 16			
Conon Wood and Rha Glen, Uig, Skye	1	NG400637	19
Region 16	***1***		
West Coast	36		480
GB coast	71		1,590

Source: Woodland Trust (1996). Key: *to the nearest whole 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 7.5.6 John Muir Trust sites

Site name	*No. of sites*	*Grid ref.*	*Area (ha*)*	*Date designated*
Region 16				
Li and Coire Dhorrcail		NG845060	1,300	1987
Torrin, Skye		NG567220	2,200	1991
Strathaird Estate, Skye		NG525120	6,073	1994
Sandwood		NC185617	4,600	1993
Region 16	***4***		***14,173***	
GB	4		14,173	

Source: John Muir Trust (1994). Key: to the nearest whole hectare.

7.5.6 John Muir Trust

The John Muir Trust was established in 1983 and aims to educate the public about the inherent importance of wild lands and actively seeks to sustain and enhance wild land in the UK. To date, all four John Muir Trust sites occur in Region 16 (14,173 ha) (Table 7.5.6; Map 7.5.1).

7.5.7 Acknowledgements

The authors wish to thank Andrea Firth (MoD), Dr J. Fenton (National Trust for Scotland), Dr A. Somerville (Scottish Wildlife Trust), Bob Scott (RSPB), Mark Pollitt (Wildfowl & Wetlands Trust), Sarah Hawkswell (the Wildlife Trusts), Jo Burgon and Richard Offen (The National Trust), Nigel Hawkins (John Muir Trust) and The Woodland Trust.

7.5.8 Further sources of information

A. References cited

John Muir Trust. 1994. *Conserving the wild.* Edinburgh, John Muire Trust. (Information leaflet.)

National Trust for Scotland. 1996. *Guide to over 100 properties 1996.* Edinburgh, The National Trust for Scotland.

Royal Society for the Protection of Birds. 1993. *Nature reserves - information for visitors.* Sandy, Royal Society for the Protection of Birds.

Royal Society for the Protection of Birds. 1994. *Enjoying wildlife - a guide to RSPB nature reserves.* Sandy, Royal Society for the Protection of Birds.

Scottish Wildlife Trust. 1996. *Reserves 1996 - a visitors' guide.* Edinburgh, Scottish Wildlife Trust.

Woodland Trust. 1996. *Directory of Woodland Trust properties 1996.* Grantham, Woodland Trust.

B. Further reading

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.

National Trust. 1993. Enterprise Neptune - saving our unspoiled coastline. *Coastline 1993, 2*: 1-11.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
National Trust for Scotland sites	*The National Trust for Scotland, Edinburgh, tel: 0131 226 5922
RSPB sites	*Regional Officer, RSPB North Scotland Office, Inverness, tel: 01463 715000
Scottish Wildlife Trust sites	*Dr Kenny Taylor, Scottish Wildlife Trust (Northern Office), Dingwall, tel: 01349 877625
The Woodland Trust sites	The Woodland Trust, Autumn Park, Dysart Road, Grantham, Lincolnshire NG31 6LL, tel: 01476 74297
John Muir Trust sites	The John Muir Trust, 13 Wellington Place, Leith, Edinburgh EH6 7JD, tel: 0131 554 0114
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 Appendix.

Chapter 8 Land use, infrastructure and coastal defence

M.J. Dunbar & S.L. Fowler

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, ferries and power generation; and coastal defence, including sea defence and coast protection. Oil and gas exploration and production are covered in section 9.5.

Both of these regions are covered by the Highlands and Islands Objective 1 Programme, which was adopted by the European Commission in 1994 and provides £240 million of EC support to the area up to the end of 1999 and is managed by the Highlands and Islands Partnership Programme. Objective 1 promotes the structural adjustment of regions within the EU that are considered to be in need of development. Public agencies in the regions may access funds for the development of local infrastructure to allow business expansion, under four headings: the European Regional Development Fund, the European Social Fund, the European Agricultural Guidance and Guarantee Fund and the Financial Instrument for Fisheries Guidance.

Small-scale agriculture is the main land use in Region 15 (Western Isles), but there are also important tourism and fish farming activities. The population of Region 15 is just under 30,000, and the islands contain extensive undeveloped areas, particularly in Lewis and Harris and on the east coast of the Uists. The coastline of the islands mostly comprises a combination of marginal agricultural land and semi-natural vegetation. There are extensive swathes of machair along the western shores of the islands, and a rich diversity of other features, including rocky shores, open moor, steep coastal mountains and long fjordic sea lochs.

Land use in Region 16 (west Highland) is predominantly agricultural, albeit often on marginal agricultural land. Most of the coastline is characterised by semi-natural habitats and is mainly used for livestock grazing. Some important coastal woodlands occur in the region. Tourism and recreational activities are the second most important land use (see section 9.7).

Overall, industrial activity in the regions is low, but there is industrial infrastructure at Fort William and some industry at Mallaig and near the larger ports. Important ports include Stornoway in Region 15, and Fort William, Mallaig, Uig and Ullapool in Region 16. There are many smaller ports and harbours.

Only a very small amount of the coastline in either region is protected against coastal erosion or flooding.

Agriculture in west Highland and the Western Isles is usually small-scale and often takes the form of crofting, as here at Port Henderson, Loch Gairloch (Region 16). The plentiful and ubiquitous seaweed is frequently spread on the land as fertiliser - a traditional practice on the thin soils of these regions. Photo: S. Whitehorne, Scottish Natural Heritage.

8.2 Land use

M.J. Dunbar & S.L. Fowler

8.2.1 Introduction

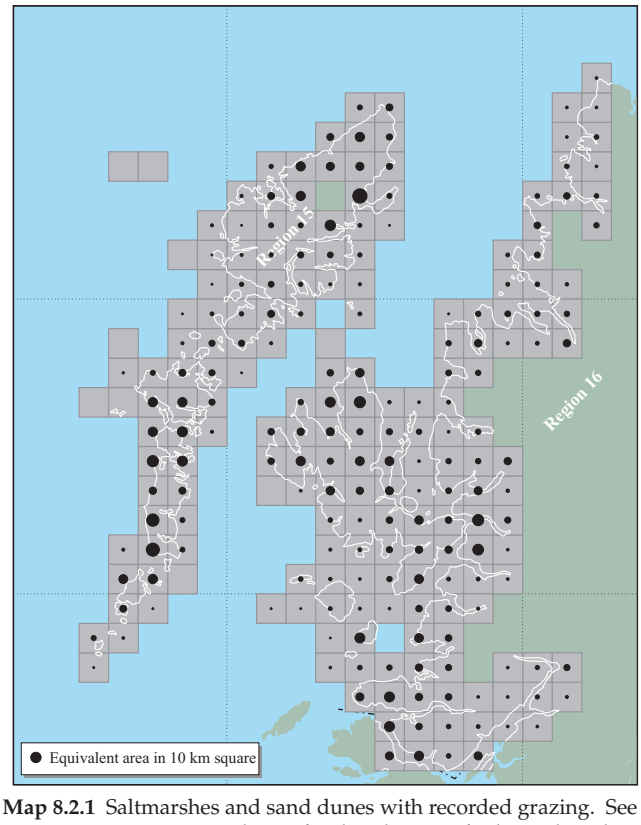
Agriculture is the major land use in both Regions 15 (Western Isles) and 16 (west Highland). It is generally of low intensity and traditional in nature. Patterns of agriculture have undergone major changes in the last 150 years, with a decline in subsistence farming practices. Although crofting is still the dominant agricultural structure in the regions, the crofters that remain often supplement their income from other sources, including fish farming and tourism. It is also supported by various agricultural and nature conservation land management agreements (for example on SSSIs and in Environmentally Sensitive Areas - see sections 7.2 and 7.3).

Almost all the coastal land in Region 15 is of the poorest agricultural quality (classes 5, 6 and 7), with a few very small pockets in land class 4, while all the coastal land in Region 16 is of the poorest agricultural quality. Two-thirds of coastal land in Region 15 and the majority of the coastal land in Region 16 is of limited agricultural value, mostly capable of use only as rough grazing (classes 6 and 7). There is no prime quality land in either of these regions.

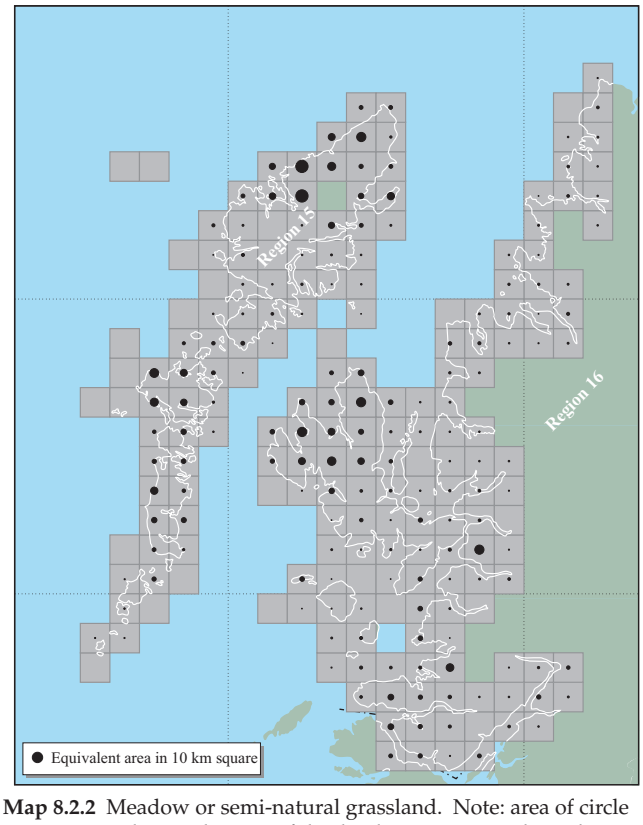
8.2.2 Locations and land uses

The main crofting activity in Region 15 is the cultivation of machair, which takes place mainly on the Uists. Agricultural practices and land use in the region, particularly on the machair of the coastal fringe, are virtually unique in Britain, occurring elsewhere only on some of the islands of the Inner Hebrides (Regions 14 and 16) and parts of the west coast of Ireland. In some areas seaweed is still collected and used to fertilise the soil, in which crops such as potatoes and oats are grown on rotation. In other areas a more intensive system is used: modern fertilisers and herbicides are applied with more frequent rotation of crops such as cereals. At many locations sand dune and saltmarsh vegetation is grazed by cattle (Map 8.2.1). Sheep are grazed inland, although the traditional transhumance - seasonal grazing on upland pastures - virtually ceased after the First World War. There is little cultivation in Lewis and Harris. Overall in Region 15, the area of tilled land and improved grazing is extremely small. As a result there has been some coastal land claim for agricultural purposes and the conversion to agriculture of species-rich wet grassland on North and South Uist (Doody undated), although the extent of loss of semi-natural habitat has been small.

Crofting is practised in the remoter areas of Region 16, particularly on the islands and in the northern part of the region. The poor agricultural land quality restricts farming developments and agricultural intensification. There are large areas of semi-natural grassland and meadows, most widespread in the south and on Skye (Map 8.2.2), with virtually all agricultural land used for rough grazing of sheep. There are also some areas of marsh and rough grassland (Map 8.2.3) and in many localities saltmarsh is



Map 8.2.1 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.



Map 8.2.2 Meadow or semi-natural grassland. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE Monks Wood (1993).

used for grazing (Map 8.2.1). Tilled land is sparsely distributed in the region, with very small areas located around Fort William and Ullapool.

Owing to a combination of climate, traditional land use and soil types, Region 15 is virtually devoid of tree cover. The only examples of coastal woodland present are small areas of mixed woodland on the sheltered east coast at Stornoway (*c.* 100 ha) and on the shores of Loch Seaforth (*c.* 150 ha) (Maps 8.2.4, 8.2.5 and 8.2.6). Region 16 includes numerous areas of coastal woodland, particularly in the south. Maps 8.2.4 and 8.2.5 demonstrate the considerable area of coastal 10 km squares under woodland cover on the mainland. Much of this is conifer plantation, but there are also important ancient semi-natural woodlands, particularly along the steeper sides of some of the sea lochs. Most of these sites are designated as Sites of Special Scientific Interest (SSSI) (see section 7.3.2). The larger ancient woodland sites, those with a semi-natural area greater than 5 ha and whose central grid references lie within 500 m of the coast, are shown on Map 8.2.6. Overall, 10% of the land area in Scotland is devoted to forestry, with about 60% of this worked by Forest Enterprise.

8.2.3 Information sources used

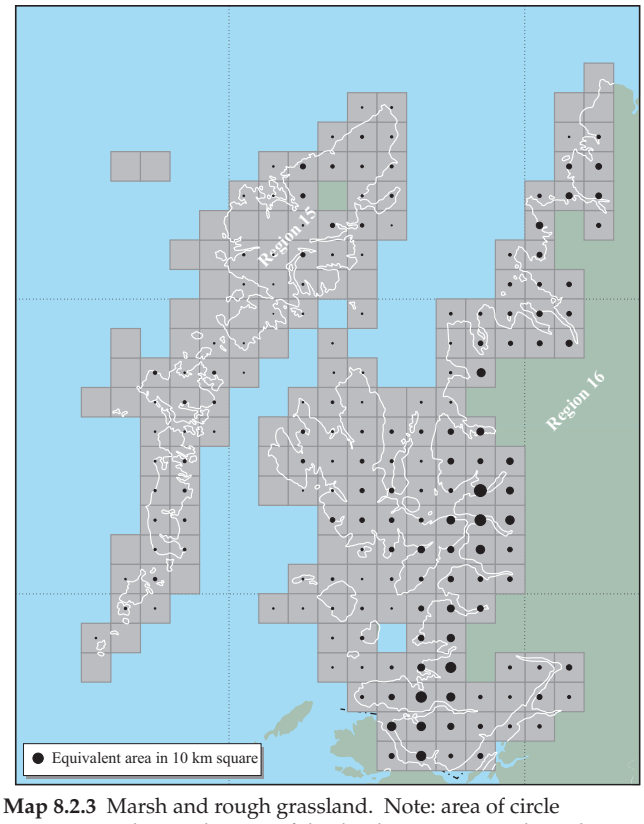
The main source of information for this section was the Countryside Survey 1990 (ITE 1993), which is based primarily on high resolution satellite images. These images show the dominant land cover for each 25 m x 25 m area (pixel) of Great Britain. Land cover is classified into seventeen key types (including tilled land and managed grassland), and field surveys of randomly selected areas were used to check the results. Maps 8.2.2, 8.2.3, 8.2.4 and 8.2.5 are derived from these data, which are held in the DoE Countryside Information System. The main limitations of the data derive from errors in classifying areas covered by a mixture of land types. The proportional dots shown in the maps represent the equivalent (proportional) area of that 10 km^2, including sea, that is occupied by the land type. 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 is held in local plans or is available from the Scottish Office Agriculture, Environment and Fisheries Department. Scottish Natural Heritage can advise on the sensitive management of semi-natural habitats for agriculture and forestry (for example, management of machair SSSIs).

Sand dune and saltmarsh grazing information for Map 8.2.1 was adapted from data in JNCC's Coastal Database. Ancient woodland information (Map 8.2.6) was obtained from the Scottish Natural Heritage Geographic Information System (GIS) data on ancient woodlands and from the 1:50,000 scale Ordnance Survey Landranger maps. The Forestry Authority has afforestation maps that cover the regions.

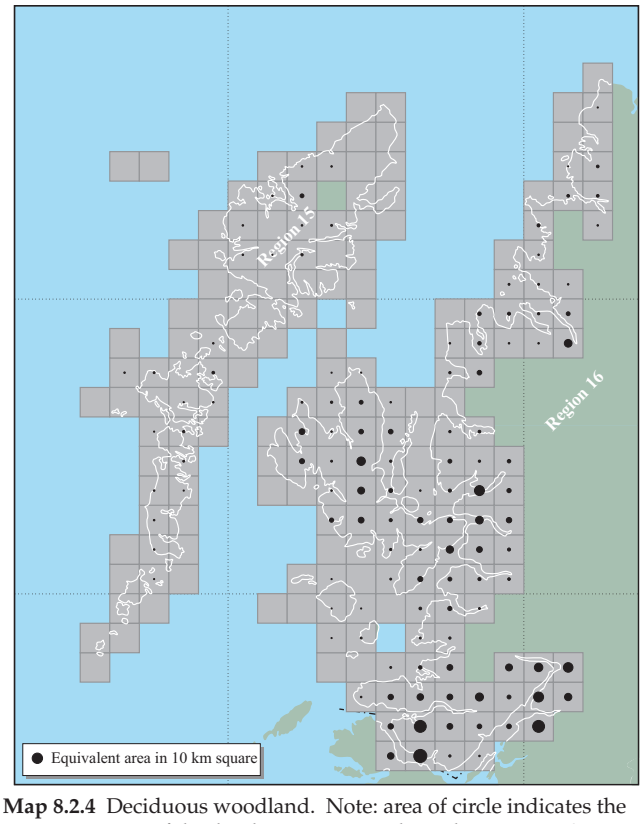
Highland Regional Council produced an indicative forestry strategy (Highland Regional Council 1992) to direct new afforestation and identify land in three categories: preferred, potential and sensitive. It identifies existing areas of significant productive woodland and land unsuitable for tree crops owing to physical or climatic limitations.

8.2.4 Acknowledgements

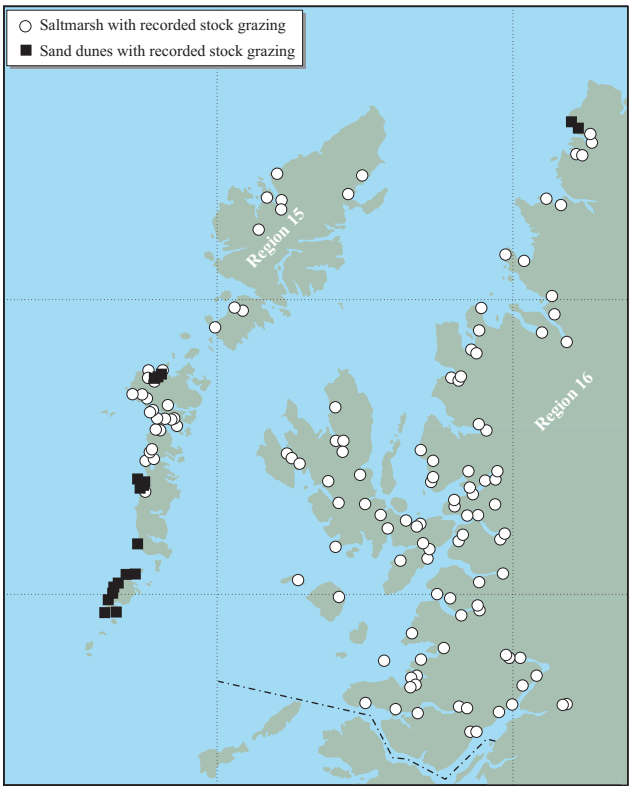
Thanks go to Robin Fuller, ITE Monks Wood, for providing information on the Countryside Survey, and to John Kupiec, SNH, for ancient woodland data.



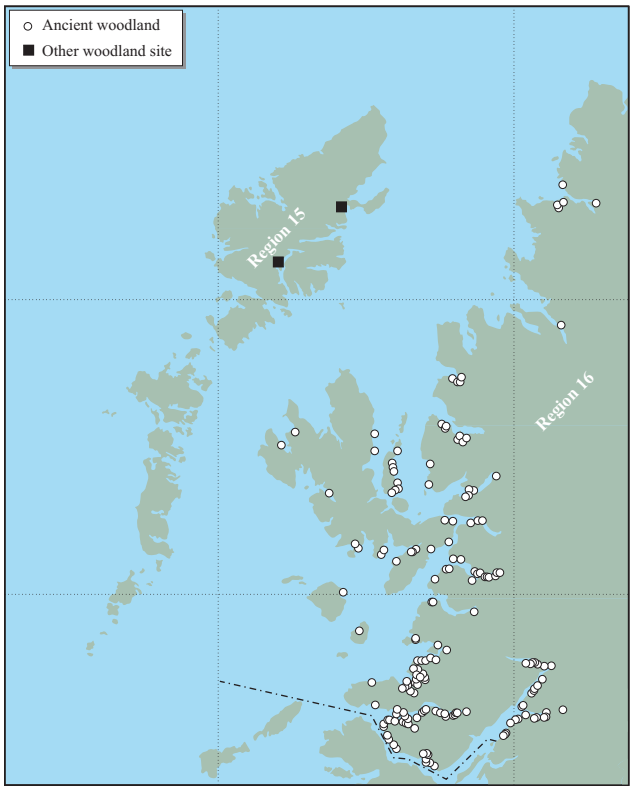
Map 8.2.3 Marsh and rough grassland. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE Monks Wood (1993).



Map 8.2.4 Deciduous woodland. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE Monks Wood (1993).



Map 8.2.5 Coniferous woodland. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE Monks Wood (1993).



Map 8.2.6 Coastal woodland sites. Sources: SNH Ancient Woodland Inventory; Ordnance Survey Landranger maps. © Crown copyright.

8.2.5 Further sources of information

A. References cited

Doody, J.P. Undated. *Coastal habitat change - a historical review of man's impact on the coastline of Great Britain.* Peterborough, Joint Nature Conservation Committee (unpublished draft).

Institute of Terrestrial Ecology. 1993. *Countryside survey 1990: main report*. London, Department of the Environment.

Highland Regional Council. 1992. *Highland Region indicative forestry strategy and survey report.* Inverness, Highland Regional Council.

B. Further reading

Bryan, A. 1994. *The Minch review*. Stornoway, Western Isles Islands Council and Scottish Natural Heritage.

Forestry Commission and Macaulay Land Use Research Institute. 1989. *Land capability for forestry. Field Book 3: northern Scotland.* Aberdeen, The Macaulay Land Use Research Institute.

Forestry Commission and Macaulay Land Use Research Institute. 1989. *Land capability for forestry. Field Book 4: Western Scotland*. Aberdeen, The Macaulay Land Use Research Institute.

Highland Regional Council. 1985. *Amenity woodland survey. Technical report No. 1.* Inverness, Highland Regional Council.

Highland Regional Council. 1989. *Structure Plan review*. Inverness, Highland Regional Council.

Highland Regional Council. 1987. *Development opportunities in forestry and related industries*. Inverness, Highland Regional Council.

Highland Regional Council. 1987. *Key issues in crofting: the need for action*. Inverness, Highland Regional Council.

Macaulay Institute for Soil Research. 1982. *Soil and land capability for agriculture. Sheet 3: Northern Scotland. Sheet 4: Western Scotland.* Aberdeen, The Macaulay Institute for Soil Research.

Macaulay Land Use Research Institute. 1988. *Land cover of Scotland. Digital dataset (LCS 88)*. Aberdeen, The Macaulay Land Use Research Institute.

Macaulay Land Use Research Institute. 1988. *Land cover of Scotland. Executive summary*. Aberdeen, The Macaulay Land Use Research Institute.

Macaulay Land Use Research Institute. 1988. *Land cover of Scotland. Main report and statistical tables*. Aberdeen, The Macaulay Land Use Research Institute.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Land use and agricultural land grades, set aside	*SOAEFD, Edinburgh, tel: 0131 244 6015
Land use information	Macaulay Land Use Research Institute, Craigbuckler, Aberdeen AB9 2QJ, tel: 01224 318611
ITE Countryside Survey 1990	*Department of Rural Affairs, DoE, Bristol, tel: 0117 987 8000, or *Land Use Group, ITE Merlewood, tel: 01539 532264, or *Environmental Information Centre, ITE Monks Wood, tel: 01487 77338
Crofting	Crofters Commission, 4/6 Castle Wynd, Inverness IV2 3EQ, tel: 01463 237231
Crofting	Scottish Crofters Union, Old Mill, Broadford, Isle of Skye, Inverness-shire IV49 9AQ, tel: 01463 663450
Crown agricultural and forestry estates	The Crown Estate, 10 Charlotte Square, Edinburgh EH2 4DR, tel: 0131 226 7241
Woodland extent, ownership, management	Forestry Commission Headquarters, 231 Corstorphine Road, Edinburgh EH12 7AT, tel: 0131 334 0303
Distribution, ownership, management of woodlands	Forestry Authority, Highland Conservancy, Woodlands, Fodderty Way, Dingwall, Ross-shire IV15 9XB, tel: 01349 862144
Forestry and grant-aided woodland management	Forestry Authority Scotland, Scotland National Office, Portcullis House, 21 India Street, Glasgow G2 4PL, tel: 0141 248 3931
Ancient woodlands GIS database	*SNH HQ, Edinburgh, tel: 0131 447 4784
Coastal woodlands of nature conservation significance - Region 15	*SNH, Stornoway, Isle of Lewis, tel: 01851 705258
Coastal woodlands of nature conservation significance - Region 16	*SNH North West Region, Inverness, tel: 01463 239431

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

8.3 Infrastructure

M.J. Dunbar & S.L. Fowler

8.3.1 Introduction

Region 15 (Western Isles) is one of the least populated areas in Britain; it has few areas of major residential development and a total population just under 30,000. There is also very little industrial development in the archipelago, and most attempts since the early 19th century to expand industrial activity in the islands have been unsuccessful.

Highland is one of the most sparsely populated large areas of Britain, with a total population of only about 207,000 (Registrar General Scotland 1995), largely located close to the long coastline. Most residential development in Region 16 (west Highland) occurs in the south of the region and on Skye. Many of the deeply indented and sheltered sea inlets have a narrow strip of residential land along coastal roads. Industrial activities are limited, being concentrated in only a few locations such as Fort William, which is the main centre for communications; other industries are located at fishing or ferry ports. Road communications are generally concentrated along the coast in this region and there are many ferry routes, both between the islands and the mainland and across some sea lochs.

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. Power generating capacity in Region 15 accounts for 0.4% of Scotland's total of 10,456 MW, and in Region 16, 0.07%. The figure for Scotland's total power output capacity includes the outputs of Scottish Power, Scottish Hydro-Electric and Scottish Nuclear, and does not include that from other smaller producers. The difference is likely to be minimal, however, and will only increase by around 0.7% (76 MW) once the Scottish Renewables Obligation - First Renewables Order (SRO-1) proposed schemes come on-stream. Assessments of the potential for renewable energy in Scotland have been produced by a group of bodies including Scottish Hydro-Electric, Scottish Power, the Scottish Office, Scottish Enterprise and the Department of Trade and Industry (DTI). The DTI (1992) and established that there was potential to generate electricity from wave power along the whole north and west coasts of the British Isles corresponding to 11-15% of current UK electricity capacity. The potential for wind farming in Regions 15 and 16 is excellent, due to the prevailing westerly and south-westerly winds. Currently (1995), however, no wind farms exist in either region (British Wind Energy Association pers. comm.).

Highlands and Islands Enterprise, with its network of local enterprise companies, including Western Isles Enterprise, Lochaber Limited, Skye and Lochalsh Enterprise, Ross & Cromarty Enterprise and Caithness & Sutherland Enterprise, has a remit for economic and social development, training and environmental renewal in the regions (Highlands and Islands Enterprise 1996).

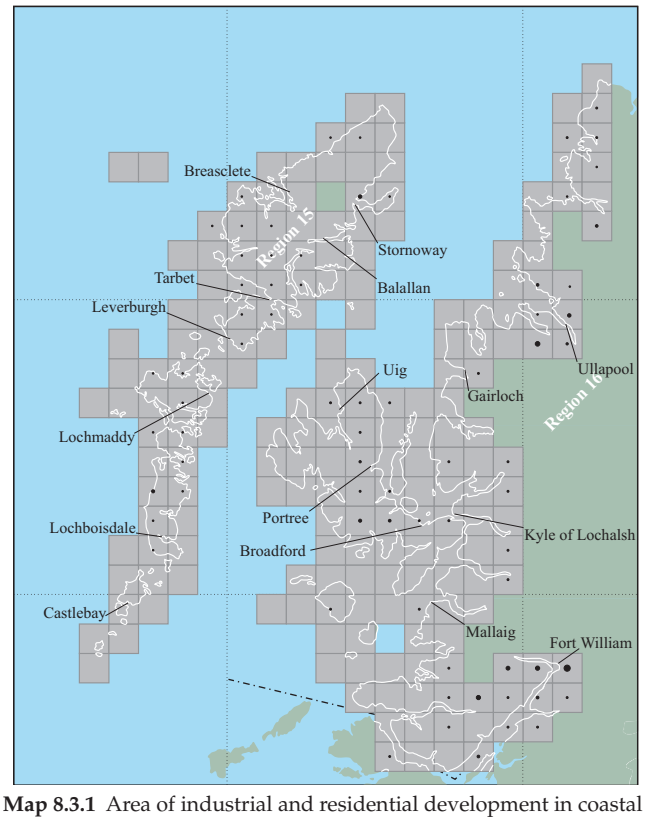
8.3.2 Important locations

Residential development

Stornoway is the only sizeable town in Region 15. Other settlements in the Western Isles are small and occur sparsely along roads. Most of Region 16's population is concentrated in the south around Fort William, near the shores of Loch Linnhe, and on Skye (which had a population of about 12,500 in 1991). Other towns in the region have very small resident populations (Table 8.3.1). The larger settlements in the regions are shown on Map 8.3.1, with an indication of the scale and distribution of residential development.

Industry

There is very little industry in the Western Isles. Stornoway has a yard for oil-related construction at Arnish, and marine engineering and small boat-building and repair businesses. There is potential to expand the facilities here if offshore oil exploration is successful. Stornoway is the centre of the Harris tweed industry, which is spread throughout most of Region 15 and takes place on all the major islands. A pharmaceuticals plant on East Loch Roag has recently been extended. There are small fish processing plants associated



Map 8.3.1 Area of industrial and residential development in coastal 10 km grid squares (some areas of bare rock appear as urban in satellite classification). Major towns are also shown. Note: area of circle indicates the area of this land cover type in the 10 km square. Source: ITE Monks Wood (1993).

Table 8.3.1 Coastal population in Regions 15 & 16

Location	*Population*
Region 15	***29,310***
Stornoway	8,600
Region 16	
Lochaber	**19,400[a]**
*Mallaig	1,000
*Fort William	11,100
Skye & Lochalsh	**11,970[a]**
*Portree	1,500
*Kyle of Lochalsh	800
Ross & Cromarty	**50,460[a]**
*Ullapool	1,100
Sutherland	**13,180[a]**

Sources: mid-1994 population estimates (Registrar General Scotland 1995); except *Cook (1993). Key: [a]figures for whole district, not just coastal population.

with a few of the numerous fish farms in sea lochs, and two large salmon processing factories in Stornoway with associated packing works.

There are few major industrial developments in Region 16 (Table 8.3.2; Map 8.3.2). Industrial activity is very localised, occurring chiefly around the main centres of population (particularly in the Fort William area) and in fishing and ferry ports or harbours. The platform construction yard at Kishorn, having been closed in 1986 owing to lack of work, is now involved in production for a wider range of industrial uses. In addition to these major developments a number of small industrial estates are found throughout the region, for example at Dunvegan, Uig, Portree and Broadford on Skye. These contain small printing works, electronics factories, fishery-related works and other light industry. The coast of the region is mostly unmodified by industrial or urban use, and is likely to remain so for the foreseeable future.

Power generation

Following the commissioning of two submarine cables in 1992, Region 15 became linked to the main Scottish

Map 8.3.2 Locations of industrial infrastructure, coastal power stations and proposed power schemes.

electricity system, from which the islands now receive the majority of their electricity requirements. The cables link Ardmore on Skye to Loch Carnan on South Uist and to Beacravik on Harris. From Beacravik, power is transmitted to Stornoway, where it is transformed and distributed. Prior to connection to the main system, Region 15 depended on two small remotely-operated hydro-electric schemes (which still operate) and two diesel generators, which remain on standby should the submarine cables fail. Power demands vary considerably on the Western Isles, as does the proportion of power that is produced locally. The islands' only gas turbine power station at Stornoway has now been

Table 8.3.2 Main areas of coastal industrial development in Regions 15 & 16

Site	*Grid ref.*	*Details*
Region 15		
Stornoway	NB4333	Oil fabrication yard; marine engineering/small boat building and repair business; Harris tweed industry
East Loch Roag	NB23	Pharmaceuticals plant
Region 16		
Kinlochleven	NN1962	Aluminium works
Fort William	NN1074	Main industrial, communications and residential centre for region. Aluminium works, distillery, carbon works.
Corpach	NN0977	Pulp and paper mill; entrance to Caledonian Canal
Mallaig	NM6897	Ferry port, terminus of railway from Glasgow via Fort William, fish market, fish processing, harbour redevelopment
Kyle of Lochalsh	NG7627	Bridge to Skye, terminus of Highland Railway
Carbost	NG3832	Talisker Distillery
Uig	NG3964	Main Skye to Outer Hebrides ferry port, industrial estate
Portree	NG4843	Tweed mill, industrial estate
Kishorn	NG8240	Construction yard (previously for oil rigs)

Sources: Ordnance Survey 1:50,000 maps, Buck (1993).

decommissioned. There are no schemes under the Scottish Renewables Obligation - First Renewables Order (SRO-1) proposed for Region 15.

In Region 16, power is produced exclusively by hydro-electric generating methods, and several small stations are located near the coast. Much of Scotland's remaining untapped hydro-electric power is in Region 16, and Highland Council favours the development of this resource (Highland Regional Council 1990). In the first round of contracts awarded under the SRO-1 announced in December 1994, three new hydro schemes were approved in the region, all of them in coastal locations.

Map 8.3.2 shows the location of coastal power stations in Regions 15 and 16, all owned by Northern Hydro group (Table 8.3.3), together with proposed schemes in Region 16 that have been awarded contracts under the SRO-1 ~ (Table 8.3.4).

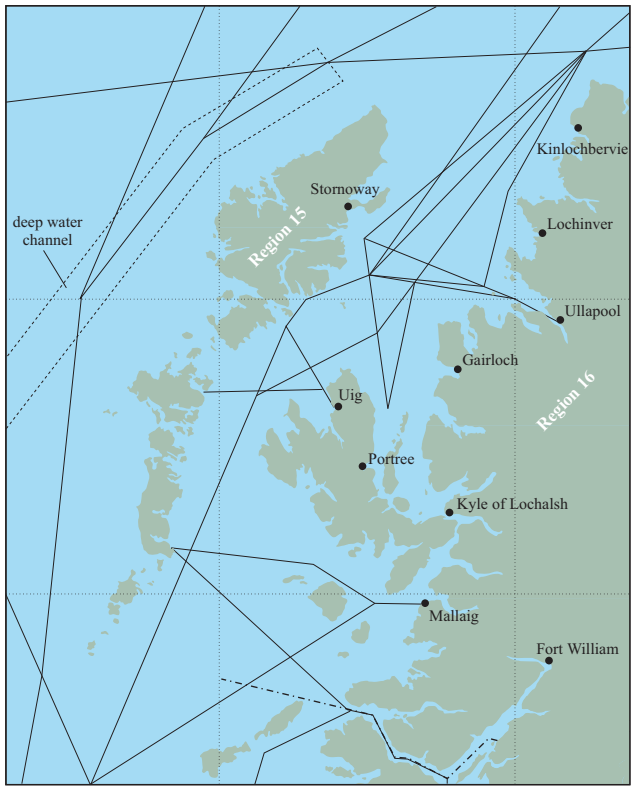
Table 8.3.3 Power generation schemes in Regions 15 & 16

Location	*Type*	*Capacity (MW)*
Region 15		***43.90***
Stornoway	Diesel (stand-by only)	30.29
Loch Carnan	Diesel (stand-by only)	12.07
Chliostair (Harris)	Hydro	1.00
Gisla (Lewis)	Hydro	0.54
Region 16		***7.30***
Morar	Hydro	0.75
Nostie Bridge	Hydro	1.25
Storr Lochs	Hydro	2.85
Kerry Falls	Hydro	1.25
Loch Dubh	Hydro	1.20
Regions 15 & 16		***51.20***

Source: Scottish Hydro-Electric pers. comm.

Ports and harbours; ferries

There are numerous small fishing ports and harbours in both regions. Many of the ports are operated by the Western Isles Council. Ports and harbours, including ferry ports, in the regions are listed in Table 8.3.5; the larger ones are shown on Map 8.3.3. Stornoway (Isle of Lewis) is the most significant port in Region 15. It is an important fishing, ferry and supply port and a popular stopping point for cruises in the region. The larger ports in Region 16 include Mallaig, Uig, Ullapool, Lochinver and Kinlochbervie, some of which are important bases for fishing fleets from a number of European countries. Many of the fishing harbours are also ferry ports. Ferry transport is of great importance in Regions 15 and 16; the harbours are central to the economy of the regions, particularly as many of the islands are dependent upon supplies from the



Map 8.3.3 Ports, harbours and well-used shipping routes. Sources: Walker (1996) and others. Shipping routes reproduced from the COAST database, held by Dovre Safetec Ltd.

mainland. The main ferry crossings are operated by Caledonian MacBrayne. Region 15 has several ferry ports, with regular services between the three main island groups and to the mainland. Many of the sites in Region 16 only service short, sheltered crossings (e.g. across the Sound of Mull) and most operate from piers or jetties. Some run only in summer. There are also a number of short, regular ferry crossings which cut across the sea lochs of the deeply indented coastline.

Lord Donaldson (1994) records that there is 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 computer-assisted ship traffic database (COAST), which provides details of 3,500 shipping routes across the UK continental shelf giving the number of vessels and their distribution by ship, type, age and flag. An extract from this database is plotted on Map 8.3.3. There is a traffic separation scheme north of Skye and a voluntary loaded-tanker exclusion zone in the Minches, which form a 'short cut' for shipping travelling along the west coast of Britain, but which present navigational hazards. There is substantial shipping traffic along the western Scottish

Table 8.3.4 SRO-1 schemes in Region 16

Location	*Site name*	*Technology*	*Proposer*	*Capacity (MW)*
Kishorn	Garry Gualach	Hydro	Bear Ellice Ltd	0.78
Sheildaig	Shieldaig Hydro Project	Hydro	Highland Light & Power Co. Ltd.	2.1
Stoer	Loch Poll Hydro Project	Hydro	Assynt Crofter's Trust	0.23

Source: Scottish Office pers. comm.

Table 8.3.5 Ports and harbours

Port	*Grid ref.*	*Details*
Region 15		
Stornoway, Lewis	NB4333	Owned and operated by Stornoway Pier and Harbour Commission; three berths, ferry to Ullapool, vehicles/wheeled cargoes, passengers, dry bulks, hazardous cargoes, oil/petroleum, other liquid bulk, fish; ship repair/graving, leisure craft, lay-up berths, yacht marina
Tarbert	NB1501	Ferry to Uig (Skye) and Lochmaddy
Leverburgh	NB1501	Ferry to North Uist
Scalpay	NG2395	Small harbour
Borve	NF9282	Small harbour
Newtonferry	NF8978	Small harbour
Lochmaddy	NF6268	Ferry to Uig (Skye) and Tarbert
Lochboisdale	NF7919	Ferry terminal owned and operated by Caledonian MacBrayne Ltd; one 109 m berth, ferry to Oban and Castlebay; leisure craft use
Castlebay	NL6697	Ferry to Oban and Lochboisdale
Region 16		
Fort William	NN1074	Ferry port for Oban, entrance to the Caledonian Canal
Glensanda	NM8246	Owned and operated by Foster Yeoman Limited; one 100 m berth, 5,500,000 tonnes p.a., exclusively engaged in shipping of aggregates from Glensanda superquarry
Loch Aline	NM6844	Commercial jetty, slip
Mallaig	NM6797	Small port owned and operated by Mallaig Harbour Authority; ro-ro (roll-on, roll-off) and summer ferry to Armadale; fishing
Armadale	NG6404	Terminal for summer ferry from Mallaig
Isle of Muck	NM4279	Pier and port, ferries to Eigg, Rum and Mallaig
Isle of Eigg	NM4884	Pier for ferries to Mallaig, Glenuig, Muck, Canna and Rum
Kinloch, Rum	NM4199	Pier in Loch Scrisort for sailings to Muck, Eigg, Canna and Armadale (mainland)
Canna	NG2805	Pier for ferry to Mallaig and islands
Lochaline	NM6844	Ferry pier for short crossings to Fishnish, Mull
Kilchoan	NM4863	Ferry pier (passengers) for Tobermory, Mull
Glenuig	NM6778	Jetty for summer sailings to Small Isles (Rum, Canna, Eigg)
Arisaig	NM6686	Small harbour, summer ferries to Small Isles
Inverie	NG7700	Pier for passenger ferries to Mallaig and across Loch Nevis to Tarbet
Armadale (Skye)	NG6404	Ferry pier for sailings to Mallaig and the Small Isles
Kylerhea/Glenelg	NG7921	Small vehicle ferry crossing
Kyle of Lochalsh	NG7627	Municipal ferry port owned and operated by Highland Council; summer passenger sailings to Mallaig
Uig, Skye	NG3964	Owned and operated by Highland Council, one 270 m berth (pier), 500 sq. m of open storage, passenger and freight ferry terminal for Outer Hebrides (Tarbert and Loch Maddy), ro-ro, vehicles/wheeled cargoes, passengers, forest products, fish; ship repair/graving docks
Portree	NG4843	Small fishing port, pier
Sconser	NG5332	Small pier for ferry crossings to Suisnish, Raasay
Toscaig	NG7138	Pier for passenger ferry from Kyle of Lochalsh
Summer Isles	NB9907	New pier at Tanera Mor
Gairloch	NG8076	Fishing port and pier owned and operated by Highland Council, eight berths, total length 100 m, dry bulks, oil/petroleum, fish
Ullapool	NH1394	Owned and managed by Ullapool Harbour Trustees; three berths, total length 220 m, 55,000 tonnes p.a., ferry port (including ro-ro) to Stornoway and across Loch Broom; busy fishing port
Lochinver	NC0922	Municipal port owned and operated by Highland Council; 400 m length of berths, oil/petroleum, fish, road salt; lay up berths, yacht marina
Kinlochbervie	NC2256	Municipal fishing port owned and operated by Highland Council; 400 m length of berths

Sources: Walker (1996), D'Oliveira & Featherstone (1993) and Ordnance Survey Landranger 1:50,000 maps. Note: larger ports are shown on Map 8.3.3; see also Map 9.1.1 for fishing ports.

seaboard, including many supertankers destined for the oil terminals on Shetland and Orkney. Traffic in the Minches includes ferries and cargo vessels within the Hebrides and between the Western Isles and mainland Scotland, as well as cruise ships and a considerable volume of through traffic. The proposed superquarry on Harris and any future oil-related developments could further increase traffic. Because of these hazards, large tankers over 10,000 tonnes are recommended to keep to the Deep Water Route to the west of the Western Isles, to minimise the danger of environmental damage from oil spills. However, a survey in 1989 showed that only 19% of laden tankers were using the preferred route (Habberley 1989). Recommendations for this area have been made by Lord Donaldson (1994), including the provision of a tug stationed in Stornoway during the winter. A voluntary reporting scheme enables the general public to report tanker movements to Stornoway Coastguard. In 1994 the European Sea Ports Organisation (ESPO 1994) issued an Environmental Code of Practice.

Lord Donaldson also reports 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 quantification of port waste reception facilities for the International Maritime Organisation.

Road and rail communications; airfields

Much of the road system throughout Region 15 is single track. Roads run close to the coast in many places, both alongside sea lochs and on the open coast. The road system on Lewis is generally of a good quality and provides access to much of the north-west and east coast. Roads reach much of the Harris coast, but the east coast of the Uists has only restricted access. Several causeways and bridges connect the islands of the Uists. Bryan (1994) suggests that sedimentary coastal habitats in the region may come under increasing pressure from road, bridge and causeway building, especially at the North Uist - Benbecula - South Uist link roads. In Region 16 there are many places where roads run along the coast, particularly in the south of the region, such as at Loch Linnhe, Loch Eil, Arisaig to Mallaig, Loch Duich and Loch Alsh, and to the south of Loch Carron. The road bridge from Kyle of Lochalsh (at the entrance to Loch Alsh on the mainland) to Kyleakin, Skye, provides the first permanent connection between Skye and the mainland, replacing the Kyleakin ferry. There is a railway line from Fort William to Mallaig, and one to Kyle of Lochalsh from Inverness.

The three main island groups in Region 15 (Lewis/Harris, Uists/Benbecula and Barra) each have an airstrip. The landing strip on Barra is on intertidal sand, a situation unique in the UK. Work associated with the airfields has affected coastal habitats (ASH Consulting Group 1994), with the extension of the airfield at Stornoway involving the loss of some intertidal habitat (Buck 1993). Most sea crossings in Region 16 are short and across sheltered waters, and so short-distance air transport is less important than in Region 15, the routes being served by ferries. There is a coastal airstrip at Broadford, Skye, and one at Plockton, at the entrance to Loch Carron.

Table 8.3.6 lists major bridges and airfields in the regions.

Table 8.3.6 Major bridges and airfields

Name	*Grid ref.*	*Feature*
Region 15		
Claddach a Luib, Samala	NF8063	Two road bridges
Between North Uist and Benbecula	NF8658	Road bridges/ causeways
Between Benbecula & South Uist	NF8047	Large bridge/ causeway
Caltinish	NF8341	Bridge
Stornoway	NB4633	Airfield
Benbecula	NF7956	Airfield
Barra/Traigh Mhor	NF7006	Airfield
Region 16		
Loch Leven	NN0560	Major bridge across mouth of loch
Loch Long	NG8826	Bridge across entrance to loch
Skye bridge	NG7627	Between Kyle of Lochalsh and Kyleakin
Broadford Aerodrome	NG6924	Airfield
Plockton Aerodrome	NG7933	Airfield

Source: Ordnance Survey Landranger 1:50,000 maps

8.3.3 Information sources used

The main sources of information for this section were Buck (1993), Cook (1993), Walker (1996), Ordnance Survey Landranger 1:50,000 maps, Bryan (1994), Caledonian MacBrayne (1994) and D'Oliveira & Featherstone (1993). Up-to-date information on infrastructural development is held by local planning authorities. Most of the information on power generation was provided by the major Scottish power producing companies. Information on road and rail links, bridges, ferries and airfields was derived from 1:50,000 Land Ranger Ordnance Survey maps and Bryan (1994). Additional data are held by the Western Isles Council Roads and Transport Department and by Highland Council.

8.3.4 Acknowledgements

The assistance of Amanda Bryan is gratefully acknowledged. Information was also kindly supplied by Western Isles Council, Highland Council, Scottish Natural Heritage, the British Wind Energy Association, Scottish Hydro-Electric, Scottish Power, Scottish Nuclear and the Scottish Office. Shipping routes on Map 8.3.3 are reproduced from the COAST Database, developed and held by Dovre Safetec Ltd.

8.3.5 Further sources of information

A. References cited

ASH Consulting Group. 1994. *Coastal erosion and tourism in Scotland*. Edinburgh, Scottish Natural Heritage. (SNH Review, No. 12.)

Bryan, A. 1994. *The Minch review*. Stornoway, Western Isles Islands Council, and Inverness, Scottish Natural Heritage.

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

Caledonian MacBrayne. 1994. *Ferry guide to 23 Scottish islands*. Gourock, Caledonian MacBrayne.

Cook, C. 1993. *Pears cyclopaedia 1993-1994*. London, Penguin Books.

Department of Trade & Industry. 1992. *Review of wave energy*. London, HMSO. (ETSU-R-72.)

D'Oliveira, B., & Featherstone, N.L. 1993. *The Macmillan and Silk Cut nautical almanac 1994*. Basingstoke, Macmillan Press.

Donaldson, J., Lord. 1994. *Safer seas, cleaner ships. Report of Lord Donaldson's inquiry into the prevention of pollution from merchant shipping*. London, HMSO. (CM2560.)

European Sea Ports Organisation. 1994. *Environmental code of practice*. Brussels, European Sea Ports Organisation.

Habberley, J.S. 1989. *Review of tanker traffic in the deep water route west of the Hebrides and through the Minches*. Warsash, Southampton Institute of Higher Education.

Highland Regional Council. 1990. *Highland Region Structure Plan 1990: written statement*. Inverness, Highland Regional Council Planning Department.

Highlands and Islands Enterprise. 1996. *Strategy for enterprise development*. Inverness, Highlands and Islands Enterprise.

Registrar General Scotland. 1995. *Mid-1994 population estimates: Scotland*. Edinburgh, HMSO.

Walker, N., *ed*. 1996. *Compass UK ports directory 1996/97*. King's Lynn, Compass Publications.

Water Research Council. 1995. *The survey of UK reception facilities for oil and garbage*. Southampton, Marine Safety Agency. (Report No. 352.)

B. Further reading

Admiralty. 1990. *West coast of Scotland pilot*. Taunton, Hydrographic Office.

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

Brady, P. 1995. *Fishing vessels of Britain & Ireland 1995*. 3rd ed. London, EMAP Business Communications.

British Marine Industries Federation. Undated. *Steering a balanced course: the boating industry and the marine environment*. Egham, British Marine Industries Federation.

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

British Ports Association. 1994. *British Ports Association 1994*. King's Lynn, Charter International.

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.

Department of Trade & Industry. 1994. The non-fossil fuel obligation. London, Department of Trade & Industry. *REview: the magazine of renewable energy, 22* (supplement).

Department of Trade and Industry. 1994. *Digest of UK energy statistics 1994*. London, HMSO.

Department of Transport. 1991. *Port statistics 1990.* London, Department of Transport & British Ports Federation.

Doody J.P. Undated. *Coastal habitat change - a historical review of man's impact on the coastline of Great Britain*. Peterborough, Joint Nature Conservation Committee. (Unpublished draft report.)

ENDS. 1994. *Cleaner combustion technology - a revolution waiting to happen*. Environmental Data Services Ltd. (ENDS Report, No. 230.)

Institute of Terrestrial Ecology. 1993. *Countryside survey 1990: main report*. London, Department of the Environment.

Probert, P.K., & Mitchell, R. 1983. Environmental implications of wave energy proposals for the Outer Hebrides and Moray Firth. *Ocean Engineering, 10:* 459-469.

Scottish Hydro-Electric. 1994. *Power from the glens.* Perth, Scottish Hydro-Electric Plc.

Scottish Local Government Information Unit. 1996. *The directory of Scottish local government*. Edinburgh, Convention of Scottish Local Authorities.

Stornoway Pier & Harbour Commission. Undated. *Stornoway: the harbour.* Stornoway, Stornoway Pier & Harbour Commission.

Sutton, G., *ed.* 1989. *ABP '89, a guide to the ports and shipping services of Associated British Ports Holdings plc.* King's Lynn, Charter International Publications.

Technica. 1985. *Shipping routes in the area of the United Kingdom continental shelf*. London, HMSO. (Report to the Department of Energy.)

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Regional development	
Regional developments and infrastructure - Western Isles	*Western Isles Council, Stornoway, tel: 01851 703773
Regional developments and infrastructure - Highland	*Highland Council, Inverness, tel: 01463 702000
Economic development: Highlands and Islands Objective 1 area	Highlands and Islands Partnership Programme, Bridge House, 20 Bridge Street, Inverness IV1 1QY, tel: 01463 244292
Industrial and economic development	Scottish Council for Development and Industry, 23 Chester Street, Edinburgh EH3 7ET, tel: 0131 225 7911
Industrial and economic development	Scottish Enterprise, 120 Bothwell Street, Glasgow G2 7JP, tel: 0141 248 2700
Economic and urban development policy including European Funds (Scotland)	*Scottish Office Development Department, tel: 0131 556 8400
Economic development, redevelopment/renewal	*Highlands and Island Enterprise, Inverness, tel: 01463 234171/244469
European Regional Development Funds	Department of Trade and Industry, Regional Policy Division, Room 317, Kingsgate House, 66-74 Victoria Street, London SW1E 6SW, tel: 0171 215 8594
Enterprise Zones	*SOAEFD, Planning Division, Victoria Quay, Edinburgh EH6 6QQ, tel: 0131 244 4082
Ports and shipping	
Mallaig Harbour Authority	*Harbour Office, Mallaig, tel: 01687 462154
Ullapool Harbour	*Harbour Office, Ullapool, tel: 01854 612091
Stornoway Harbour	*Stornoway Pier and Harbour Commissioners, Stornoway, Isle of Lewis, tel: 01851 702688
Base information on tanker avoidance areas in the Outer Hebrides	International Maritime Organisation, 4 Albert Embankment, London SE1 7SR, tel: 0171 735 7611

Type of information	*Contact address and telephone no.*
Ports and shipping (continued)	
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
Power generation	
Renewable energy potential report for Scotland	*Highlands and Island Enterprise, Inverness, tel: 01463 234171
Renewable energy	Secretary, Energy Technology Support Unit (ETSU), Renewable Energy Enquiries Bureau, Harwell, Oxfordshire OX11 0RA, tel: 01235 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
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
Hydro-electric power	Scottish Hydro-Electric plc., 10 Dunkeld Road, Perth PH1 5WA, tel: 01738 455040
Conventional power	Scottish Power plc, Cathcart House, Spean Street, Glasgow G44 4BE, tel: 041 637 7177
Nuclear power production	Scottish Nuclear Limited, 3 Redwood Crescent, Peel Park, East Kilbride G74 5PR, tel: 01352 62000
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

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

8.4 Coastal defence

S.L. Fowler

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 by the sea. Sea (or flood) defences protect low-lying land from flooding by the sea or rivers, especially to preserve human life and property in coastal settlements and industrial areas; many were built to protect agricultural land from flooding and to allow agricultural improvement and drainage. Some forms of coastal defence may protect against both erosion and flooding. It may be difficult to differentiate between the two different forms of coastal works, particularly where they are owned and maintained privately or by bodies (such as the MoD) not usually responsible for coastal defences. For this reason this section describes coastal defence works in general, irrespective of the purpose for which they were constructed.

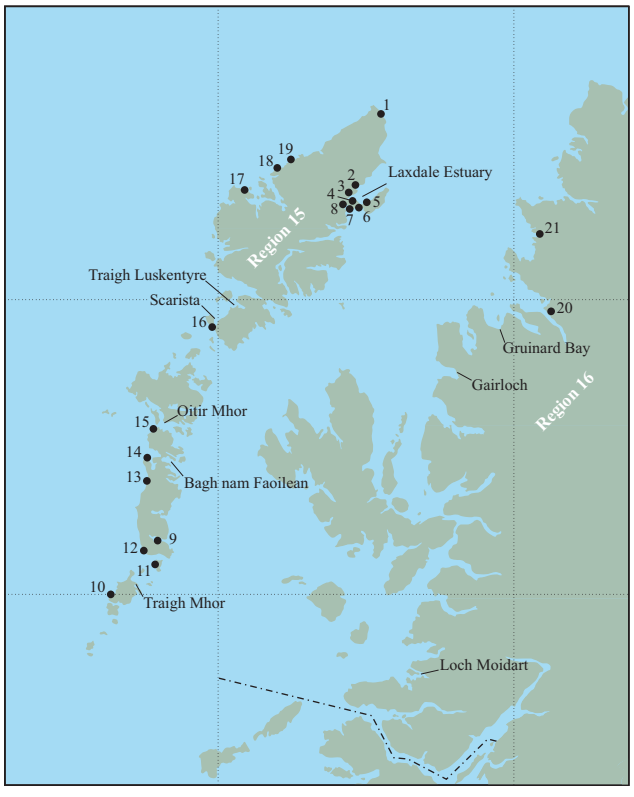
In the UK, coastal works are most widely distributed along eroding coasts with relatively soft geological formations, along urban and industrial coastlines, or bordering very low-lying, sinking coastal land. They are therefore particularly prevalent in south and south-east England. Rising sea levels from climate change and increasing frequency of storm conditions in the Atlantic and North Sea are increasing the future potential for erosion and flooding and decreasing the expected useful life of coastal works.

Generally there are far fewer coastal defence works in Regions 15 and 16 and in other sparsely populated northern regions than in the south of the UK (Angus & Elliott 1992). Coastal defence works in these regions are mainly built to protect settlements, industrial areas or historical sites from erosion or sea encroachment in a few low-lying areas, and to protect bridges or road and rail embankments. They range from simple wooden groynes installed on beaches to control coastal sediment movement, to major concrete engineering works (berms and seawalls). The risk of coastal erosion or flooding in Regions 15 (Western Isles) and 16 (west Highland) is mainly confined to small areas, because much of the coastline is rocky and undeveloped. However, erosion occurs along the machair coastlines of the Western Isles. Storm surges, particularly when combined with high spring tides and/or heavy rain causing peak river flows, are the major flooding threat to low-lying coastal areas (Angus & Elliott 1992).

8.4.2 Important locations

Table 8.4.1 lists sites of coastal defence works in the regions that are noted in HR Wallingford (1995a) (Map 8.4.1). In Region 15, Buck (1993) reports further linear defences at Laxdale, Traigh Mhor, Bagh nam Faoilean, Oitir Mhor, Scarista and Traigh Luskentyre.

ASH Consulting Group (1994) list sites where erosion is occurring as a result of visitor use, wind and waves (particularly during high water of spring tides), or a combination of these factors (Table 8.4.2). Many problems have been exacerbated by sand extraction (Currie pers. comm.).



Map 8.4.1 Locations of coastal defence works. Numbers refer to Table 8.4.1. Other locations are those mentioned in the text. Sources: ASH Consulting Group (1994); HR Wallingford (1995a, b).

Table 8.4.1 Coastal works in Regions 15 and 16

No. on Map 8.4.1	*Location*	*Notes*
	Region 15	
1	Port of Ness	Harbour breakwater
2	Coll Sands	Gabions
3	Tong	Rock armouring, gabions
4	Stornoway Airport	Rock armouring
5	Aignish	Rock armouring
6	Eye Peninsula isthmus	Sea wall, groynes
7	Holm, Suardail Bay	Rock apron, gabions
8	Stornoway	Sea wall
9	Lochboisdale	Sea wall
10	Halaman Bay	Rock revetment
11	Balla	Rock wall
12	East & West Kilbride	Rock revetment
13	Firing Ranges, South Uist	Gabion mattresses
14	Balgarva	Rock revetment
15	Balivanich	Rock revetment
16	Northton	Rock revetment
17	Valtos	Rock protection
18	Dalmore	Timber breastwork
19	Shawbost	Rock protection
	Region 16	
20	Ullapool	Sea wall & harbour
21	Lochinver	Rock revetment

Source: HR Wallingford (1995a).

Table 8.4.2 Eroding sites with coastal defence works

Site	*Details*
Dalbeg, Lewis	Unauthorised vehicular access has contributed to severe erosion to the machair at this site. Vehicular access has been prevented by placing large rocks as a barricade.
Dalmore, Lewis	Gabions have been placed to alleviate machair erosion. They have had limited success, with further erosion taking place around the gabions.
Gress Saltings SSSI, Lewis	In 1986 there was severe erosion below Gress Lodge, at the northern end of the site, caused by a combination of sea, wind and sand extraction. The affected area has since been protected by rock armouring.
Loch na Cartach SSSI, Lewis	An area of severely eroded machair was successfully reinstated in 1986 by spreading peat, seeding and planting with marram grass and fencing. There are plans to exclude grazing and control vehicular access to improve the quality of machair at the site. Wind action has been a problem.
Northton Bay SSSI, Harris	Uncontrolled vehicular access to the machair is causing erosion problems. Unauthorised camping and pit digging have also been a problem.
Stornoway Harbour, Lewis	Sea walls protect the entire frontage of Stornoway. During adverse conditions at spring tides, the protection is insufficient to prevent flooding of much of the town centre.
Tong Saltings SSSI, Lewis	After extension of the runway, the land surrounding the northern extreme of the runway was protected by rock armouring to prevent undermining by marine erosion.
The Braighe, Lewis	Both sides of the isthmus are protected by sea walls and the beaches have groynes present. There is a large shingle bund to the west that protects the airfield from flooding at spring tides. In heavy weather conditions this bund is regularly breached, needing frequent maintenance.
Traigh na Berie, Lewis	Unauthorised caravan site on the machair (up to 86 caravans, some on the edge of the machair) has caused a significant degree of erosion. An alternative authorised site has been identified and caravans moved.

Source: ASH Consulting Group (1994)

In Region 16 Buck (1993) reports linear defences at Loch Moidart, and ASH Consulting Group (1994) records coastal defences at Gairloch and Gruinard Bay.

8.4.3 Management

Legislation relating to the carrying out of flood or sea defence works is included in the Water Resources Act 1991 and the Land Drainage Act 1994. In these regions, departmental responsibility for flood defence and coast protection lies with the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD). The local councils in Scotland have powers as coast protection authorities under the Coast Protection Act (1949) to protect land from erosion and encroachment and to prevent flooding of non-agricultural land. At the time of writing there are no formal regional coastal (engineering) groups in Scotland to co-ordinate the work of adjacent coastal defence agencies, as occurs in England and Wales. Highland Council wishes to increase its annual spend on sea defences from £120,000 to £250,000 to take account of increasing erosion rates, which may be due to increased storminess and wave height. Other councils have programmes of new capital coastal works and maintenance of existing defences.

8.4.4 Information sources used

Little collated information on coastal defence works in Scotland is available. HR Wallingford are conducting a study on coastal process cells in Scotland (HR Wallingford 1995a), co-sponsored by Scottish Natural Heritage, the Scottish Office Environment Department and Historic Scotland. Phase one, a broad delineation and description of cells, is now complete and is to be followed by a further two years work to provide a comprehensive description of the cells. This study will set out for the first time a framework for management of coastal areas in Scotland. HR Wallingford (1995a) include coastal defence within the scope of their description of coastal cells and name specific sites in Region 15 and a few in Region 16. Coastal defence works in Scotland are also discussed in the *Review of Scottish coastal issues* (Burbridge & Burbridge 1994).

HR Wallingford (1995b) lists all the defences along the dune and machair coasts of Region 15. ASH Consulting Group (1994) provide an incomplete list of sites in Region 16 where coastal defence techniques are known to have been used or a perceived coastal erosion problem exists (derived from information provided by Scottish Natural Heritage regional offices and some local authorities), including case studies for Gairloch and Gruinard Bay. The Scottish Office have published a discussion paper regarding a general coastal strategy (SOAEFD 1996).

8.4.5 Acknowledgements

The assistance of Highland Council, Amanda Bryan and Andrew Currie is gratefully acknowledged. Thanks are also due to Dr George Lees, Scottish Natural Heritage, for his useful comments.

8.4.6 Further sources of information

A. References cited

Angus, S., & Elliott, M.M. 1992. Erosion in Scottish machair with particular reference to the Outer Hebrides. *In: Coastal dunes: geomorphology, ecology and management for conservation*, ed. by R.W.G. Carter, T.G.F. Curtis & M.J. Sheehy-Skeffington, 93-112. Rotterdam, Balkema.

ASH Consulting Group. 1994. *Coastal erosion and tourism in Scotland.* Edinburgh, Scottish Natural Heritage. (SNH Review, No. 12.)

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

Burbridge, P.R., & Burbridge, V. 1994. *Review of Scottish coastal issues*. Edinburgh, Scottish Office.

HR Wallingford. 1995a. *Coastal cells in Scotland.* Wallingford, HR Wallingford, for Scottish Natural Heritage, Scottish Office (Environment Department) and Historic Scotland. (Report No. EX 3176.)

HR Wallingford. 1995b. *Survey of coastal erosion in the Western Isles.* Wallingford, HR Wallingford, for the Minch Project (Scottish Natural Heritage and the Western Isles Island Council). (Report No. EX 31.)

Scottish Office Agriculture, Environment & Fisheries Department. 1996. *Scotland's coast: a discussion paper*. Edinburgh, HMSO.

B. Further reading

Boorman, L., & Hazelden, J. 1995. Saltmarsh creation and management for coastal defence. *In: Directions in European coastal management*, ed. by M.G. Healy & J.P. Doody, 175-183. Cardigan, Samara Publishing Ltd.

CIRIA. 1996. *Beach management manual.* London, Construction Industry Research and Information Association.

House of Commons. 1992. *Coastal zone protection and planning.* London, House of Commons. (Environment Select Committee Report.)

HR Wallingford. 1991. A summary guide to the selection of coast protection works for geological Sites of Special Scientific Interest. *Nature Conservancy Council, CSD Report,* No. 1,245.

Irish Sea Forum. 1992. *Global warming and climatic change.* Liverpool, University Press.

Lee, E.M. 1995. Coastal cliff recession in Great Britain: the significance for sustainable coastal management. *In: Directions in European coastal management*, ed. by M.G. Healy & J.P. Doody, 185-193. Cardigan, Samara Publishing Ltd.

Ministry of Agriculture, Fisheries & Food. 1994/95. *Shoreline management plans. A procedural guide for operating authorities*. London, MAFF.

Swash, A.R.H., Leafe, R.N., & Radley, G.P. 1995. Shoreline management plans and environmental considerations. *In: Directions in European coastal management*, ed. by M.G. Healy & J.P. Doody, 161-167. Cardigan, Samara Publishing Ltd.

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 556 8400 or 0131 244 0204
Coast protection and flood defence - Highland	*Highland Council, Inverness, tel: 01463 702000
Coast protection and flood defence - Western Isles	*Western Isles Council, Stornoway, Isle of Lewis, tel: 01851 703773
Storm tide warning service	Meteorological Office, Johnstone House, London Road, Bracknell, Berkshire RG12 2SZ, tel: 01344 420242
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.

The Sound of Mull features a number of spectacular underwater cliffs covered in sponges, anemones and other sea-bed creatures. The jetty at the entrance to Lochaline is popular with scuba divers investigating the wildlife on a vertical wall of rock that drops to a depth of over 90 m. Photo: Bill Sanderson, JNCC.

Chapter 9 Human activities

9.1 Fisheries

D. Murison & C.F. Robson

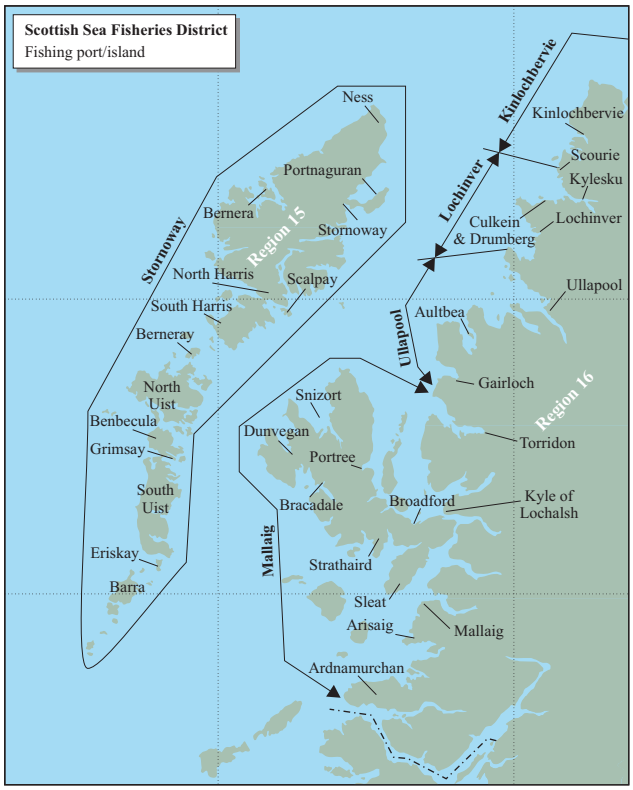
9.1.1 Introduction

This section gives an overview of the main fishing activities in the coastal waters and rivers of Regions 15 (Western Isles) and 16 (west Highland). There are fisheries for pelagic, demersal 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 and islands in the regions where landings are recorded by SOAEFD, and the Scottish Sea Fisheries Districts in the regions, are shown in Map 9.1.1. The ports where the largest landings are made are Stornoway, Barra, Mallaig, Ullapool, Lochinver and Kinlochbervie, and there are many island and coastal fishing communities, often situated in the sheltered areas around lochs. The larger islands, such as Skye and Lewis, support fishing fleets, and shellfish buyers and processors are now establishing themselves on many of the islands, as markets and transport links improve.

In 1992, 15.1% of all recorded landings of fish and shellfish species in Britain and the Isle of Man were made in Regions 15 and 16, mostly landed in Region 16. The total tonnages of pelagic, demersal and shellfish species landed in the regions represent 25.2%, 7.4% and 11.0% respectively of the British totals. The total tonnage of pelagic species represents 27.8% of the Scottish total. The tonnage of mackerel landed in the regions represents 35.1% of the British total for the species, and there are also significant landings of sprat (11.1%) and herring (10.8%). 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 six ports in Regions 15 and 16 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 is based.



Map 9.1.1 Fishing ports/islands and Scottish Sea Fisheries Districts. Source: SOAFD (1995a). © Crown copyright.

In the Scottish Salmon Fishery Statistical Districts in Regions 15 and 16 (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

Table 9.1.1 Species group landings in 1992 (tonnes)

Species group	*Region 15*	*Region 16*	*Regions 15 & 16*	*West Coast**	*Scotland*	*Britain and Isle of Man*	*% of West Coast* total landed in Regions 15 & 16*	*% of combined British and Isle of Man total landed in Regions 15 & 16*
Pelagic	9	63,468	63,477	68,026	227,669	252,335	93.3	25.2
Demersal	1,449	18,922	20,371	47,404	193,914	275,460	43.0	7.4
Shellfish	4,669	6,882	11,551	42,984	46,112	104,917	26.9	11.0
All groups	***6,127***	***89,272***	***95,399***	***158,414***	***467,695***	***632,712***	***60.2***	***15.1***

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 six Region 15 and 16 ports 1991-1994 (thousands of tonnes)

	1991	*1992*	*1993*	*1994*
Region 15	***3.7***	***4.0***	***4.6***	***4.5***
Stornoway	2.1	2.2	2.6	2.5
Barra	1.6	1.8	2.0	2.0
Region 16	***89.3***	***86.5***	***93.3***	***66.1***
Mallaig	8.5	7.8	10.3	11.1
Ullapool	61.6	63.6	61.8	29.4
Lochinver	7.0	5.4	5.4	6.9
Kinlochbervie	12.2	9.7	15.8	18.7
Regions 15 & 16	***93.0***	***90.5***	***97.9***	***70.6***
Scotland	458.4	467.7	491.8	487.8
% of Scottish total landed in above ports	20.3	19.3	19.9	14.5

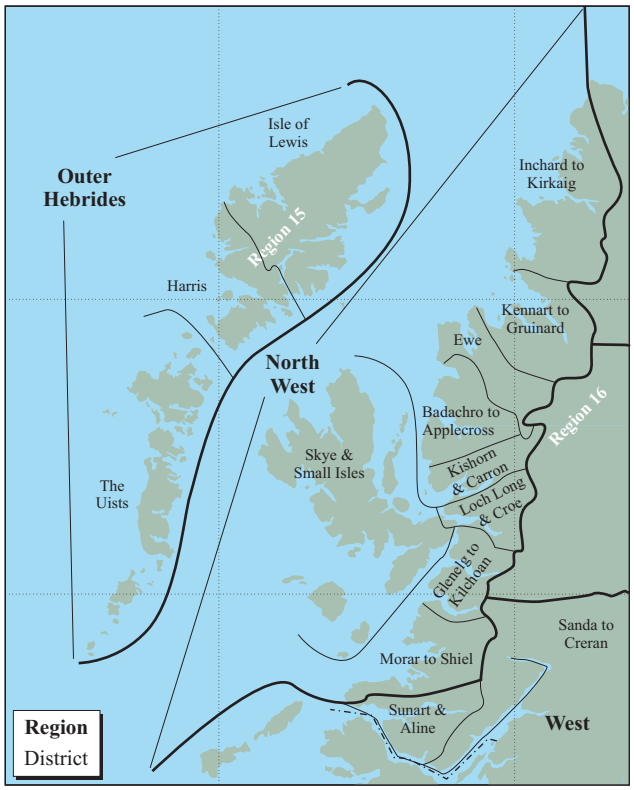
Source: Ministry of Agriculture, Fisheries and Food (1995b). Key: [a]landings totals relate to 'nominal live weight', i.e. weight of the whole fish. Note: calculating the figures in this table was a complex process: refer to section 9.1.4.

fisheries from rivers, as well as 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 1993 in the regions represents 6.0% of the British total and 26.3% of the total for the 'West Coast'. A large proportion of the regions' recorded catch of salmon and grilse is from Region 16. The average total recorded catch of sea trout made by all methods between 1989 and 1993 in the regions represents 3.3% of the British total and 12.8% of the total for the 'West Coast'.

9.1.2 The fisheries

Pelagic species

Table 9.1.4 gives the quantities of various pelagic species landed in 1992 in the regions, compared with landings nationally. The Minch herring fishery, which was based at Mallaig, has reduced in significance since the collapse in herring stocks that took place in the late 60s and 70s, which led to a two-year closure in the late 1970s to protect the remaining stock. Even now, there is a reduced demand for herring (and West Coast herring are considered to be only lightly exploited), yet 10.8% of the British and Isle of Man total is landed to Regions 15 and 16, mainly to Region 16. Following the decline of the herring fishery, effort was shifted towards catching more demersal species, *Nephrops* and mackerel, which is targeted mainly between January and March. The mackerel fishery peaked in the early eighties, and even though landings have decreased since then, owing to a change in the mackerel migration pattern, the landings are still a significant proportion of the British total. In the Western Isles, mackerel are fished mainly around Lewis and Harris and are landed at ports in Region 16. Ullapool is the main landing port for mackerel, and many boats in the pelagic fishing fleet are based there for the mackerel season. Russian and East European klondykers (factory ships) anchor off Ullapool and buy much of the mackerel landed. The sprat fishery is targeted on overwintering concentrations of adults. Sprats are fished between October and January, mainly from the Minch and



Map 9.1.2 Scottish salmon fishery statistical districts. Source: Scottish Office (1994). © Crown copyright.

Table 9.1.3 Average catch (numbers of fish) of salmon and grilse and sea trout 1989-1993

	Salmon and grilse	*Sea trout*
Region 15	1,959	2,122
Region 16	13,429	2,618
Regions 15 & 16	15,388	4,740
West Coast*	58,582	37,024
Scotland	187,481	65,468
GB	***254,829***	***141,813***
% of West Coast* total in Regions 15 & 16	26.3	2.8
% of GB total in Regions 15 & 16	6.0	3.3

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.

around Skye and the Small Isles. A significant proportion (23.3%) of the total landings of argentines for Britain and the Isle of Man were made in the regions in 1992; however, the amount landed - 42 tonnes - is very small, compared with amounts of mackerel and herring.

Demersal species

Table 9.1.5 gives the quantities of various demersal species landed in 1992 in the regions, compared with landings nationally. The mixed demersal fishery is concentrated in open waters of the North Minch and to the south of the

Table 9.1.4 Pelagic species landings in 1992 (tonnes)

Species	*Region 15*	*Region 16*	*Regions 15 & 16*	*West Coast**	*Scotland*	*Britain and Isle of Man*	*% of West Coast* total landed in Regions 15 & 16*	*% of combined British and Isle of Man total landed in Regions 15 & 16*
Argentines	0	42	42	43	180	180	97.7	23.3
Herring	9	9,246	9,255	10,944	83,879	85,650	84.6	10.8
Horse mackerel	0	95	95	125	473	1,499	76.0	6.3
Mackerel	0	52,969	52,969	55,360	141,583	150,726	95.7	35.1
Pilchard	0	0	0	P	0	4,244	0	0
Sprat	0	1,116	1,116	1,554	1,554	10,032	71.8	11.1
Others	0	0	0	0	0	4	0	0
Total	***9***	***63,468***	***63,477***	***68,026***	***227,669***	***252,335***	***93.3***	***25.2***

Sources: 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). 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 9.1.5 Demersal species landings in 1992 (tonnes)

Species	*Region 15*	*Region 16*	*Regions 15 & 16*	*West Coast**	*Scotland*	*Britain and Isle of Man*	*% of West Coast* total landed in Regions 15 & 16*	*% of combined British and Isle of Man total landed in Regions 15 & 16*
Elasmobranchs								
Dogfish	628	2,581	3,209	5,899	9,657	13,348	54.4	24.0
Skates and rays	75	1,197	1,272	4,011	3,670	7,827	31.7	16.3
Gadoids								
Cod	88	2,425	2,513	6,084	35,898	59,524	41.3	4.2
Haddock	84	3,485	3,569	4,365	49,867	53,586	81.8	6.7
Hake	61	406	467	3,031	1,993	3,620	15.4	12.9
Ling	30	376	406	1,433	4,318	6,027	28.3	6.7
Pollack (lythe)	1	55	56	1,102	1,285	3,023	5.1	1.9
Saithe	8	686	694	1,570	10,310	12,602	44.2	5.5
Whiting	149	1,677	1,826	4,322	35,923	41,055	42.2	4.4
Whiting, blue	0	0	0	0	6,531	6,531	0	0
Flatfish								
Brill	P	4	4	126	50	443	3.2	0.9
Dab	P	75	75	198	759	1,215	37.9	6.2
Dover sole	P	2	2	855	57	2,876	0.2	<0.1
Flounders	0	P	P	106	4	273	-	-
Halibut	1	15	16	28	114	194	5.7	8.2
Halibut, Greenland	0	0	0	18	20	137	0	0
Lemon sole	32	165	197	569	2,566	5,573	34.6	3.5
Megrim	19	1,127	1,146	2,658	2,566	4,037	43.1	28.4
Plaice	26	1,225	1,251	3,138	7,902	23,887	39.9	5.2
Turbot	6	44	50	181	196	742	27.6	6.7
Other species								
Catfish	0	31	31	39	1,378	1,935	79.5	1.6
Conger eel	3	49	52	411	107	510	12.7	10.2
Gurnard	0	13	13	259	32	627	5.0	2.1
Monkfish/angler	153	2,638	2,791	4,865	11,557	14,678	57.4	19.0
Redfish	0	23	23	56	193	774	41.1	3.0
Sand eel	0	0	0	0	4,152	4,152	0	0
Torsk (tusk)	0	37	37	42	194	207	88.1	17.9
Witch	85	245	330	576	1,789	1,981	57.3	16.7
Others	0	315	315	1,414	682	3,833	22.3	8.2
Fish roes	0	26	26	48	144	243	54.2	10.7
Total	***1,449***	***18,922***	***20,371***	***47,404***	***193,914***	***275,460***	***43.0***	***7.4***

Sources: 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.

Western Isles and landings are made to both Regions 15 and 16. Catches, which are highest in winter, have recently been declining. The majority of trawlers targeting demersal species in the Minch are registered in the east coast of Scotland but based at west coast ports such as Kinlochbervir, Lochinver and Mallaig. Landings of dogfish, made using longlines and nets, have been increasing, with 24% of the British total landed to the regions in 1992. Megrim and monkfish (angler) are targeted in deep water on the edge of the continental shelf, and landings of these species are very significant for north-west Scotland. In the past there was a significant sand eel fishery in the area, with landings made to fishmeal processing factories at Barra and Stornoway. However, both were closed in 1989 and this has greatly reduced fishing effort. Restrictions imposed on fishing for sand eels (introduced in 1995) have further affected this fishery.

Shellfish species

Table 9.1.6 gives the quantities of various shellfish species landed in 1992 in the regions, compared with landings nationally.

Shellfish, such as *Nephrops*, lobsters, crabs and scallops, are a very important resource to the inshore fleet of north-west Scotland and the Western Isles. The majority of the inshore trawling fleet is dependent on *Nephrops,* which are landed all year in the regions, representing 34.1% of the British total. Catch levels have been declining since the mid 1980s and fishermen have responded by increasing effort. The main *Nephrops* fishing areas are from the middle of the Minch down through the Inner Sound and south and west of Skye. At the height of the *Nephrops* fishing season, in June and July, trawlers from the east coast often arrive to work the grounds. From spring, there is an increase in *Nephrops* trawling in inshore areas, especially where mobile gear is prohibited during the winter. *Nephrops* are also caught all year in creels placed in the deeper-water lochs and sheltered areas of the Minch; squat lobsters are also taken in these creels. Some creel boats of up to 12 m set over 1,000 creels - in some cases up to 1,500.

The lobster, edible crab, velvet crab and crawfish fishery, which uses creels and (for crawfish only) tangle nets, forms a mainstay industry for many fishing communities in the regions, particularly in the Western Isles. The quantities of lobster and crabs landed in both regions, the majority of which were landed to ports in the Western Isles, represent 19.6% and 16.6% respectively of the British totals. Some inshore creel boats of up to 10 m in length use in excess of 1,000 creels, 50 creels being attached to one line; however, the average is between 200-300 pots. The directed lobster fishery peaks between the end of summer and autumn. The edible crab is exploited further offshore by several local and visiting vivier-equipped creel boats (boats with water tanks for transporting the catch alive), of up to 20 m in length, to work from and land into various ports in the regions. Velvet crabs, which are caught in creels, are specifically targeted all year, although they are most valuable during winter.

Scallop dredging effort increased in the 1980s, when market demand was high and demersal species started becoming scarce. Scallops are exploited by vessels using dredges; inaccessible scallop grounds are harvested by divers. Scallops are dredged inshore along the coast of Highland and around the Western Isles, although the boats will work any grounds around the coast of Scotland. Scallop dredging occurs more frequently during the summer and, in winter, outside the regions, as the regions' coasts are too exposed to make winter fishing practical.

Occasional landings of squid are made by trawlers. Large quantities of periwinkles are collected by hand in the regions and the tonnage of periwinkles recorded in the two regions represents 34% of the British and Isle of Man total. Mussels and cockles are also collected by hand, but in much smaller quantities than periwinkles.

Diadromous species

The distribution of diadromous fish species in rivers in the regions is discussed in section 5.8 and shown on Map 5.8.1. In Regions 15 and 16, two diadromous species - salmon (including grilse) and sea trout - support rod-and-line fisheries from rivers, as well as netting stations. Net-and-

Table 9.1.6 Shellfish landings* in 1992 (tonnes)

Species	*Region 15*	*Region 16*	*Regions 15 & 16*	*West Coast***	*Scotland*	*Britain and Isle of Man*	*% of West Coast** total landed in regions*	*% of combined British and Isle of Man total landed in Regions 15 & 16*
Cockles	32	0	32	5,848	2,546	32,047	0.5	0.1
Crabs	1,918	893	2,811	7,853	7,501	16,970	35.8	16.6
Lobsters	169	40	209	447	564	1,069	46.8	19.6
Mussels	0	0	0	1,690	3,067	6,555	0	0
Nephrops	1,733	4,970	6,703	11,271	17,707	19,639	0.6	34.1
Periwinkles	244	427	671	1,592	1,837	1,907	42.1	35.2
Queen scallops	0	0	0	9,066	5,518	11,273	0	0
Scallops	520	356	876	3,771	5,068	8,290	23.2	10.6
Shrimps	0	0	0	128	180	743	0	0
Squids	18	163	181	623	1,071	2,005	29.1	9.0
Whelks	0	0	0	488	858	2,393	0	0
Others	35	33	68	207	195	2,026	32.9	3.4
Total*	***4,669***	***6,882***	***11,551***	***42,984***	***46,112***	***104,917***	***26.9***	***11.0***

Sources: 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: *excluding landings of farmed shellfish - see section 9.2; **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.

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. Both fixed engines and net-and-coble fisheries operate in Regions 15 and 16. Table 9.1.7 shows the average numbers of salmon and grilse and sea trout caught in the statistical districts in Regions 15 and 16 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 is not as prolific as on the east coast of Scotland because the rivers support smaller stocks of salmonids.

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.

In Regions 15 and 16, sea angling is popular and occurs in many places, for example in Portree Harbour on Skye and 4 miles south-east of Portree in the sheltered Camastianavaig Bay. Boats from the Kyle of Lochalsh catch species such as pollack, cod, mackerel and whiting. Sea fishing also occurs in the sheltered sea lochs of Shieldaig, Torridon and Upper Torridon. Sea angling in Gair Loch is especially good around Longa Island. Charter boats leave from Ullapool for the good sea angling around the Summer Isles, which is noted for its large rays (Orton 1996). There is also good fishing from the shore at Morefield, Rhu and Achiltibuie. Sea angling in the Western Isles takes place around Stornoway, Tarbert, Loch Roag, Lochmaddy and Lochboisdale, and the Western Isles host an annual open angling festival. Orton (1996) gives further information on places where sea angling takes place in the regions, the facilities available and potential catch species.

Bait collection

Bait collection for sea angling occurs in many areas in the regions, 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 a few locations in west Highland: at Portree and Broadford on Skye, Plockton and Loch a' Mhuilinn. Occasional bait-digging was reported from the Western Isles.

Table 9.1.7 Salmon & grilse and sea trout five-year (1989-1993) average catch (as numbers of fish reported to SOAEFD)

Scottish Salmon Fishery Statistical District (Map 9.1.3)	*Salmon & grilse*	*Sea trout*
Region 15	**1,959**	**2,122**
The Uists	261	511
Harris	259	507
Isle of Lewis	1,439	1,103
Region 16	**11,331**	**2,498**
Sanda to Creran[b, c]	906	175
Sunart & Aline[a]	105	201
Skye & Small Isles[a]	3,286	303
Morar to Shiel[b]	715	169
Glenelg to Kilchoan[b]	207	83
Loch Long & Croe[a]	568	76
Kishorn & Carron[a]	87	85
Badachro to Applecross[b]	2,032	93
Ewe	265	721
Kennart to Gruinard[b]	888	155
Inchard to Kirkaig[b]	2,272	437
Regions 15 & 16	***13,290***	***4,619***

Sources: Scottish Office Department of Agriculture and Fisheries (1990), Scottish Office (1991, 1992, 1993, 1994). Key: [a]Statistical District covers the two named Salmon Fishery Districts; [b]Statistical District covers the two named Salmon Fishery Districts plus those in between; [c]partly in Region 14 but totals included here. Note: 'sea trout' here includes all migratory trout.

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 the British Territorial Seas) access for vessels from the other member states is limited based on historic fishing rights and for those from non-member

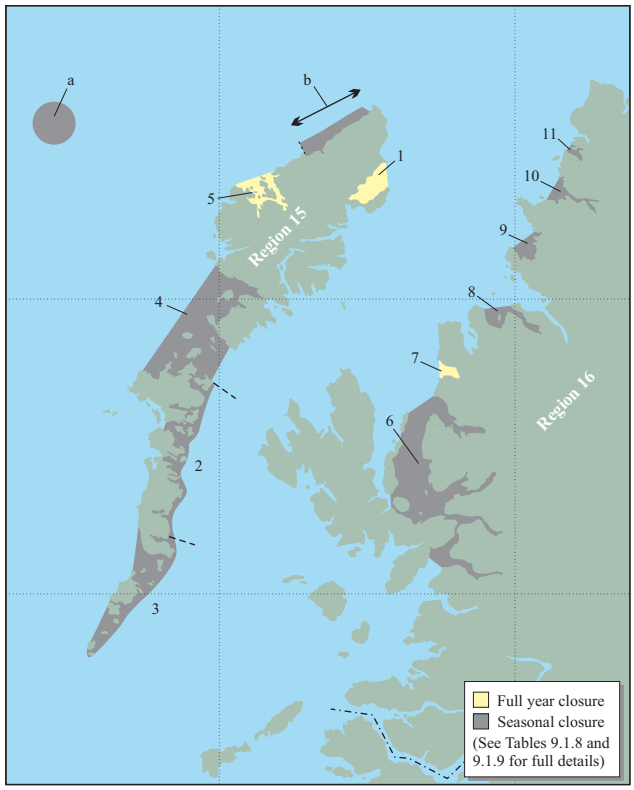
countries by reciprocal agreements with the European Union.

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 these regions 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 take account of, amongst other management needs, 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 covering the regions 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 five Sea Fisheries Districts partly or wholly within the regions (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 principal 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 mobile fishing gear (trawl, seine net, dredge (including suction dredging) etc.) in the regions, and Table 9.1.9 lists the seasonal closures on creel fishing, all 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 and



Map 9.1.3 Full year and seasonal closures on the use of mobile fishing gear and/or creel fishing. Note: this map is for illustrative purposes only - see associated text and Tables 9.1.8 and 9.1.9. Source: Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989.

permits the restriction of time that a fishing vessel can spend at sea. Fisheries managers have been given environmental responsibilities under the Environment Act 1995 and the Conservation (Natural Habitats etc.) Regulations 1994. There are currently no Regulating Orders in Scotland, compared with a total of nine 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 Mallaig and North West 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 Councils 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 regions 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

Table 9.1.8 Full year and seasonal closures on the use of fishing gear

No. on Map 9.1.3	*Sea area within which prohibition applies*	*Full year/ seasonal closure*	*Period of prohibition (inclusive dates):*		*Method of fishing for species of sea fish excepted from mobile fishing gear and/or suction dredging prohibition and period of exception*
			mobile fishing gear	*suction dredging*	
	Region 15				
1	Broad Bay	Full year	1 January - 31 December	n/a	None
2	Loch Maddy to Stuley Island	Seasonal	March - October	January - February and November - December	a) Dredging (but not suction dredging for scallops) between 1 May and 24 August inclusive.
3	Stuley Island to Barra Head and Gurney Point	Seasonal	March - October	January - February and November - December	a) Fishing for sand eels between March and October inclusive. b) Dredging (but not suction dredging) for scallops between 1 May and 24 August inclusive.
4	Sound of Harris	Seasonal	March - September	January - February and October - December	a) Dredging (but not suction dredging for scallops) between March and September inclusive.
5	Loch Roag	Full year	1 January - 31 December	n/a	None
	Region 16				
6	The Inner Sound, including Lochs Torridon, Carron, Kishorn, Duich, Alsh and Hourn	Seasonal	October - March	April - September	None
7	Loch Gairloch	Full year	1 January - 31 December	n/a	None
8	Little Loch Broom and Gruinard Bay	Seasonal	October - March	April - September	None
9	Enard Bay	Seasonal	October - March	April - September	None
10	Eddrachillis Bay	Seasonal	October - March	April - September	None
11	Loch Laxford	Seasonal	October - March	April - September	None

Source: Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989. Key: n/a = not applicable. 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.

Table 9.1.9 Seasonal prohibition of creel fishing

Letter on Map 9.1.3	*Sea area within which prohibition applies*	*Period of prohibition (inclusive dates)*
a	The Flannan Isles	January to March, and 1-31 December
b	Bragar to Dell	July to September

Source: Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 1989.

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.

Issues relating to the fisheries for pelagic, demersal, shellfish and diadromous species and sea angling and bait collection are closely linked to wildlife conservation in several ways. Issues include the effects 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. Further information on issues concerning fisheries can be found in references such as Bryan (1994) and 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

The *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 regions may be obtained from *The Scottish fishing fleet at December 1995* (SOAEFD 1996b). Numbers of full-time and part-time fishermen resident in Sea Fisheries Districts within the regions 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).

Bryan (1994) contains additional detailed information on fisheries, aquaculture and salmon and sea trout for the Minch area, which covers the same geographical area as Regions 15 and 16. Robertson (1993) contains information on fisheries for the Isle of Skye.

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 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 Regions 15 and 16 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 Kinlochbervie Sea Fisheries District within Region 16 were provided by SOAEFD.

The landings for the Sea Fisheries Districts have been combined to give the figures in the 'Regions 15 & 16' 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 regions on the west coast of Great Britain, as defined in section 1.1. The figures in the 'Scotland' column of these tables were 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 sand eels (which are not gutted), so that all the data presented are in '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 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 regions. In order to protect commercial confidentiality, the reported catches for each district are published without an indication of catch method. The *Statistical Bulletin* for 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 (CEFAS (Centre for Environment, Fisheries and Aquaculture Science, formerly MAFF DFR)), Mike Pawson (CEFAS), 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 Bill Lart (Sea Fish Industry Authority) and John Gordon (Dunstaffnage Marine Laboratory) for checking drafts and maps.

9.1.6 Further sources of information

A. References cited

Brady, P. 1995. *Fishing vessels of Britain & Ireland 1995*. 3rd ed. London, Emap Business Communications.

Bryan, A. 1994. *The Minch review*. Inverness, Scottish Natural Heritage.

Cleator, B., & Irvine, M. 1994. *A review of legislation relating to the coastal and marine environment in Scotland*. Edinburgh, Scottish Natural Heritage. (SNH Review, No. 30.)

Coffey, C. 1995. *Introduction to the Common Fisheries Policy: an environmental perspective*. London, Institute for European Environmental Policy. (IEEP London Background Briefing, No. 2.)

Commission of the European Communities. 1995. *Evaluation of the biological impact of fisheries*. Brussels, Commission of the European Communities. (5.5.95, COM (95) 40.)

Eno, N.C., & Hiscock, K. 1995. *Key statutes, Directives and Conventions for marine wildlife conservation in Great Britain.* Peterborough, Joint Nature Conservation Committee. (Marine Information Notes, No. 3 (edition 1, June 1995).)
European Council. 1992. EC Regulation No. 3760/92. *Official Journal of the European Communities, L 389* (35).
European Council. 1995. EC Regulation No. 3074/95. *Official Journal of the European Communities, L 330* (38).
Fowler, S.L. 1992. Survey of bait collection in Britain. *Joint Nature Conservation Committee Report,* No. 17.
Gray, M.J. 1994. *Inshore fisheries review of England, Scotland and Wales, 1992/1993.* Godalming, World Wide Fund for Nature.
Highlands and Islands Enterprise. 1993. *A sea fisheries strategy for the Highlands and Islands of Scotland*. Inverness, Highlands and Islands Enterprise.
MacKay, G.A., & Adam, J. 1995. *Trends in fish landings at Scottish ports, 1989-1994.* Unpublished report. Inverness, MacKay Consultants.
Ministry of Agriculture, Fisheries and Food. 1994. *UK sea fisheries statistics 1991 and 1992.* London, HMSO.
Ministry of Agriculture, Fisheries and Food. 1995a. *List of Fishery Orders in England, Scotland and Wales*. London, MAFF. (Unpublished.)
Ministry of Agriculture, Fisheries and Food. 1995b. *UK sea fisheries statistics 1994*. London, HMSO.
National Rivers Authority. 1991. *Salmonid and freshwater fisheries statistics for England and Wales, 1989*. Almondsbury, NRA.
National Rivers Authority. 1992. *Salmonid and freshwater fisheries statistics for England and Wales, 1990.* Almondsbury, NRA.
National Rivers Authority. 1993. *Salmonid and freshwater fisheries statistics for England and Wales, 1991*. Almondsbury, NRA.
National Rivers Authority. 1994a. *Salmonid and freshwater fisheries statistics for England and Wales, 1992*. London, HMSO & NRA.
National Rivers Authority. 1994b. *Salmonid and freshwater fisheries statistics for England and Wales, 1993*. London, HMSO & NRA.
Orton, D.A., *ed.* 1996. *Where to fish 1996 - 1997.* 85th ed. Beaminster, Thomas Harmsworth.
Robertson, G. 1993. *Isle of Skye data atlas.* Portree, Skye Forum.
Scottish Office. 1991. *Scottish salmon and sea trout catches: 1990*. Edinburgh, Scottish Office. (Scottish Office Statistical Bulletin, Fisheries Series.)
Scottish Office. 1992. *Scottish salmon and sea trout catches: 1991*. Edinburgh, Scottish Office. (Scottish Office Statistical Bulletin, Fisheries Series No. Fis/1992/1.)
Scottish Office. 1993. *Scottish salmon and sea trout catches: 1992*. Edinburgh, Scottish Office. (Scottish Office Statistical Bulletin, Fisheries Series No. Fis/1993/1.)
Scottish Office. 1994. *Scottish salmon and sea trout catches: 1993*. Edinburgh, Scottish Office. (Scottish Office Statistical Bulletin, Fisheries Series No. Fis/1994/1.)
Scottish Office. 1995. *Scottish salmon and sea trout catches: 1994*. Edinburgh, Scottish Office. (Scottish Office Statistical Bulletin, Fisheries Series No. Fis/1995/1.)
Scottish Office. 1996. *Scottish salmon and sea trout catches: 1995*. Edinburgh, Scottish Office. (Scottish Office Statistical Bulletin, Fisheries Series No. Fis/1996/1.)
Scottish Office Agriculture and Fisheries Department. 1993. *Scottish sea fisheries statistical tables 1992*. Edinburgh, Scottish Office.
Scottish Office Agriculture and Fisheries Department. 1994. *Scottish sea fisheries statistical tables 1993*. Edinburgh, Scottish Office.
Scottish Office Agriculture and Fisheries Department. 1995. *Scottish sea fisheries statistical tables 1994*. Edinburgh, Scottish Office.
Scottish Office Agriculture, Environment and Fisheries Department. 1996a. *Scottish sea fisheries statistical tables 1995*. Edinburgh, Scottish Office.
Scottish Office Agriculture, Environment and Fisheries Department. 1996b. *The Scottish fishing fleet at December 1995*. Edinburgh, Scottish Office.
Scottish Office Department of Agriculture and Fisheries. 1990. *Scottish salmon and sea trout catches: 1989*. Edinburgh, Scottish Office. (DAFS Statistical Bulletin 1/90.)

B. Further reading

Bailey, R.S., Hislop, J.R.G., & Mason, J. 1979. The fish and shellfish resources in sea adjacent to the Outer Hebrides. *Proceedings of the Royal Society of Edinburgh, (B) 77:* 479-494.
Bonfil, R. 1994. *Overview of world elasmobranch fisheries.* Rome, Food and Agriculture Organization of the United Nations. (FAO Fisheries Technical Paper, No. 341.)
Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides: a natural history*. London, Collins.
Dunn, E., & Harrison, N. 1995. *RSPB's vision for sustainable fisheries*. Sandy, Royal Society for the Protection of Birds.
Hall, S.G. In press. *The effects of fishing on marine ecosystems and communities*. Oxford, Fishing News Books.
Holden, M. 1994. *The Common Fisheries Policy: Origin, evaluation and future*. Oxford, Fishing News Books.
Huggett, D. 1992. *Foreshore fishing for shellfish and bait.* Sandy, Royal Society for the Protection of Birds.
Hutcheon, J.R. 1973. The Scottish Norway pout fishery. *Scottish Fisheries Bulletin, 40:* 15-17.
Lutchman, I. 1991. *A general overview of European and UK fisheries.* Godalming, WWF International.
Mackay Consultants. 1993. *Trends in fish landings at Scottish ports 1987-1992.* Inverness, Mackay Consultants.
Mason, J. 1987. *Scallop and queen fisheries in the British Isles*. Farnham, Fishing News Books for Buckland Foundation.
Ministry of Agriculture, Fisheries and Food. 1995. *UK sea fisheries statistics 1993*. London, HMSO.
Ministry of Agriculture, Fisheries and Food. 1996. *UK sea fisheries statistics 1995*. London, HMSO.
Scottish Office. 1996. *Scottish Office business directory.* Edinburgh.
Sea Fish Industry Authority. 1992. *Regional, socio-economic study in the fisheries sector. United Kingdom: Scotland and Northern Ireland.* Edinburgh, Sea Fish Industry Authority. (A report for the Commission of the European Communities, Directorate-General for Fisheries.)
Thomas, N.J. 1973. Scottish squid fisheries. *Scottish Bulletin, 39:* 35-39.
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 shellfisheries 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

Type of information	*Contact address and telephone no.*
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 (Scottsih 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, SNH HQ, 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, c/o University College Scarborough, Filey Road, Scarborough YO11 3AZ, 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 Regions 15 and 16 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 coast of these regions.

9.2.2 Locations and species

Maps 9.2.1 and 9.2.2 show the location of commercial mariculture areas where salmon and shellfish are cultivated in the regions. Table 9.2.1 lists the main species that are under commercial cultivation in the regions and in Great Britain and the Isle of Man. There is currently no cultivation of polychaetes in the regions.

Table 9.2.1 Main species that are cultivated in Regions 15 & 16 and in Great Britain

Species	*Species status*	*Cultivated in regions?*
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 (pers. comms.), SOAEFD (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

Compared with other regions, marine salmon farm sites are widespread throughout Regions 15 and 16. The areas where marine salmon farm sites are located are shown on Map 9.2.1. There may be other sites that are leased for salmon farming but not currently used for cultivation. Separate smolt units, hatcheries and freshwater sites are not shown. 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 from Regions 15 and 16, compared with the whole of Scotland. Together the regions produced half of the Scottish total tonnage of salmon at sea sites in 1995. The Western Isles have shown steady increases in production since 1992. However, in Highland this was the case until 1995, when production fell from 25,003 tonnes in 1994 to 22,509 in 1995. A map in Bryan (1994) shows the distribution of fish farm leases as at April 1993.

Table 9.2.2 Numbers of employees and annual production (tonnes) of salmon at sea sites in the regions in 1995

	*No. of staff***	*Annual production*
Region 15 - Western Isles	223	14,348
Region 16 - Highland*	455	22,509
Regions 15 & 16	***678***	***36,857***
Scotland	1,355	70,060

Source: Scottish Office Agriculture, Environment and Fisheries Department (1996a). Key: *includes a few salmon farming areas outside of Region 16; **full time and part time.

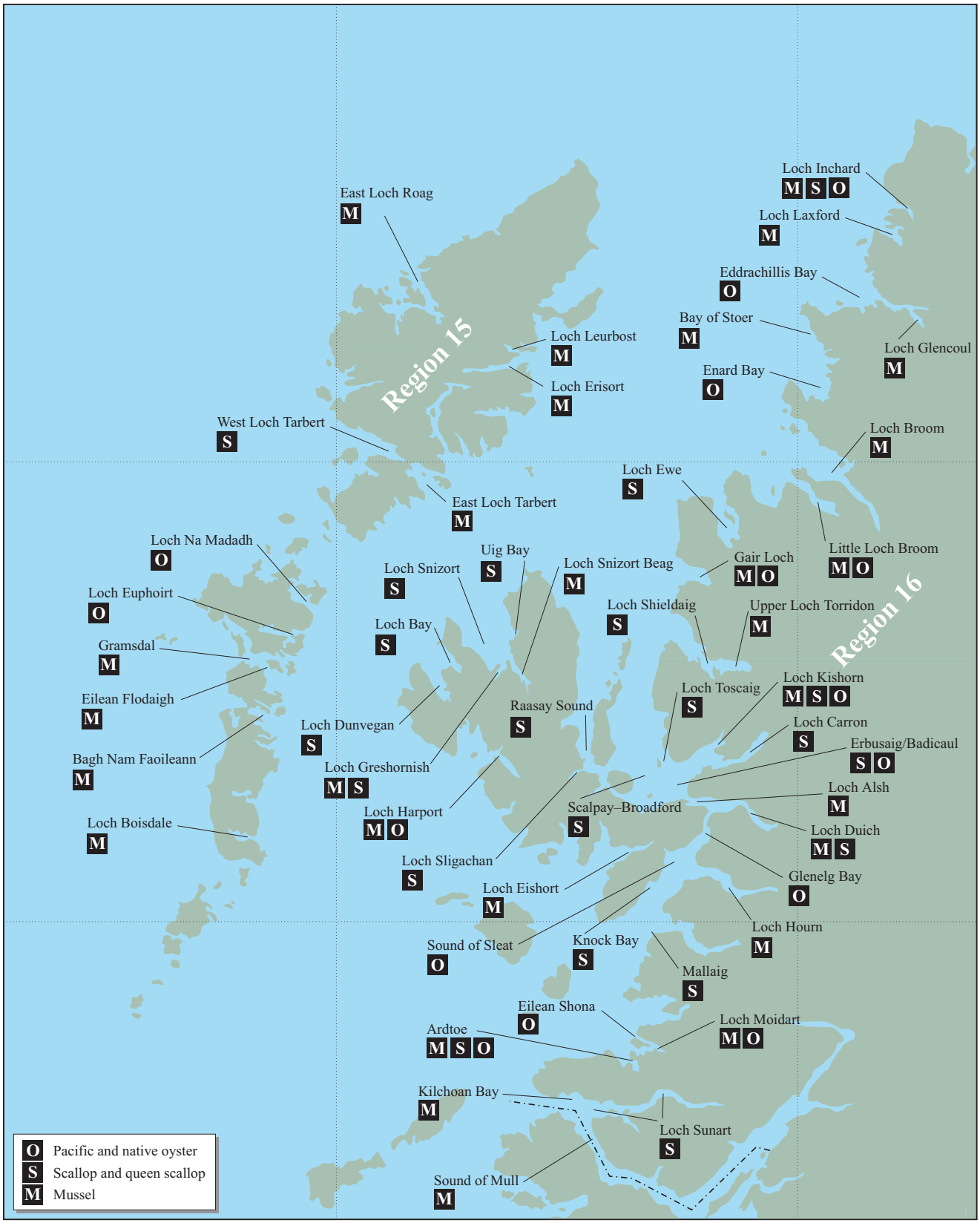
Shellfish

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 shellfish farm sites and the species farmed in the regions 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 hatcheries unit sites are not shown. A map in Bryan (1994) shows the distribution of shellfish farm leases as at April 1993. Pacific and native oysters are grown to market size from hatchery-reared 'spat' suspended in the sea above the sea bed in bags made from net. 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 production survey of shellfish companies for Regions 15 and 16. The Sea Fish Industry Authority Research Station at Ardtoe is also a lobster hatchery.

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

Map 9.2.1 General locations of marine salmon farm sites. Source: The Crown Estate (pers. comm.), SOAEFD (pers. comm.), La Tene Maps (1995a).



Map 9.2.2 General locations of shellfish farm sites and species in culture. Sources: The Crown Estate (pers. comm.), SOAEFD (pers. comm.), La Tene Maps (1995b).

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 15 (Western Isles)	17	18	<1	<1	114	<1	0
Region 16 (Highland)+	80	128	128	0	226	6	14
Regions 15 & 16+	***97***	***146***	***128***	***<1***	***340***	***6***	***14***
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; **includes full time, part time and casual staff; +includes an area outside Region 16. 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.

consumption is permitted. Samples are taken regularly and the classification can change. Shellfish must also meet the 'End Product Standard', with 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 about 55% of the foreshore and the same proportion of the beds of tidal rivers between mean high and low water springs in Scotland (as opposed to mean high and low water in England and Wales), 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, b). 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 spring 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.

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 are no Several Orders in Region 15, but two in Region 16 (Table 9.2.4), 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 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. Diagnosis, collation of information and research on fish- and shellfish-related diseases in Scotland are 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

Table 9.2.4 Several Orders in the Region 16

Title	*Species covered*	*Grid ref.*	*Location*	*Grantee*	*Approx. area (ha)*	*Year of expiry*
Loch Moidart North Channel Scallop Fishery Order	Scallops	NM637760	Loch Moidart, Highland	Sea Fish Industry Authority	100	2000
Loch Ewe West Ross Scallop Fishery Order	Scallops	NG833860	Loch Ewe, Highland	Sea Fish Industry Authority	148	2004

Source: Ministry of Agriculture, Fisheries and Food (1995). Note: Regulating Orders are discussed in section 9.1.3.

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 also 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 area is the subject of active research and monitoring 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, 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 Acknowledgements

Thanks go to David Fraser (SOAEFD Marine Laboratory), Bill Lart (Sea Fish Industry Authority) and David Donnan (Scottish Natural Heritage) for comments on drafts.

9.2.5 Further sources of information

A. References cited

Bryan, A. 1994. *The Minch review*. Inverness, Scottish Natural Heritage.

Crown Estate. 1987. *Fish farming: guidelines on siting and design of marine fish farms in Scotland.* Edinburgh, Crown Estate.

Crown Estate. 1989a. *Marine fish farming in Scotland. Guidelines on siting procedures and principles*. Edinburgh, Crown Estate.

Crown Estate. 1989b. *Marine fish farming in Scotland. Development strategy and area guidelines*. Edinburgh, Crown Estate.

Galbraith, C. 1992. *Mussel farms; their management alongside eider ducks*. Edinburgh, Nature Conservancy Council.

La Tene Maps. 1995a. *Major Scottish finfish farms*. Dublin, La Tene Maps.

La Tene Maps. 1995b. *Scottish shellfish farming*. Dublin, La Tene Maps.

Ministry of Agriculture, Fisheries and Food. 1995. *List of Fishery Orders in England, Scotland and Wales.* London, MAFF. (Unpublished.)

Scottish Office Agriculture, Environment and Fisheries Department. 1996a. *A report of the SOAEFD annual survey of fish farms for 1995*. Aberdeen, SOAEFD.

Scottish Office Agriculture, Environment and Fisheries Department. 1996b. *A report of the SOAEFD annual survey of shellfish farms for 1994*. Aberdeen, SOAEFD.

B. Further reading

Boyd, J.M., & Boyd, I.L. 1990. *The Hebrides: a natural history*. London, Collins.

Brown, J.R., Gowen, R.J., & McLusky, D.S. 1987. The effect of salmon farming on the benthos of a Scottish sealoch. *Journal of Experimental Biology and Ecology, 109:* 39-51.

Burton, C.A. 1993. The United Kingdom stock enhancement experiments. *In: Proceedings of the 1st British conference on artificial reefs and restocking, 12 September, 1992,* 22-35. Stromness, Orkney.

Cobham Resource Consultants. 1987. *An environmental assessment of fish farms*. Final report to Countryside Commission for Scotland, Crown Estate Commissioners, Highlands and Islands Development Board and Scottish Salmon Growers Association.

Coull, J.R. 1988. Fish farming in the Highlands and Islands: boom industry of the 1980s. *Scottish Geographical Magazine, 104*(1)*:* 4-13.

Dixon, F. 1986. *Development of the bottom culture mussel industry in the UK.* Hull, Sea Fish Industry Authority. (Industrial Development Unit Internal Report, No. 1,271.)

Drinkwater, J. 1987. *Shellfish cultivation in Scotland*. Aberdeen, SOAFD Marine Laboratory. (Scottish Fisheries Information Pamphlet, No. 13.)

Drinkwater, J., & Howell, T.R.W. 1985. *Experiments on the cultivation of oysters in Scotland.* Aberdeen, SOAFD Marine Laboratory. (Scottish Fisheries Research Reports, No. 35.)

Frid, C.L.J., & Mercer, T.S. 1989. Environmental monitoring of caged fish farming in macrotidal environments. *Marine Pollution Bulletin, 20:* 379-383.

Hardy, D., & Walford, A. 1994. *The biology of scallop farming*. Kyle, Aquaculture Support.

Highland Regional Council. 1988. *Review of fish farming in Highland Region*. Inverness, Highland Regional Council. (Planning Department Information Paper, No. 3.)

Hislop, J.R.G., & Webb, J.H. 1992. Escaped farmed Atlantic salmon, *Salmo salar* L., feeding in Scottish coastal waters. *Aquaculture & Fisheries Management*, *6(23):* 721-723.

Hooper, A.G., & MacDiarmid, H.D. 1991 *Highland Region: the prospects for fisheries and aquaculture in the 1990's*. Inverness, Highland Regional Council. (Sea Fish Industry Authority Consultancy Report, No. 41.)

Institute of Offshore Engineering. 1991. *A review of nature conservation implications of molluscan shellfish farming*. Edinburgh, Joint Nature Conservation Committee/Nature Conservancy Council for Scotland. (IOE 90/1073.)

Lumb, C.M., & Fowler, S.L. 1987. Assessing the benthic impact of fish farming. *In: Developments in estuarine and coastal study techniques*, ed. by J. McManus & M. Elliot, 75-78. Dundee, ESCA.

Mason, J., & Drinkwater, J. 1981. *Experiments on suspended cultivation of mussels in Scotland.* Aberdeen, SOAFD Marine Laboratory. (Scottish Fisheries Information Pamphlet, No. 4.)

Ministry of Agriculture, Fisheries and Food. 1982. Bonamia, *a new threat to the native oyster fishery.* Weymouth, MAFF. (Directorate of Fisheries Research Fisheries Notices, No. 71.)

Nature Conservancy Council. 1989. *Fish farming in the UK.* Peterborough, Nature Conservancy Council. (Memorandum to the House of Commons Agriculture Committee.)

Robertson, G. 1993. *Isle of Skye data atlas.* Portree, Skye Forum.

Ross, A. 1988. Fish farms and wildlife: are they really compatible? *Marine Conservation*, summer 1988.

Scottish Office. 1996. *The Scottish environment - statistics, No. 5 1994.* Edinburgh, Government Statistical Service.

Scottish Salmon Growers Association. 1990. *Salmon farming and predatory wildlife: a code of practice.* Perth, Scottish Salmon Growers Association.

Smith, H. 1993. Day-to-day impact of salmon farming on the work of River Purification Boards. *Underwater Technology, 18*(1): 7-10.

Spencer, B.E. 1990. *Cultivation of Pacific oysters*. Lowestoft, MAFF. (Directorate of Fisheries Research Laboratory Leaflet, No. 63.)

Torrissen, O.J. 1994. Symposium on cultivation of Atlantic salmon. *Aquaculture and Fisheries Management, 25* (Part 1).

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.*
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, PO Box 101, Victoria Road, Aberdeen AB9 8DB, 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), North Region HQ, Dingwall, tel: 01349 862021
Market research and technical advice on shellfish purification	Sea Fish Industry Authority, 18 Logie Mill, Logie Green Road, Edinburgh, EH7 4HG, tel: 0131 5583331
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: 0131 440 2116
Commercial advice on shellfish	Director, Shellfish Association of the UK, Fishmongers Hall, London Bridge, London EC4R 9EL, tel: 0171 6263531

Type of information	*Contact address and telephone no.*
Interaction between mariculture activities and marine nature conservation issues	*Aquatic Environments Branch, SNH HQ, 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 nature conservation issues	*Conservation Officer, Marine Conservation Society, Ross-on-Wye, tel: 01989 566017
Seals and mariculture	Co-ordinator, Wildlife & Countryside Link Seals Group, 105 Halsford Park Road, East Grinstead, West Sussex RH19 1PR, tel: 01342 315440
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.

Sand and gravel are extracted from ten workings in the Western Isles, including two here at Uig Sands, North Harris. They make a sharp visual contrast to the imposing natural grandeur of their setting. Photo: P.A. Macdonald, Scottish Natural Heritage.

9.3 Quarrying and landfilling

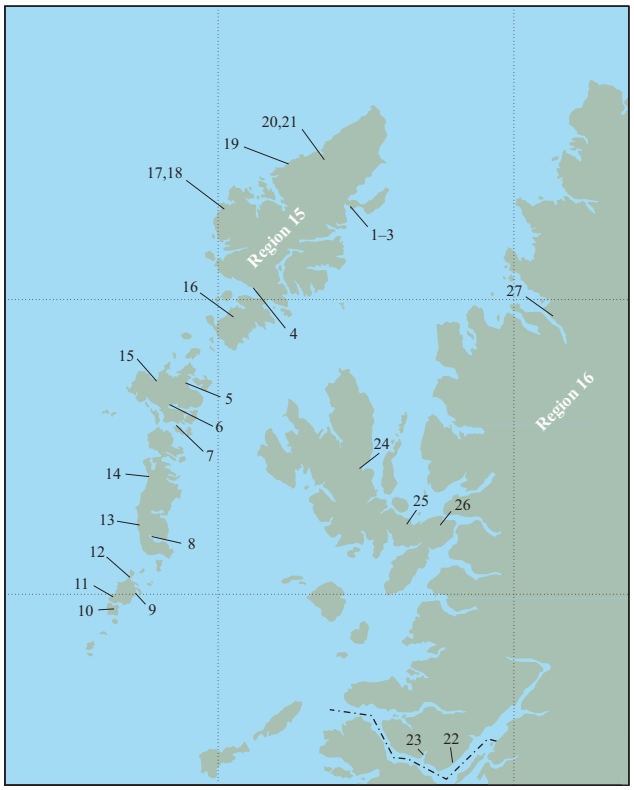
M.J.Goodwin & C.A.Crumpton

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 Regions 15 (Western Isles) and 16 (west Highland) on a commercial basis include silica (industrial) sand, sand and gravel, limestone (including shell sand) and 'igneous' rock (which, although so categorised for industrial purposes, is mostly metamorphic in origin). These minerals have a variety of uses, including concrete mix, roadstone and other constructional uses.

Table 9.3.1 presents production levels for both regions, compared with British levels, for the main minerals quarried. Figures for the regional production of certain minerals are not available as this might compromise the commercial confidentiality of the operations. This is particularly the case in Region 15, where there are relatively few operators.

The sand and gravel and crushed rock industry in Scotland produces over 30 million tonnes of material annually for the construction industry (Scottish Office Environment Department 1995). Because of the bulkiness of the product, aggregate is normally produced locally, to keep distribution costs down. Aggregate is, however, also produced from the regions, particularly at Glensanda Quarry in Region 16, on a very large scale for export to south-east England and other areas. Interest is growing in developing large-scale coastal quarries similar to Glensanda Quarry within the rest of the north of Scotland (Highland Regional Council 1992), such as the proposal currently under consideration for Lingerabay (Harris) in Region 15.



Map 9.3.1 Coastal quarries. Numbers refer to Table 9.3.2. Sources: BGS (1994) and Western Isles Council (1996). © Crown copyright.

9.3.2 Important locations

There are 21 coastal quarries in Region 15 and six in Region 16 (Table 9.3.2; Map 9.3.1). Three extract limestone, eleven sand and gravel, one silica sand, twelve 'igneous' rock and one sandstone. In order to minimise transport costs, quarries are usually located close to their markets, but in these regions the high quality of the minerals justifies their relatively remote locations, often long distances from their markets.

With the exception of Glensanda Quarry in Lochaber (Region 16), the majority of minerals quarried in both regions are used to meet demand from within the regions (97% in 1991 - Highland Regional Council 1992). Glensanda is by far the largest coastal quarry operating in Scotland at present. It produces approximately 5,500,000 tonnes of aggregate a year. In 1991, all material quarried at Glensanda was exported outside Region 16. The opening of the Skye Bridge in 1995 has facilitated the movement of sand and gravel reserves from the major workings at Altnavaig, Kyleakin.

The silica sand quarried in Region 16 at Lochaline is used for glassmaking, foundry moulding, glass fibre, water filtration, hydraulic fracturing of oil reservoirs and the manufacture of sodium silicate and carborundum; the quarry produces sand pure enough for the manufacture of high grade domestic and decorative glassware. At current extraction rates, many years' reserves are reported to exist at Lochaline. The material is transported by sea to export markets including England, Ireland and Scandinavia.

Table 9.3.1 Minerals production* in Regions 15 & 16 (1993)

	Limestone		*Sand & gravel*		*Silica sand*		*'Igneous' rock*		*Sandstone*	
	Tonnes	*% of GB total*	*Tonnes*	*% of GB total*	*Tonnes*	*% of GB total*	*Tonnes*	*% of GB total*	*Tonnes*	*% of GB total*
Region 15	0	0	n/a	n/a	0	0	n/a	n/a	1,000	<0.1
Region 16**	79,000	0.1	1,173,000	1.5	107,000	3.0	5,450,000	11.1	196,000	1.6
Scotland+	1,432,000	1.4	11,359,000	14.3	511,000	14.2	20,806,000	42.3	1,716,000	14.2
Great Britain+	***105,885,000***		***79,380,000***		***3,587,000***		***49,209,000***		***12,100,000***	

Main source: Central Statistical Office (1994). Key: *amounts rounded up to next whole thousand tonnes; **includes inland areas and coastal parts of Highland Region outside Region 16; +whole country totals; n/a = not available.

Table 9.3.2 Coastal quarries in Regions 15 & 16

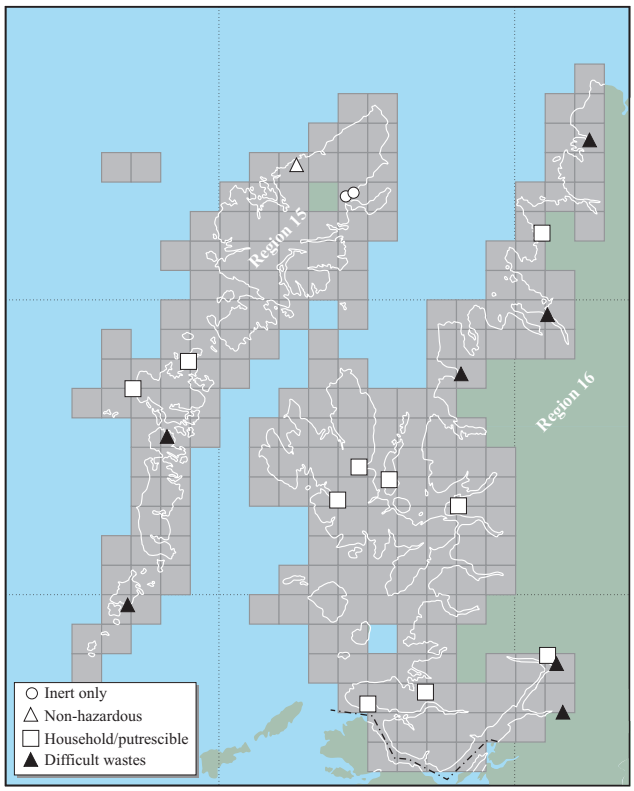
Site no. on Map 9.3.1	*Location*	*Operator*	*Mineral*
	Region 15		
1	Stornoway	Evered Bardon - John Fyfe Ltd.	'Igneous'
2	Stornoway	Evered Bardon - John Fyfe Ltd.	'Igneous'
3	Stornoway	Lewis Land Services	'Igneous'
4	Ardhasaig	R. MacAskill Ltd.	'Igneous'
5	Crogarry Beag	Donald A. Johnson (North Uist) Ltd.	'Igneous'
6	Locheport	A. Maclean	'Igneous'
7	Gairbh Eilean	A. MacDonald	'Igneous'
8	Lochboisdale	Askernish Quarry Co. Ltd.	'Igneous'
9	Barra	John Maclennan	'Igneous'
10	Barra	R. Macmillan	Sand and gravel
11	Tangasdale	Hector McNeil	Sand and gravel
12	Eoligarry	Barra Shell Ltd.	Limestone (shell sand)
13	Garryheille	Uist Builders	Sand and gravel
14	Drimore	South Uist Estate	Sand and gravel
15	Balmartin	Norman Macauley	Sand and gravel
16	Horgabost	John Mackay	Sand and gravel
17	Uig	Angus Maciver Ltd.	Sand and gravel
18	Uig	D.H.M & N. Maciver	Sand and gravel
19	Raoinbhat	John Fyfe	'Igneous'
20	Barvas	Angus Maciver Ltd.	Sand and gravel
21	Barvas	D.H.M & N. Maciver	Sand and gravel
	Region 16		
22	Glensanda	Foster Yeoman (Morvern) Ltd.	'Igneous'
23	Lochaline	Tilcon - Mortar & Special Products	Silica sand
24	Torrin	Leith Transport (Aberdeen) Ltd.	Limestone
25	Sconser	Highland Regional Council	Sandstone
26	Kyleakin	Redland Aggregates	Sand and gravel
27	Ullapool	Thistle Aggregates	'Igneous', limestone

Sources: BGS (1994), Highland Regional Council pers. comm., SNH pers. comm.

Recent investment in new plant has increased production capacity to around 100,000-150,000 tonnes a year.

Shell sand has long been extracted from the beaches of the Western Isles for constructional and agricultural purposes.

Map 9.3.2 shows the location of currently used coastal landfill sites in Regions 15 and 16, according to Aspinwall's Sitefile Digest (Aspinwall 1994); the status codes are defined in Table 9.3.3. Seven landfill sites are located in Region 15 and thirteen in Region 16, including two on Skye and one on Raasay.



Map 9.3.2 Coastal landfill sites. Source: Sitefile Digest (Aspinwall 1994).

9.3.3 Management

The British Geological Survey estimates that in the period 1992-2006 demand for land-won aggregates in England will be about 3.1 billion tonnes, of which 1.2 billion tonnes would comprise sand and gravel and 1.9 billion tonnes crushed rock (BGS 1995). A further 1.1 billion tonnes is expected to be derived from marine sources, from imports from Scotland and Wales or from secondary and recycled materials. These figures, if realised, would represent a significant shift in production since the late 1980s from onshore quarrying towards the use of imported and secondary materials. In order to help meet the extra demand, the development of a number of large coastal quarries is envisaged.

In a 1992 report (Whitbread & Marsay 1992) the Department of the Environment found no reasonable

Table 9.3.3 Status of coastal landfill sites in Regions 15 & 16

Status code (Map 9.3.2)	*Definition*	*No. in region*	
		15	*16*
1 Inert only	Uncontaminated excavated natural earth materials, and uncontaminated brick rubble and concrete with similar properties to natural earth materials.	2	0
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.	1	0
3 Household/putrescible	Typical contents of a household dustbin and similar wastes of industrial origin e.g. food processing wastes.	2	8
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.	2	5
Total		*7*	*13*

Source: Aspinwall & Co. (1994).

prospects for superquarry development along the coastlines of England and Wales, with the greatest potential being found on the north and west coasts of Scotland. However, superquarries here are unlikely to be developed to their full potential, owing to the sensitive environmental settings of the favoured locations. A public inquiry into the commissioning of the superquarry at Lingerabay on Harris had not returned its verdict at the time of writing. The main environmental objection to this development is the potential release of contaminated ballast water from transport ships. It is thought this may result in damage to the aquatic environment, including impacts on local fish farms. Landscape issues are also 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 Environment Department 1994). Regions considered suitable for the development of superquarries are listed in NPPG4 (Scottish Office Environment Department 1994). These are: the north coast of Highland Region, Shetland (Region 1) and the Western Isles. Whitbread & Marsay (1992) speculated that there may be scope for five superquarries in Scotland. However, NPPG4 notes that no more than four sites should be identified by 2009.

SEPA came into force in April 1996 under the terms of the Environment Act 1995, integrating the functions of three predecessor bodies: Her Majesty's Industrial Pollution Inspectorate (HMIPI), the local waste regulatory authorities and the River Purification Boards (RPBs). The activities of the agency are grouped under two broad headings: pollution prevention and control and water management. There will be a strong link between the two to ensure the continuing integrity of estuarine and coastal management.

Landfill site licensing in Scotland is the responsibility of the Scottish Environment Protection Agency (SEPA). 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. SEPA is required to maintain a public register of waste management licences for private sites in its area and a register of resolutions referring to its own sites. Council strategy for landfilling is contained in the Western Isles and Highland Waste Management Plans, produced by the respective councils.

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 future pollution from minewater. Also relevant to quarrying and landfilling are the provisions relating to producer responsibility for waste. These will provide a mechanism to ensure that business initiatives on re-using, recovering and recycling waste are not undermined by those seeking to avoid their obligations.

9.3.4 Information sources used

Data on quarrying were obtained from the British Geological Survey's *Directory of mines and quarries* (BGS 1994), the Central Statistical Office's *Business monitor (minerals)* (Central Statistical Office 1994) and Western Isles Council (1996). These are the most up to date and comprehensive reports available. In a small number of cases, exact locations of quarries were not listed and therefore it was not known if they were coastal. 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.

The data for landfilling were provided by Aspinwall & Co. (1994) from their *Sitefile digest* on waste treatment and disposal. This contains regularly updated information from the 152 Waste Regulation Authorities (now included in SEPA) and represents the most up to date collection of public information on British waste management available.

Local mineral plans are available through local authorities, which are listed in section 9.3.6.

9.3.5 Acknowledgements

Thanks go to Dr Ron Moore and Susan Morley (Aspinwall and Co.) for providing information from the *Sitefile digest*, and to Keith Bray, Western Isles Council, for data on quarrying activity.

9.3.6 Further sources of information

A. References cited

Aspinwall & Co. 1994. *Sitefile digest. A digest of authorised waste treatment and disposal sites in Great Britain.* Shrewsbury, Environment Press.

BGS (British Geological Survey). 1994. *Directory of mines and quarries 1994.* 4th ed. Keyworth, Nottingham, British Geological Survey.

British Geological Survey. 1995. *United Kingdom minerals yearbook 1994.* Keyworth, Nottingham, British Geological Survey.

Central Statistical Office. 1994. *Business monitor - minerals*. London, HMSO. (PA1007.)

Highland Regional Council. 1992. *Highland Region Minerals Survey 1992*. Inverness, Highland Regional Council Department of Planning.

Scottish Office Environment Department. 1994. *Land for mineral working*. Edinburgh, Scottish Office. (National Planning Policy Guideline (NPPG) 4.)

Scottish Office Environment Department. 1995. *Survey of aggregate working in Scotland: 1993 - collated results and commentary*. Edinburgh, Scottish Office.

Western Isles Council. 1996. *Local Minerals Plan, Western Isles*. Stornoway, Western Isles Council. (Draft report.)

Whitbread, M., & Marsay, A. 1992. *Coastal superquarries to supply south-east England aggregate requirements.* London, HMSO. (Department of the Environment Geological and Minerals Planning Research Programme.)

B. Further reading

Department of the Environment. 1994. *Minerals Planning Guidance Note 6: guidelines for aggregate provision in England.* London, HMSO.

Eno, N.C., *ed*. 1991. *Marine conservation handbook.* 2nd ed. Peterborough, English Nature.

Link Quarry Group. 1996. *The case against the Harris superquarry.* Perth, Scottish Wildlife and Countryside Link.

Scottish Office. 1994. *The Scottish environment - statistics, No. 4, 1993.* Edinburgh, Government Statistical service.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Landfill database and Sitefile Digest	Aspinwall & Co., Walford Manor, Baschurch, Shrewsbury SY4 2HH, tel: 01939 262200
Mines and quarries (British Directory of Mines and Quarries)	Director, British Geological Survey, Keyworth, Nottingham NG12 5GG, tel: 0115 936 3393
General information on Scottish mining	British Geological Survey - Scottish Office, Murchison House, West Mains Road, Edinburgh EH9 3 LA, tel: 0131 667 1000
Scottish Environment Protection Agency	*SEPA, North Region HQ, Dingwall, tel: 01349 862021
General information on mining and minerals planning: Highland	*Director of Planning, Highland Council, Inverness, tel: 01463 702831
Minerals planning: Western Isles	*Forward Planning and Economic Development Dept., Western Isles Council, Stornoway, tel: 01851 703773

*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 in 1995 but exported to landing ports abroad. No aggregate was extracted in Scottish waters or landed in Scottish ports in 1993 (Crown Estate 1995).

No dredging for marine aggregates currently takes place in Region 15 (Western Isles) or Region 16 (west Highland). Generally, prospecting for sand and gravel deposits in Scotland's waters has been unpromising, with only limited reserves being located, although some good quality gravels in shallow waters have been reported from reconnaissance surveys, but not in these regions (see also section 2.2). Also, there is a lack of local demand for marine-based resources, local requirements being adequately met from land-based supplies. 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.

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. The majority of dredged material, which can range in composition from silts to boulder clay and rock, is deposited at sea, although dredged material is 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). In these regions, disposal sites are used infrequently, and in 1993 only one was licensed, off Stornoway (Region 15). In 1993 dredged material deposited in Regions 15 and 16 (19,714 tonnes) constituted less than 0.1% of the total dredged material deposited around the UK as a whole (approx. 30 million wet tonnes); in 1994 no dredged material was licensed or deposited in the regions (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 of (sewage sludge) dry solids (tds) annually and disposes of approximately 300,000 tds (equivalent to about 10,000,000 wet tonnes) to the sea. Disposal from ships, none of which originates from Regions 15 and 16, currently accounts for 75% of Scotland's sewage sludge disposal. UK sewage sludge production is set to increase dramatically over the next decade, with predicted increases to 3.3 million tds by 2006.

There is no significant dredging for calcareous algae (maerl - used in agriculture) in these regions.

9.4.2 Important locations

Marine aggregates dredging

Only a very small amount of aggregate was extracted in Scottish waters and landed in Scottish ports in 1995 (Crown Estate 1996), none of it from Regions 15 and 16. The sea bed of Region 15 has not been surveyed in detail and the resource potential is unknown. Surveying for sand and gravel deposits in Region 16 has been largely unpromising, with only limited resources being identified. Most of the material which makes up the accessible coastal shelf in this region is muddy sand (see also section 2.2) (Fyfe *et al*. 1993; Stoker *et al*. 1993).

Navigational dredging

Navigational dredging takes place as necessary in the regions' ports, on a relatively small scale. However, as oil exploration activity increases in the West of Shetland area, the Western Isles may have an increasingly important role in servicing the industry. This may require the expansion of existing harbour facilities and consequent deepening of shipping channels.

Dredged material disposal

Licensing of the disposal of dredged material has taken place intermittently over the last few years in Region 15 at Stornoway and in the Sound of Harris off Leverburgh (Map 9.4.1; Table 9.4.2). In Region 16 licensed disposal has taken place at Lochinver. There may be a gap of several years

Table 9.4.1 Dredged material licensed and disposed of at sea (1994)

	Licences issued	*Sites under licence*	*Sites used*	*Tonnes licensed*	*Wet tonnage deposited*
Regions 15 & 16	0	0	0	0	0
Scotland	23	28	22	3,643,250	1,822,053
UK	***134***	***120***	***98***	***56,843,459***	***35,962,835***

Sources: SOAEFD (pers. comm.), MAFF (pers. comm.). Note: licences may commence at any time and generally last for one year.

between the use of these sites; no sites in the regions were used for the disposal of dredged material in 1994.

9.4.3 Management and issues

All dredging activities have short-term, localised effects, such as the removal of material and organisms, but long-term effects on, say, 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).

Marine aggregates dredging

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). As part of this process SOAEFD undertakes a comprehensive assessment of the potential effect of the new aggregate extraction areas on the marine environment, on commercial fisheries and fisheries operations. The government intends that, in future, applications for marine aggregate extraction licences should be subject to the same type of process as terrestrial planning applications under the Town and Country Planning Acts, regardless of the ownership of the sea bed. A consultation exercise outlining options for a new system in Scotland was undertaken by the Scottish Office. No statement of intent has yet been issued.

In general, the principal biological impact of marine aggregate extraction is the disturbance and removal of benthic infauna and epifanuna and alteration of the substrate upon which colonisation depends. Where the remnant substrate is identical to the sediments previously found on the surface of the sea bed, disturbance is unlikely to be permanent and the extraction area will be recolonised. Licences are generally only granted where these conditions are fulfilled (Campbell 1993).

Navigational dredging

Navigational dredging is the responsibility of individual harbour authorities, although a licence from SOAEFD is required for the disposal of dredged material offshore (see below).

Solid waste (including dredged material) disposal

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). Also, the Oslo

Map 9.4.1 Sites used in 1992 and 1993 for licensed disposal of dredged materials at sea (see Table 9.4.2). Source: SOAEFD (1995). © Crown copyright.

Table 9.4.2 Dredged material disposed of at licensed sites in Regions 15 & 16 in 1993

	MAFF code (see Map 9.4.1)	*Dredging waste type*	*Deposited tonnage*
Region 15			***19,714***
Leverburgh	HE033	-	0
Stornoway	HE035	Maintenance	19,714
Region 16			***0***
Lochinver	HE040	-	0

Source: SOAEFD Marine Laboratory (pers. comm.)

Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft and the London Convention on the Dumping of Wastes at Sea include within their scope disposal of solid wastes and dredged material at sea. 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 the Food and Environment Protection Act 1985. Each licence is subject to certain conditions, which have become more stringent in the last few years. UK sewage sludge production is set to increase dramatically in relation to other methods of disposal over the next decade, to a predicted 3.3 million tds by 2006. Under the Urban Waste Water Treatment Directive (91/271/EEC), all sewage sludge disposal by marine vessels is set to be phased out by 1998. It will have to be replaced by disposal on land, by tipping or incineration.

Blanketing of the sea bed is the main impact of the disposal of dredged material. Benthic flora may be killed

when the input rate is significantly greater than the natural sedimentation rate, through the prevention of respiration and feeding (Kenny & Rees 1994). Other impacts include the localised elevation of metal levels, caused by the disturbance of industrial waste and effluent discharged into the rivers from which the dredged material originated. Some sewage sludges are principally of domestic origin and contain low levels of metals and other persistent components. Others include industrial inputs, resulting in higher concentrations of contaminants, which can affect marine organisms. Localised increases in water column turbidity, which are often caused by the disposal of all kinds of solid waste, may interfere with fish migration, but only on a temporary basis. Changes in sediment particle size can result in changes in benthic flora and fauna which, whilst not damaging *per se*, can 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).

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. The information on disposal of dredged material is derived from licences granted by SOAEFD.

9.4.5 Acknowledgements

Thanks are due to Derek Saward, SOAEFD Marine Laboratory, Aberdeen for comments on the draft, and to the Crown Estate for information on marine aggregate extraction in the regions. Dr C. Vivian of MAFF Fisheries Laboratory, Burnham-on-Crouch (now Centre for Environment, Fisheries and Aquaculture Science (CEFAS)), provided information on solid waste disposal at sea.

9.4.6 Further sources of information

A. References cited

Campbell, J.A. 1993. *Guidelines for assessing marine aggregate extraction*. Lowestoft, MAFF. (Directorate of Fisheries Research, Laboratory Leaflet, No. 73.)

Crown Estate. 1994. *Marine aggregates - Crown Estate licences - summary of statistics 1993*. London, Crown Estate.

Crown Estate. 1995. *Marine aggregates - Crown Estate licences - summary of statistics 1994*. London, Crown Estate.

Crown Estate. 1996. *Marine aggregates - Crown Estate licences - summary of statistics 1995*. London, Crown Estate.

Doody, J.P., Johnston, C., & Smith B. 1993. *Directory of the North Sea coastal margin*. Peterborough, Joint Nature Conservation Committee.

Fyfe, J.A., Long, D., & Evans, D. 1993. *The geology of the Malin-Hebrides Sea area*. London, HMSO. (British Geological Survey, United Kingdom Offshore Regional Report.)

Irish Sea Study Group. 1990. *The Irish Sea; an environmental review. Part 2; waste inputs and pollution.* Liverpool, Liverpool University Press.

Kenny, A.J., & Rees, H.L. 1994. The effects of marine gravel extraction on the macrobenthos: early post-dredging recolonisation. *Marine Pollution Bulletin*, *7:* 442-447.

Ministry of Agriculture, Fisheries and Food (Directorate of Fisheries Research). 1995. *Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1993*. Lowestoft, MAFF. (Aquatic Monitoring Report, No. 44.)

NERC. Undated. *Marine sand and gravel: resources and exploitation.* London, NERC.

Stoker, M.S., Hitchen, K., & Graham, C.C. 1993. *The geology of the Hebrides and West Shetland shelves, and adjacent deep-water areas.* London, HMSO. (British Geological Survey, United Kingdom Offshore Regional Report.)

B. Further reading

Anon. 1987. Shift on sewage sludge disposal methods. *Marine Pollution Bulletin, 18*(12)*:* 619.

Anon. 1989. Sewage sludge statistics. *Marine Pollution Bulletin, 20*(2)*:* 54.

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

BMAPA. 1994. *Aggregates from the sea: why dredge?* London, British Marine Aggregate Producers Association.

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

British Marine Aggregate Producers Association. 1994. *Aggregates from the sea: why dredge?* London, British Marine Aggregate Producers Association (BMAPA).

Campbell, J.A. 1991. The disposal of capital dredging - the role of the licensing authority. *In: Capital dredging*, ed. by the Institution of Civil Engineers, 111-123. London, Thomas Telford.

Campbell, J.A. 1993. *Guidelines for assessing marine aggregate extraction.* Lowestoft, MAFF. (DFR Laboratory Leaflet, No. 73.)

Construction Industry Research and Information Association. 1996. *The beach management manual.* London, Construction Industry Research and Information Association.

Crown Estate. 1994. *Marine aggregate extraction and the Government view procedure*. London, Crown Estate.

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.

Department of the Environment. 1995. *Policy guidelines for the coast.* London, HMSO.

ICES. 1978. Input of pollutants to the Oslo Commission area. *Cooperative Research Report of the International Council for the Exploration of the Sea, 77:* 57.

Ministry of Agriculture, Fisheries and Food (Directorate of Fisheries Research). 1994. *Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1992*. Lowestoft, MAFF. (Aquatic Monitoring Report, No. 40.)

Ministry of Agriculture, Fisheries and Food (Department of Agriculture and Fisheries for Scotland). 1989. *Report on the disposal of waste at sea, 1986 and 1987.* London, MAFF.

Nunney, R.S., & Chillingworth, P.C.H. 1986. *Marine dredging for sand and gravel.* London, HMSO, for Department of the Environment. (Minerals Planning Research Project No. PECD 7/1/163 - 99/84.)

Parker, M.M. 1987. The future for the disposal of dredged material in the UK. *Maintenance dredging*. London, TTL.

Parker, M.M., & McIntyre, A.D. 1987. Sewage sludge disposal at sea - options and management. *In: Marine treatment of sewage and sludge*, ed. by the Institution of Civil Engineers, 123-136. London, Thomas Telford. (Proceedings of the conference organized by the Institution of Civil Engineers and held in Brighton on 29-30 April 1987.)

Posford Duvivier Environment. 1992. *Capital and maintenance dredging: a pilot case study to review the potential benefits for nature conservation.* Peterborough, English Nature. (English Nature Research Reports, No. 7.)

Pullen, S. Undated. *Dumping of dredged spoils from ports: contamination, pollution controls.* Godalming, World Wild Fund for Nature.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Marine aggregate extraction licensing	The Crown Estate, Marine Estates (Scotland), 10 Charlotte Square, Edinburgh EH2 4DR, tel: 0131 226 7241
Marine resource management (managing agents offshore for the Crown Estate)	Posford Duvivier, Eastchester House, Harlands Road, Haywards Heath, West Sussex RH16 1PG, tel: 01444 458551
Offshore geoscience data including 1:250,000 maps of geology of coastline	Director, British Geological Survey, Keyworth, Nottingham NG12 5GG, tel: 01602 363100
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 sand and gravel extraction	British Marine Aggregate Producers Association (BMAPA) and British Aggregate Construction Materials Industries (BACMI), 156 Buckingham Palace Road, London SW1 9TR, tel: 0171 730 8194
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: 071 735 7611
Scientific assessments of dredging and waste disposal, and database of licensed disposal operations at sea	*Head of Laboratory, Centre for Environment, Fisheries & Aquaculture Sciences, Burnham-on-Crouch Laboratory, tel: 01621 787200

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

9.5 Oil and gas developments

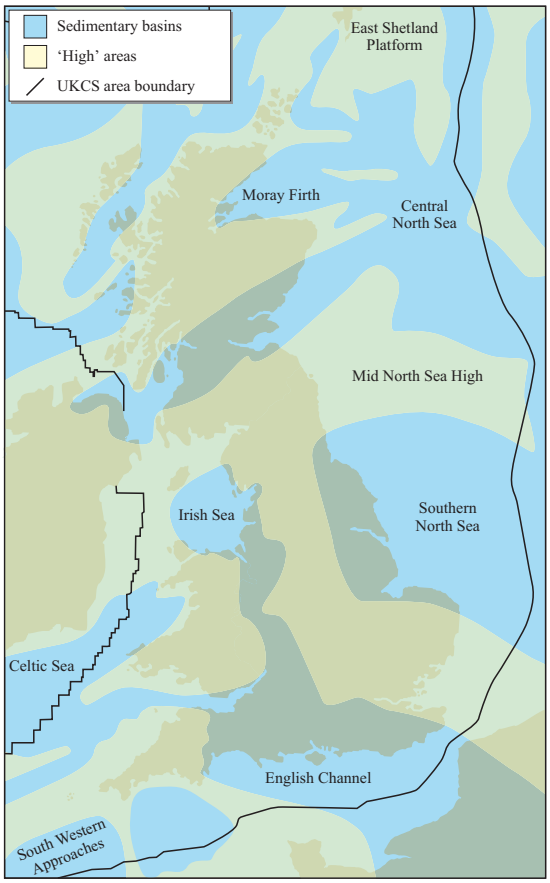
C.A Crumpton & M.J. Goodwin

9.5.1 Introduction

This section describes oil and gas exploration and related development in Regions 15 (Western Isles) and 16 (west Highland); oil and gas infrastructure is described in section 8.3.

Map 9.5.1 shows sedimentary basins and structural 'highs', which determine the distribution of oil and gas deposits. There is currently no exploration for oil or gas in these regions; however, The 17th Offshore Oil and Gas Licensing Round is currently under consideration. Map 9.5.2 shows areas under offer in the regions, north-west of the Western Isles. 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 the Minches and indeed most of the coastal waters of these regions. Results were announced in March 1996, when 74 blocks were awarded, none of them in these regions.

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 around 2% of Gross Domestic Product (DTI 1996). A total of 98 exploration and appraisal wells were drilled in 1995 and seven significant discoveries were announced, although none in these regions.

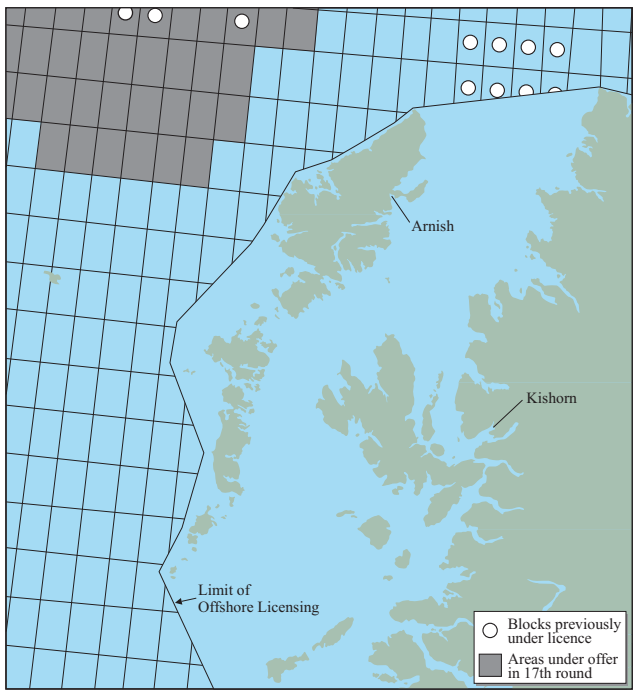


Map 9.5.1 UK Continental Shelf (UKCS) sedimentary basins and structural 'highs'. Source: DTI (1996). © Crown copyright.

9.5.2 Important locations

Map 9.5.2 shows the location of past oil and gas related activity in Regions 15 and 16. There are now no areas under licence in these regions.

There is oil-related fabrication in Region 15 at Arnish, Stornoway. Oil-related activities may increase as the area west of Shetland is developed, perhaps offering the Western Isles the opportunity to develop as a forward supply base. Oil and gas production is important economically for Highland Region, with over 3,000 people directly employed by the industry (Highland Regional Council 1990); however, nearly all service activity is concentrated on the North Sea coast (Region 3). The platform construction yard at Kishorn, having been closed in 1986 owing to lack of work, is now involved in a wider range of industrial uses.



Map 9.5.2 Oil and gas licensing. Source: DTI (1996). © Crown copyright.

9.5.3 Management and issues

Licences for oil and gas exploration 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; for more recent sets of conditions consult the DTI.

The range of potential issues for nature conservation is wide. For example, 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). Concern has been expressed particularly about the potential risk to seals and dolphins of oil-related developments in the region (see also sections 5.14.3 and 5.15.3). There is a very small risk of injury to seals in the immediate vicinity of a vessel conducting seismic surveys. The air-gun arrays used in seismic surveys generate high levels of low frequency sound, most of which is outside the known hearing range of marine mammals and is unlikely to disturb them. 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

Most of the data used here 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 are due to Colin Macduff-Duncan, Esso, and Mark Tasker, JNCC, for assistance with this section.

9.5.6 Further sources of information

A. References cited

Davies, G.J., & Wilson, J.L.J. 1995. *Wildlife sensitivity criteria for oil and gas developments in Great Britain.* Peterborough, Joint Nature Conservation Committee. (Consultation report prepared by Environment and Resource Technology Ltd.)

Department of Trade and Industry. 1996. *The energy report 2: oil and gas resources of the UK.* London, HMSO.

Evans, P.G.H., Lewis, E.J., & Fisher, P. 1993. *A study of the possible effects of seismic testing upon cetaceans in the Irish Sea.* Oxford, Sea Watch Foundation. (Report to Marathon Oil UK.)

Goold, J.C. 1996. Acoustic assessment of populations of common dolphins *Delphinus delphis* in conjunction with seismic surveying. *Journal of the Marine Biological Association of the UK, 16:* 811-820.

Highland Regional Council. 1990. *Highland Region structure plan 1990: written statement.* Inverness, Highland Regional Council Planning Department.

United Kingdom Offshore Operators Association (UKOOA). 1994. *Environmental guidelines for exploration operations in near-shore and sensitive areas.* London, UKOOA.

B. Further reading

Advisory Committee on the Pollution of the Sea. 1990. Surveys of oil pollution around the coasts of the United Kingdom. *In: ACOPS year book 1990,* 158-163. Oxford, Pergamon Press.

British Gas. 1994. *Transportation and storage.* Solihull, British Gas Transco.

Hailey, N. 1995. *Likely impacts of oil and gas activities on the marine environment and integration of environmental considerations in licensing policy.* Peterborough, English Nature Research Reports, No. 145.

Institute of Petroleum Information Service. 1993. *Know more about oil: the UK refining industry.* London, Institute of Petroleum.

Institute of Petroleum Information Service. 1993. *UK petroleum industry statistics: consumption and refinery production for 1991 and 1992.* London, Institute of Petroleum.

Turnpenny, A.W.H., & Nedwell, J.R. 1994. *The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys.* Southampton, Fawley Aquatic Research Laboratories Ltd.

Western Isles Islands Council. 1988. *Western Isles structure plan: written statement.* Stornoway, Western Isles Islands Council.

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 (UKOOA), 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 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
Licensing the use of dispersants for oil spill - Scotland	*Marine Environment and Wildlife Branch, SOAEFD, Pentland House, Edinburgh, tel: 0131 244 6232
Effects of gas and oil exploitation on the marine environment	*SOAEFD, Marine Laboratory, Aberdeen, tel: 01224 876544
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 Street, 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
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

M.J.Goodwin & C.A.Crumpton

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 pollutants and water quality is complex and beyond the scope of this book.

Waste products and effluents containing contaminants reach the marine environment in these regions 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 under licensed discharge or by accidental release. Discharges occurring outside the region may also have a detrimental effect on coastal water quality.

The water quality of the coastlines of Region 15 and 16 is among the best in Britain, owing to the low level of industrialisation and small population. The main industries likely to affect water quality are fish and shellfish farming (see section 9.2), paper and board manufacture and food processing. Small, untreated outfalls from coastal settlements are relatively numerous, especially in Region 15.

There are 23 bathing waters in Scotland identified under the EC Bathing Water Directive (76/160/EEC) (although none in these regions). Nineteen of them complied with mandatory standards in 1995, which was the best year on record for UK bathing water quality, with 89% exceeding EU standards, compared with 82% in 1994 and 80% in 1993.

There are 165 Tidy Britain Group Seaside Award beaches in Britain, twelve of them in Scotland but none in Regions 15 and 16. There are twenty Blue Flag beaches in Britain, none of which are in Scotland.

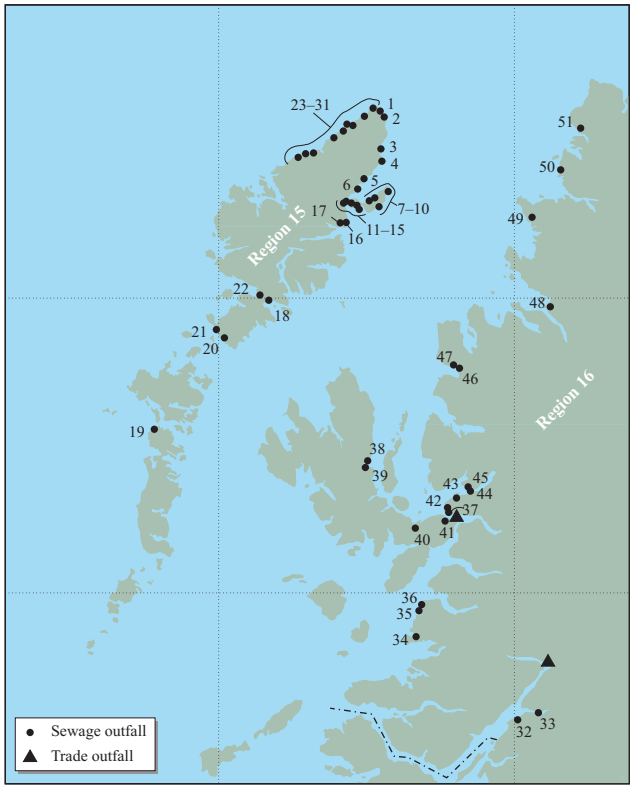
9.6.2 Important locations

Table 9.6.1 lists the 51 sewage outfalls in the regions that serve populations of more than 200 people (Map 9.6.1), with their locations and the type of treatment. By far the largest outfall is at Stornoway in Region 15, followed by Ullapool in Region 16. Table 9.6.2 gives the numbers of trade and sewage outfalls in the area covered by the Minch Review (Bryan 1994) and Table 9.6.3 lists the major sources of trade

Table 9.6.1 The regions' coastal sewage outfalls serving population equivalents >200

No. on Map 9.6.1	*Location*	*Grid ref.*	*Population equivalent*	*Type of treatment*
	Region 15			
1	Port of Ness	NB539639	300	None
2	Eorodale	NB542629	200	None
3	Tolsta (Mid)	NB542480	400	Secondary
4	Tolsta (South)	NB541464	200	Primary
5	Bac	NB489397	500	Primary
6	Coll/Gearraidh Ghuirm	NB473390	353	Primary
7	Aignis	NB493327	600	Primary
8	Garrabost	NB518342	300	Primary
9	Port Mholair	NB568367	300	None
10	Pabail	NB528308	936	None
11	Melbost (Branahuie)	NB464316	200	None
12	Parkend (Holm)	NB461317	300	None
13	Sandwick	NB440320	300	Primary
14	Stornoway (Sandwick Cottage)	NB435322	1,000	None
15	Stornoway (Main Outfall)	NB431320	10,000	None
16	Leurbost (East)	NB383247	200	Primary
17	Leurbost (West)	NB362257	300	Primary
18	Tarbert	NG158998	1,000	None
19	Balivanich	NF769555	1,000	None
20	Leverburgh	NG014869	500	None
21	Northton	NF987903	500	None
22	Tarbert No. 2	NB147005	200	None
23	North Shawbost	NB258478	720	None
24	South Bragar	NB284490	200	None
25	North Bragar	NB295490	200	None
26	Shader	NB377547	400	None
27	Borve	NB405573	257	Primary
	Region 15 (continued)			
28	South Dell	NB479627	200	None
29	South Dell/North Dell	NB490616	200	Primary
30	Swainbost	NB505640	399	None
31	Eoropie	NB511649	1,030	Primary
	Region 16			
32	South Ballachulish	NN077586	810	Primary
33	Kinlochleven	NN178619	500	Tertiary
34	Arisaig	NM659861	250	Primary
35	Mallaig (Central)	NM674970	400	None
36	Mallaig (East Bay)	NM679973	200	Primary
37	Kyle of Lochalsh (Lochalsh Rd)	NG755272	220	None
38	Kyleakin	NG753264	390	Primary
39	Portree (Budhmor)	NG486438	200	None
40	Portree Main	NG483431	3,100	Preliminary
41	Broadford	NG645237	240	Primary
42	Kyle of Lochalsh (Pladaig)	NG760275	280	Primary
43	Plockton No.1 (Harbour St)	NG805335	200	None
44	Lochcarron No.1 (East)	NG910400	375	None
45	Lochcarron (Dal a'chladaich)	NG893384	225	Primary
46	Gairloch No. 4	NG801767	200	None
47	Gairloch No. 1 Strath	NG796772	215	None
48	Ullapool (Point)	NH124937	4,900	Preliminary
49	Lochinver (Village)	NC094228	280	Primary
50	Scourie Septic Tanks	NC154448	200	Primary
51	Kinlochbervie (Innes Road)	NC230558	320	Primary

Source: Scottish Office (pers. comm.)



Map 9.6.1 Consented sewage outfalls and trade effluent discharges. Map shows sewage outfalls with a population equivalent >200, and trade outfalls with a consented daily flow >100 m^3. Source: Scottish Office. © Crown copyright.

Table 9.6.2 No. of effluent discharges into Minch waters

Effluent type/treatment	*Region 15*	*Region 16*
Sewage/treatment works	1	0
Sewage/septic tank	100	16
Sewage/none	26	2
Sewage/other	20	3
Trade (fish farms)/none	50	59
Trade (other)/usually none	0	2
Total	***197***	***82***

Source: Bryan (1994)

effluent in the regions, with their maximum consented output.

In the Coastwatch UK survey in 1994, beach quality in the regions was found to be above the national average overall, although the length of coastline surveyed in these regions was generally less than elsewhere (Table 9.6.4). Plastics, including fishing gear, were found to be the dominant litter items. Recreation, sewage and erosion were regarded as being the principal threats to the quality of coastal waters, although occurring at levels well below the national averages.

Table 9.6.4 Beach quality in the regions compared with national standards in 1993/1994

	% of beaches rates as:					
	excellent		*moderate*		*polluted*	
	1993	***1994***	***1993***	***1994***	***1993***	***1994***
Region 15	3	27	47	34	50	39
Region 16*	21	20	25	56	54	24
Scotland	7	7	37	37	56	56
Great Britain	***8***	***8***	***42***	***42***	***50***	***50***

Source: Coastwatch UK (1994). Key: *includes the whole of Highland, part of which lies in Region 3.

9.6.3 Management and issues

Responsibility for coastal water quality in the regions lies with the Scottish Environment Protection Agency (SEPA), which became operational in April 1996. The activities of SEPA are grouped under two broad headings: pollution prevention and control, including the functions of the former waste regulatory authorities, the work of Her Majesty's Industrial Pollution Inspectorate (HMIPI) and the regional River Purification Boards' (RPBs) work on water quality; and water management, covering the RPBs' other functions. There is a strong link between pollution prevention and control and water management, to ensure continuing integrity of estuarine and coastal management.

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.

Fish and shellfish farms are required to carry out their own monitoring of water quality, which is periodically audited by SEPA, but the effects of pesticides designed to maintain fish health are often hard to detect. Outfalls from whisky distilleries may lead to raised concentrations of copper, as well as organic contaminants. Silled lochs, where the rate of exchange of water with the open sea is low, are the most vulnerable to de-oxygenation and the build-up of contaminants.

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

Table 9.6.3 Trade effluent outfalls to tidal waters with consented daily flow >100 m^3 (excluding fish farms)

Location	*Grid ref.*	*Owner*	*Consented daily flow (m^3)*	*Type of effluent*
Corpach	NN078688	Arjo Wiggins	19,000	Paper and board making
Kyle of Lochalsh	NG763271	Amazon Seafoods (UK) Ltd	109	Food processing

Source: Highland River Purification Board (pers. comm.)

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. Stornoway has the only outfall in the regions to which this measure may apply. However, some outfalls will be permitted to discharge sewage with a minimum of primary treatment, provided that studies show that there will be no adverse effects on the environment.

There are currently several schemes (statutory and non-statutory) 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), now carried out by SEPA. 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 sewerage authorities. Under the terms of the Environmental Protection Act 1990, the quality of bathing beaches is the responsibility of local authorities. Secondly, there is the European Blue Flag Award Scheme for beaches that meet the EC guideline standards of beach and water quality, as well as certain land-based criteria. Thirdly, there is the Tidy Britain Group Seaside Award Scheme, designed to complement the Blue Flag scheme, for beaches that meet the minimum standards of beach and water cleanliness and selected land-based criteria but not the Blue Flag standard. 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 Readers Digest and the Marine Conservation Society.

9.6.4 Information sources used

Monitoring of water quality in the regions is carried out by SEPA and SOAEFD, with SEPA concerned mainly with point sources of contamination from outfalls in the nearshore environment. SEPA carries out video and photographic surveys of the sea bed under fish farms, to detect fungal deposits and uneaten food. The interests of SOAEFD lie with 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.

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, now Centre for Environment, Fisheries and Aquaculture Science (CEFAS)) publishes two annual Aquatic Environment Monitoring Reports (AEMR). One reports on radioactivity in the marine environment (e.g. MAFF 1994), the other on non-radioactive pollution and waste disposal operations at sea (e.g. MAFF 1995).

Schemes such as the Tidy Britain Group Seaside Award and the European Blue Flag are monitored 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 takes 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 either region. The results may therefore sometimes be unrepresentative because of the small sample size.

Further information on water quality and effluent discharges can be obtained from the regional and area offices of SEPA (see section 9.6.5 C and Appendix A.1).

9.6.5 Further sources of information

A. References cited

Bryan, A. 1994. *The Minch review*. Inverness, Western Isles Island Council and Scottish Natural Heritage.

Coastwatch UK. 1994. *1994 Survey Report*. Farnborough, Farnborough College of Technology.

Department of the Environment. 1989. *Circular 7/89*. London, HMSO.

Department of the Environment. 1995. *Digest of environmental protection and water statistics*. London, HMSO.

Ministry of Agriculture Fisheries and Food. 1994. *Radioactivity in surface and coastal waters of the British Isles, 1993*. Lowestoft, MAFF Directorate of Fisheries Research. (Aquatic Environment Monitoring Report, No. 42.)

Ministry of Agriculture, Fisheries and Food. 1995. *Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1993*. Lowestoft, MAFF (Directorate of Fisheries Research). (Aquatic Monitoring Report, No. 44.)

B. Further reading

Anon. 1993. Lies, damned lies and statistics in the great water debate. *ENDS Report*, *227*(12/93): 16-19.

Ash Consulting Group. 1994. *Beach litter management in Scotland: an assessment of current procedures and recommendations for best practice*. Glasgow, Scottish Enterprise. (Report prepared for Scottish Enterprise as part of the Tourism and the Environment Initiative.)

Baker, B. 1993. The burning issue. *Surveyor*, 2/12/93: 18-19.

Boxall, S.R., Chaddock, S.E., Matthews, A., & Holden, N. 1993. *Airborne remote sensing of coastal waters*. Southampton, Department of Oceanography. (R & D Report No. 4, prepared for NRA.)

Brown, A. 1992. *The UK environment*. London, HMSO.

Coastwatch UK. In prep. *1995 survey report*. Farnborough, Farnborough College of Technology.

Earll, R., *ed*. 1995. *Coastal and riverine litter: problems and effective solutions*. Kempley, Marine Environmental Management and Training.

Eno, N.C., *ed*. 1991. *Marine conservation handbook*. 2nd ed. Peterborough, English Nature.

HMIP (Marine Pollution Monitoring Management Group - Monitoring Co-ordination Subgroup). 1994. *UK national monitoring plan*. London, HMIP.

Irving, R. 1993. *Too much of a good thing: nutrient enrichment in the UK's coastal waters.* A report to the World Wide Fund for Nature (UK). London, WWF.

Kay, D., & Wyer, M. 1994. Making waves: recreational water quality. *Biologist, 41*(1)*:* 17-20.

Marine Conservation Society. 1994. *The Reader's Digest good beach guide.* Newton Abbot, David & Charles.

Mathieson, S., & Atkins, S.M. 1995. A review of nutrient enrichment in the estuaries of Scotland: implications for the natural heritage. *Netherlands Journal of Aquatic Ecology, 29*(3-4)*:* 437-448.

McGilvray, F. 1994. *Beachwatch 1993.* Ross-on-Wye, Marine Conservation Society & Readers' Digest.

Scottish Office. 1992. *Water quality survey of Scotland.* Edinburgh, Scottish Office.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Pollution control & water quality information, sewage pipeline outfalls and waste regulation - Regions 15 & 16	*SEPA North Region, Dingwall, tel: 01349 862021
Aquatic environmental research and monitoring related to radioactivity in the aquatic environment, non-radioactive waste disposal at sea; consented outfalls database	*SOAEFD, Marine Laboratory, Aberdeen, tel: 01224 876544
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
Tidy Britain Group Seaside Awards and Blue Flag beaches	Tidy Britain Group, Lion House, 26 Muspole St., Norwich NR3 1DJ, tel: 01603 762888

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

9.7 Leisure and tourism

M.J. Dunbar, S.L. Fowler, I. Fuller & M. Irvine

9.7.1 Introduction

Regions 15 (Western Isles) and 16 (west Highland) are popular for leisure and tourism. The rugged coastline, picturesque bays and beaches and relatively small population in both regions are features that attract visitors. Leisure and tourism activities are predominantly based in the coastal zone, with patterns of activity being influenced by difficulty of access, particularly in Region 15 (Edinburgh University 1979; System Three Scotland 1991; TMS 1995).

Table 9.7.1 shows tourist activities undertaken and tourism expenditure in the whole of Scotland in 1991.

According to Scottish Tourist Board figures, more than 11 million tourists took overnight trips in Scotland in 1995, spending over £2.1 billion and supporting around 8% of all employment. The Highlands and Islands as a whole, which includes Regions 1, 2, 3 and part of 14 as well as Regions 15 and 16, attracted 2.6 million trips from British tourists and an estimated 700,000 trips from overseas tourists in that year. Tourism is vital to local economies: Region 15 receives around 100,000 visitors a year, and in 1995 tourism was estimated to be worth £12 million with a further £3 million spent on ferry services (TMS 1995). In Region 16 tourism in 1990 was estimated to be worth £20 million to the Skye economy alone (System Three Scotland 1991).

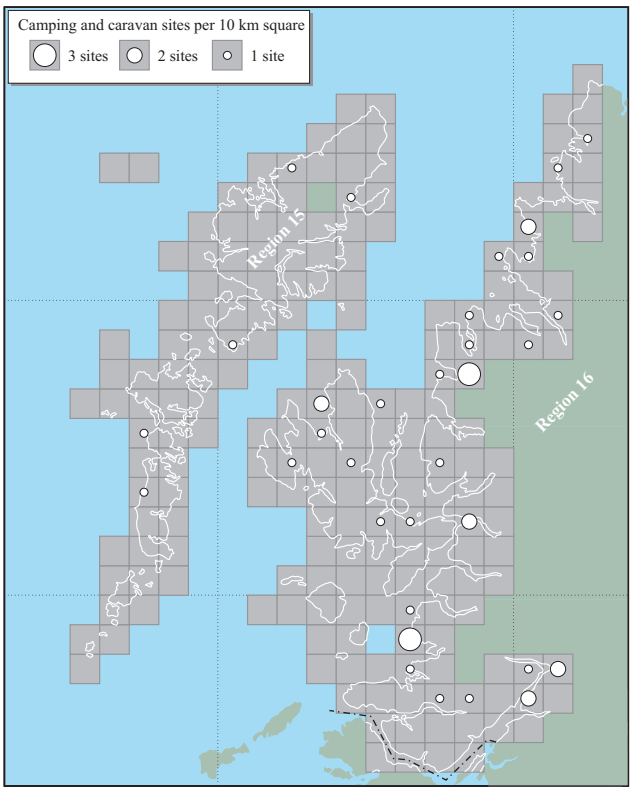
Table 9.7.1 Activities undertaken by British tourists to Scotland in 1991

Activity	*Nights spent (million)*	*Expenditure (million £)*
Hiking/walking	3.8	91
Visiting castles/monuments	1.7	59
Visiting museums/galleries	0.4	16
Golfing	1.0	35
Fishing	1.4	42
Activity holidays	9.9	297
Total	***18.2***	***540***

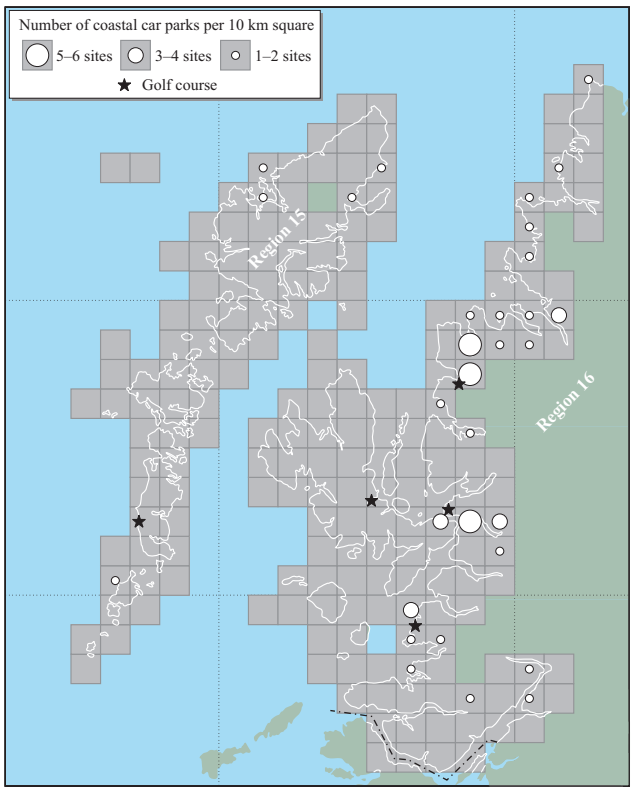
Source: Scottish Tourist Board (1993)

Region 16 receives more visitors than Region 15, mainly owing to its easier access and the provision of more leisure and tourism facilities. Land-based activities in both regions include cycling, hiking, mountaineering, angling (from beaches, lochs, river banks and boats), natural history, golf, shooting and Gaelic culture, as well as visiting attractions such as castles, gardens and heritage sites. Among the most important examples of land-based leisure infrastructure on the coast are camping and caravan sites (Map 9.7.1), golf courses and coastal car parks (Map 9.7.2).

The main significance of the regions for water sports and leisure is derived from the unspoilt coastal and marine environment. However, water-based leisure is small in scale in comparison with areas further south, such as the Clyde. The main activities undertaken at sea along the coasts of Regions 15 and 16 are sailing, boat trips (including whale, dolphin and seal watching), sea angling, swimming, surfing,



Map 9.7.1 Number of camping & caravan sites in coastal 10 km squares in the region. Source: Ordnance Survey & Hamlyn (1995). Copyright Ordnance Survey & Hamlyn.



Map 9.7.2 Locations of coastal car parks and golf courses. Source: Ordnance Survey & Hamlyn (1995). Copyright Ordnance Survey & Hamlyn.

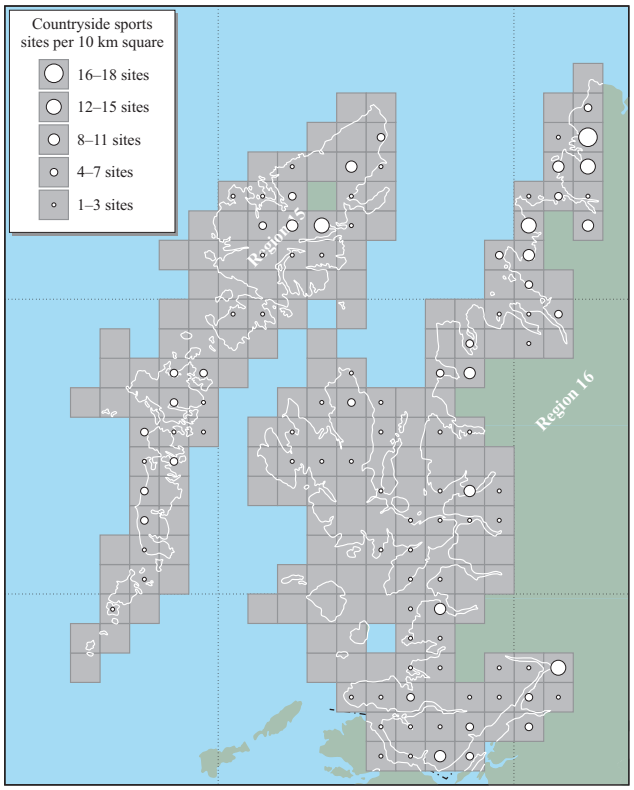
canoeing and scuba diving. Local fishing ports and sheltered sea lochs are regularly used by visiting leisure craft. Infrastructure developments for water-based leisure activities in the regions include yacht moorings, launching slips, water sports centres and sea angling (Map 9.7.3).

The Countryside Sports Database, held by the Scottish Sports Council (SSC), holds records of sport and recreation sites in the whole of Scotland. The most popular activities recorded in the coastal 10 km squares of these regions are game angling (403 sites), sailing (52), sub-aqua (34), shooting (twelve), board sailing (ten), canoeing (ten) and cycling (eight). More than one activity may occur at a site. Coverage in the database is not systematic, for example it is likely that sea angling is more popular than the figures indicate. Table 9.7.2 and Map 9.7.3 indicate the distribution of leisure activities in the regions, in terms of the number of sites at which one or more such activities are taking place.

Table 9.7.2 Number of sites at which recreational activities are taking place

District	*No. of sites*
Region 15	***134***
Isle of Lewis	72
Harris	6
North Uist	31
Benbecula	6
South Uist	14
Barra	5
Region 16	***420***
Sutherland	128
Lochaber	127
Isle of Skye	55
Ross & Cromarty	110
Regions 15 & 16	***554***

Source: Scottish Sports Council Countryside Sports Database. Note: data are still being added to the database.



Map 9.7.3 Countryside sports sites within 10 km of the coast, counted by 10 km square. Source: Scottish Sports Council.

9.7.2 Important locations

Wildlife tourism in the regions is largely terrestrial, but many such tours include coastal walks and organised boat trips, for example to Handa Island, the Summer Isles or the Small Isles (Bryan 1994). Wildlife tourism is currently more common in Region 16 than Region 15, which has only one water-based operation, out of Stornoway.

A low level of wildfowling activity was recorded on the soft sediment shores of North Uist and Benbecula by the Nature Conservancy Council's Estuaries Review (Davidson *et al.* 1991). The North Uist Gun Club operates on Oitir Mhor, Traigh Vallay and Oronsay and wildfowling also occurs on the North and South Uist Estates. Greylag geese are the main species targeted and the season runs from September to the end of January.

Table 9.7.3 lists the main harbours, moorings and anchorages in the regions and locations of other water-based leisure infrastructure, including centres providing water sport tuition, facilities and equipment (Map 9.7.3).

Yachting takes place in most areas around Regions 15 and 16, but most activity is concentrated in the south of Region 16: for example around 900 yachts pass through the Caledonian Canal to or from Loch Linnhe annually. Yacht chartering operations are mostly based outside the regions, to the south, but there are a small number of operators based on Lewis in Region 15 and on Skye and Gairloch in Region 16 (Bryan 1994). Many sailing charters, self-manned and crewed, pass through the regions and berth at local harbours. Sea angling from the shore or boats is widespread throughout the regions, with boats available for hire locally and organised fishing trips provided by owners. In Region 15 Stornoway is the main location, although Tarbet, Lochmaddy and Lochboisdale are also popular. In the Western Isles an angling festival is held each year, which attracts international competitors (Bryan 1994). Regions 15 and 16 are known for their clear waters and diverse marine life, which attract many divers. Most diving activity takes place in the south of Region 16, owing to the ease of access and the facilities for diving. In addition to the centres offering diving facilities and boat trips listed in Table 9.7.3, dive boat charters are run to the more remote areas of Regions 15 and 16, including St. Kilda, by operators based within the regions and in Oban. Other water sports include water skiing, sea canoeing, windsurfing, surfing and dinghy sailing. Swimming from beaches is not a very widespread activity in either region, because of the climate.

9.7.3 Management and issues

Responsibility for the management of leisure and tourism lies with a number of bodies in Scotland. The Scottish Tourist Board is an independent statutory body and is financed primarily by the Scottish Office to encourage tourism. It liaises with the fourteen local tourist boards in Scotland; there is one in each of Regions 15 and 16 (see also section 9.7.6). Western Isles Council and Highland Council

Table 9.7.3 Locations of water-based leisure infrastructure

Site	*Grid ref.*	*Description*
Region 15		
Stornoway, Lewis	NB4334	Wildlife cruises, sea angling base, diving facilities, yacht moorings
Tarbert, Harris	NB1600	Sea angling base
Rodel, Harris	NG0583	Yacht moorings
Lochmaddy, North Uist	NF9269	Yacht moorings, sea angling base, diving facilities, activity centre
Kallin, Benbecula	NF8856	Yacht moorings
Loch Carnan, South Uist	NF8344	Yacht moorings
Lochboisdale, South Uist	NF7920	Yacht moorings, sea angling base
Acairseid, Eriskay	NF7909	Yacht moorings
Castlebay, Barra	NL6798	Yacht moorings
Region 16		
Fort William	NN1074	Yacht harbour, wildlife cruises
Lochaline	NM6845	Yacht anchorage, diving facilities
Loch Sunart	NM6964	Yacht anchorage
Kilchoan	NM4863	Sea angling base
Arisaig	NM6686	Yacht harbour, wildlife cruises
Mallaig	NM6897	Yacht harbour, wildlife cruises, sea angling base
Kyle of Lochalsh	NG7627	Yacht harbour, wildlife cruises, sea angling base, diving trips
Kyleakin, Skye	NG7526	Yacht harbour, wildlife cruises
Armadale, Skye	NG6404	Yacht moorings
Loch Dunvegan, Skye	NG2549	Sea angling, wildlife cruises
Stein, Skye	NG2666	Yacht moorings
Uig, Skye	NG3964	Sea angling, activity centre
Portree, Skye	NG4843	Yacht harbour, wildlife cruises, sea angling base
Raasay	NG5536	Activity centre
Plockton	NG8033	Yacht moorings, wildlife cruises
Gairloch	NG8077	Yacht anchorage/chartering; wildlife cruises, sea angling base, activity centre
Loch Ewe	NG8689	Yacht anchorage
Ullapool	NH1294	Yacht harbour, wildlife cruises, sea angling base
Achiltibuie	NC0209	Wildlife cruises, sea angling base
Summer Isles	NB9908	Yacht anchorage, wildlife cruises, diving facilities, boat charter
Lochinver	NC0922	Yacht harbour, sea angling base
Unapool	NC2334	Wildlife cruises
Scourie	NC1545	Wildlife cruises, sea angling base
Loch Laxford	NC2050	Wildlife cruises

Sources: Bryan (1994), D'Oliveira & Featherstone (1993) and miscellaneous publications, e.g. tourist brochures. Note: there are many other areas with small numbers of leisure moorings, and most coastal towns have slipways for leisure craft.

are closely concerned with tourism in the area, and tourism developments are considered within their structure and local plans. Highlands and Islands Enterprise and Western Isles Enterprise have published a tourism strategy.

A Tourism Management Initiative (TMI) was launched in 1992 to support a 'sustainable tourism' strategy, which aims to reconcile the development of tourism with the need to conserve and protect the environment. The initiative is being developed by the Tourism and Environment Task Force, which comprises a number of bodies with responsibilities for leisure, tourism and environmental protection in Scotland. These include the Scottish Tourist Board, Scottish Enterprise, Highland and Island Enterprise, Scottish Natural Heritage, Forest Authority, Scottish Sports Council, Historic Scotland, Scottish Office Industry Department and the Convention of Scottish Local Authorities (Tourism and Environment Task Force 1996). At local level the TMI is delivered through Tourism Management Programmes (TMPs), which provide a link between local and national priorities. There are currently ten TMPs in Scotland, with one in Region 16 (Skye & Lochalsh) and one in Region 15 (Callanish in Lewis). Alongside the TMPs there are a range of other 'green tourism initiatives', including CADISPA (Conservation and Development in Sparsely Populated Areas) and LIFE (an EU programme which promotes sustainable development in rural economies).

Local authority policies and regional planning guidance recognise the need to conserve the natural qualities of the undeveloped coast while at the same time developing and managing the tourist and leisure industry. Local planning policies recognise the need to support and develop the range of leisure facilities that are currently available, with particular emphasis on the golfing industry, redevelopment of redundant dockland sites, informal countryside recreation and the promotion of off-peak tourism. 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.

Some of the conflicts between nature conservation and golfing interests in key locations are being resolved through a partnership approach between nature conservation bodies and golfing enterprises, and as a result of new environmental management initiatives agreed by members of national and European golfing organisations (European Golf Association Ecology Unit 1995, 1996).

Map 9.7.4 Important locations for water-based leisure. Sources: tourist brochures, Ordnance Survey Land Ranger maps, RYA (1992) and D'Oliveira & Featherstone (1993). © Crown copyright.

Increasing interest in cetacean, seal and bird watching can lead to disturbance, particularly during breeding seasons. There are a number of voluntary schemes and codes of practice currently being developed to protect vulnerable species from disturbance by leisure and tourism activities (Morrison 1995).

Wildfowling, a traditional activity that was originally practised commercially, is now carried out solely for recreation. The sport is managed through wildfowling clubs. The British Association for Shooting and Conservation (BASC) is the representative body for sporting shooting in the UK and has 200 affiliated wildfowling clubs, but there are currently no BASC registered clubs in these regions. Targeted wildfowl species and shooting seasons are regulated through the Wildlife & Countryside Act 1981 and wildfowlers are also bound by firearms legislation, principally the Firearms Act 1968 (as amended). The open season for coastal wildfowling in Scotland varies from species to species, but is mainly 1 September to 20 February. During periods of severe winter weather, disturbance to waterfowl from shooting threatens the birds' survival; at these times statutory wildfowling bans can be imposed after fourteen days of freezing conditions, although voluntary restraint is called for after seven days.

9.7.4 Information sources used

Whilst information on total numbers of people visiting an area and the overall income generated can be obtained, details of the specific activities in which people participate and the distribution of these activities are difficult to determine (System Three Scotland 1991). Information in this section is derived from Bryan (1994), TMS (1995), Highland and Islands Enterprise, the Scottish Sports Council (which holds information about the geographical distribution of activities throughout Scotland), tourist brochures, Ordnance Survey & Hamlyn (1995) and from Ordnance Survey 1:50,000 Landranger maps, Admiralty Charts and a nautical almanac (D'Oliveira & Featherstone 1993). It is not possible to indicate the size and capacity of some facilities, such as campsites, from this information. The Scottish Sports Council database is still under development and coverage across 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

We are grateful to Stewart Angus and Amanda Bryan (SNH) for much of the information in this section, Duncan Bryden (Highland and Islands Enterprise), who provided information on the Tourism Management Initiative, and Vicki Eachus (University of Edinburgh), who provided information from the Scottish Sports Council database.

9.7.6 Further sources of information

A. References cited

Bryan, A. 1994. *The Minch review*. Stornoway, Western Isles Islands Council and Scottish Natural Heritage.

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.

D'Oliveira, B., & Featherstone, N.L. 1993. *The Macmillan and Silk Cut nautical almanac 1994.* Basingstoke, Macmillan.

Edinburgh University. 1979. *Visitors to the Scottish Islands*. University of Edinburgh, Tourism and Recreation Unit. (Research Report, No. 43.)

European Golf Association Ecology Unit. 1995. *An environmental strategy for golf in Europe*. Newbury, Pisces Publications.

European Golf Association Ecology Unit. 1996. *An environmental management programme for golf courses*. Newbury, Pisces Publications.

Market Research Solutions Ltd. 1994. *National survey of boating and water sports participation.* Egham, British Marine Industries Federation (BMIF).

Morrison, D. 1995. *Wildlife tourism in the Minch - distribution, impact and development opportunities*. Stornoway, The Minch Project.

Ordnance Survey & Hamlyn. 1995. *Super scale atlas of Great Britain.* Southampton, Ordnance Survey and Hamlyn.

Royal Yachting Association. 1992. *RYA affiliated organisations*. Eastleigh, RYA.

Scottish Office. 1995. *Draft national planning policy guidance on sport and physical recreation.* Edinburgh, Scottish Office.

Scottish Tourist Board. 1993. *Activities undertaken by British tourists to Scotland in 1991.* Edinburgh, Scottish Tourist Board Factsheet. Market Research Results.

System Three Scotland. 1991. *Skye tourism study; final report.* Report to Skye and Lochalsh District Council, Highlands and Islands Enterprise and Countryside Commission for Scotland.

TMS. 1995. *Western Isles Tourism Strategic Development Plan*. TMS, Edinburgh. (Unpublished report to Western Isles Tourist Board, WIE, WIIC and SNH.)

Tourism and Environment Task Force. 1996. *Tourism and the environment initiative - review and future direction*. Edinburgh, Scottish Tourism Co-ordinating Group.

B. Further reading

ASH Consulting Group. 1994. *Coastal erosion and tourism in Scotland.* Edinburgh, Scottish Natural Heritage. (SNH Review, No. 12.)

Association for the Protection of Rural Scotland. 1990. *Report on the golf courses and allied developments in Scotland.* Edinburgh, Association for the Protection of Rural Scotland.

Bartholomews. 1994. *Scottish graded caravan and camping parks.* Edinburgh, Bartholomew Press.

Bell, D.V., & Fox, P.J.A. 1991. Shooting disturbance: an assessment of its impact and effects on overwintering waterfowl populations and their distribution in the UK. *Nature Conservancy Council, CSD Report,* No. 1,242.

British Marine Industries Federation. 1992. *A guide to boating and the environment.* Egham, The British Marine Industries Federation. (BMIF Environment Initiative.)

British Marine Industries Federation. Undated. *Steering a balanced course: the boating industry and the marine environment*. Egham, British Marine Industries Federation.

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

Darling, J. 1982. *The sea angler's guide to Britain and Ireland.* London, Lutterworth Press.

D'Oliveira, B., 1996. *The Macmillan nautical almanac 1997.* Basingstoke, Macmillan.

Doody, J.P. Undated. *Coastal habitat change - a historical review of man's impact on the coastline of Great Britain.* Peterborough, Nature Conservancy Council. (Unpublished draft.)

Eno, N.C., *ed*. 1991. *Marine conservation handbook.* 2nd ed. Peterborough, English Nature.

Environmental Resource Group. 1991. *Feasibility study for clean beaches: an action plan to clean and groom amenity beaches in Ross and Cromarty area.* Report to Ross & Cromarty District Council and Highlands & Islands Enterprise.

Highlands and Islands Development Board. Undated. *Yacht moorings in the Scottish Highlands and Islands. West Coast and Caledonian Canal locations.* Inverness, Highlands and Islands Development Board.

Hydrographic Office. 1990. *West coast of Scotland pilot.* Rev. ed. Taunton, Hydrographer of the Navy.

Marine Conservation Society. 1994. *The Reader's Digest good beach guide*. Newton Abbot, David & Charles.

Mudge, G.P. 1989. Night shooting of wildfowl in Great Britain: an assessment of its prevalence, intensity and disturbance impact. *Nature Conservancy Council, CSD Report,* No. 987.

Owen, M. 1992. An analysis of permit systems and bag records on NNRs. *JNCC Report,* No. 68.

Ridgill, S.C., & Fox., A.D. 1990. *Cold weather movements of waterfowl in western Europe.* Slimbridge, International Waterfowl & Wetlands Research Bureau. (IWRB Special Publication, No. 13.)

Robinson, L. 1970. *Sea fishing in Scotland.* London, Adam & Charles Black.

Scottish Office. 1994. Golf courses and associated developments. *Planning Advice Note PAN 43*. Edinburgh, Scottish Office Environment Department.

Scottish Natural Heritage. 1992. *Enjoying the outdoors. A consultation paper on access to the countryside for enjoyment and understanding*. Edinburgh, Scottish Natural Heritage.

Scottish Sports Council. 1991. *Sport and the economy of Scotland.* Edinburgh, Scottish Sports Council. (Research Digest No. 21.)

Scottish Tourist Board. 1991. *Activities undertaken by overseas tourists to Scotland in 1991.* Edinburgh, Scottish Tourist Board Factsheet. (Market research results.)

Scottish Tourist Board. Undated. *British tourism 1989-1991: activity holidays in Scotland*. Edinburgh, Scottish Tourist Board.

Sidaway, R. 1993. *Recreation and the natural environment. Report to Scottish Natural Heritage and Scottish Sports Council.* Edinburgh, Research and Policy Consultants.

Sports Council. 1992. *Countryside and water recreation*. London, Sports Council. (Planning and managing watersports on the coast: lessons from Canada and the USA. Factfile 3.)

Sports Council. 1993. *Water skiing and the environment*. London, Sports Council.

C. Contact names and addresses

Type of information	*Contact address and telephone no.*
Tourist information service	Scottish Tourist Board, 23 Ravelstone Terrace, Edinburgh EH4 3EU, tel: 0131 332 2433
Tourist Information Centre open all year - Region 15. (There are seasonal offices at Castlebay, Lochboisdale, Lochmaddy and Tarbert.)	Western Isles Tourist Board, 26 Cromwell Street, Stornoway, Isles of Lewis HS1 2TD, tel: 01851 703088
Tourist Information Centres open all year - Region 16. (There are seasonal offices at Strontian, Kilchoan, Mallaig, Kyle of Lochalsh, Shiel Bridge, Uig, Broadford, Lochcarron, Ullapool, Gairloch and Lochinver.)	Tourist Office, Cameron Square, Fort William PH33 6AJ, tel: 01397 703781 Highlands of Scotland Tourist Board, Tourist Information Centre, Meall House, Portree, Isle of Skye IV51 9BZ, tel: 01478 612137
Tourism strategy - Region 15	*Western Isles Enterprise, Stornoway, Isle of Lewis, tel: 01851 703703
Tourism strategy - Region 16	*Highlands and Islands Enterprise, Inverness, tel: 01463 234171
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
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	*Publicity Officer, Wildfowl & Wetlands Trust, Slimbridge, tel: 01453 890333
Wildfowling (general, including details of affiliated clubs)	Conservation & Training Officer, The British Association for Shooting and Conservation, Trochry, Dunkeld PH8 0DY, tel: 01350 723226
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	
Camping	Secretary, The Camping and Caravanning Club (Scottish Region), 70 Douglas Road, Longniddry, East Lothian EH32 0LJ, tel: 01875 853292
Canoeing - Britain	British Canoe Union, Agbolgon Lane, West Bridgford, Nottingham NG2 5AS, tel: 0115 982 1100
Canoeing - Scotland	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
Sub Aqua	Scottish Sub Aqua Club, 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, tel: 01383 620123
Wildfowling (the sport)	Press and Information Officer, British Field Sports Society, 59 Kennington Road, London SE1 7PZ, tel: 0171 928 4742
Wind surfing - Scotland	Secretary, Scottish Windsurfing Association, c/o Royal Yachting Association, Scotland, Caledonia House, South Gyle, Edinburgh EH12 9DQ, tel: 0131 317 7388
Wind surfing - Britain	British Windsurfing Association, 86, Sinah Lane, Hayling Island, Hants. PO11 9JX, tel: 01705 468182
Board sailing	UK Board Sailing Association, PO Box 28, Fareham, Hants PO14 3XD, tel: 01329 664779
Yacht harbours	The Yacht Harbour Association, Hardy House, Somerset Road, Ashford, Kent TN24 8EW, tel: 01303 814434
Yachting	Honorary Secretary, Royal Yachting Association, Scotland, Caledonia House, South Gyle, Edinburgh EH12 9DQ, tel: 0131 317 7388
Marine leisure industries; small craft marine industries	British Marine Industries Federation, Meadlake Place, Thorpe Lea Road, Egham, Surrey TW20 8HE, tel: 01784 473377
Harbour Masters	See Appendix A.2

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

Rockall, which rises abruptly out of the North Atlantic more than 350 km west of St Kilda, is the most westerly outlier of the British Isles. Visitors have to leap onto the rock at the crest of a wave. As can be seen by the width of the band of rock unoccupied by birds, the swell can carry a boat half way up the rock - or plummet it ten metres or more lower down. Photo: Marine Nature Conservation Review, JNCC.

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 Regions 15 (Western Isles) and 16 (west Highland). 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 zone 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 zone management ensures that all land and sea use issues are co-ordinated, including development, conservation, waste disposal, fisheries, transport, and coastal 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 zone 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 Agriculture, Environment and Fisheries Department 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 Agriculture, Environment and Fisheries Department 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 February 1996 the European Commission published a *Demonstration programme on integrated management of coastal zones* (European Commission Services 1996), intended as a spur to urgent co-operative action for Europe's coast.

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, CoastNET (the Coastal Heritage Network) and the Royal Society for the Protection of Birds (RSPB) (see section 10.2.5). Many other diverse interest groups and organisations now have national policies with regard to coastal management and estuaries management, such as 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. Regionally-led coastal management initiatives are dealt with in section 10.3.

10.2.2 National coastal fora

The Scottish Coastal Forum

The formation of a Scottish Coastal Forum, which was proposed in the discussion paper *Scotland's coasts* (Scottish Office Agriculture, Environment and Fisheries Department 1996), has recently (1996) been confirmed. A wide range of organisations with interests in coastal matters will be invited to participate in the Scottish Coastal Forum, including representatives from the Association of Shellfish Growers, CBI Scotland, CoastNET, Convention of Scottish Local Authorities, Crown Estate, Highlands and Islands Enterprise, Scottish Enterprise, Scottish Environment Protection Agency, Scottish Fishermen's Federation, Scottish Natural Heritage, Scottish Salmon Growers' Association, Scottish Sports Council, Scottish Tourist Board, Scottish Wildlife and Countryside Link and the Scottish Office. The Forum will provide a focus for coastal issues as well as a national context for the work of local coastal forums, such as the Forth Estuary Forum.

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. It recently (November 1996) held a national workshop for coastal managers in Scotland (CoastNET 1997).

10.2.3 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.

10.2.4 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 will 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. None of these initiatives is within Regions 15 or 16.

10.2.5 Coastal (engineering) groups

There are no formal coastal (engineering) groups in Scotland. HR Wallingford 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, such as the coastal (engineering) groups established in England and Wales. 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 has compiled mapped and numerical information on land use and selected human activities for 57 major UK estuaries, none of which is in Regions 15 or 16. 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).

10.2.7 Designated sites

Site designations are discussed in detail in Chapter 7. However, several statutory and non-statutory designations are also relevant here because they 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 in management planning 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, the Scottish Wildlife Trust, local authorities, the RSPB and other bodies, and National Scenic Areas, 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 may include intertidal areas, subtidal areas and/or lagoonal areas; 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 Scottish Natural Heritage, 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 classification is used by Scottish Natural Heritage to indicate important sites and stimulate consultation over developments there (NCC 1990). There are a total of fourteen Marine Consultation Areas in Regions 15 and 16, seven in each region (see section 7.4.3).

10.3 Regional coastal management groups and initiatives

10.3.1 Introduction

There are currently a number of new regional coastal zone management (CZM) initiatives arising around the coastline under the leadership of local planning, harbours and ports authorities. Additionally, a number of the local or regional CZM projects (Table 10.3.1) are part of national initiatives under organisations such as the statutory nature conservation agencies or non-governmental bodies. Other locally-based coastal management initiatives are also underway; these include management plans for protected areas of coast, ranging from National Nature Reserves, managed by Scottish Natural Heritage for nature conservation objectives, to non-statutory Marine Consultation Areas and the proposed Special Areas of Conservation (under the EC Habitats & Species Directive), which will require the participation of a range of bylaw-making authorities for successful management. A further initiative is the establishment by Highland Council of local environmental fora throughout Highland, to take an active role in protecting and enhancing beaches and coastlines. Table 10.3.1 lists regional coastal management initiatives.

10.3.2 Minch Project and Forum

The Minch Project, covering the whole of Region 15 and nearly all of Region 16 (from Ardnamurchan Point to Cape Wrath), was established in 1993. The project is a collaborative venture, with a partnership comprising ten funding bodies (Table 10.3.1). The partnership came together as a result of realisation of the need for a more integrated approach to the management of the Minch, if development pressures were to be accommodated and environmental quality safeguarded. The overall aim of the project is to promote, through partnership, a wiser use of the natural resources of the area in the interest of the economic and social needs of neighbouring communities and the environment. *The Minch review* (Bryan 1994) initially identified key issues that the project, with guidance from the partnership, sought to develop. These include major studies in littoral seaweed resource assessment, wildlife tourism study, coastal erosion and sand and gravel resources.

The Minch Forum was originally established as a forerunner of the Minch Project. The present function of the Forum, however, is to act as a vehicle for open discussion on the key issues affecting the Minch area. The forum is a voluntary partnership and, although not bound by rigid rules, operates around a number of agreed principles. Participants in the Minch Forum (up to twenty members) are committed to securing a positive future for both the people and the resources of the Minch. This is partly achieved through allowing the participating organisations to reach a consensus regarding the main objectives and ways forward with regard to the identified issues. Through these discussions it is expected that communication on key issues will be greatly enhanced. This will lead to an increase in the awareness and understanding of each organisation's role with regard to the issues. It is also intended that the forum will reach agreements on common ground that can be used for the benefit of the whole Minch area.

10.3.3 Local planning authority and port/ harbour initiatives

The maritime local planning authorities are involved in most, if not all, of the major coastal management initiatives described in this chapter (Table 10.3.1) and are beginning to instigate their own, not least through their planning documents. Local planning authorities in the regions have published regional, district and local plans, which provide the statutory planning framework for development control purposes. In most cases these plans are supplemented by regular reviews, monitoring documents and survey reports covering a variety of topics. Port and harbour authorities (see Appendix A.2) also have a statutory remit to control activities within their areas of authority, which may include coastal waters.

In Region 15 the Western Isles Council has far-reaching powers over developments in both land and sea areas. It is the single Local Planning Authority for the islands as well as being the Harbour Authority for all harbours except Stornoway (which is managed by a separate public trust) and the authority for issuing works licences for structures in the sea (such as salmon cages). As a result the council is in a position to undertake integrated coastal management on a statutory basis, rather than simply in voluntary co-operation with other statutory organisations.

In Region 16 a single planning authority, Highland Council, operates and is involved in all the major coastal management initiatives described in this chapter. The council has a pilot coastal management study underway for the area from the Point of Ardnamurchan to Loch Gairloch, including the Small Isles and Skye. This in-house study aims to identify key planning issues in the coastal zone and management approaches that may be applied here and elsewhere around the Highland coastline. It is currently at the information collation stage, having concentrated on survey work and issue identification in relation to the main uses of the study area. Draft topic papers are out for consultation (as at March 1997).

10.3.4 Acknowledgements

Thanks are due to Steven Atkins, Jill Strawbridge (Scottish Natural Heritage) and Amanda Bryan (Highlands and Islands Enterprise).

Table 10.3.1 Regional coastal management initiatives

Initiative name	*Scope/aims*	*Organisations involved*	*Contact details*
Region 15			
Marine Consultation Areas: Loch Obe (Barra), Loch Eynort, Loch Maddy, The Obbe (Harris), Loch Seaforth, Loch Roag and St. Kilda	Non-statutory designation to indicate importance of site and highlight need for consultation over developments.	Scottish Natural Heritage	*Scottish Natural Heritage Edinburgh, tel: 0131 447 4784
Region 16			
Pilot coastal study for Highland Region west coast	Pilot CZM study, initiated in 1994, for an area of Highland from Loch Gairloch to Ardnamurchan, including Skye and the Small Isles. Aims to identify key planning issues, and management approaches that could be applied. Strategy paper for wider distribution due summer 1996.	Highland Council	*Colin Wishart, Planning Department, Highland Council, Inverness, tel: 01463 702000
Marine Consultation Areas: Lochs Sunart, Duich, Long, Carron and Torridon, Dunvegan Head (Skye) and Loch Laxford	Non-statutory designation to indicate importance of site and highlight need for consultation over developments.	Scottish Natural Heritage	*Scottish Natural Heritage Edinburgh, tel: 0131 447 4784
Regions 15 &16			
Minch Project	Integrated and effective management of the marine and coastal environments of the area.	Scottish Natural Heritage, Western Isles Council, Highland Council, Scottish Tourist Board, the five local Enterprise companies bordering the Minch, Highlands and Islands Partnership Programme.	*Minch Project Officer, Scottish Natural Heritage, Stornoway, Isle of Lewis, tel: 01851 705258
Minch Forum	Community Forum or conference to facilitate discussion on marine issues and participation by communities in management.	Scottish Natural Heritage, Minch Project, Western Isles Council, Highland Council, Scottish Environment Protection Agency, Highlands and Islands Enterprise, 'Leader' Project.	Gordon Frith, Western Isles Council, Council Offices, Sandwick Road, Stornoway, Isle of Lewis, tel: 01851 703773

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

10.3.5 Further sources of information

A. References cited

Bryan, A. 1994. *The Minch review*. Inverness, Western Isles Islands Council and Scottish Natural Heritage.

Burbridge, P., & Burbridge, V. 1994. *Review of Scottish coastal issues.* Edinburgh, Scottish Office. (Consultants report to the Central Research Unit.)

CoastNET. 1997. *CoastNET: a new deal for the Scottish coast.* Manchester, CoastNET. (Report of a national workshop for coastal managers in Scotland, 14 November 1996, University of Edinburgh.)

Department of the Environment. 1994. *The conservation (natural habitats etc.) Regulations.* London, HMSO (SI 2716).

Earll, R.C., *ed.* 1994. *Statutory and non-statutory plans in the estuarine and coastal environment. Overlapping plans - is this an issue?* Kempley, Gloucestershire, Marine Environmental Management and Training. (Unpublished report of a meeting held in July 1994.)

European Commission Services. 1996. *Demonstration programme on integrated management of coastal zones*. Brussels, European Commission.

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.)

HR Wallingford. 1995. *Coastal cells in Scotland.* Wallingford, HR Wallingford. (Report to Scottish Natural Heritage, the Scottish Office and Historic Scotland. EX/3176.)

Laffoley, D.d'A., *ed.* In prep. *A generic management model for marine SACs.* Peterborough, English Nature.

Local Government Management Board. 1995. *Local agenda 21 roundtable guidance: action on the coast*. Luton, Local Government Management Board.

Macaulay Land Use Research Institute. 1995. Integrated catchment management. *In: The Macaulay Land Use Research Institute Annual Report 1994.* Craigiebuckler, Aberdeen, MLURI.

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.

Royal Society for the Protection of Birds. 1995. *Review of coastal zone management powers.* Sandy, RSPB.

Scottish Development Department. 1974. *Coastal planning guidelines and land-use summary sheet.* Edinburgh, Scottish Development Department.
Scottish Development Department. 1981. *National planning guidelines.* Edinburgh, Scottish Development Department.
Scottish Natural Heritage. 1995. *Natura 2000: a guide to the 1992 EC Habitats Directive in Scotland's marine environment*. Perth, Scottish Natural Heritage.
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.)
Scottish Office Agriculture, Environment and Fisheries Department. 1996. *Scotland's coast: a discussion paper.* Edinburgh, HMSO.
Skinner, D. 1974. *The coast of Scotland: some recently collected survey material prepared for the Scottish Development Department.* Edinburgh, Scottish Development Department.

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.* Bangor.
Department of the Environment. 1995. *Policy guidelines for the coast.* London, HMSO.
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.
English Nature. 1994. *Environmental objective setting for shoreline management plans.* Peterborough, English Nature (Marine Guidance Note).
European Commission. 1995. *Communication from the Commission to the Council and European Parliament on the integrated management of coastal zones.* Brussels. (COM(95)511 final.)
Gilbert, D., & McGinn, D., *eds.* 1993. *The Future Firth Conference - a conference on the status and future of the Moray Firth as an area for people and wildlife.* Edinburgh, Scottish Wildlife Trust. (Conference proceedings, March 1993.)
Gubbay, S. 1994. *Seas: the opportunity. Working together to protect our marine life*. Sandy, Royal Society for the Protection of Birds.
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. 1993. *Strategy for flood and coastal defence in England and Wales.* London, MAFF.
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).
National Coasts and Estuaries Advisory Group. 1993. *Coastal planning and management: a good practice guide*. Maidstone, National Coasts and Estuaries Advisory Group.
Rendel Geotechnics. 1994. *Coastal planning and management: a review.* London, HMSO. (Report for the Department of the Environment.)
Royal Society for the Protection of Birds. 1992. *A shore future. RSPB vision for the coast*. Sandy, Royal Society for the Protection of Birds.
Royal Society for the Protection of Birds. 1993. *Making the coast count: strategic planning and management on the north-west coast.* Sandy, RSPB.
Scottish Natural Heritage. 1990. *Marine Consultation Areas.* Edinburgh, Scottish Natural Heritage.
Scottish Natural Heritage. 1997. *Natura 2000: managing European marine sites - an introduction.* Edinburgh, Scottish Natural Heritage.
Scottish Office. 1993. *The Scottish environment - statistics, No. 4.* Edinburgh, The Government Statistical Service.
Scottish Wildlife and Countryside Link. 1993. *All at sea? Coastal zone management, the case for Scotland*. Perth, Scottish Wildlife and Countryside Link.
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.)
World Wide Fund For Nature. 1995. *Integrated coastal zone management UK and European initiatives.* Godalming, World Wide Fund For Nature UK. (Marine Update, No. 19.)

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.
Marine Update. A briefing to highlight World Wide Fund For Nature's work in marine conservation. Published by WWF.
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	An independent Charitable Trust and membership organisation. 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. Augustine's, 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, Maritime Team, English Nature, Northminster House, Peterborough PE1 1UA, tel: 01733 340345 (secretariat)
Eurocoast UK	The Eurocoast Association 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 & International Transport, UWCC, P.O. 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, P.O. Box 11059, NL-2301 EB Leiden, tel: +31 71 122900/123952
European Union for Coastal Conservation-United Kingdom (EUCC-UK)	UK membership network affiliated to EUCC, providing focus for information exchange about European-level coastal conservation issues.	EUCC, c/o 5 Green Lane, Brampton, Huntingdon, Cambridgeshire PE18 8RE, tel: 01480 457624
Highlands and Islands Partnership Programme	Administers Highlands and Islands Objective 1 Programme (European Structural Funds)	Highlands and Islands Partnership Programme, Bridge House, 20 Bridge Street, Inverness IV1 1QR, tel: 01463 244478
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
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
Joint Nature Conservation Committee - 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
Leader Project	Funded by European Structural Funds, supporting community projects across Europe. The Western Isles, Skye and Lochalsh Leader Group operates in the regions.	*Carola Bell, Leader Project Officer, c/o Western Isles Enterprise, Stornoway, tel: 01851 703703
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, Professor Graham King, CZM Associates, 2 Newton Villas, Newton, Swansea SA3 4SS, tel: 01792 367552

C. Contact names and addresses (continued)

(See also Table 10.3.1.)

Organisation/group	*Activities*	*Contact address and telephone no.*
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, Marine Forum for Environmental Issues, Scarborough, tel: 01723 362392
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
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.	*D. Huggett, Coastal Policy Officer, RSPB HQ, Sandy, tel: 01767 680551
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 and disposal authorities, and other functions with respect to pollution control, and must be consulted over land drainage proposals to controlled waters.	*SEPA North Region HQ, Dingwall, tel: 01349 862021
Scottish Natural Heritage	Marine Consultation Areas, coastal cells in Scotland	*Aquatic Environments Branch, SNH, Edinburgh, tel: 0131 447 9797
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.	*Alan Burdekin, SOAEFD, Victoria Quay, Edinburgh, tel: 0131 244 0213
Scottish Office Development Department	Coastal policy and planning. Preparation of Rural White Paper.	Dr Cath Murphy, Room 6/61, Scottish Office Development Department, New St. Andrew's House, Edinburgh EH1 3TG, tel: 0131 244 4807
The Wildlife Trusts, including the Scottish Wildlife Trust	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 and publications on marine conservation and 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.

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, European Wildlife Division/Dept. of Rural Affairs	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, Cambs. PE17 2LS, tel: 01487 773381
Joint Nature Conservation Committee (JNCC), Headquarters	Monkstone House, City Road, Peterborough, Cambs. PE1 1JY, tel: 01733 62626
JNCC, Seabirds and Cetaceans Team	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 Northern Region HQ	Graesser House, Fodderty Way, Dingwall IV14 9XB, tel: 01349 862021
Scottish Natural Heritage (SNH), HQ	12 Hope Terrace, Edinburgh EH9 2AS, tel: 0131 447 4784
SNH Research & Advisory Services Directorate	2 Anderson Place, Edinburgh EH6 5NP, tel: 0131 554 9797
SNH North-west Region Head Office	Fraser Darling House, 9 Culduthel Road, Inverness IV2 4AG, tel: 01463 239431
SNH Stornoway Office (Area Office)	17-19 Francis Street, Stornaway, Isle of Lewis HS1 2ND, tel: 01851 705258
SNH South Uist Office	135 Stilligarry, South Uist, Western Isles HS8 5RS, tel: 01870 620238
SNH Lochaber & Lochalsh Office	Mamore House, The Parade, Fort William, Inverness-shire PH33 6BA, tel: 01397 704716
SNH Isle of Skye Office	Bridge Road, Portree, Isle of Skye IV51 9ER, tel: 01478 613329
SNH Ross & Cromarty Office	Anacaun, Kinlochewe, by Achmasheen, Ross-shire IV22 2PA, tel: 01445 760254
SNH Sutherland Office	Knockan Cottage, Elphin, by Lairg IV27 4HH, tel: 01854 666234

Name	*Contact address and telephone no.*
Statutory bodies (continued)	
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 556 8400
SOAEFD Marine Laboratory	Fisheries Research Services, PO Box 101, Victoria Road, Aberdeen AB9 8DB, tel: 01224 876544
Western Isles Enterprise	3 Harbour View, Cromwell Street Quay, Stornoway, Isle of Lewis HS1 2DF, tel: 01851 703703
Wildlife Trusts	
Scottish Wildlife Trust (SWT) HQ	Crammond House, Kirk Crammond, Crammond Glebe Road, Edinburgh EH4 6NS, tel: 0131 312 7765
Scottish Wildlife Trust (Northern Office)	Easter Brae, Culbockie, Dingwall, Ross-shire IV7 8JU, tel: 01349 877625
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 North Scotland Office	Etive House, Beechwood Park, Inverness IV2 2BW, tel: 01463 715000
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
Others	
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

Name	*Contact address and telephone no.*
Region 15	
Western Isles Council	Council Offices, Sandwick Road, Stornoway, Isle of Lewis HS1 2BW, tel: 01851 703773
Stornoway Pier and Harbour Commissioners	Harbour Office, Amity House, Esplanade Road, Stornoway, Isle of Lewis PA87 2XS, tel: 01851 702688

Name	*Contact address and telephone no.*
Region 16	
Highland Council, Head Office	Regional Buildings, Glenurquhart Road, Inverness IV3 5NX, tel: 01463 702000
Mallaig Harbour Authority	Harbour Office, Mallaig, Highland Region PH41 4QB, tel: 01687 462154
Ullapool Harbour Trustees	Harbour Office, Ullapool, Ross-shire IV26 2UJ, tel: 01854 612091

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.

Bryan, A. 1994. *The Minch review.* Inverness, Western Isles Island Council and Scottish Natural Heritage.

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.

Local Government Management Board. 1995. *Local agenda 21 roundtable guidance: action on the coast*. Luton, Local Government Management Board.

Robinson, A., & Millward, R. 1983. *The Shell book of the British coast*. Newton Abbot, David and Charles.

Scottish Office Agriculture, Environment and Fisheries Department. 1996. *Scotland's coast: a discussion paper.* Edinburgh, HMSO.

Steers, J.A. 1964. *The coastline of Scotland*. Cambridge, Cambridge University Press.

A.4 Contributing authors

Author	*Address*
Dr R.N. Bamber	Fawley Aquatic Research Laboratories Ltd, Marine and Freshwater Biology Unit, Fawley, Southampton, Hants. SO4 1TW
J.H. Barne	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
Dr R.S.K. Barnes	Department of Zoology, Downing Street, Cambridge CB2 3EJ
British Geological Survey	Coastal Ecology Group, British Geological Survey, Keyworth, Nottingham NG12 5GG
D.M. Craddock	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
C.A. Crumpton	RSK Environment, 47 West Street, Dorking, Surrey RH4 1BU
Dr T.C.D. Dargie	Loch Fleet View, Skelbo Street, Dornoch, Scotland IV25 3QQ
Dr N.C. Davidson	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
Dr J.P. Doody	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
C.D. Duck	Sea Mammal Research Unit, Gatty Marine Laboratory, University of St. Andrews, Fife KY16 8LB
M.J. Dunbar	Nature Conservation Bureau, 36 Kingfisher Court, Hambridge Road, Newbury, Berkshire RG14 5SJ
M. Edwards	Sir Alister Hardy Foundation for Ocean Science, c/o Plymouth Marine Laboratory, Citadel Hill, Plymouth, Devon PL1 2PB
Dr P.G.H. Evans	Seawatch Foundation, Dept of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS
V. Fenwick	Riverbank House, River Road, Taplow, Maidenhead SL6 0BG
A.P. Foster	23 The Dawneys, Crudwell, Malmesbury, Wiltshire SN16 9HE
S.L. Fowler	Nature Conservation Bureau, 36 Kingfisher Court, Hambridge Road, Newbury, Berkshire RG14 5SJ
I. Fuller	6 Bowhill Terrace, Edinburgh EH3 5QY
A.B. Gale	Riverbank House, River Road, Taplow, Maidenhead SL6 0BG
Dr H.T. Gee	SGS Environment, Yorkshire House, Chapel Street, Liverpool L3 9AG
M.J. Goodwin	RSK Environment, 47 West Street, Dorking, Surrey RH4 1BU
Dr M.I. Hill	SGS Environment, Yorkshire House, Chapel Street, Liverpool L3 9AG

Author	*Address*
N.G. Hodgetts	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
M. Irvine	Environmental Quality Ltd, 7 Marchmont Crescent, Edinburgh EH9 1HN
R.A. Irving	14 Brookland Way, Coldwaltham, Pulborough, W. Sussex RH20 1LT
A.W.G. John	Sir Alister Hardy Foundation for Ocean Science, c/o Plymouth Marine Laboratory, Citadel Hill, Plymouth, Devon PL1 2PB
R.G. Keddie	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
A.B. Law	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
R.T. May	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
K.D. Meakin	SGS Environment, Units 15 & 16, Pebble Close, Amington, Tamworth, Staffs. B77 4RD
V.M. Morgan	2, Flaxen Walk, Warboys, Huntingdon PE17 2TR
D. Murison	Scottish Office Agriculture, Environment and Fisheries Department, Marine Laboratory, PO Box 101, Victoria Road, Aberdeen AB9 8DB
M.S. Parsons	3, Stanton Road, Raynes Park, London SW20 8RL
J. Plaza	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
Dr G.W. Potts	The Marine Biological Association of the UK, The Laboratory, Citadel Hill, Plymouth PL1 2PB
Dr R.E. Randall	Girton College, Huntingdon Road, Cambridge CB3 0JG
C.F. Robson	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
Dr W.G. Sanderson	JNCC, Monkstone House, City Road, Peterborough PE1 1JY
S.E. Swaby	The Marine Biological Association of the UK, The Laboratory, Citadel Hill, Plymouth PL1 2PB
Dr M.J.S. Swan	Amphibian Habitat Advisory Services, 19 St. Judith's Lane, Sawtry, Huntingdon, Cambs. PE17 5XE
M.L. Tasker	JNCC, 7 Dunnet House, Thistle Place, Aberdeen AB10 1UZ
R. Threadgould	Scottish Natural Heritage, 2 Anderson Place, Edinburgh EH6 5NP
Dr C.E. Turtle	SGS Environment, Units 15 & 16, Pebble Close, Amington, Tamworth, Staffs. B77 4RD