JOINT NATURE CONSERVATION COMMITTEE

Marine Nature Conservation Review

Sector 10

Cardigan Bay and north Wales

Area summaries

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1999

Series editor: David Connor

Coasts and seas of the United Kingdom - MNCR series

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Preface

The *Marine Nature Conservation Review* (MNCR) was initiated by the Nature Conservancy Council in 1987 as the third major resource survey, following the *Nature Conservation Review* and the *Geological Conservation Review*. Since April 1991, the MNCR has been undertaken within the Support Unit of the Joint Nature Conservation Committee. The JNCC is a forum through which the three country agencies, the Countryside Council for Wales, English Nature and Scottish Natural Heritage, deliver their special statutory responsibilities for Great Britain as a whole and internationally. These special responsibilities, known as special functions, contribute to sustaining and enriching biological diversity, enhancing geological features and sustaining natural systems.

The MNCR has drawn together information on marine ecosystems around Great Britain with the objectives of:

- extending our knowledge of benthic marine habitats, communities and species in Great Britain, particularly through description of their characteristics, distribution and extent; and
- identifying sites of nature conservation importance.

The data collected also provide information to support more general measures to minimise adverse effects of development and pollution, particularly on sites and species of nature conservation importance.

The area included in the MNCR is the coastline of England, Scotland and Wales (excluding the Isle of Man and the Channel Isles), extending on the shore from the lower limit of terrestrial flowering plants and within marine inlets from the limit of marine influence out to the limit of British territorial seas. Saline lagoons are also included. The MNCR included a major field survey programme of the shores and near-shore sublittoral zone, undertaken to standard methodology.

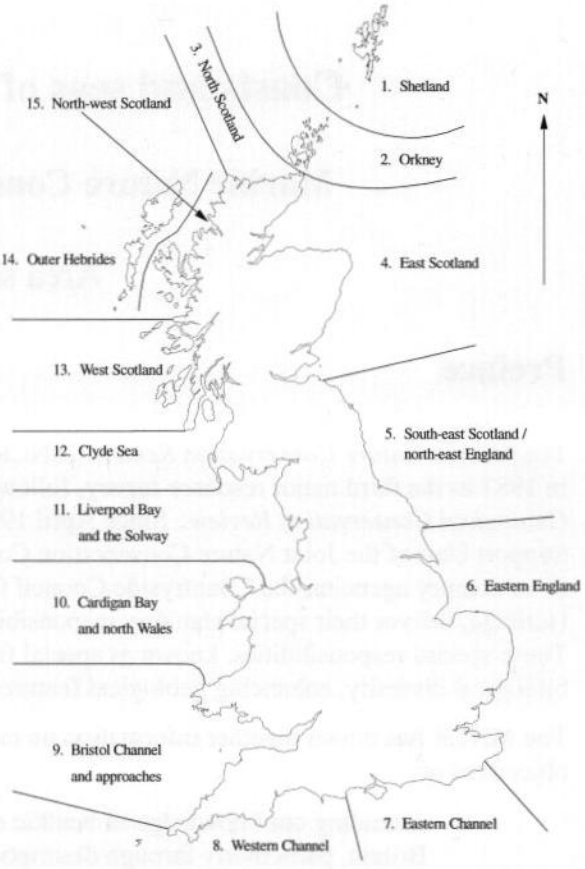
MNCR studies have been undertaken within particular coastal sectors around Britain (see map overleaf) or of major physiographic types, such as lagoons and sealochs. These studies are being presented, in the *Coasts and seas of the United Kingdom - MNCR series*, as *area summaries*, each of which provides an account of a discrete stretch of open coast, a marine inlet or a lagoon within the area of study. A list of *area summary* volumes and other major publications from the MNCR is given overleaf.

A full list of MNCR and other JNCC marine reports is available from the Marine Information Officer, JNCC. JNCC publications can be purchased from NHBS Ltd, 2-3 Wills Road, Totnes, Devon, TQ9 5XN (tel. 01803-865 913; fax. 01803-865 280; e-mail nhbs@nhbs.co.uk). JNCC reports are available directly from JNCC (tel. 01733-562 626; fax 01733-555 948).

David Connor

Joint Nature Conservation Committee

Publications in the MNCR series



MNCR coastal sectors, as used in the *Coasts and seas of the United Kingdom - MNCR series.*

Volumes published or near publication:

Sector	Title	Authors	Date
	Foundation volumes		
1-15	Rationale and methods	Hiscock, *ed.*	1996
1-15	Benthic marine ecosystems of Great Britain and the north-east Atlantic	Hiscock, *ed.*	1998
	Biotope classification		
1-15	Marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes (*JNCC Report*, No. 229)	Connor, Brazier, Hill & Northen	1997
1-15	Marine biotope classification for Britain and Ireland. Volume 2. Sublittoral biotopes (*JNCC Report*, No. 230)	Connor, Dalkin, Hill, Holt & Sanderson	1997
	Area summaries		
1	Shetland	Howson	Due 1999
1-2	Lagoons in Shetland and Orkney	Thorpe	1998
2	Orkney	Murray, Dalkin, Fortune & Begg	Due 1999
3, 4, 12, 13, 15	Lagoons in mainland Scotland and the Inner Hebrides	Covey, Fortune, Nichols & Thorpe	1998
5	South-east Scotland and north-east England	Brazier, Davies, Holt & Murray	1998
6	Inlets in eastern England	Hill, Emblow & Northen	1996
8	Inlets in the western English Channel	Moore, Smith & Northen	1999
9	Inlets in the Bristol Channel and approaches	Moore, Smith, Northen & Little	1998
10	Cardigan Bay and north Wales	Brazier, Holt, Murray & Nichols	1999
11	Liverpool Bay and the Solway Firth	Covey	1998
12	Sealochs in the Clyde Sea	Dipper & Beaver	1999
13	Sealochs in west Scotland		Due 2000
14	Lagoons in the Outer Hebrides	Thorpe, Dalkin, Fortune & Nichols	1998
14	Sealochs in the Outer Hebrides		Due 1999
15	Sealochs in north-west Scotland		Due 1999

Marine Nature Conservation Review

MNCR Sector 10

Cardigan Bay and north Wales

Area summaries

Synopsis

In 1995 the MNCR initiated a survey of Cardigan Bay and north Wales (MNCR Sector 10), to provide information to support the implementation of the 1992 EC Habitats Directive and to contribute to the general MNCR survey programme. Field surveys undertaken between 1995 and 1997 covered 23 sections of coast, or *areas*, within Sector 10; three *areas* (Menai Strait; north Anglesey; Conwy estuary) were not surveyed by the MNCR.

The studies included field surveys of the shores and the subtidal zone of each *area* to describe their habitats and communities (together referred to as biotopes) and to assess their natural heritage importance. Comparable data from other organisations or previous studies have been added to provide information from over 700 sites in Sector 10, and the data analysed to classify the biotopes present. Information on the designated conservation sites and main human influences in each *area* has also been compiled.

The information is presented here as 23 *area summaries*:

1	Cwm-yr-Eglwys to New Quay (Ceinewydd)	13	Tremadog Bay
2	Nyfer estuary (Newport Bay)	14	South-west Lleyn Peninsula (Penrhyn Llŷn)
3	Teifi estuary	15	Bardsey Island (Ynys Enlli)
4	New Quay (Ceinewydd) to Clarach Bay	16	Caernarfon Bay
5	Aeron estuary (Aberaeron)	17	Menai Strait (Afon Menai)
6	Rheidol and Ystwyth estuaries (Aberystwyth)	18	West Anglesey (Ynys Môn)
7	Clarach Bay to Mochras Point (Sarnau)	19	Cefni estuary (Malltraeth Sands)
8	Dovey estuary (Afon Dyfi)	20	Inland Sea (Cymyran Strait)
9	Dysynni estuary (Broad Water)	21	North-east Anglesey (Ynys Môn)
10	Mawddach estuary (Aber Mawddach)	22	Penmon Point to Great Ormes Head
11	Mochras Lagoon (Artro estuary)	23	Great Ormes Head to Rhôs Point
12	Traeth Bach (Glaslyn and Dwyryd estuaries)		

Each *area* is described in a standard format, giving details of its physical and biological character, the biotopes present and their distribution, current nature conservation designations, the main human influences and relevant literature. The *areas* surveyed and the marine biotope information are also presented in a series of maps. These *area summaries* are supported by a summary of the biotopes defined for Sector 10 (from Connor *et al.* 1997a, b) and by a list of species recorded from the surveys.

The coastline of Cardigan Bay and north Wales supports an exceptionally high diversity of biotopes (over 160), although some of these, such as maerl and eelgrass *Zostera* spp. beds, are not very extensive. It is best known for its wild ruggedness and long stretches of clean sand. Examples of the most wave-exposed habitats are seen on the west coast of Anglesey and the Lleyn Peninsula, although there are also extensive areas of sheltered, estuarine sandflats adjoining Cardigan Bay and at either end of the Menai Strait. Sand also influences the species composition of rocky habitats throughout much of Sector 10, particularly along the extensive cobble beaches in Cardigan Bay. Boulder shores south of Harlech are consolidated by mounds of sandy tubes built by the honeycomb reef worm *Sabellaria alveolata*. The shallow Sarnau reefs comprise boulder ridges which stretch up to 16 km offshore in mid-Cardigan Bay. The boulders merge with extensive plains of sand and gravel and support many ephemeral species characteristic of sand-scour and disturbance that only appear during the calm spring and summer months. Longer-lived species on the Sarnau have to be resistant to scour and firmly attached to the rock to survive the battering they receive during the winter. Finer grades of muddy sediment in deeper water (~25 m), for example in Tremadog Bay, contain a rich burrowing fauna.

Large bivalves, brittlestars, crabs and burrowing urchins are immediately recognisable, although these are outnumbered by the huge variety of polychaete worms which are recorded only by infaunal sampling techniques.

Strong tides and the clarity of the water influence the biotopes around the Lleyn Peninsula and Bardsey Island (Ynys Enlli). Kelp grows deeper in the clear water here than elsewhere in Sector 10 and most rocky surfaces are coated with dense turfs of suspension-and filter-feeding animals such as sponges, hydroids, bryozoans, anemones and ascidians. Many of the species found here are characteristic of south-west Britain and a few are more commonly found in the Mediterranean.

Very strong tides race through the central narrows of the Menai Strait, a 20 km-long channel which separates the island of Anglesey from the Welsh mainland. However, the water is turbid, encouraging communities characterised by huge growths of the sponge *Halichondria panicea* to thrive on the plentiful food supply. Even the waters around the rocky, open coast of Anglesey are not particularly clear, especially during rough weather. Consequently, dense beds of silt-tolerant ascidians cover the rocky seabed here, often outnumbering the other filter-feeders common elsewhere in Sector 10.

Limestone, by virtue of its friable nature and, to some extent, chemical composition, is colonised by species which display a preference for this rock type. Limestone reefs on the east coast of Anglesey and the Great and Little Ormes are riddled by the rock-boring sponge *Cliona celata*, piddocks *Hiatella arctica* and acorn worms *Phoronis hippocrepia*. The sheltered, turbid nature of parts of this area also encourages large growths of the sponge *Suberites* spp.

References

Connor, D.W., Brazier, D.P., Hill, T.O., & Northen, K.O. 1997a. Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. *JNCC Report*, No. 229.

Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.H.F., & Sanderson, W.G. 1997b. Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 2. Sublittoral biotopes. Version 97.06. *JNCC Report*, No. 230.

Introduction

Background

A wide variety of marine biotopes are present around the north Wales and Cardigan Bay coast, reflecting the very wide range of seabed types, wave exposures, tidal regimes and salinity. Various combinations of these factors each leads to a different associated community. Previous marine biological studies have concentrated on small parts of this area, mostly research and conservation-related studies aimed at features and species of interest. Early survey work carried out by Pyefinch (1943), Jones (1955) and Knight-Jones & Jones (1955) recognised the natural heritage value of certain locations in north Wales, in particular Bardsey Island and the Lleyn Peninsula. Bardsey received further attention in the mid-1970s when it was offered for sale. To combat the threat of losing the island to unsympathetic ownership, local interest groups formed the Bardsey Island Trust, and subsequently a series of surveys was carried out to determine its value as a potential Marine Nature Reserve (Hoare & Jones 1981; Hiscock 1984; Rostron 1984). The early beginnings of MNCR-style survey techniques had already been established by Hiscock (1976), based at the University College of North Wales (now University of Wales) School of Ocean Sciences in Menai Bridge, whose work correlated water movement to community composition on sublittoral rocky habitats in the region. By the mid-1980s the Nature Conservancy Council were using adaptations of these methods to carry out surveys in other potentially interesting areas including the Menai Strait (Lumb 1983) and the Sarnau (Hiscock 1986). Menai Strait was proposed as a Marine Nature Reserve in 1988 (Countryside Council for Wales 1992), but it was not until 1996 that the Secretary of State for Wales consulted on a draft Order for its designation; a final decision is still pending.

The surveys of Cardigan Bay and north Wales were initiated by the MNCR, as part of its general survey programme of the coast of Britain, to provide more comprehensive coverage of the coast in MNCR Sector 10 (between Cwm-yr-Eglwys in Pembrokeshire, and Rhôs Point in Conwy). The information gained also supports the implementation of the EC Habitats Directive (1992). The Directive requires that the UK Government designate Special Areas of Conservation (combined with SPAs from the 1979 EC Directive on the Conservation of Wild Birds) towards a series of European sites called Natura 2000. In Wales, management of marine SACs will be the joint responsibility of a range of authorities including the Countryside Council for Wales (CCW), the Environment Agency, Unitary Authorities, Sea Fisheries Committees, and port and harbour authorities (CCW 1996). A substantial proportion of the west coast of Sector 10 is in two candidate SACs:

SAC name	Qualifying interest
• Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau	Estuaries; Reefs
• Bae Ceredigion / Cardigan Bay	Bottlenose dolphin *Tursiops truncatus*

To help meet the requirements of the designation process, CCW has an ongoing programme of biotope mapping (Richards *et al.* 1996). CCW's Phase 1 shore surveys have covered some of the same ground as MNCR littoral surveys and both parties have benefited from a highly-valued sharing of information. Similar benefits have been gained by MNCR and CCW from broad-scale sublittoral habitat mapping surveys in the SACs using the acoustic ground discrimination system (AGDS) RoxAnn™, side-scan sonar, benthic sampling and submersible video techniques carried out by the School of Ocean Science, Menai Bridge (I. Rees, pers. comm.), North Western and North Wales Sea Fisheries Committee and BioMar. Habitat/biotope maps, produced through interpretation of the data, have been used both in the planning stages of MNCR surveys, to target sites for survey, and in the production of biotope maps in the *area summaries* presented here. Menai Strait, north Anglesey and the Conwy estuary were not surveyed by the MNCR; *area summary* 17 (Menai Strait) is based on previous studies.

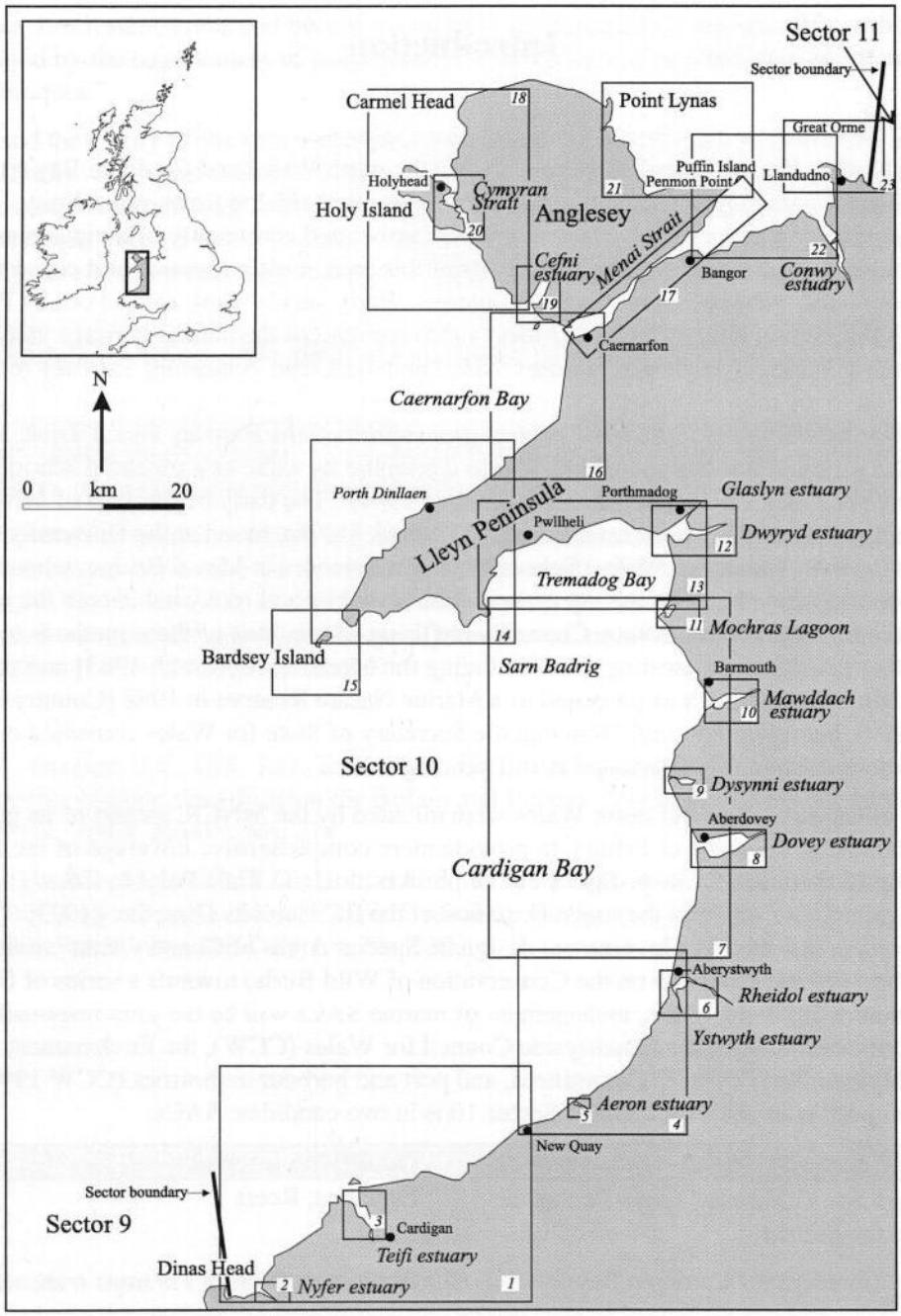


Figure 1 Location of the areas surveyed (*area summaries*) in Cardigan Bay and north Wales.

Data collection and the classification of biotopes

Survey sites were located by inspection of Admiralty charts, Ordnance Survey maps, through discussion with Countryside Council for Wales local staff, local fishermen and other local users, and by studying existing literature and survey information. Field surveys were undertaken by the MNCR in 1995, 1996 and 1997, complementing surveys carried out previously and concurrently by other organisations and covering the areas shown in Figure 1. The data from these surveys have been used to describe the biology of each section of coast thus enabling assessment of their natural heritage

importance. A summary of these surveys is given in Table 1. Note that MNCR methodology involves recording at least one, occasionally many, *habitat* records at each survey *site* visited. Further references to other studies are given in the individual *area summary* reports.

Table 1 Sources of MNCR and MNCR-compatible field survey information

MNCR database survey no.	*Survey*	*Source*	*No. of sites*	*No. of habitats surveyed*
125	1986 mid-Wales sarns (reefs): Sarn Badrig, Sarn-y-Bwch and Cynfelin Patches, sublittoral survey.	Hiscock (1986)	20	58
129	1982 hard substrata of the Menai Strait, littoral survey.	Jones (1983)	14	26
186	1983 Bardsey and the Lleyn Peninsula, sublittoral survey.	Hiscock (1984)	63	107
205	1983 Bardsey and the Lleyn Peninsula littoral survey.	Rostron (1984)	25	148
228	1977 marine biological survey of Bardsey Island.	Hoare (1978), Hoare & Jones (1981)	32	50
265	1970-1980 SMBA/MBA Great Britain intertidal survey.	Powell *et al.* (1979)	3	2
280	1990 Porcupine/Conchological Society field meeting, Anglesey shores.	Porcupine & Conchological Society (1990)	2	4
291	1989 hydraulic cockle dredging experiments on intertidal sediment flat communities. Lavan Sands study.	Moore (1990)	6	27
292	1990 hydraulic cockle dredging experiments on intertidal sediment flat communities. Lavan Sands study.	Moore (1990)	40	160
293	1982 Menai Strait sublittoral survey.	Lumb (1983)	39	66
468	1994 MNCR Menai Strait littoral survey.	MNCR survey	1	5
498	1993 Sarn Badrig reef, sublittoral survey.	Bunker (1994)	6	8
625	1995 MNCR Ceredigion coast, littoral survey.	MNCR survey	7	34
626	1995/7 MNCR Ceredigion coast, sublittoral survey.	MNCR survey	16	16
627	1995 MNCR north Lleyn Peninsula and Tremadog Bay, littoral survey.	MNCR survey	32	146
628	1995 MNCR Lleyn Peninsula and Tremadog Bay, sublittoral survey.	MNCR survey	28	38
629	1995 MNCR Cardigan Bay estuaries, littoral survey.	MNCR survey	43	120
630	1995 MNCR Sarnau of Cardigan Bay, sublittoral survey.	MNCR survey	21	23
633	1978 survey of macro-invertebrate populations in the Glaslyn/Dwyryd estuary.	Cook & Rees (1978)	8	82
634	1989-91 BIOMÔR, benthic biodiversity of the southern Irish Sea, sublittoral survey.	Mackie, Oliver & Rees (1995)	30	30
638	1996 MNCR / CCW Bardsey Island, littoral survey.	MNCR survey	1	7
640	1996 MNCR west Anglesey sublittoral survey.	MNCR survey	38	60
641	1996 MNCR west Anglesey littoral survey.	MNCR survey	24	127
642	1997 MNCR Cardigan Bay, littoral survey.	MNCR survey	61	266
643	1997 NW&NWSFC Cardigan Bay infaunal sublittoral survey.	MNCR contracted survey	56	65
644	1997 MNCR Bardsey Island and south-west Lleyn Peninsula, sublittoral survey.	MNCR survey	29	65
646	1997 MNCR east Anglesey littoral survey.	MNCR survey	29	130
647	1997 MNCR west Anglesey sublittoral survey.	MNCR survey	25	37
648	1997 MNCR east Anglesey sublittoral survey.	MNCR survey	17	28
693	1993/4 assessment of the impact of hydraulic cockle dredging on the macroinvertebrate faunas of Traeth Lafan.	Allen (1995)	4	8
-	CCW marine intertidal Phase 1 and SSSI mapping	Richards *et. al.* 1996.*	-	-
		Total	**720**	**1943**

Abbreviations: BIOMÔR – National Museum of Wales project to compile marine species data; MNCR – JNCC's Marine Nature Conservation Review; NW&NWSFC – North Western and North Wales Sea Fisheries Committee; SMBA/MBA – Scottish Marine Biological Association/Marine Biological Association of the UK.

*Specific CCW habitat (biotope) mapping survey numbers given in each *area summary*.

During the MNCR field surveys, information was collected on the nature of the coastline, together with its habitats and their associated communities of species (together referred to as biotopes).

Photographs were taken to illustrate the biotopes, species and the general layout of the sites to provide a permanent visual record. An aerial survey of the whole of Sector 10 was carried out at low water of spring tides during early June 1997. Oblique, continuous photographic coverage was obtained for the shoreline, including inside the estuaries and around the off-lying islands. This provided valuable information on the extent of littoral and shallow sublittoral habitats and communities. Over 1400 35 mm slides were taken on the aerial survey; these are held by JNCC.

Survey protocol followed standard MNCR recording and infaunal sampling techniques (Connor & Hiscock 1996). The location and physiographic characteristics of each site were recorded on a standard MNCR Site form. The physical details of each habitat and the species present in it were recorded on standard MNCR Habitat forms (Littoral or Sublittoral as appropriate). The conspicuous species were recorded using the MNCR semi-quantitative abundance scales. Species which could not be identified *in situ* were collected for later identification in the laboratory.

For sediment habitats, eight 0.0083 m^2 (10.3 cm diameter) core samples or grab samples (0.1 m^2 Day grab) were taken for infaunal analysis. These were combined and sieved over a 0.5 mm mesh sieve. Material retained on the sieve was preserved in seawater-formalin for subsequent identification and enumeration of the species present. A separate sediment sample was taken for particle-size analysis.

Once fully processed the data were entered onto the MNCR database (MacDonald & Mills 1996) to facilitate subsequent analysis and reporting. Data from other organisations, when collected with compatible techniques, was added to the database to increase the volume of information available and its geographical coverage.

The species data from the surveys were analysed, in conjunction with their associated habitat data, to identify which biotopes, as defined in the MNCR national biotope classification (Connor *et al.* 1997a, b), were present in the dataset. Multivariate analytical techniques, including TWINSPAN and DECORANA, were employed to facilitate the identification of distinct assemblages of species within the data set, using the procedures given in Mills (1994). Data from over 700 sites (over 1900 different habitat records – see Table 1) from Cardigan Bay and north Wales were used in the analyses, resulting in the identification of 166 biotopes or sub-biotopes from the national classification (Appendix A). Full descriptions of each biotope and the general approach to biotope classification are given in Connor *et al.* (1997a, b). Appendix B gives the distribution of biotopes throughout Sector 10.

Species recorded from the surveys listed in Table 1 are given in Appendix C.

Area summaries and their format

Each of the 23 areas is described in a standard *area summary* format:

1 Cwm-yr-Eglwys to New Quay (Ceinewydd)
2 Nyfer estuary (Newport Bay)
3 Teifi estuary
4 New Quay (Ceinewydd) to Clarach Bay
5 Aeron estuary (Aberaeron)
6 Rheidol and Ystwyth estuaries (Aberystwyth)
7 Clarach Bay to Mochras Point (Sarnau)
8 Dovey estuary (Afon Dyfi)
9 Dysynni estuary (Broad Water)
10 Mawddach estuary (Aber Mawddach)
11 Mochras Lagoon (Artro estuary)
12 Traeth Bach (Glaslyn and Dwyryd estuaries)
13 Tremadog Bay
14 South-west Lleyn Peninsula (Penrhyn Llŷn)
15 Bardsey Island (Ynys Enlli)
16 Caernarfon Bay
17 Menai Strait (Afon Menai)
18 West Anglesey (Ynys Môn)
19 Cefni estuary (Malltraeth Sands)
20 Inland Sea (Cymyran Strait)
21 North-east Anglesey (Ynys Môn)
22 Penmon Point to Great Ormes Head
23 Great Ormes Head to Rhôs Point

Each *area summary* contains the following sections:

Location

The geographic location is given as the central Latitude/Longitude position and Ordnance Survey grid reference, together with the local government administrative area and the nature conservation agency (Countryside Council for Wales) and its local area office. Place names are taken from the most recent available Ordnance Survey 1:50,000 scale Landranger series or 1:25,000 scale Pathfinder series maps. A map shows the location, including the geographic limits of the area considered by the *area summary*. The sites surveyed are shown according to four main types of survey: recording on littoral (▲) or sublittoral (●) rock/hard substrata and sampling in littoral (Δ) or sublittoral (○) sediment habitats.

Physical features

Physiographic type	As defined in Connor & Hiscock (1996)
Area of inlet, where applicable	Measured, to the nearest hectare, from the relevant 1:50,000 Ordnance Survey (Landranger series) map, or from Buck (1993).
Maximum length of coast	Measured from the relevant 1:50,000 Ordnance Survey (Landranger series) map. Inlets are measured from the mouth of the inlet to the limit of tidal influence.
Bathymetry	The maximum depth below chart datum, as indicated from Admiralty charts.
Wave exposure	Taken from field observations, as defined in Connor & Hiscock (1996) and from Admiralty charts.
Tidal streams	Taken from field observations and tidal streams atlas, as defined in Connor & Hiscock (1996) (1 knot ≅ 0.5 m/s).
Tidal range	Figures for mean spring and mean neap tidal range, quoted for the nearest secondary port, and based on Admiralty tide tables and charts, or as estimated during the survey (the latter applies to semi-enclosed sections of coast such as lagoons which have a restricted tidal range).
Salinity	The salinity range, as categorised in Connor & Hiscock (1996), is as estimated at the time of survey (based on the species present and their known salinity tolerances and the presence of freshwater sources) or as given in available literature.

All heights and depths given are corrected to chart datum.

Introduction

The overall physical characteristics of the area and significant human influences and activities are described.

Marine biology

A table lists marine biological surveys of the shores and sublittoral which have been used in compiling the *area summary* are listed to include the survey type (littoral/sublittoral), survey method, date of survey and reference source (MNCR database survey number in the case of recent MNCR surveys). The distribution of survey sites is shown on the location map.

The marine biological nature of the area is described with reference to the biotopes present and their distribution within the area, based primarily on the findings of the most recent MNCR

survey but with reference to previous studies where appropriate. The heights and depths noted in the text are corrected to lowest tide level (chart datum). The biotope codes given in parentheses are from the MNCR national classification, as listed in Appendix A; a summary of biotopes present within each area is presented in Appendix B. Marine species nomenclature follows Howson & Picton (1997); that for lichens follows Purvis *et al.* (1992), and that for higher plants follows Stace (1991).

A map illustrates the distribution of the main biotopes and biotope complexes within the area; some mapped areas represent more than one biotope.

NOTE: The biotopes maps give an indication of the *likely* distribution and extent of biotopes and biotope complexes, based on the data available, including sketch maps of biotope distribution made at the time of survey, cited literature and information on Admiralty charts. In some areas data are sparse and additional data or more comprehensive survey would enable more accurate maps to be drawn.

Nature conservation

A summary of statutory and non-statutory wildlife and landscape conservation designations for the marine and coastal parts of the area is given (from Barne *et al.* 1995, where further information on the types of designation can be found).

Key to abbreviations used: (c = candidate; p = proposed):

AONB	Area of Outstanding Natural Beauty
CP	Country Park
CWT	County Wildlife Trust
ESA	Environmentally Sensitive Area
FC	Forestry Commission
GCR	Geological Conservation Review site
HC	Heritage Coast
LNR	Local Nature Reserve
MNR	Marine Nature Reserve
NCR	Nature Conservation Review site
NNR	National Nature Reserve
NP	National Park
NT	National Trust site
Ramsar	Ramsar site
RSPB	Royal Society for the Protection of Birds nature reserve
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest

Human influences

This section describes the main uses of and activities in the area, including urbanisation, industrial or commercial activities that have (or potentially have) an impact on the area. These can include sewage discharges, industrial effluent, development, dredging, spoil-dumping, artificial damming or culverting, fishing, recreation and shipping. Although as accurate as possible at the time of writing, readers should be aware that further developments, particularly improvements to sewage treatment and disposal, are likely to have occurred since then. Further details of human influences are given in Barne *et al.* (1995) and, for estuaries, Buck (1993) and Countryside Council for Wales (1993).

References and further reading

This lists cited references and other relevant literature.

Sites surveyed

This lists the sites surveyed within the area from the surveys shown in Table 1, with additional information on the location of each site, the date of survey and an inventory of the biotopes present at the time of survey.

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Paul Kay (Marine Wildlife Photo Agency)
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Gabrielle Wyn (CCW)
Kate Northen
Dervila O'Brien (Catering)
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Mandy Richards (CCW)
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Rachel Welsh (student)
John Woolford ('Seawolf' Independent surveyor)

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1 Cwm-yr-Eglwys to New Quay (Ceinewydd)

Location		
Position (centre)	SN 170 540	52° 08'N 4° 39'.50W
County/district	Pembrokeshire, Ceredigion	Preseli
Conservation agency/area	Countryside Council for Wales	West Area

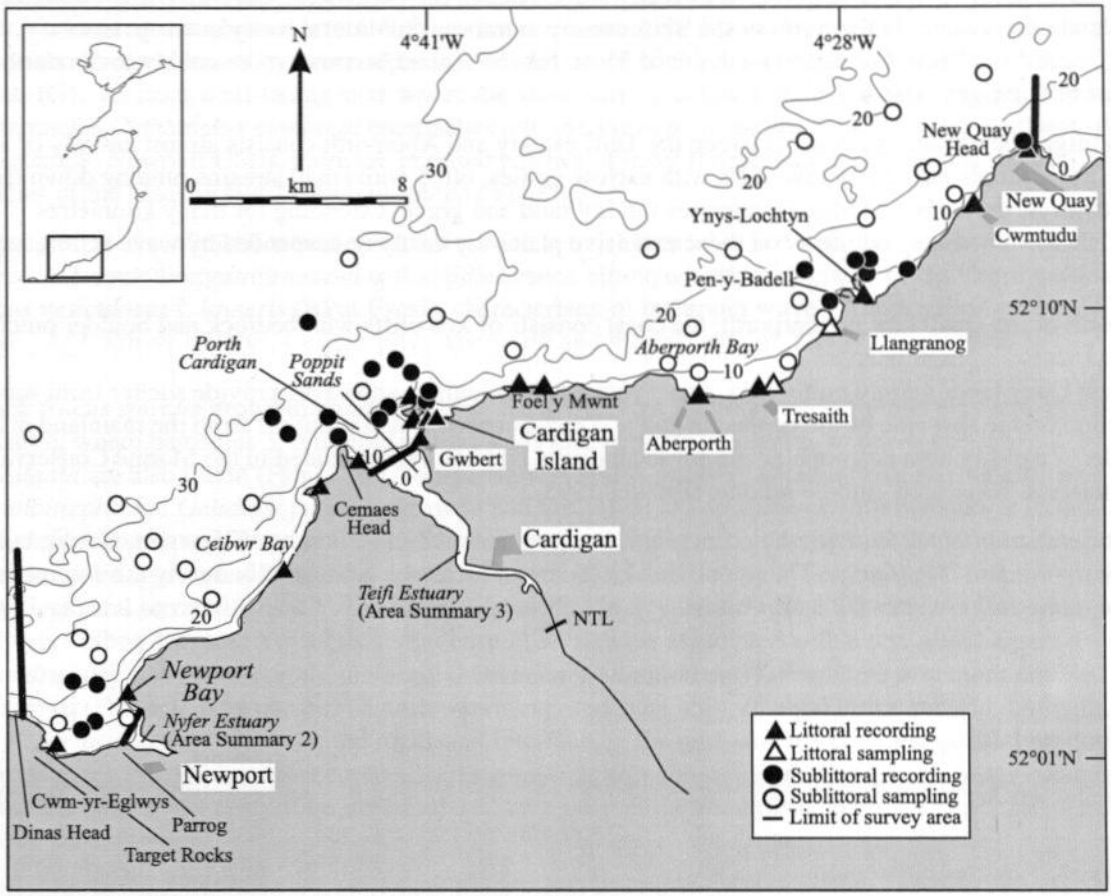

Figure 1.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Linear open coast
Length of coast	51 km
Bathymetry	Maximum depth 32 m within the 3 mile limit
Wave exposure	Moderately exposed
Tidal streams	Moderate to negligible
Tidal range	4.1 m spring and 1.6 m neap tide (Porth Cardigan)
Salinity	Fully marine (with localised areas of reduced salinity)

Introduction

The predominantly north-west facing coast of Cardigan Bay (Bae Ceredigion) north from Cwm-yr-Eglwys to New Quay (Ceinewydd) consists of steep cliffs interspersed by small bays. The shores below these steep cliffs are inaccessible from land, except from the small bays such as at Newport,

Ceibwr Bay, Aberporth, Tresaith, Llangranog and Cwmtudu. The open coast is moderately exposed to wave action with swell influence from the open Irish Sea, although there are localised areas of shelter behind small headlands. The north-bound flood tide is stronger than the south-bound ebb tide, resulting in a net tidal flow to the north (Huckbody *et al.* 1992).

Igneous rock intrusions, resistant to coastal erosion, form the steep, rocky shores at the southern limit of Sector 10. The headlands either side of Newport Bay (Dinas Head and Newport Cliffs) provide a degree of shelter to the sandy entrance of the Nyfer estuary (*area summary* 2). The 20 m isobath is within 2 km of the shore at this point, the seabed being made up predominantly of sandy sediments. Porth Cardigan is a wide embayment bounded by cliffs and forms the entrance to the Teifi estuary (*area summary 3*). The largest area of rocky seabed lies to the north-west, encompassing Cardigan Island immediately to the north of the Teifi estuary entrance. Sublittoral rocky outcrops extend offshore from Porth Cardigan to a depth of 35 m, but the seabed becomes more cobbly to the north-east of Cardigan Island.

Cardigan Island and the coast between the Teifi estuary and Aberporth consists almost entirely of steep bedrock shores backed by low cliffs with narrow gullies, often with small streams running down them. However, the seabed offshore comprises muddy sand and gravel extending for many kilometres offshore. The finer sediments on these extensive plains are easily re-suspended by wave action, resulting in turbid water which limits the photic zone to only a few metres throughout Area 1.

North of the small bay at Aberporth, the coast consists of low cliffs with bedrock and boulder outcrops punctuated by sand beaches at Cwmtudu, Llangranog and Tresaith. The coast between Aberporth and New Quay faces mainly north-west. Steep rugged cliffs, gullies and caves provide shelter from wave action on the east side of the peninsula and at Ynys-Lochtyn which is cut off from the mainland at high tide. Ynys-Lochtyn is a popular site for local divers and has been included in the Marine Conservation Society's 'Seasearch' survey scheme (Bunker 1993).

The human population along the coast is low and concentrated in the towns of Newport, Cardigan, Aberporth and New Quay. The population on the coast increases substantially during the summer as the many caravan sites fill with visitors.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	1	May 1976	Powell *et al.* 1979
	Recording (epibiota)	6	May 1995/February 1997	MNCR survey 625
		18	June 1997	MNCR survey 642
	Habitat (biotope) mapping		May 1996	CCW surveys: 9.39.1, 9.37.1, 9.36.1, 9.35.1
	Infaunal sampling - cores	1	May 1995	MNCR survey 625
	cores	13	June 1997	MNCR survey 642
Sublittoral	Video recording (epibiota)	21	February 1997	SFC/MNCR survey 643 *
	Recording (epibiota)	12	June 1995/June 1997	MNCR survey 626
	Infaunal sampling - Day grab	6	August 1991	Mackie, Oliver & Rees (1995)
	Day grab	35	March 1997	SFC/MNCR survey 643 *

* SFC = Sea Fisheries Committee, video ground-truthing for RoxAnn™ AGDS survey under contract for JNCC.

Littoral

The rocky shores along this stretch of coast vary in their aspect and ruggedness due to the striking folds and steeply-sloping strata of the shales and slates. At Newport Cliffs north of Newport, the hard slate has distinct shear planes resulting in a steep, but stepped shore. The softer slates and shales further north are slightly more eroded, forming steep shores with small crevices and notches and, on the west side of Porth Cardigan, large boulders and bedrock ridges. On the mainland east of Cardigan

Island, the slate strata are almost vertical, presenting a very steep and smooth face to seaward. This is most clearly seen on the north-facing coast between Gwbert and Aberporth. From Dinas Head to Aberporth, there are many areas of soft limestone which have eroded unevenly due to wave action, resulting in deep caves. East and north-east of Aberporth, the rocks are generally softer, resulting in flat rock platforms on the mid- and lower shores and patches of boulders at Aberporth and Cwmtudu. The exceptions to this are at Ynys-Lochtyn and Target Rocks, New Quay Head, where the shores are steep and rugged.

All of the rocky shores have typical littoral zonation with the orange lichens *Caloplaca* spp. and *Xanthoria parietina* and the grey lichens *Lecanora atra* and *Ochrolechia parella* in the supralittoral (YG), black lichen *Verrucaria maura* with the littorinids *Melarhaphe neritoides* and *Littorina saxatilis* (Ver.Ver) and sparse channel wrack *Pelvetia canaliculata* in the littoral fringe (Pel). Rockpools on the upper shore are colonised by green algae, often with dense populations of the copepod *Tigriopus fulvus* (G). At steep west-facing sites where the wave surge reaches high on the shore, a narrow band of barnacles *Chthamalus montagui* encroaches into the *Verrucaria maura* zone (Ver.B). At these sites, for example Newport Cliffs, there are exposed patches of laver *Porphyra umbilicalis* and shaded patches of the black lichen *Lichina pygmaea* (Ver.Por).

At most sites the eulittoral zone consists of a wide zone of barnacles *Semibalanus balanoides* and *C. montagui* and limpets *Patella vulgata* (BPat), often with the bladderless form of bladder wrack *Fucus vesiculosus* f. *linearis* (BPat.Fvesl), characteristic of the upper wave-exposure limit of fucoid algae. At Cwm-yr-Eglwys, Ceibwr Bay, Aberporth and the east side of Ynys-Lochtyn there is sufficient shelter from wave action for a dense canopy of fucoids to grow in the eulittoral zone. Spiral wrack *Fucus spiralis* grows in greatest abundance at the most sheltered sites, Ceibwr Bay and Ynys-Lochtyn, where barnacles *S. balanoides*, littorinids *Littorina littorea* and *L. saxatilis* and limpets *P. vulgata* are also found (Fspi). At Cwm-yr-Eglwys and Aberporth, small tufts of red algae *P. umbilicalis* and *Gelidium pusillum* grow in patches. Here, *F. vesiculosus* with bladders is found with *S. balanoides* and *P. vulgata* (FvesB). At Aberporth, the gently-sloping mid- and lower shore has a dense covering of mussels *Mytilus edulis* with patches of the fucoids *F. vesiculosus* f. *linearis* (MytFves) and serrated wrack *Fucus serratus* (MytFR) in a typical zonation pattern. At Cwm-yr-Eglwys, Ceibwr Bay and Ynys-Lochtyn, dense *F. serratus* is associated with a turf of red algae *Chondrus crispus*, *Mastocarpus stellatus*, *Osmundea pinnatifida* and *Lomentaria articulata* and *L. littorea* (Fser.R). At a number of more wave-exposed sites, this red algal turf is present, but without the *F. serratus* cover (Mas). At the rock/sand interface on the mid- and lower shore at Aberporth, a band of the honeycomb reef worm *Sabellaria alveolata* with the red algae *O. pinnatifida* and *Corallina officinalis* is present (Salv). The only other locations in Area 1 where *S. alveolata* occurs in significant numbers are Tresaith, on gully sides at New Quay Head and in the caves.

Rockpools in the eulittoral zone on the open coast are characterised by coralline crusts with small tufts of filamentous red algae *Polysiphonia* spp. and green algae *Enteromorpha* sp. (Cor). The pools in the mid- and lower eulittoral zones also contain the limpet *Patella ulyssiponensis*. Deep rockpools are unusual on this stretch of coast due to the steep, hard rocky shores. However, a single deep cleft on Cardigan Island holds a deep pool with similar densities of coralline crust and limpets to the shallow pools, but with the addition of dense stands of the kelps *Laminaria digitata* and *Laminaria hyperborea* (FK).

The three most wave-exposed locations, Newport Cliffs, between Gwbert and Aberporth and the west-facing side of Ynys-Lochtyn, have flora characteristic of wave-exposed conditions with a narrow band of dabberlocks *Alaria esculenta* and kelp *L. digitata*, dense *C. officinalis* and pink coralline crusts in the sublittoral fringe (Ala.Ldig). The almost vertical shores of north-west Cardigan Island and west of Aberporth have very sparse kelp in the sublittoral fringe, the dominant flora being *C. officinalis*, pink coralline crusts and small tufts of filamentous red algae (Coff). *S. balanoides*, *P. ulyssiponensis* and very small *M. edulis* also cover these rocks on the mid- and lower shore. The sublittoral fringe at the majority of sites along this stretch of coast is characterised by *L. digitata* and *M. stellatus*, *C. officinalis*, *O. pinnatifida*, pink coralline crusts and other red algae with *S. balanoides* and

P. vulgata and *P. ulyssiponensis* (Ldig.Ldig). At Aberporth the sublittoral fringe is characterised by *M. edulis* and the sand-tolerant red alga *Cystoclonium purpureum* (MytFR; Ldig.Ldig).

The numerous caves between Dinas Head and Aberporth are not a common feature of the mid-Wales coast, although caves are more common to the south of Dinas Head (MNCR Sector 9). The caves are typically up to 30 m long, with entrances between 1 and 3 m wide and with a barrier beach of rounded mobile cobbles or boulders towards the back of the cave. The vertical walls at the entrance of caves are typically characterised by pink coralline crusts, shade-tolerant red algae including *Plumaria plumosa* and *L. articulata*, barnacles *C. montagui*, the keel worm *Pomatoceros triqueter* and spirorbids *Spirorbis* spp. (SR). Overhanging bedrock near to cave entrances can also have a considerable cover of the sponges *Halichondria panicea*, *Hymeniacidon perleve* and *Clathrina coriacea* (SByAs). In the dark of the inner cave, the ceiling is typically dominated by spirorbids *Spirorbis* spp. and *C. montagui* to above high water mark (Ov; biotope to be described). Within the cave at the equivalent heights of upper and mid-shore, bryozoan crusts, *P. triqueter* and the barnacle *Verruca stroemia* (more usually associated with under-boulders) are also common (Ov; biotope to be described). Often, the bedrock at low tide level is completely scoured clean by sand, pebbles and cobbles from the cave floor (CC.BalPom), often to the point where no species are found. The species richness increases with proximity to low water, provided that sand- and boulder-scour is not too intense. Total cover of *S. alveolata* may occur on steep walls on the mainland adjacent to Cardigan Island and at Cwmtudu (Salv). The caves along this stretch of coast are frequented by grey seals *Halichoerus grypus*, which use the cobble beaches to pup and moult.

Tresaith beach, Llangranog and Cwmtudu are the only littoral sediment areas other than those at the entrances to the Newport and Teifi estuaries. The sand is clean and mobile, containing robust species of the amphipods *Bathyporeia* spp. and *Pontocrates arenarius* and the polychaete *Scolelepis squamata* (AP.P).

Sublittoral

Surveys using the RoxAnn™ acoustic ground discrimination system (AGDS) indicate that the seabed in this area consists of bedrock and boulders close inshore, particularly around Cemaes Head and Cardigan Island and patches of sand and cobbles throughout most of the rest of the Area. Shallow (inshore) sublittoral sediment tends to be clean sand, whilst the nearshore sediment (< 4 km) is largely muddy sand and gravel and offshore (> 4 km) the sediment is a less muddy coarse sand and gravel.

In Newport Bay, the shallow sublittoral sand community is characterised by the polychaetes *Nephtys cirrosa* and *Chaetozone setosa* (NcirBat). Shallow, clean sand is recorded is at Llangranog, where the community is dominated by *N. cirrosa* and the amphipods *Bathyporeia* spp., although clean sand and the associated community is likely to fringe the coast between Newport Cliffs and Cemaes Head and from Aberporth Bay to New Quay Head. At Newport, sublittoral sand extends into a patch of rippled sand bounded to the north, east and west by cobbles and small boulders. The epifaunal community on the hard substrata is characterised by hydroids and hornwrack *Flustra foliacea* (Flu.SerHyd). The hard ground appears to extend a short distance to the north of Dinas Head, where larger boulders and bedrock are covered by *F. foliacea* and dead man's fingers *Alcyonium digitatum* (Flu.HByS). Beyond 25 m depth, approximately 2 km offshore, towed video footage shows the cobbles grade into pebbles and gravel with a matrix of muddy sand, but still with patches of boulders with hydroids and the keel worm *Pomatoceros triqueter*. The sediment consists of rippled muddy sand and muddy gravel with infauna probably characterised by bivalves with sparse brittlestars *Ophiothrix fragilis* (?AbrNucCor).

From Dinas Head to Cemaes Head, a strip of muddy sand between 1.5 and 4 km offshore supports an infaunal community dominated by the polychaete *Nephtys hombergii* and the sipunculid nut worm *Golfingia procera* (AbrNucCor). Further offshore lies a strip of coarser sediment, probably characterised by venerid bivalves (?Ven). Further grab sampling would confirm the community composition. The British Geological Survey (1988) seabed sediments chart indicates a muddier area of sediment immediately west of Cemaes Head where grab sampling recorded greater species richness than in the adjacent sediment areas. The infauna is characterised by *G. procera*, the polychaetes

Euclymene oerstedi and *Lumbrineris gracilis*, the bivalve *Abra alba* and the brittlestar *Amphiura filiformis* (AbrNucCor). Off Cemaes Head to the three mile limit and extending east around Cardigan Island, cobbles and pebbles are covered by a short faunal turf of *F. foliacea*, *Pomatoceros* sp. and hydroids including *Sertularia argentea* and *Hydrallmania falcata* (Flu.SerHyd); additionally, the hydroid *Tubularia indivisa* is found near to the headland where tidal streams are accelerated. AGDS results suggest that the seabed substratum off Cemaes Head and Cardigan Island is very patchy, ranging from cobbles and pebbles with epifauna, through shingle and coarse sand to muddy sand with small patches of clean sand 5 km offshore. Closer inshore to Cemaes Head the bedrock ridges and boulders are less sand-influenced, are exposed to greater tidal streams and are colonised by *A. digitatum* and *T. indivisa* (AlcTub).

On the east side of Cardigan Island, boulders and cobbles heavily smothered by silt are colonised by the hydroid *Nemertesia antennina* and erect bryozoans including *F. foliacea* with a crust of the honeycomb reef worm *Sabellaria spinulosa* (Flu.HByS). The matrix of sandy mud between the cobbles has very dense sand mason worm *Lanice conchilega* and *A. alba*. East and north of Cardigan Island, at depths of less than 12 m, bedrock ridges dominate the seabed. The bedrock provides a stable substratum for a dense carpet of the solitary ascidians *Molgula manhattensis* and *Polycarpa scuba* with sponges including *Tethya aurantium*, *Suberites carnosus*, *Cliona celata* and axinellid sponges, mussels *Mytilus edulis*, hydroids and bryozoans (MolPol). Kelp forests are poorly developed here and throughout the Area. Consistently high turbidity prevents kelp *Laminaria hyperborea* from growing much below 4-5 m depth, and instead turfs of silt- and scour-tolerant and opportunistic algae such as *Plocamium cartilagineum*, *Polyides rotundus* and *Laminaria saccharina* are present (XKScrR and PolAhn). No data are available for the south and west of Cardigan Island, including the narrow channel between the island and the mainland.

From AGDS data the north-facing coastline east of Cardigan Island to Tresaith is fringed by silted rock with a mixed algal/faunal turf. Muddy sand and muddy gravel 1.5 km offshore has an infauna characterised by the *L. gracilis* with *A. alba* in some cases with *A. filiformis* (AbrNucCor; AfilEcor). The sediment is less muddy further offshore between Cardigan Island and New Quay Head, with a patchy distribution of species, including the polychaetes *N. cirrosa*, *Chaetozone* sp., *L. gracilis* (in muddier sediments), the bivalves *Chamelea galena* and *Phaxas pellucidus* (NcirBat; FabMag; Ven). Ynys-Lochtyn provides an 'oasis' of bedrock in this predominantly sediment seabed, merging into a boulder field at 2 m depth and becoming a cobble field below 8 m. At a depth of 12 m, the seabed consists of sparse boulders and cobbles surrounded by mobile clean sand, extending to a clean sand plain at 23 m depth. In the shallows, boulders are dominated by sparse *L. hyperborea* and the red algae *Plocamium cartilagineum*, *Phyllophora crispa*, *Rhodymenia pseudopalmata*, *Ceramium* spp., *Hypoglossum hypoglossoides* and the less-common south-western species *Chondria dasyphylla* (XKScrR). Vertical faces are colonised by the colonial ascidians *Polyclinum aurantium* and *Aplidium punctum* (SCAs.ByH) and at the bases of the boulders, the anemone *Urticina felina* is present, partially buried by sand (Urt.Urt). Large numbers of lobsters *Homarus gammarus* and crabs *Cancer pagurus* are tucked away in the boulder holes. At 8 m depth, there are very few red algae due to the high turbidity of the water, and the community is characterised by *F. foliacea*, hydroids *H. falcata*, *S. argentea* and *Nemertesia antennina*, erect bryozoans *Scrupocellaria* spp. and *Bugula* spp. and ascidians *Clavelina lepadiformis* and *Aplidium punctum* (Flu.HByS). Sparse boulders and surrounding sediment 500 m north of Ynys-Lochtyn support dense stands of *A. digitatum*, the hydroid *Tubularia indivisa* and plumose anemone *Metridium senile* reflecting a tide-swept environment. The high abundance of the bryozoan *Alcyonidium diaphanum* reflects the degree of scour from the surrounding coarse sand (SNemAdia). The infaunal community of the adjacent sand is fairly species-rich and is dominated by the polychaetes *Spiophanes bombyx* and *Mediomastus fragilis* (SpiSpi).

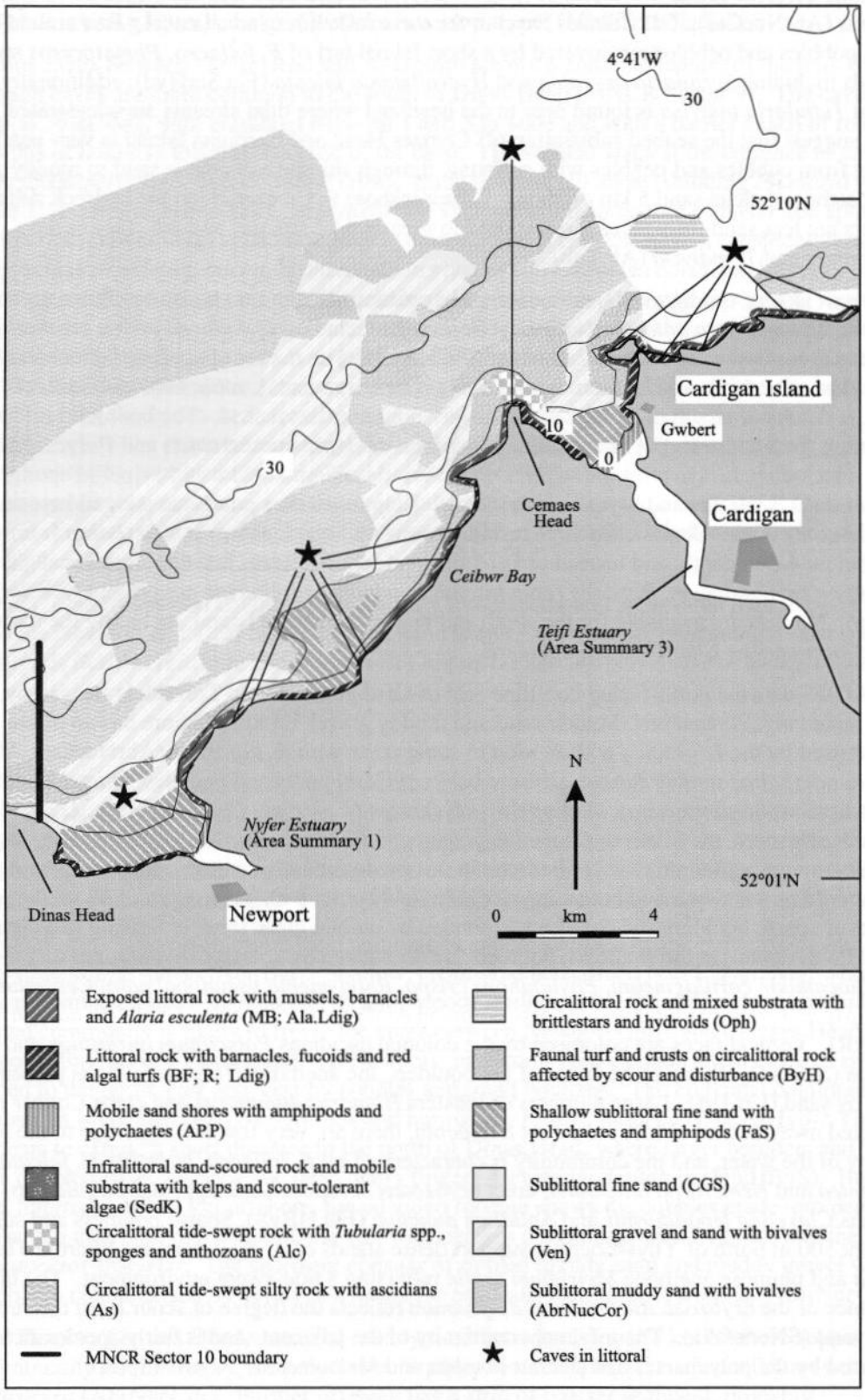

Figure 1.2 Indicative distribution of the main biotopes in the area (sourthern part) (based on data from survey sites shown in Figure 1.1, AGDS results, cited literature and additional field observations).

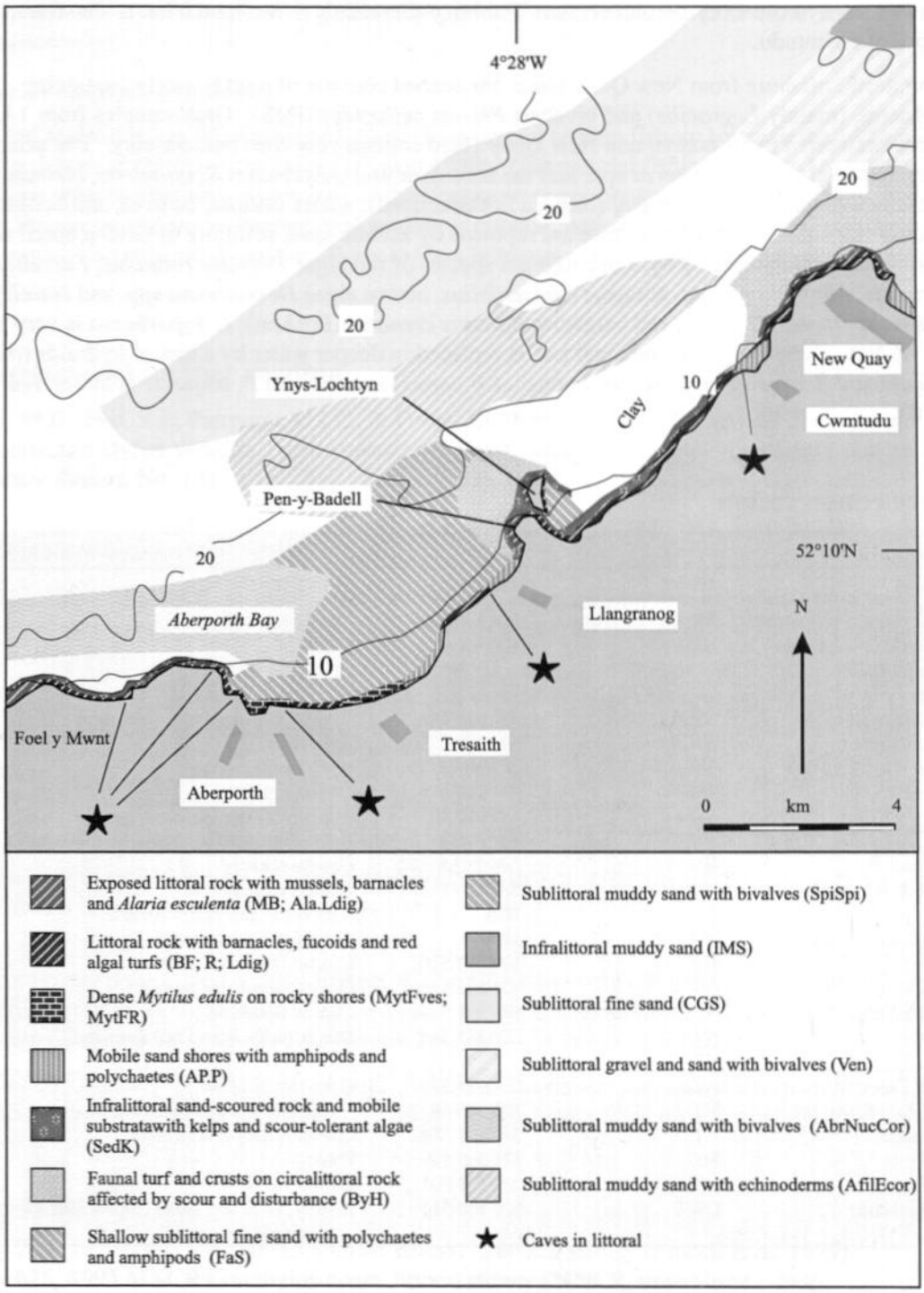

Figure 1.3 Indicative distribution of the main biotopes in the area (northern part) (based on data from survey sites shown in Figure 1.1, AGDS results, cited literature and additional field observations).

At a depth of 23 m, some 4 km offshore, the sediment is not influenced by wave action to the same extent as in shallower water. This is reflected by the presence of less robust species such as the sea cucumber *Labidoplax digitata*, the masked crab *Corystes cassivelaunus* and a particularly dense turf

of the solitary hydroid Corymorpha nutans (?FabMag/?EcorEns). A similar habitat is also found offshore of Cwmtudu.

Further north, offshore from New Quay Head, the seabed consists of muddy sandy containing polychaetes, (mainly *L. gracilis*) and bivalves *Phaxas pellucidus* (IMS). Grab samples from 1 km offshore between Ynys-Lochtyn and New Quay Head contain very firm boulder clay. The principal species recorded are *Pomatoceros* spp. and the tube-dwelling polychaetes *S. spinulosa*, *Melinna palmata* and *Ampharete lindstroemi* (biotope not described). Close inshore, bedrock and boulders extending from the bottom of the shore are replaced by mobile sand, resulting in sand-scoured rock. The community is dominated by scour-tolerant species of red algae *Polyides rotundus*, *Furcellaria lumbricalis*, *Ahnfeltia plicata*, *Halurus equisetifolius*, brown algae *Desmarestia* spp. and *Halidrys siliquosa*, anemones *U. felina* and barnacles *Balanus crenatus* (PolAhn); *L. hyperborea* is very sparse here. At New Quay Head, the red algal turf is replaced in deeper water by a turf of hydroids (mainly *H. falcata* and *S. argentea*), *U. felina*, barnacles *Balanus crenatus* and *P. triqueter* (Flu.SerHyd; Urt.Urt).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Craig yr Adar (Birds Rock)	SSSI	SN 376 599	Ornithological
Cwm Byrlip a Chreigiau Castell Bach	SSSI	SN 366 578	Botanical
Creigiau Penbryn	SSSI; GCR	SN 286 520	Geological
RAE Aberporth cliffs	SSSI; GCR	SN 244 526	Coastal heathland and geological
Creigiau Mwnt	SSSI	SN 200 522	Botanical
Creigiau Traeth y Mwnt	SSSI; GCR	SN 194 519	Geological
Cemaes Head	SSSI	SN 132 500	Ornithological
Newport Cliffs	SSSI	SN 054 407	Botanical; ornithological; grey seal haul-out .
Cardigan Bay	cSAC	SN 30 50	Bottlenose dolphins *Tursiops truncatus*.
Ceredigion	HC	SN 35 55	Coastal scenery
St Dogmaels and Moylgrove	HC	SN 45 11	Coastal scenery
Preseli	ESA	N/A	Agri-environmental scheme.
Pembrokeshire coast	NP	N/A	(South of Teifi estuary)
Mwnt	NT	SN 193 520	Coastal farmland
Ty Hen	NT	SN 285 520	Coastal scrub and pasture
Llanborth Farm	NT	SN 295 519	Coastal farmland
Lochtyn	NT	SN 315 545	Beach, cliffs, island and farmland
Penparc Farm	NT	SN 354 574	Coast
Caerllan Farm	NT	SN 355 577	Coast
Pen-y-Graig Farm	NT	SN 360 582	Coastal farm, island and beach
Cwm Soden	NT	SN 365 584	Coastal valley and farmland
Coybal	NT	SN 369 589	Coast
Craig-yr-Adar	NT	SN 378 601	Cliffs
Cardigan Island	CWT	SN 160 516	History, flora and fauna (esp. ornithology) of regional importance.

Human influences

Coastal developments and uses

This stretch of coast is largely undeveloped with a small coastal population concentrated in the small villages and towns of Parrog, Aberporth, Tresaith, Llangranog and Cwmtudu. At each of these locations, small sea defence walls at the top of the shore protect the villages from coastal erosion. At Aberporth, Tresaith and Llangranog the population increases substantially in the summer as the caravan parks near the coast fill with visitors. At the time of writing, untreated sewage was discharged

at Newport and Tresaith under consent from the Environment Agency (up to 5000 m^3 and 2000 m^3 per day respectively).

Marine developments and uses

South and mid-Cardigan Bay supported a large commercial herring fishery between the 14th and 19th centuries, although this has now ceased (Corlett 1990). Commercial fishing is limited to inshore potting for lobsters *Homarus gammarus*, crabs *Cancer pagurus*, prawns *Palaemon serratus*, and whelks *Buccinum undatum*. Recreational angling is popular, mainly from New Quay, and in recent years, tourist boat trips run from New Quay to view bottlenose dolphins *Tursiops truncatus*, seals and seabirds.

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Sites surveyed

Survey 265: 1970-1980 SMBA/MBA Great Britain intertidal survey (Powell *et al.* 1979).
Survey 625. 1995 MNCR Ceredigion coast, littoral survey (MNCR, unpublished data).
Survey 626. 1995/7 MNCR Ceredigion coast, sublittoral survey (MNCR, unpublished data).
Survey 634. 1989-91 BIOMÔR, benthic biodiversity of the southern Irish Sea, sublittoral survey (Mackie, Oliver & Rees 1995).
Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).
Survey 643. 1997 NWNWSFC Cardigan Bay infaunal sublittoral survey (unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
265	6	Cwm-yr-Eglwys E, Newport.	SN 016 401	52°01.4'N 04°53.5'W	F
625	1	Target Rocks (Carreg Walltog), New Quay.	SN 385 605	52°13.1'N 04°21.8'W	YG, Ver.Ver, Ver.Por, Pra, FvesB, Salv, Ent, Cor, SR, Coff, Ver.B
625	2	Llangranog beach, Aberporth.	SN 310 543	52°09.6'N 04°28.2'W	AEur, AP.P
625	3	NE Ynys-Lochtyn, New Quay.	SN 315 555	52°10.2'N 04°27.8'W	BPat.Cht, G, YG, Fspi, Fser.R, Ala.Ldig, Ver.B, Ldig.Ldig.Bo, PelB,
625	4	South-west of Pwll Tro, Cemaes Head, Cardigan.	SN 123 489	52°06.3'N 04°44.4'W	BPat.Cht, SByAs
625	5	Cardigan Island Sound cave.	SN 162 513	52°07.7'N 04°41.1'W	Salv, SR
625	6	Cardigan Island Sound, North cave.	SN 164 513	52°07.7'N 04°40.9'W	Ov, SR
642	1	Cwm-yr-Eglwys, Newport.	SN 017 402	52°01.4'N 04°53.4'W	BPat.Cht, G, YG, FvesB, Fser.R, PelB
642	6	Pen-y-bal, Newport.	SN 049 416	52°02.2'N 04°50.6'W	YG, Ver.Por, Ala.Ldig, FvesB
642	7	W Ceibwr Bay, Cardigan.	SN 108 458	52°04.6'N 04°45.6'W	BPat.Sem, YG, Fspi, Ldig.Ldig, Cor, PelB
642	8	Ceibwr Bay, Cardigan.	SN 109 458	52°04.6'N 04°45.5'W	BPat.Sem, YG, Fspi, Fser.R, PelB
642	9	Careg Aderyn, Cardigan.	SN 135 498	52°06.8'N 04°43.4'W	BPat.Sem, Ver.Ver, Ldig.Ldig, Mas
642	22	Craig y Gwbert, Cardigan.	SN 158 502	52°07.1'N 04°41.4'W	BPat.Sem, BPat.Cht, YG, Cor, BPat.Fvesl
642	23	SW Cardigan Island shore.	SN 158 514	52°07.8'N 04°41.4'W	G, YG, BPat.Fvesl, Ldig.Ldig, Ver.B
642	24	NW Cardigan Island.	SN 160 518	52°08.0'N 04°41.3'W	BPat.Cht, Ver.Ver, Pra, FK, Cor, Coff, BPat.Fvesl
642	25	Foel y Mwnt, Cardigan.	SN 192 522	52°08.2'N 04°38.5'W	YG, Ver.Por, Ala, Ver, BPat.Fvesl
642	26	Hatling Bigni, Cardigan.	SN 204 522	52°08.3'N 04°37.4'W	BPat.Sem, Ver.Ver, Ver.Por, Coff, Ala.Ldig
642	27	E Aberporth.	SN 259 518	52°08.1'N 04°32.6'W	Salv, Fspi, Ldig.Ldig, FK, Ver.B, BPat.Fvesl, MytFR
642	28	W Tresaith, Aberporth.	SN 276 516	52°08.1'N 04°31.1'W	BPat.Sem, MytB, EntPor
642	29	Tresaith beach, Aberporth.	SN 278 515	52°08.0'N 04°30.9'W	Tal, AEur, AP.P
642	31	Cwmtudu Headland, New Quay.	SN 354 576	52°11.5'N 04°24.5'W	BPat.Sem, Ov, Fser.Fser, BPat.Fvesl, Pel

Sublittoral sites

Survey	Site	Place	Grid reference	Latitude/longitude	Biotopes present
626	1	N of Pen y Badell, New Quay.	SN 345 597	52°12.6'N 04°25.3'W	AbrNucCor
626	2	N of Carreg Ifan, Aberporth.	SN 311 551	52°10.0'N 04°28.2'W	Urt.Urt, XKScrR, SCAs.ByH
626	3	NE of Ynys-Lochtyn, Aberporth.	SN 320 564	52°10.8'N 04°27.4'W	SNemAdia, SpiSpi
626	4	N end of Ynys-Lochtyn, Aberporth.	SN 314 558	52°10.4'N 04°27.8'W	Flu.HByS
626	5	Offshore N of Ynys-Lochtyn, Aberporth.	SN 311 611	52°13.3'N 04°28.3'W	FabMag,
626	6	Off Llangranog beach, Aberporth.	SN 308 545	52°09.7'N 04°28.4'W	NcirBat
626	7	NE offshore of Ynys-Lochtyn, Aberporth.	SN 301 562	52°10.6'N 04°29.1'W	SNemAdia
626	8	Inshore N of Ynys-Lochtyn, Aberporth.	SN 330 556	52°10.4'N 04°26.5'W	XKScrR
626	10	Cwmtudu, New Quay.	SN 356 581	52°11.7'N 04°24.2'W	PolAhn
626	12	Carreg Walltog, New Quay.	SN 384 606	52°13.2'N 04°21.9'W	Urt.Urt
626	15	E Cardigan Island.	SN 163 517	52°07.9'N 04°41.0'W	Flu.HByS
626	16	N Cardigan Island.	SN 159 519	52°08.0'N 04°41.3'W	MolPol
634	36	Far N of Aberporth, Cardigan Bay.	SN 216 723	52°19.2'N 04°37.0'W	ModMx, CMX
634	37	Off Aberporth, Cardigan Bay.	SN 261 544	52°09.6'N 04°32.5'W	AbrNucCor
643	1	Inshore Newport.	SN 045 408	52°01.8'N 04°50.9'W	NcirBat
643	2	Inshore E of Dinas Head, Newport.	SN 023 411	52°01.9'N 04°52.9'W	Oph
643	3	NE of Dinas Island, Newport.	SN 028 430	52°03.0'N 04°52.5'W	MolPol.Sab
643	4	Inshore NE of Newport Cliffs.	SN 080 447	52°04.0'N 04°48.0'W	IMS
643	5	W of Ceibwr Bay, Cardigan.	SN 069 461	52°04.7'N 04°49.0'W	IMS
643	6	Offshore N of Newport.	SN 039 483	52°05.8'N 04°51.7'W	Mob
643	7	Inshore N of Ceibwr Bay, Cardigan.	SN 101 486	52°06.1'N 04°46.3'W	AbrNucCor
643	8	Centre of Bay of Porth Cardigan.	SN 140 512	52°07.6'N 04°42.9'W	MolPol.Sab
643	9	Off N of Cemaes Head, Newport.	SN 108 545	52°09.3'N 04°45.9'W	MCR
643	10	Inshore N of Foel Mwnt, Cardigan.	SN 193 537	52°09.1'N 04°38.4'W	AfilEcor, IMX
643	11	Offshore N of Cardigan Island.	SN 167 551	52°09.8'N 04°40.7'W	Oph
643	12	Offshore N of Porth Cardigan.	SN 136 574	52°11.0'N 04°43.5'W	IMX
643	13	Inshore W of Aberporth.	SN 248 536	52°09.1'N 04°33.6'W	IMS
643	14	Inshore N of Aberporth.	SN 264 524	52°08.5'N 04°32.2'W	AbrNucCor
643	15	Inshore NE of Tresaith, Aberporth.	SN 291 533	52°09.0'N 04°29.8'W	FabMag
643	16	Offshore Aberporth.	SN 251 580	52°11.5'N 04°33.5'W	NcirBat
643	17	Inshore W of Ynys-Lochtyn, Aberporth.	SN 299 552	52°10.1'N 04°29.2'W	NcirBat
643	18	Offshore N of Tresaith, Aberporth.	SN 274 573	52°11.2'N 04°31.4'W	AfilEcor
643	19	Inshore N of Ynys-Lochtyn, Aberporth.	SN 314 561	52°10.6'N 04°27.9'W	IMX
643	20	Offshore N of Ynys-Lochtyn, Aberporth.	SN 318 577	52°11.5'N 04°27.6'W	IMS
643	21	Inshore N of Cwmtudu, New Quay.	SN 355 585	52°12.0'N 04°24.3'W	IMS
643	22	N of Cwmtudu, New Quay.	SN 352 598	52°12.6'N 04°24.7'W	IMS, MolPol.Sab
643	25	Offshore N of New Quay Head	SN 375 640	52°15.0' N 04°22.8'W	IMS
643	41	Cardigan Bay SFC video 06 280197, Newport.	SN 023 435	52°03.2'N 04°53.0'W	AbrNucCor, Oph
643	42	Cardigan Bay SFC video 07 280197, Newport.	SN 022 423	52°02.6'N 04°53.0'W	Flu.SerHyd
643	43	Cardigan Bay SFC video 08 280197, Newport.	SN 032 422	52°02.5'N 04°52.1'W	Flu.SerHyd, PomByC
643	44	Cardigan Bay SFC video 09 280197, Newport.	SN 037 411	52°02.0'N 04°51.7'W	Flu.SerHyd
643	45	Cardigan Bay SFC video 10 280197, Newport.	SN 030 406	52°01.7'N 04°52.3'W	FabMag
643	46	Cardigan Bay SFC video 01 290197.	SN 143 528	52°08.5'N 04°42.7'W	Flu.SerHyd
643	47	Cardigan Bay SFC video 02 290197.	SN 153 533	52°08.8'N 04°41.9'W	Flu.SerHyd
643	48	Cardigan Bay SFC video 03 290197.	SN 158 527	52°08.5'N 04°41.4'W	Flu.SerHyd
643	49	Cardigan Bay SFC video 04 290197.	SN 152 518	52°07.9'N 04°42.0'W	MolPol.Sab
643	50	Cardigan Bay SFC video 05 290197.	SN 139 519	52°08.0'N 04°43.1'W	AbrNucCor
643	51	Cardigan Bay SFC video 06 290197.	SN 128 513	52°07.6'N 04°44.1'W	AlcTub, PomByC
643	52	Cardigan Bay SFC video 07 290197.	SN 127 506	52°07.3'N 04°44.1'W	AlcTub
643	53	Cardigan Bay SFC video 08 290197.	SN 111 504	52°07.1'N 04°45.5'W	Flu.SerHyd
643	54	Cardigan Bay SFC video 09 290197.	SN 105 512	52°07.6'N 04°46.0'W	Flu.SerHyd
643	55	Cardigan Bay SFC video 10 290197.	SN 061 466	52°05.0'N 04°49.7'W	Ven
643	56	Cardigan Bay SFC video 11 290197, Newport.	SN 056 458	52°04.6'N 04°50.2'W	AbrNucCor

2 Nyfer estuary (Newport Bay)

Location		
Position (centre)	SN 055 398	52° 01'.3N 4°50'.2W
County/district	Ceredigion	Preseli
Conservation agency/area	Countryside Council for Wales	West Area

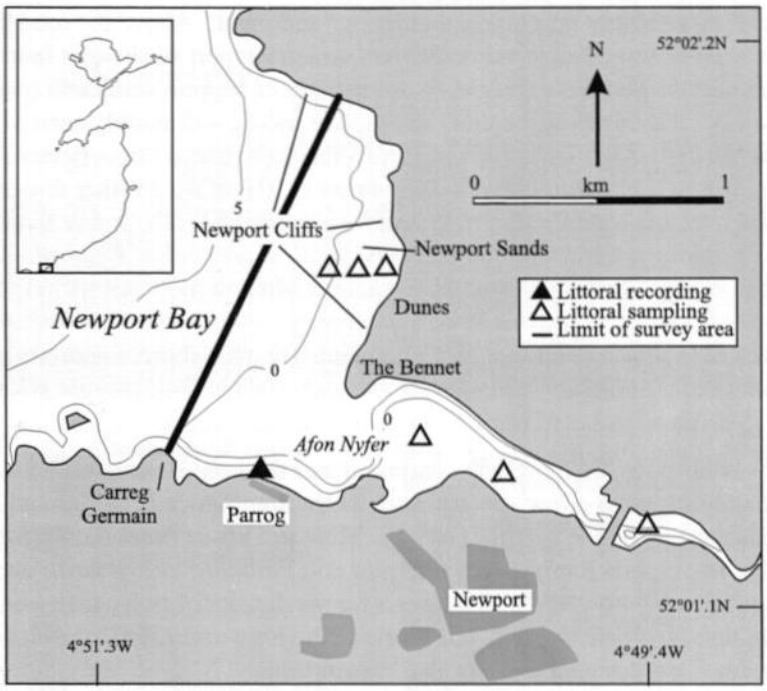

Figure 2.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Bar-built estuary
Length of inlet	1.6 km
Area of inlet	100 ha total, 75 ha intertidal
Bathymetry	Intertidal with a shallow river channel
Wave exposure	Moderate to ultra sheltered
Tidal streams	Weak to negligible
Tidal range	4 m springs; 1.4 m neaps (Fishguard)
Salinity	Fully marine to reduced

Introduction

The Afon Nyfer enters the south-western part of Newport Bay at Carreg Germain, as a small, shallow estuary which drains almost completely at low tide, leaving only a shallow meandering river channel. The sandflat near the mouth of the estuary gradually becomes muddier towards the east, due to sheltered conditions provided by Newport Sands and the narrowing of the estuary. There are areas of saltmarsh along the southern shore (Buck 1993) and upstream of the bridge at Newport. On the northern shore there is a small area of sand dunes known as The Bennet fronted by a 150 m-wide sand beach. On either side of the mouth there are limited areas of intertidal rock.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	1	April 1997	MNCR survey 642
	Recording (epibiota)	1	May 1976	Powell *et al.* (1979)
	Infaunal sampling (cores)	3	April 1997	MNCR survey 642

Littoral sediment

Virtually all of the Nyfer estuary is composed of littoral sediment. Above the road bridge, the upper estuary consists of numerous gravel-bottomed creeks which support freshwater fauna such as stonefly larvae (Plecoptera). Sediment banks lying between the creeks support saltmarsh communities containing *Spartina* sp. The sides of the creeks comprise anoxic soft muddy sand over gravel with abundant polychaetes, including *Hediste diversicolor*, the enchytraeid oligochaetes *Paranais litoralis* and *Heterochaeta costata* and the amphipod *Corophium* sp. (HedOl). Further downstream, just below the bridge near Newport, the sediment is composed largely of sand. The lower shore contains fine muddy sand with abundant polychaetes characterised by *H. diversicolor*, *Pygospio elegans*, *Manayunkia aestuarina* and the oligochaete *H. costata*. Common molluscs include the tellin *Macoma balthica*, the mud snail *Ventrosia ventrosa* and the peppery furrow shell *Scrobicularia plana* (HedScr). Juvenile shore crabs *Carcinus maenas* are also abundant. The mid-shore comprises medium-fine sand with a few infaunal species including abundant amphipods such as *Bathyporeia pilosa* and *Corophium* sp., and common *P. elegans* and mud snail *Ventrosia ventrosa* (BatCor).

On Newport Sands conditions are more wave-exposed and the sand is more mobile. The upper shore medium-fine sand only supports a few species, such as the amphipods *B. pilosa* and *Haustorius arenarius* and the isopod *Eurydice pulchra* (AEur). Mid- and lower shore communities are characterised by the amphipods *Bathyporeia pelagica* and *Pontocrates arenarius* and the polychaetes *Paraonis fulgens* and *P. elegans* (AP.P). There is a higher density of polychaetes on the lower shore including *Spio* spp. and *Mediomastus fragilis*. Casts of the lugworm *Arenicola marina* and tubes of the sand mason worm *Lanice conchilega* are also conspicuous.

Littoral rock

On the south side of the estuary, between Parrog and Carreg Germain, there is a stretch of bedrock influenced by sand and freshwater with communities generally characteristic of sheltered coasts. On the upper shore there are narrow zones of the black lichen *Verrucaria maura* (Ver), channelled wrack *Pelvetia canaliculata* (Pel) and spiral wrack *Fucus spiralis* (Fspi). Wide zones of the fucoids *Ascophyllum nodosum* (Asc.Asc), *Fucus vesiculosus* (Fves) and *Fucus serratus* (Fser.Fser) are found on the mid- and lower shore. Amongst the fucoids, an underlying mat of the red alga *Audouinella* spp. binds the sand into hummocks. Upper eulittoral rockpools contain beds of dense green alga *Enteromorpha* sp. (G) and rockpools on the lower shore are dominated either by mussels *Mytilus edulis* (?MytX) or coralline crusts (Cor) and a turf of the green algae *Cladophora* sp. and *Enteromorpha* sp. The bedrock extends down to the course of the Afon Nyfer where there are pebbles and cobbles emerging from the sand covered by horned wrack *Fucus ceranoides* and *Enteromorpha* sp., indicating reduced salinity (FcerX). Although not surveyed in detail, the rocks to the north end of Newport Sands supported fucoid and barnacle communities with a zone of lichens in the supralittoral. The rock at the interface with the sand was characteristically scoured clean of animals and plants.

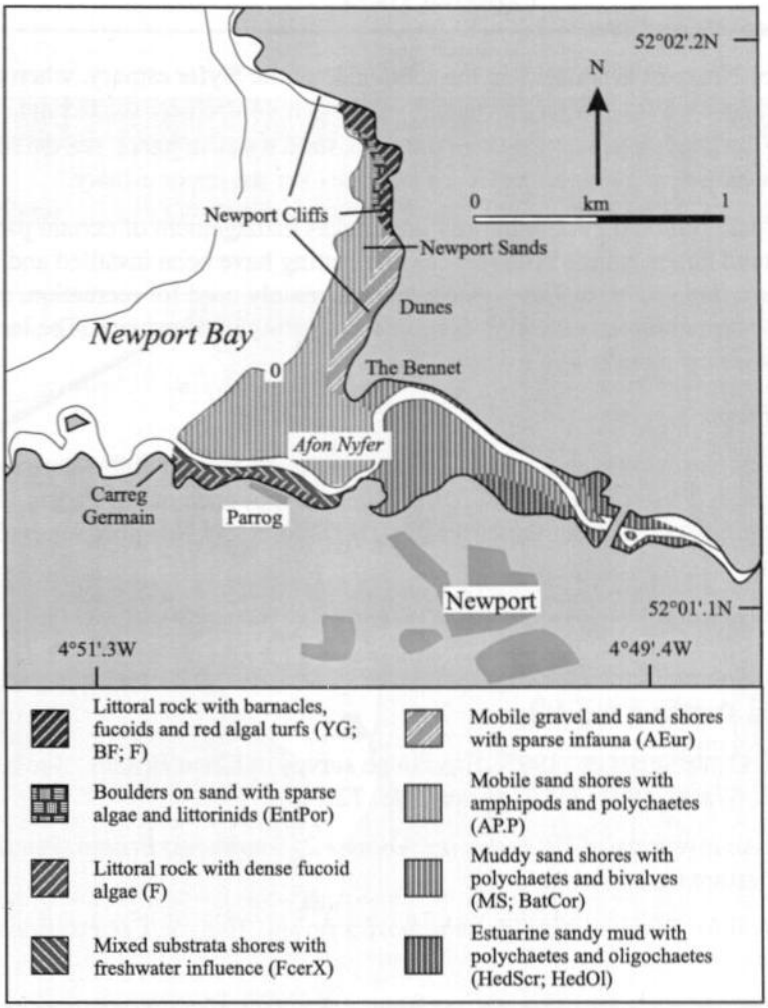

Figure 2.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 2.1).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Pembrokeshire Coast	NP	N/A	
Preseli	ESA	N/A	Agri-environmental scheme
Newport Cliffs	SSSI	SN 054 407 – SN 064 432	Sea-cliff vegetation; ornithology; grey seal haul-out.
Pembrokeshire: St Dogmaels and Moylgrove	HC	SN 054 407 – SN 160 485	Coastal scenery

Human influences

Coastal developments and uses

The small town of Newport is situated on the south side of the Nyfer estuary, whereas the north side is far less developed, comprising largely farmland with a golf course near the Bennet. Other developments on the south side include three medium-sized caravan parks, sea defences at Parrog, land-claim for housing near Newport and a road bridge over the upper estuary.

Pembrokeshire Coast National Park Authority undertakes management of certain parts of the estuary, in particular the sand dunes, where brush fences and netting have been installed and public access is controlled to reduce dune erosion. The Nyfer estuary is mainly used for recreation, especially in the lower reaches. Birdwatching and walking takes place all around the estuary. The local gun club treat the estuary as a wildfowl reserve and refuge.

Marine developments and uses

In Parrog there is a disused quay, moorings, a dinghy park and a yacht club where sailing and wind-surfing races are held. Power-boats and SCUBA divers also operate out of Parrog. Bathing and beach recreation occur on the north side of the estuary at The Bennet and Newport Sands. Some bait-digging occurs in the softer sediment in the estuary.

On the saltmarsh there is small-scale *Salicornia* harvesting, sheep grazing and turf cutting.

References and further reading

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Sites surveyed

Survey 265: 1970-1980 SMBA/MBA Great Britain intertidal survey (Powell *et al.* 1978).
Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
265	9	Parrog, Newport Bay	SN 048 398	52°01.2'N 04°50.7'W	F
642	2	Newport	SN 048 398	52°01.3'N 04°50.7'W	G, Fves, Fspi, FcerX, Asc.Asc, Fser.Fser, MytX, Cor, Ver, Pel
642	3	Newport Sands	SN 053 406	52°01.7'N 04°50.3'W	AEur, AP.P
642	4	Newport estuary	SN 057 397	52°01.2'N 04°49.9'W	HedScr, BatCor
642	5	Newport upper estuary	SN 064 394	52°01.1'N 04°49.3'W	HedOl

Compiled by: Dora Nichols

3 Teifi estuary

Location		
Position (centre)	SN 165 483	52°06'N 4°41'W
County/district	Ceredigion	Preseli
Conservation agency / area	Countryside Council for Wales	West Area

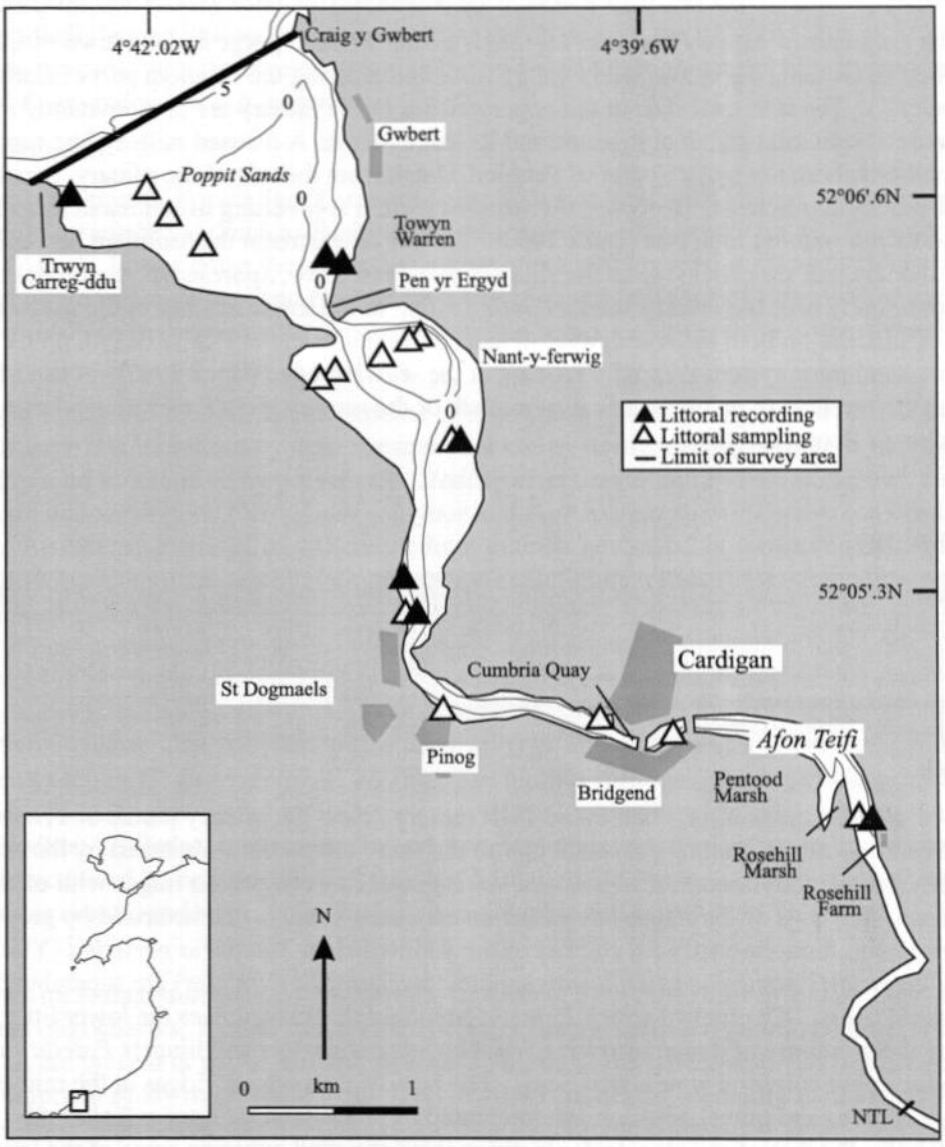

Figure 3.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Bar-built estuary
Length of inlet	10 km
Area of inlet	301 ha total; 181 ha intertidal
Bathymetry	Intertidal with a shallow channel
Wave exposure	Moderately exposed to ultra sheltered
Tidal streams	Moderately strong to negligible
Tidal range	4.1 m springs; 1.6 m neaps (Port Cardigan)
Salinity	Fully marine to reduced

Introduction

The Teifi is a long narrow estuary that flows through a deep wooded gorge and the town of Cardigan (Aberteifi) before crossing a shallow sandy valley floor and entering the southern part of Cardigan Bay (*area summary* 1). The intertidal flats in the upper reaches of the estuary are predominantly mud, with extensive areas of estuarine marsh at Pentood and Rosehill Marsh. A disused railway line running along the southern shore has isolated part of Pentood Marsh from the rest of the estuary, creating a largely freshwater environment. However, the western section is reverting to saltmarsh as a result of the incursion of sea water at high tide (Buck 1993). Further downstream the sediment becomes sandier and marsh areas on either side of the channel more extensive; *Spartina* sp. dominates the saltmarsh community near the estuary mouth (Buck 1993). In the lower reaches of the estuary there is an expanse of sandflat on both sides with a small sand and shingle spit at Pen yr Ergyd, on the eastern shore where a sand dune system is rapidly eroding at the seaward edge (Buck 1993). A sand-bar extends from the western shore eastwards across much of the estuary mouth, exposing a large expanse of sand, known as Poppit Sands.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Phase 1 habitat mapping		May 1996	CCW survey 9.38.1
	Recording (epibiota)	6	June 1997	MNCR survey 642
	Infaunal sampling (cores)	9	June 1997	MNCR survey 642

Littoral rock

There are two main outcrops of bedrock in the Teifi estuary. Near the estuary mouth at Trwyn Caregddu, rugged bedrock ridges running perpendicular to the shore are partially sheltered by the headlands on either side of the estuary mouth. Cobbles and stone gravel lie between the ridges with medium fine sand at the base. The tops of the ridges have a lichen community that is characterised by grey lichens and the green lichen *Ramalina* sp. with patches of the yellow lichen *Xanthoria parietina* (YG). The black lichen *Verrucaria maura* and rough winkles *Littorina saxatilis* (Ver.Ver) are superabundant in the upper littoral fringe. Channelled wrack *Pelvetia canaliculata* characterises the lower littoral fringe (Pel). A faunal community of dense barnacles *Semibalanus balanoides* and limpets *Patella vulgata* characterise the upper eulittoral zone (BPat.Sem). The base of the bedrock ridges in the mid-eulittoral and the stable cobbles and gravel between are dominated by spiral wrack *Fucus spiralis* and *L. saxatilis* (Fspi). Patches of red alga *Audouinella* sp. bind the sand covering some of the larger rocks. Lower eulittoral bedrock, cobbles and gravel are dominated by bladder wrack *Fucus vesiculosus* with patches of green alga *Enteromorpha* sp. in areas of sand-influence (Fves). Winkles *Littorina littorea* and *L. saxatilis* and mussels *Mytilus edulis* are present in crevices on the mid- and lower shore.

The second area of bedrock is to the north of St Dogmaels, in the mid-estuary. There are distinct zones of *Enteromorpha* sp. with sparse *P. canaliculata* (Ent) on the upper shore, dense *F. vesiculosus* and egg wrack *Ascophyllum nodosum* (Asc.VS) on the mid-shore, and thickly-silted bedrock and

boulders dominated by horned wrack *Fucus ceranoides* and *Enteromorpha* sp. on the lower shore, indicating a stronger influence of freshwater on the lower shore (Fcer).

In the lower reaches of the Teifi estuary, north of Pen yr Ergyd, an area of cobbles, pebbles and gravel is sheltered by Poppit Sands. The cobble bank on the upper shore is dominated by *F. spiralis* with amphipods (Fspi); on the lower shore, the gravel and pebbles on coarse sand have a community characterised by dense ephemeral green algae *Ulva* sp. and *Enteromorpha* sp., *F. ceranoides* and abundant gammarids and polychaetes under the stones (FcerX). In the mid-estuary to the south of Nant-y-ferwig, upper shore pebbles on muddy gravel on the eastern shore support few species other than sparse *L. saxatilis*, green alga *Cladophora* sp. and *F. vesiculosus* (FvesX). On the mid-shore, silted cobbles on fine muddy sand are dominated by *F. vesiculosus* and *Cladophora* sp. (FvesX). The cobbles gradually merge into sediment lower down the shore. On the western shore, at St Dogmaels slipway, on the banks of a freshwater stream in the mid- and lower shore, pebbles on mud have patches of *F. vesiculosus* and *F. ceranoides* (FcerX).

Littoral sediment

Near the estuary mouth, Poppit Sands comprises medium fine sand with an upper shore community characterised by amphipods such as *Bathyporeia pilosa*, *Haustorius arenarius* and *Gammarus zaddachi* (AEur). Lower down the shore the coarser, more mobile, sand is dominated by amphipods *Urothoe* spp., *Bathyporeia* spp. and *Haustorius arenarius*, and polychaetes *Paraonis fulgens* and *Spio martinensis* (AP.P). In the medium-fine sand below the bedrock ridges on the lower shore, lugworm *Arenicola marina* casts are frequent (?AP.P).

In the lower reaches of the estuary, an expanse of sand south of Pen yr Ergyd is sheltered from wave action, although it is mobilised by tidal streams. Backed by drying sand and shingle, the upper shore firm muddy sand is colonised by polychaetes *Hediste diversicolor* and *Pygospio elegans*, enchytraeid oligochaetes and amphipods *Corophium volutator* and *Bathyporeia* sp. with numerous beetles (BatCor). An extensive area of mid-shore medium grained 'aero-sand' is dominated by numerous *B. pilosa* (AEur). The 'aero-sand' is formed when sand is fluidised through having a high water content (usually due to strong tides) and then drains as the tide ebbs, leaving many pores in the sand. The lower shore consists of thixotropic well-sorted medium-grained sand and is characterised by polychaetes *Capitella* spp., *Paraonis fulgens*, *Nephtys cirrosa* and *S. martinensis* and amphipods *B. pelagica* and *H. arenarius* (AP.P). On the opposite, western shore of the Teifi estuary lies a saltmarsh with creeks of anoxic muddy fine sand with dense populations of polychaetes and oligochaetes such as *H. diversicolor*, *P. elegans*, *Streblospio shrubsolii*, *Manayunkia aestuarina* and *Tubificoides pseudogaster*. Mud snails *Ventrosia ventrosa* and tellins *Macoma balthica* are also present (HedStr). Adjacent to the river channel, where it undercuts the saltmarsh, a steep bank of fine sand is characterised by scattered *H. diversicolor*, *S. shrubsolii*, *Capitella* sp., the oligochaete *Heterochaeta costata* and amphipods *Bathyporeia pelagica* and *C. volutator* (HedStr).

South of Nant-y-ferwig, anoxic muddy sand on the lower shore is dominated by a wide variety of polychaetes including *Malacoceros fuliginosus*, *H. diversicolor*, *S. shrubsolii* and *M. aestuarina*, enchytraeid oligochaetes, *V. ventrosa*, and the peppery furrow shell *Scrobicularia plana* (HedScr). Amphipods are present in pools of standing water. At Pinog, the gently-sloping shore in the mid-estuary comprises sandy mud with a black layer at 10-15 cm depth, becoming sandier and firmer lower down the shore. The whole shore is characterised by an infaunal community of *H. diversicolor*, *S. shrubsolii*, *M. aestuarina* and *H. costata* with *Corophium* sp. and the mysid *Neomysis integer* (HedStr). North of St Dogmaels slipway, the lower shore comprises poorly-sorted muddy gravel with a layer of pebbles at 10 cm depth. The lower shore community is characterised by the polychaetes *H. diversicolor*, *S. shrubsolii* and *M. aestuarina*, the oligochaete *H. costata*, nematodes, and the mud snail *Hydrobia ulvae* (HedStr).

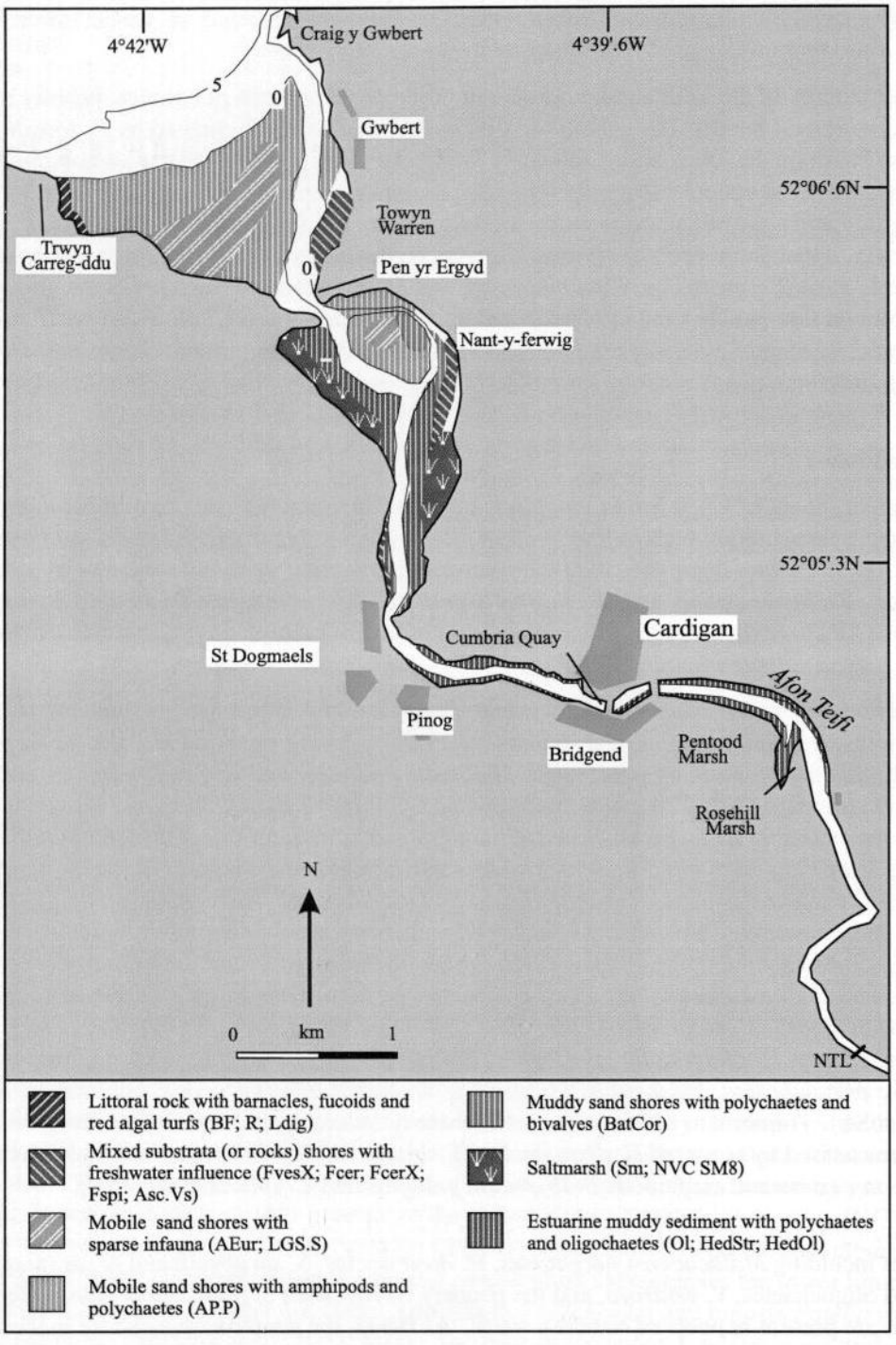

Figure 3.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 3.1, cited literature and additional field observations).

From the west end of Cardigan town to the A487 road bridge, the upper shore consists of flood defence walls. The mid-shore soft, anoxic sandy mud has a surface layer of soft mud and leaf litter and is characterised by *H. diversicolor*, *M. aestuarina*, *S. shrubsolii* and *Corophium* sp. (HedStr). Lower down the shore, the sediment comprises firm anoxic sandy mud, dominated by generally the

same species of polychaetes as the mid-shore, although *M. aestuarina* is not present (HedStr). Further upstream, beyond the A487 road bridge, very soft anoxic mud was dominated by *H. diversicolor*, the oligochaetes *Paranais litoralis* and *Heterochaeta costata*, and *C. volutator* (HedOl). The upper reaches of the Teifi estuary are composed mainly of mud. Near Rosehill farm, fine mud overlying a coarse gravel layer on the upper shore is characterised by *H. diversicolor*, *P. litoralis* and abundant fly (Diptera) larvae (HedOl). Banks of muddy gravel and silty slates in the mid-channel are dominated by a freshwater-influenced fauna including fly larvae and beetle (Coleoptera) larvae with filamentous green algae (O1).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Cardigan Bay	cSAC	SN 30 50	Bottlenose dolphin *Tursiops truncatus*
Preseli	ESA	N/A	Agri-environmental scheme
Poppit Beach & Cliffs	SSSI; GCR	SN 146 489	Geological
Coedydd a Chorsydd Aber Teifi	SSSI	SN 183 458	Biological
Pen yr Ergyd	SSSI	SN 165 488	Coastal heath and sand-dune system
Netpool Wood	SSSI	SN170462	Biological
Pembrokeshire Coast	NP	N/A	(South shore of Teifi estuary)
St Dogmaels and Moylgrove	HC	SN 054 407-SN 160 485	Coastal scenery
Teifi Marshes	CWT	SN 185 450	Ornithological
Teifi Foreshore	CWT	SN 187 457	Ornithological

Human influences

Coastal developments and uses

Industrial and urban development on the Teifi estuary is limited to the area around Cardigan and St Dogmaels, although there is continued pressure to build along either side of the estuary. Various sea defences in the estuary include gabions and large embedded boulders along the stretch of the estuary that flows through Cardigan, and an extensive coastal protection scheme to reduce erosion north of Pen yr Ergyd. Habitat management within the estuary includes control of scrub by cutting at Pen yr Ergyd, supplying shingle to the beach to protect the spit, and protection of some areas of sand-dunes by planting marram grass *Ammophila arenaria* and providing walkways.

The Pembrokeshire coast path runs along the edge of the estuary. The golf course at Towyn Warren runs up to the cliff tops at Craig y Gwbert. Bathing and beach recreation take place on Poppit Sands. At Pen yr Ergyd, the caravan park and old fishing gear encroach on the degraded dune system. Wildfowling takes place on the marshes.

Marine developments and uses

Leisure pursuits in the estuary are focused on the yacht club at south of Gwbert and the moorings and dinghy park at Cumbria Quay, west of Cardigan.

Salmon netting is licensed in the mid- and lower estuary, and bait-digging occurs at a low intensity on the sandflats of the lower estuary. A small amount of *Salicornia* harvesting occurs on the edge of the saltmarshes in the mid-estuary.

References and further reading

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Fowles, A. 1994. *Invertebrates of Wales: a review of important sites and species*. Peterborough, Joint Nature Conservation Committee.

Richards, A., Bunker, F. St.P., Foster-Smith, R. 1996. Handbook for marine intertidal Phase 1 and SSSI habitat mapping. *Countryside Council for Wales Natural Sciences Report*, No. 95/6/1.

Sites surveyed

Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude / longitude*	*Biotopes present*
642	10	Trwyn Carreg-ddu, Cardigan	SN 150 489	52°06.4'N 04°42.1'W	YG, Ver.Ver, Pel, Fspi, BPat.Sem, Fves, AP.P
642	11	Poppit Sands, Cardigan	SN 152 488	52°06.3'N 04°41.9'W	AEur, AP.P
642	12	Coronation Drive, Gwbert, Cardigan	SN 160 490	52°06.4'N 04°41.2'W	Fspi, FcerX
642	13	SE of Pen yr Ergyd, Cardigan	SN 163 484	52°06.1'N 04°40.9'W	AEur, AP.P, BatCor
642	14	E of Webley Hotel, Cardigan	SN 160 480	52°05.9'N 04°41.2'W	HedStr
642	15	S of Nant-y-ferwig, Cardigan	SN 166 477	52°05.8'N 04°40.6'W	HedStr, HedScr, FvesX
642	16	N St Dogmaels Slipway, Cardigan	SN 163 470	52°05.4'N 04°40.9'W	HedStr, Fcer, Asc.VS, Ent
642	17	St Dogmaels Slipway, Cardigan	SN 164 468	52°05.3'N 04°40.8'W	Fcer
642	18	Pinog, Cardigan	SN 165 462	52°04.9'N 04°40.7'W	HedStr
642	19	W of Cardigan town	SN 175 460	52°04.9'N 04°39.8'W	HedStr
642	20	Upstream of cattle market, Cardigan	SN 182 458	52°04.8'N 04°39.2'W	HedOl
642	21	Rose Hill Farm, Cardigan	SN 192 453	52°04.5'N 04°38.3'W	HedOl, Ol

Compiled by: Dora Nichols

4 New Quay (Ceinewydd) to Clarach Bay

Location		
Position (centre)	SN 520 690	52°18'N 4°10'W
County	Ceredigion	
Conservation agency / area	Countryside Council for Wales	West Area

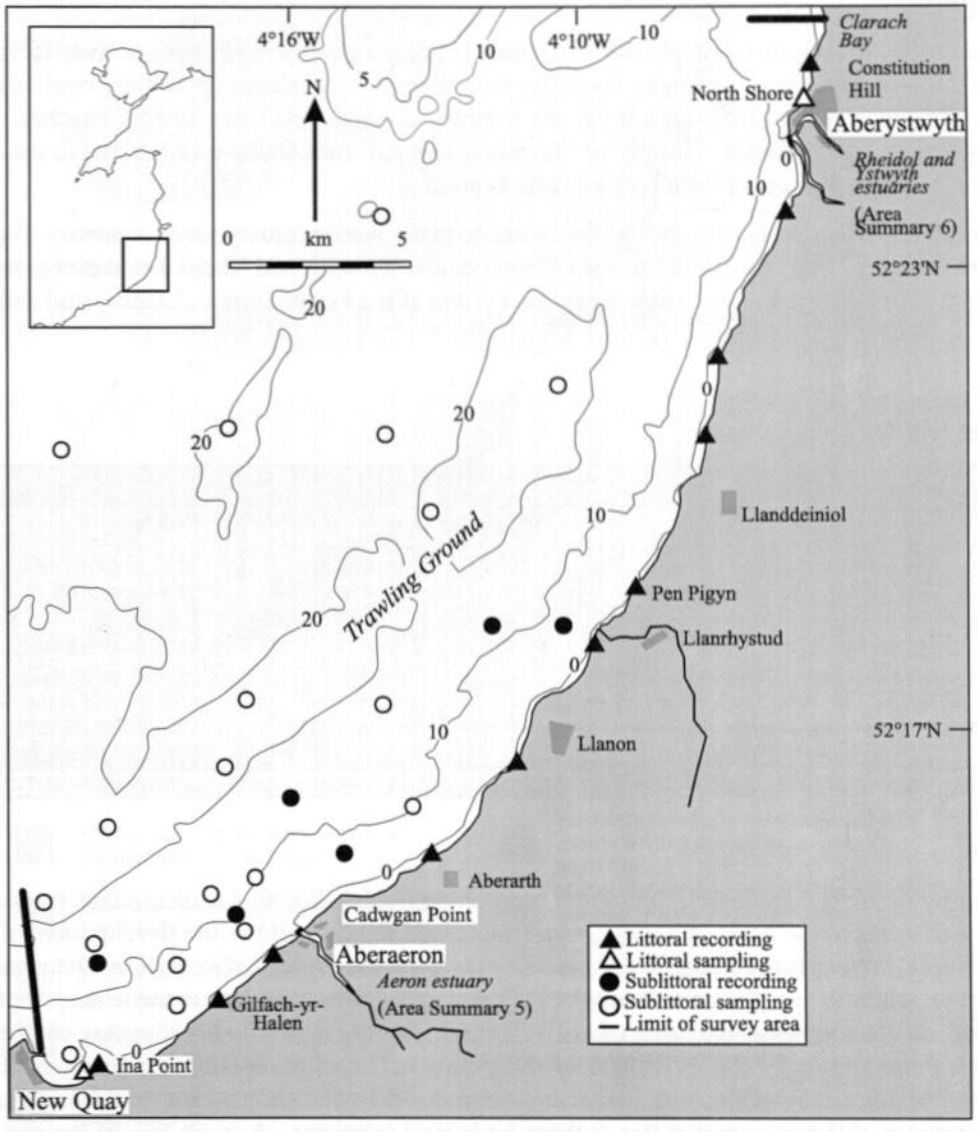

Figure 4.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Linear open coast
Length of coast	34 km
Bathymetry	Maximum depth 25 m within the 3 mile limit
Wave exposure	Moderately exposed
Tidal streams	Weak to negligible
Tidal range	4.3 m springs; 1.9 m neaps (Aberystwyth)
Salinity	Fully marine

Introduction

The coast from New Quay (Ceinewydd) to Clarach is predominantly north-west or west-facing towards the southern part of Cardigan Bay (Bae Ceredigion). The shores are mainly boulders and cobbles with some rocky platforms cut into the greywacke shales and some shingle beaches. Offshore a muddy trough known as the 'Trough' or 'Trawling Ground' runs south-west parallel to the coast, with mainly sandy and mixed sediment grounds beyond.

The Georgian town of Aberaeron lies at the entrance to the Aeron estuary (*area summary* 5) and the Victorian resort of Aberystwyth lies at the entrance to the Ystwyth and Rheidol estuaries (*area summary* 6). Small rivers and streams flow into the sea at Ina Point, Llanon, Llanrhystud and Clarach Bay.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	12	June 1997	MNCR survey 642
	Habitat (biotope) mapping		May 1996	CCW surveys 9.34.1, 9.33.1, 9.32.1
	Infaunal sampling - cores	2	June 1997	MNCR survey 642
Sublittoral	Video recording (epibiota)	3	June 1995	MNCR survey 626
	Recording (epibiota)	5	March 1997	SFC/MNCR survey 643 *
	Infaunal sampling - Day grab (& AGDS)	6	August 1991	Mackie, Oliver & Rees (1995)
	Infaunal sampling Day grab	7	March 1997	SFC/UWB/MNCR survey 643 *

* SFC = Sea Fisheries Committee and University of Wales, Bangor, video ground truthing for RoxAnn™ AGDS survey under contract for JNCC.

Littoral

The majority of the shores consist of boulder and cobble fields, all with a similar character, and markedly different to the bedrock shores, where increased stability allows the development of more extensive algal cover. Raised beaches of boulder clay back the shores between New Quay and Llanrhystud, while to the north, the shore backing and upper shore consist of friable shales, often with a beach of mobile cobbles at the bases of cliffs. Cobble shores backed by boulder clay can be clearly seen at Ina Point and rocky shores backed by shale cliffs at Constitution Hill, Aberystwyth. The mobile and friable nature of the rock in the supralittoral and littoral fringe throughout the Area results in few examples of lichen communities in these biological subzones. A small area of steeper coastline at Gilfach-yr-Halen is the only site at which a supralittoral lichen zone (YG) was recorded.

The black lichen *Verrucaria maura* occurs sporadically in the littoral fringe along this coast where there are stable, large boulders or bedrock (Ver.Ver; Ver.Por), below which a narrow zone of barnacles *Chthamalus montagui* may be present (BPat.Cht). On cobble shores, zones of the fucoids *Fucus spiralis* (Fspi), *Fucus vesiculosus* (Fves; FvesX) and *Fucus serratus* (Fser.Fser.Bo) are typically influenced by the mobility of the substratum, and consequently the algal cover is not dense. In places, barnacles *Semibalanus balanoides* and limpets *Patella vulgata* become dominant on the mid-shore (BPat.Sem).

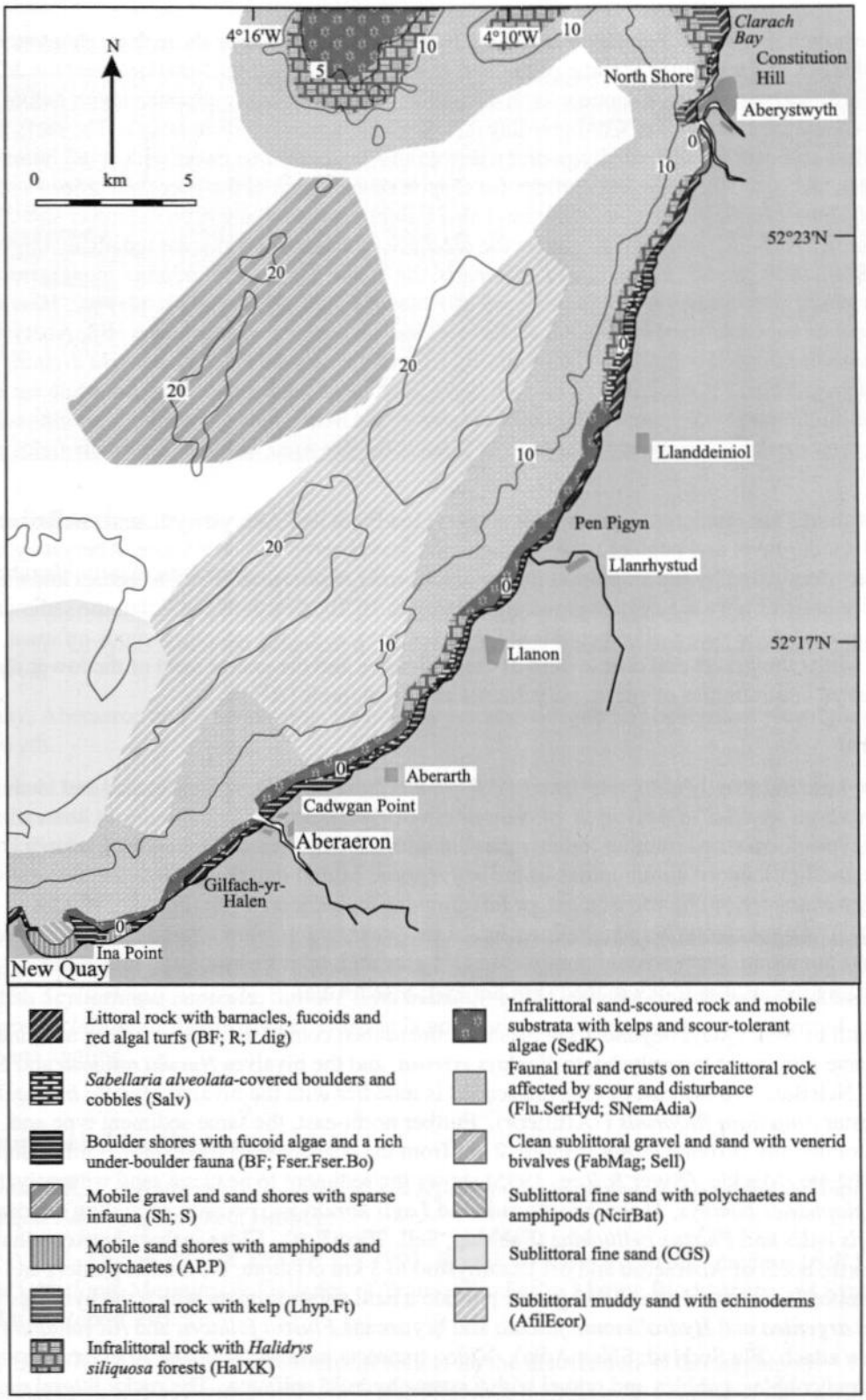

Figure 4.2 Indicative distribution of the main biotopes in the area (based on data from survey sites shown in Figure 4.1, cited literature and additional field observations).

The honeycomb reef worm *Sabellaria alveolata* forms reefs on the lower shore throughout most of this stretch of coast and accounts for some of the best examples of the littoral *Sabellaria* reefs in MNCR Sector 10 (Salv) (see also area summaries 1, 7 and 13). Area 4 probably supports about half of the total *Sabellaria* reef resource in Cardigan Bay (CCW Phase 1 survey information). The reefs stabilise the boulders and cobbles and usually permit a degree of *Fucus serratus* cover with small holes around the cobbles and boulders providing habitats for cryptic species such as the porcelain crabs *Porcellana platycheles* and *Pisidia longicornis*. The sand also influences the red algae on the lower shore and sublittoral fringe, which is characterised by the presence of sand-scour-tolerant red algae *Ahnfeltia plicata*, *Polyides rotundus*, *Furcellaria lumbricalis*, the brown algae *Cladostephus spongiosus* and *Halidrys siliquosa* and fast growing algae such as *Palmaria palmata*, *Polysiphonia* spp., *Ulva* sp. and *Enteromorpha* sp. (PolAhn; HalXK; XKScrR). At Castle Rocks and Constitution Hill, Aberystwyth, the less sand-influenced bedrock in the sublittoral fringe supports the kelps *Laminaria digitata* and *Laminaria hyperborea* (Ldig.Ldig). The *Sabellaria* reefs lie in the bedrock troughs, while the rock ridges are dominated by *S. balanoides* and *P. vulgata* (BPat.Sem). Shallow rockpools with pink coralline crusts and littorinids (Cor) are present throughout the Area, both on the cobble fields and on bedrock.

Sediment shores are restricted to around New Quay, Ina Point and Aberystwyth, and comprise various grades of sand, gravel and pebbles. Interestingly, the gravel shore at North Shore, Aberystwyth, has a community dominated by the amphipod *Pectenogammarus planicrurus* (Pec); a species known historically to be of high abundance in the area (Morgan 1970). North of Ina Point, the sediment is coarse throughout the shore. The pebbles at the top of the shore have no conspicuous infaunal species (BarSh), whilst the gravel and coarse sand of the mid-shore and the coarse sand of the lower shore have infaunal communities of sparse polychaetes and amphipods (AP.P).

Sublittoral

The seabed predominantly comprises patches of boulders and cobbles, muddy gravel and clean coarse sand and gravel. Similar to the stretch of coast south of New Quay (*area summary* 1), the various sediment types form strips running roughly parallel with the coastline. Throughout this stretch of coast, the sand-influenced communities of the lower shore extend into the shallow infralittoral with a community characterised by robust algae or fast-growing, ephemeral algae (PolAhn; HalXK; XKScrR). The photic zone here is shallow; few algae occur much below chart datum, therefore the sublittoral communities are predominantly animal-dominated, with hydroids and bryozoans characterising the inshore rocky seabed (Flu.SerHyd; SNemAdia).

To the north of New Quay, beyond 4 km offshore, the seabed comprises clean medium and fine sand with a sparse infauna of the polychaete *Nephtys cirrosa*, and the bivalves *Nucula nitidosa* and *Ensis arcuatus* (NcirBat). To the east of this, the seabed is muddier with the bivalve *Mysella bidentata* and the brittlestar *Amphiura filiformis* (?AfilEcor). Further north-east, the same sediment type and infaunal community is found closer inshore, 2 km from the coast near Llanddeiniol. Grab sampling further offshore (Mackie, Oliver & Rees 1995) shows the sediment to be clean sand with polychaetes such as *Spiophanes bombyx*, *Owenia fusiformis* and *Lagis koreni* and bivalves including the razor shells *Ensis ensis* and *Phaxas pellucidus* (FabMag, Sell, ?EcorEns). Close inshore between Ina Point and Aberarth, north of Aberaeron and off Llanrhystud to 3 km offshore, the small boulders and cobbles embedded in muddy sand and gravel provide a hard substratum on which the hydroids *Sertularia argentea* and *Hydrallmania falcata* and bryozoans *Flustra foliacea* and *Alcyonidium diaphanum* attach (Flu.SerHyd; SNemAdia). Video transects west and south of Aberystwyth show sand-scoured cobbles, pebbles and gravel with a sparse hydroid epifauna. The rocky littoral reefs at Aberystwyth extend for approximately 100 m offshore and have a community comprised of kelp *Laminaria hyperborea* and red algae (Lhyp). In general, kelp forests are very poorly-represented because of the consistently high turbidity levels in Area 4, and do not tend to grow much below chart datum (0 m).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Cardigan Bay	cSAC	SN 30 50	Bottlenose dolphins *Tursiops truncatus*.
Creigiau Aberarth-Morfa	SSSI; GCR	SN 491 649	Geological
Traeth Llanon	SSSI; GCR	SN 509 673	Geological
Creigiau Pen-y-graig	SSSI; GCR	SN 552 734	Geological, coastal woodland and ornithological
Creigiau Cwm-ceirw a ffos-las (Morfa Bychan)	SSSI; GCR	SN 560 763	Geological
Allt wen a traeth Tanybwlch	SSSI; GCR	SN 572 788 - SN 579 807	Geological, maritime heath and coastal shingle communities
Craigyfulfran	SSSI; GCR	SN 584 830	Geological
Ceredigion	HC	SN 532 702 - SN 556 746	Coastal scenery
Aber Stinchell lime kilns	CWT	SN 519 684	Botanical
Penderi	CWT	SN 550 732	Coastal cliffs and oak woodland.

Human influences

Coastal developments and uses

The coast is undeveloped apart from piers and approximately 2 km of coastal defence walls at Aberystwyth. Groynes retain the sediment on the shores at Ina Point, Aberaeron, Aberarth and Aberystwyth.

New Quay, Aberaeron and Aberystwyth are holiday resorts with popular beaches at New Quay and Aberystwyth.

Low levels of treated sewage are discharged at Ina Point, Aberarth and Llanon, with a recently improved treated sewage outfall at Aberystwyth. At Aberaeron, at the time of writing, there was consent to discharge untreated sewage into the Aeron estuary.

Marine developments

Commercial fishing is limited to potting for lobsters *Homarus gammarus*, prawns *Palaemon serratus* and whelks *Buccinum undatum* over the shallow cobble grounds, and fixed net fishing for rays *Raja* sp., dogfish *Scyliorhinus canicula*, turbot *Psetta maxima*, brill *Scophthalmus rhombus* and bass *Dicentrarchus labrax* further offshore. Boating is popular from Aberystwyth, in the form of yachting, cruising and angling.

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Richards, A., Bunker, F. St.P., Foster-Smith, R. 1996. Handbook for marine intertidal Phase 1 and SSSI habitat mapping. *Countryside Council for Wales Natural Sciences Report*, No. 95/6/1.

Sites surveyed

Survey 626. 1995/7 MNCR Ceredigion coast, sublittoral survey (MNCR, unpublished data).
Survey 634. 1989-91 BIOMÔR, benthic biodiversity of the southern Irish Sea, sublittoral survey (Mackie, Oliver & Rees 1995).
Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).
Survey 643. 1997 NWNWSFC Cardigan Bay infaunal sublittoral survey (unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude / longitude*	*Biotopes present*
642	32	W Llanina Point, Aberaeron.	SN 402 598	52°12.7'N 04°20.3'W	AP.P
642	33	Llanina Point, Aberaeron.	SN 406 598	52°12.7'N 04°20.0'W	BPat.Sem, Fspi, MytX, FvesX, Cor
642	34	SW of Gilfach-yr-Halen, Aberaeron.	SN 433 613	52°13.6'N 04°17.6'W	BPat.Cht, YG, Cor, Ver, Fser.Fser.Bo, PolAhn
642	35	S of Aberaeron.	SN 448 625	52°14.3'N 04°16.3'W	BPat.Sem, BPat.Cht, Ver.Por, Cor, XKScrR, Coff
642	37	Aberarth, Aberaeron.	SN 483 645	52°15.4'N 04°13.3'W	Fser.R, Salv, XKScrR, BLlit, FvesX, FK, Pel
642	38	S of Llanon, Aberaeron.	SN 506 668	52°16.7'N 04°11.4'W	Fves, Fspi, HalXK, Salv, Fser.Fser.Bo
642	39	Llanrhystud, Aberystwyth.	SN 526 697	52°18.3'N 04°09.7'W	BarSh, BLlit, PolAhn, FvesX, SwSed
642	40	Carreg Ti-pw, Aberystwyth.	SN 535 708	52°18.9'N 04°08.9'W	Ver.Por, BPat, XKScrR, Cor
642	41	NW of Llanddeiniol, Aberystwyth.	SN 554 742	52°20.8'N 04°07.3'W	FvesB, Salv, HalXK, SR
642	42	W of Blaenplwyf, Aberystwyth.	SN 558 758	52°21.6'N 04°07.0'W	Salv, FvesX, HalXK, FK, EntPor, Fser.Fser.Bo
642	43	S of Tanybwlch, Aberystwyth.	SN 575 796	52°23.7'N 04°05.6'W	BPat.Cht, FvesB, Fser.R, Ldig.Ldig, Cor
642	45	Aberystwyth beach.	SN 582 822	52°25.1'N 04°05.1'W	Pec
642	46	Constitution Hill shore, Aberystwyth.	SN 583 827	52°25.4'N 04°05.0'W	BPat.Cht, Ver.Ver, BPat, Salv, Ldig.Ldig, SR, Cor

Sublittoral sites					
Survey	*Site*	*Place*	*Grid reference*	*Latitude / longitude*	*Biotopes present*
626	11	NNW New Quay Head.	SN 391 628	52°14.4'N 04°21.3'W	Flu.SerHyd,
626	13	N of Carreg Ina, New Quay.	SN 401 617	52°13.8'N 04°20.4'W	Flu.HByS,
626	14	Off Carreg Gloyn, Aberaeron.	SN 436 629	52°14.5'N 04°17.4'W	SNemAdia,
634	17	NW of Aberaeron, Cardigan Bay.	SN 437 664	52°16.4'N 04°17.4'W	AfilEcor
634	18	Inshore SW of Aberystwyth, Cardigan Bay.	SN 520 752	52°21.3'N 04°10.3'W	AfilEcor
634	19	SW of Aberystwyth, Cardigan Bay.	SN 476 744	52°20.8'N 04°14.2'W	Sell
634	20	W of Llanrhystud, Cardigan Bay.	SN 434 746	52°20.8'N 04°17.8'W	FabMag
634	21	Offshore W of Llanrhystud, Cardigan Bay.	SN 399 741	52°20.5'N 04°21.0'W	EcorEns
634	35	W of Aberystwyth, Cardigan Bay.	SN 473 798	52°23.7'N 04°14.6'W	FabMag
643	23	Inshore E of New Quay, Aberaeron.	SN 396 606	52°13.1'N 04°20.8'W	FabMag
643	24	N of New Quay, Aberaeron.	SN 420 610	52°13.4'N 04°18.7'W	MCR
643	26	Offshore N of New Quay, Aberaeron.	SN 398 647	52°15.4'N 04°20.8'W	NcirBat
643	27	Inshore W of Aberaeron.	SN 427 633	52°14.7'N 04°18.1'W	IMS
643	28	Inshore N of Aberaeron.	SN 462 648	52°15.5'N 04°15.2'W	MolPol.Sab
643	29	Offshore N of Aberaeron.	SN 452 659	52°16.1'N 04°16.1'W	MCR
643	30	Offshore Aberarth, Aberaeron.	SN 443 683	52°17.4'N 04°16.9'W	IMS
643	31	Inshore N of Aberarth, Aberaeron.	SN 481 658	52°16.1'N 04°13.5'W	AfilEcor
643	32	W of Llansantffraid, Aberaeron.	SN 475 683	52°17.5'N 04°14.1'W	IMS
643	33	N of Llansantffraid, Aberaeron.	SN 500 697	52°18.3'N 04°12.0'W	Flu.SerHyd
643	34	Inshore Llanrhystud, Aberystwyth.	SN 517 700	52°18.4'N 04°10.4'W	MCR
643	35	Offshore Llanrhystud, Aberystwyth.	SN 488 718	52°19.4'N 04°13.1'W	AfilEcor

Compiled by: Paul Brazier

5 Aeron estuary (Aberaeron)

Location		
Position (centre)	SN 455 630	52°14'.5N 4°16'.7W
County	Ceredigion	
Conservation agency / area	Countryside Council for Wales	West Area

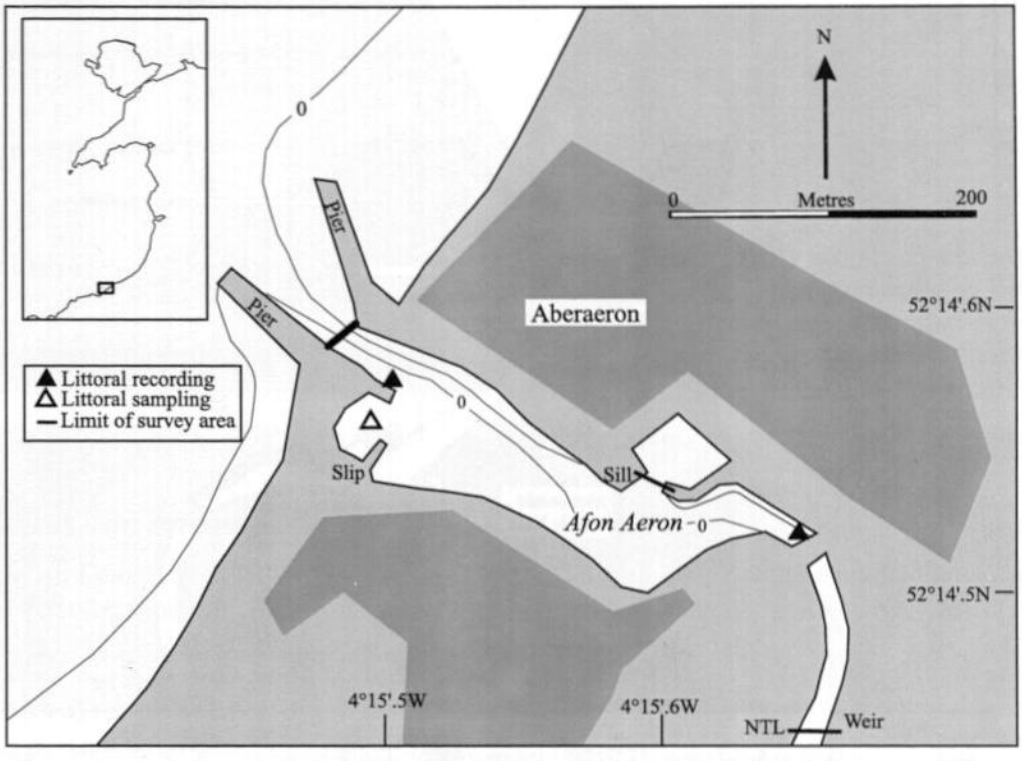

Figure 5.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Modified bar-built estuary
Length of coast	0.6 km
Area of inlet	4.5 ha total
Bathymetry	Intertidal with shallow river channel
Wave exposure	Extremely sheltered
Tidal streams	Weak
Tidal range	4.2 m spring tides; 1.8 m neap tides (New Quay)
Salinity	Variable to low

Introduction

The Aeron estuary is very small and narrow and intertidal only as far as the lowermost (A487) road bridge crossing. The estuary is largely made up of a harbour enclosed by breakwaters and quays. There are two piers at the estuary mouth and the town of Aberaeron stands on both sides of the estuary.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	1	April & June 1997	MNCR survey 642
	Habitat (biotope) mapping		May 1996	CCW survey 9.32.1
	Infaunal sampling (cores)	1	April & June 1997	MNCR survey 642

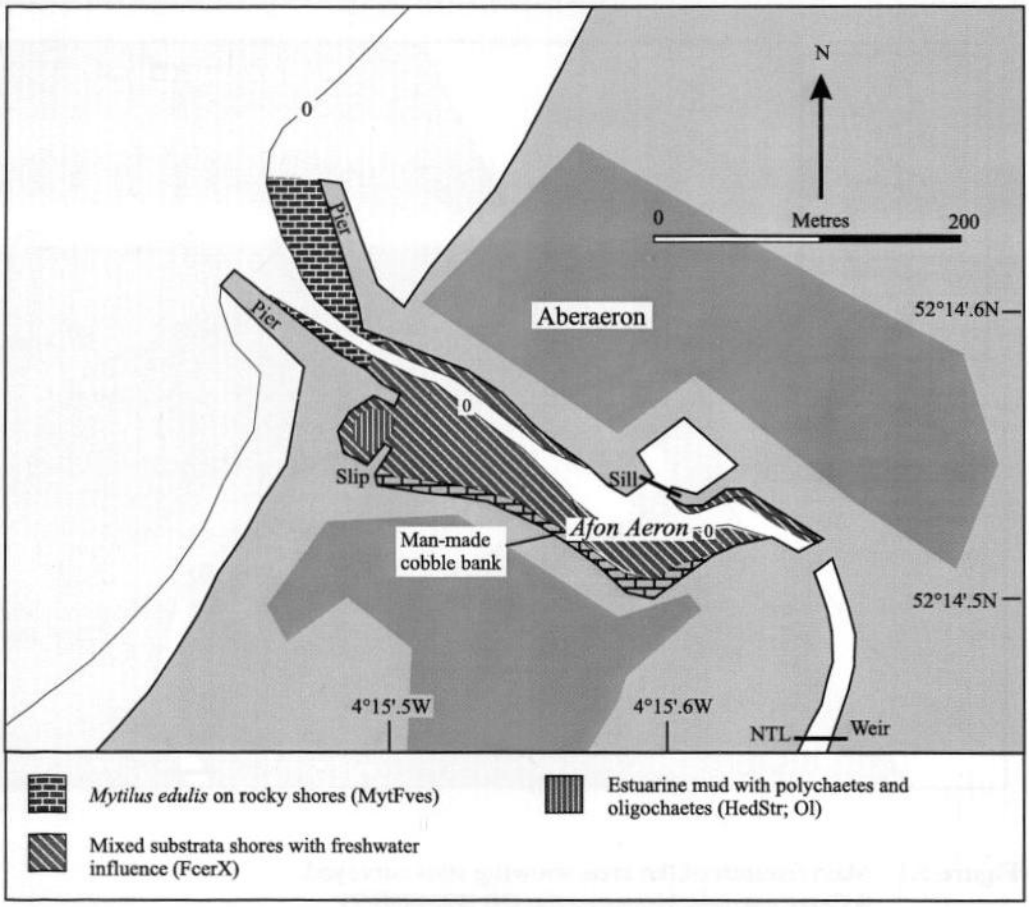

Figure 5.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 5.1 and additional field observations).

Littoral rock

The shore in the entrance channel to the estuary comprises cobbles and boulders in a coarse sand matrix and the stone walls of the breakwaters which support very few species. Those present include horned wrack *Fucus ceranoides*, the green alga *Enteromorpha* sp., barnacles *Semibalanus balanoides* and the shore crab *Carcinus maenas* (FcerX). Scattered clumps of *Fucus vesiculosus* and mussels *Mytilus edulis* (MytFves) are found on the scattered rocks at the entrance to the harbour. In the mid-estuary, silted cobbles and gravel on both shores were not sampled but had little conspicuous epifauna. The cobbles have a thick growth of the green alga *Enteromorpha* sp. In the upper reaches of the estuary, immediately above and below the road bridge, there is considerable freshwater influence and silted boulders and cobbles form a narrow shore covered with *Enteromorpha* sp. and *F. ceranoides* (FcerX).

Littoral sediment

Sediment habitats are limited to adjacent to the slipway in the mid-estuary, and may be affected by the activities of people using the slip. The area is extremely sheltered by the harbour walls and mud builds up here through deposition. The mud is particularly soft and anoxic with a high proportion of organic debris. The only species found in the mud are the polychaetes *Hediste diversicolor* and *Streblospio shrubsolii* (HedStr).

Nature conservation

No nature conservation designations at present.

Human influences

Coastal developments and uses

The Aeron estuary has been highly modified from its natural state, now being completely enclosed with concrete walls on both shores with a slipway and small harbour. The harbour is used by leisure boats, predominantly small motorboats and small yachts, with moorings throughout the mid-estuary. There are two piers at the estuary mouth and the town of Aberaeron surrounds the estuary. The A487 road bridge crosses the estuary and a footpath follows the western shore. At the time of writing, there was consent to discharge untreated sewage into the Aeron estuary.

References and further reading

Richards, A., Bunker, F. St.P., Foster-Smith, R. 1996. Handbook for marine intertidal Phase 1 and SSSI habitat mapping. *Countryside Council for Wales Natural Sciences Report*, No. 95/6/1.

Sites surveyed

Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude / longitude*	*Biotopes present*
642	36	Aberaeron estuary	SN 455 630	52°14.5'N 04°15.7'W	HedStr, FcerX

Compiled by: Dora Nichols

6 Rheidol and Ystwyth estuaries (Aberystwyth)

Location		
Position (centre)	SN 59 80	52°24'.4N 4°5'.2W
County	Ceredigion	
Conservation agency/area	Countryside Council for Wales	West Area

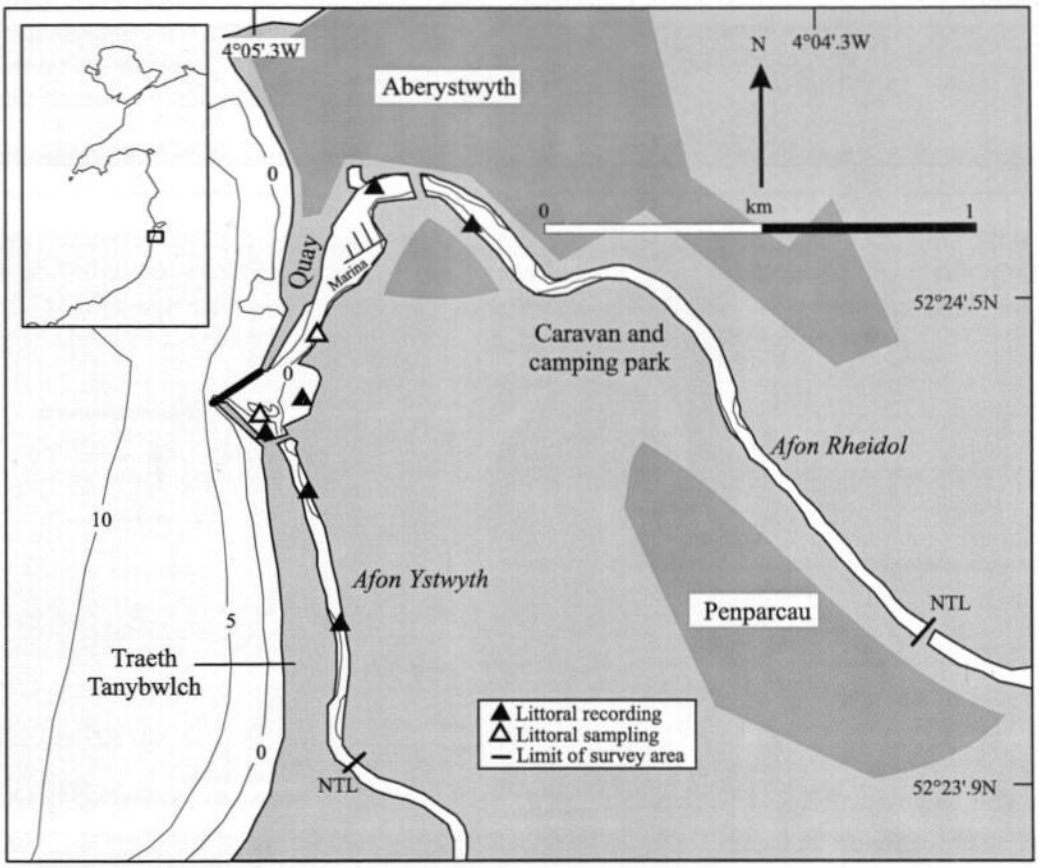

Figure 6.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Bar-built estuary
Length of coast	7.1 km shore length, 2.4 km channel length
Area of inlet	18 ha total, 5 ha intertidal
Bathymetry	Intertidal with shallow river channel
Wave exposure	Sheltered to extremely sheltered
Tidal streams	Weak
Tidal range	4.3 m springs; 1.9 m neaps (Aberystwyth)
Salinity	Variable to reduced

Introduction

The estuary at Aberystwyth is formed from the confluence of the rivers Ystwyth and Rheidol which are tidal for 1 km and 2 km inland respectively. The Ystwyth estuary is very small and has been deflected by the shingle spit, Traeth Tanybwlch, which extends northwards from Allt Wen cliffs. The

northern end of the spit has been undercut by the river while southwards the spit is more sandy and some foredunes have developed (Buck 1993). This part of the estuary is included in the Allt Wen a Traeth Tanybwlch SSSI. The Rheidol estuary is also very small and is dominated by the port of Aberystwyth in the lower and mid-estuary. The lower reaches of both the Rheidol and Ystwyth drain to stony channels at low water, and are characterised by sandy mud, with more cobbles in the upper reaches.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	1	April 1997	MNCR survey 642
	Infaunal sampling (cores)	1	April 1997	MNCR survey 642

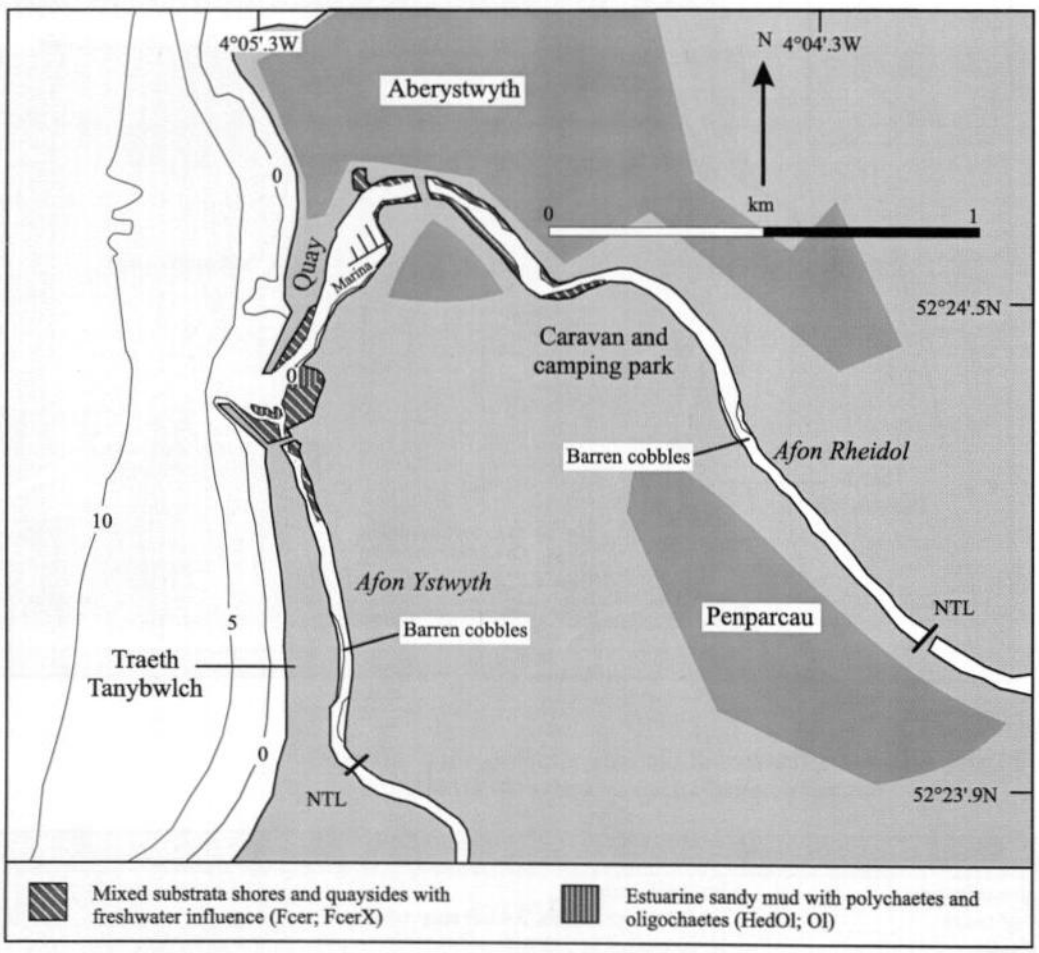

Figure 6.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 6.1 and additional field observations).

Littoral rock

Both the estuaries contain low numbers of typically estuarine species that are tolerant of variable and low salinity conditions, such as horned wrack *Fucus ceranoides* and *Enteromorpha* sp. The upper reaches of both the Rheidol and Ystwyth are characterised by cobbles and pebbles with no obvious

marine fauna or flora except for very small patches of green alga *Enteromorpha* sp. in the littoral fringe (?Ent). In the Ystwyth, mid-estuarine cobbles and pebbles have a sparse growth of horned wrack *Fucus ceranoides* with little other biota (FcerX). On both sides of the mid-Rheidol estuary, near the lower (A487) road bridge, silty areas of cobbles, pebbles and gravel support small patches of *Fucus ceranoides* (FcerX). Below the road bridge, narrow shores of cobbles and pebbles are covered by dense *F. ceranoides*, *Enteromorpha* sp. and the encrusting red alga *Hildenbrandia* sp. (FcerX). A broad basin in the lower estuary has been dredged for marina facilities, entirely replacing the muddy sandflats. At the base of piers where the two estuaries join and flow into Cardigan Bay, the community is dominated by *F. ceranoides* (Fcer). Steep and vertical bedrock opposite the estuary entrance is dominated by lichens such as *Verrucaria maura* and *Lecanora atra* (YG) at the top of the shore, with very dense *F. ceranoides* below this (Fcer). Cobbles and pebbles adjacent to the bedrock were also densely colonised by *F. ceranoides* (FcerX).

Littoral sediment

On the lower shore of the lower estuary east bank of the Rheidol, before it converges with the Ystwyth, soft anoxic sandy mud is dominated by the sparse polychaetes *Capitella* sp. and *Pygospio elegans* and oligochaetes *Tubificoides pseudogaster* (HedOl). Juvenile mussels *Mytilus edulis* are also present. Where the rivers Rheidol and Ystwyth converge, rippled mobile medium-fine sand over cobbles and pebbles is characterised by enchytraeid oligochaetes and *M. edulis* (O1; MytX).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Allt Wen a Traeth Tanybwlch	SSSI; GCR	SN 572 788 - SN 579 807	Biological and geomorphological.
Ceredigion	HC	SN 532 702 - SN 556 746	Coastal scenery.

Human influences

Coastal developments and uses

The Afon Rheidol is more developed than the Afon Ystwyth, with the town of Aberystwyth on both banks and a camping and caravan park on the southern shore. There are two large road bridges crossing the river.

By comparison, the Afon Ystwyth has undergone little development and is mostly surrounded by grazing land with only one small bridge and a footpath along the western shore.

Most of the activities on the estuaries involve watersports, and take place mainly in the Rheidol and where the estuaries converge, although canoeists use both rivers. Bathing and beach recreation including trial-biking and horse-riding take place along the Traeth Tanybwlch spit to near the estuary mouth.

Marine developments

The lower estuary is dominated by the port of Aberystwyth and a 104-berth marina development, completed in 1995. Here the estuary banks have been replaced by concrete walls with slipways, a boat park and moorings. These concrete and boulder walls reinforce most of the upper shores along the Rheidol.

There are no sewage or industrial outfalls into the estuaries, and water quality is classed as Grade A (highest quality), although the upper and middle reaches of both rivers formerly supported extensive lead-mining. Toxic metal runoff from mining works at Grogwynion on the Afon Ystwyth has

significantly influenced the vegetation on the floodplains downstream, with possible consequential impacts on the stability of the riverbanks (Higgs 1997).

References and further reading

Buck, A.L. 1993. *An inventory of UK estuaries. Volume 2. South-west Britain*. Peterborough, Joint Nature Conservation Committee.

Countryside Council for Wales. 1993. *Welsh estuaries review*. Bangor, Countryside Council for Wales (Science report).

Evans, R.G. 1947. The intertidal ecology of Cardigan Bay. *Journal of Ecology*, 34: 273-309.

Fowles, A.P. 1989. The Coleoptera of shingle banks on the River Ystwyth, Dyfed. *Entomologist's Record and Journal of Variation*, 101: 209-221.

Higgs, G. 1997. Afon Ystwyth, Ceredigion (SN 702718-SN 723721) *In*: *Fluvial geomorphology of Great Britain, ed. by* K.J. Gregory, 148-150. London, Chapman & Hall for Joint Nature Conservation Committee (Geological Conservation Review series, No. 13).

Sites surveyed

Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
642	44	Rheidol and Ystwyth estuaries, Aberystwyth	SN 580 810	52°24.4'N 04°05.2'W	HedOl, YG, Ol, Fcer, FcerX, MytX

Compiled by: Dora Nichols

7 Clarach Bay to Mochras Point (Sarnau)

Location		
Position (centre)	SH 360 220	52°46'N 4°26'W
County	Ceredigion; Gwynedd	
Conservation agency/area	Countryside Council for Wales	North-west Area & West Area

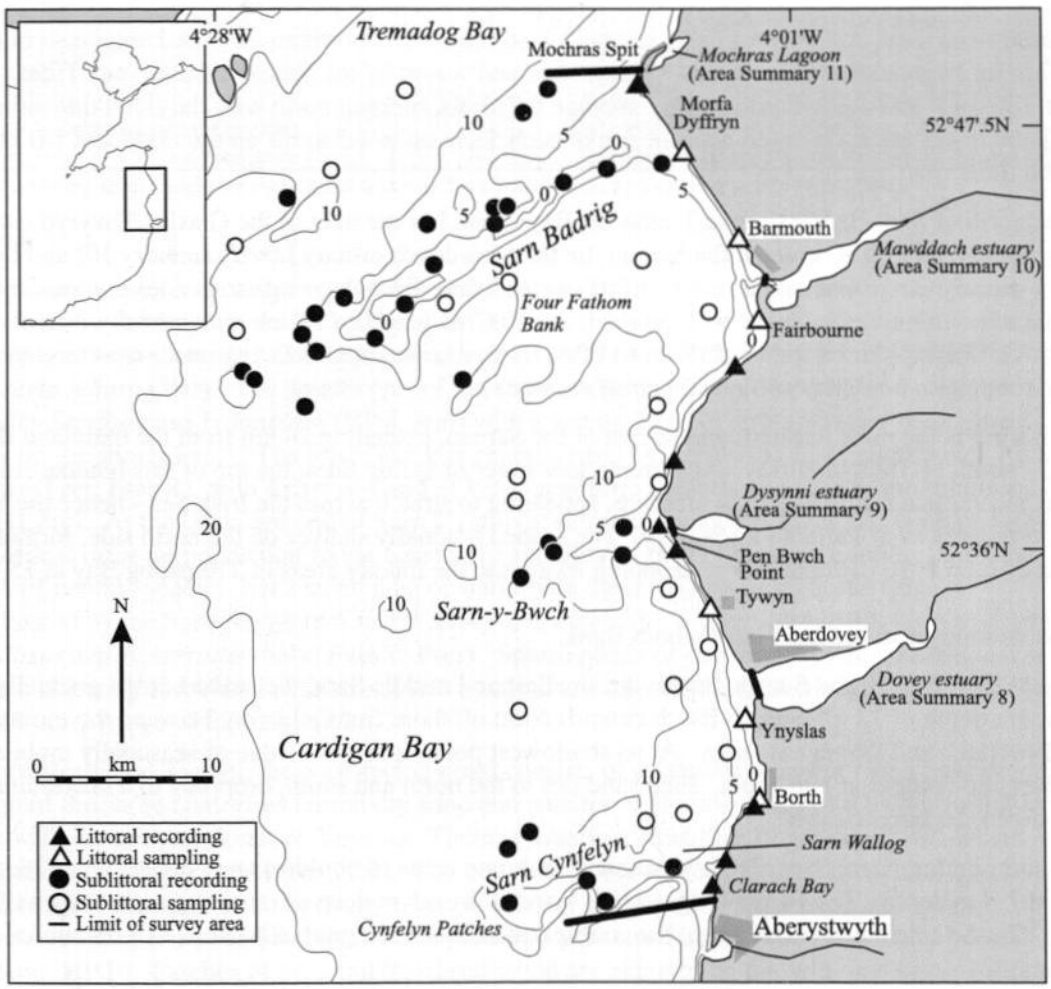

Figure 7.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Linear open coast, offshore shallows
Length of coast	45 km
Bathymetry	Maximum 20 m depth within 38 km of the shore
Wave exposure	Exposed to sheltered
Tidal streams	Moderately strong to negligible
Tidal range	4.3 m springs; 2.2 m neaps (Barmouth)
Salinity	Fully marine

Introduction

In the northern half of Cardigan Bay (Bae Ceredigion) the seabed is divided by three shallow boulder reefs known as the Sarnau, which extend south-west from the mainland to as much as 24 km offshore. The Sarnau are thought to be relics of glacial moraine deposited during the last ice-age and washed clean by the sea to leave mounds and ridges of boulders and cobbles (Foster 1970). They are considered to be unique post-glacial, submerged features within the British Isles and provide a variety of tidal stream and wave action conditions with seasonally mobile and scoured boulders and cobbles. The greatest swells enter Cardigan Bay from the south-west; the most exposed areas therefore are the southern and western edges of each Sarn. Cardigan Bay is predominantly less than 20 m deep and is sheltered from large Atlantic swells by Ireland's land mass. The northern sides and areas east of each Sarn are further sheltered from the prevailing wind and waves by the Sarnau themselves. Tidal streams in mid- and north Cardigan Bay average 0.5 knots, running north with the flood tide although the tidal streams are accelerated over the top of each Sarn, up to 1.5 knots on the flood and 1.0 knot on the ebb tide.

To the north of Sarn Badrig, on the Tremadog Bay coast, lies the inlet of the Glaslyn/Dwyryd estuary (*area summary* 12) and between the Sarnau, lie the Mawddach estuary (*area summary* 10) and the Dovey estuary (*area summary* 8). The influx of freshwater from these estuaries does not appear to significantly influence the salinity of the sea water in Cardigan Bay, which remains fully marine. South-west facing shores are of medium and fine sand, whereas shores facing north-west tend to be more stony, with boulder, cobble and pebble shores.

Sarn Badrig is the most northern and largest of the Sarnau, extending 24 km from the mainland shore into the south of Tremadog Bay. At extreme low water of spring tides, the top of this boulder ridge breaks the surface for up to 16 km offshore, appearing to stretch across the Irish Sea - hence the Welsh name translates as St Patrick's Causeway. The seabed gradually shelves on the north side, forming shoals of sand at 10 m depth before dropping away into the muddy areas of Tremadog Bay at 15-20 m depth (*area summary* 13). On the south side, the seabed drops steeply to sand at 8 m depth and forms extensive sand shoals called Four Fathom Bank.

Between Sarn Badrig and Sarn-y-Bwch, the smallest and middle Sarn, the seabed drops gradually to a maximum depth of 12 m. Sarn-y-Bwch extends 6 km offshore from mid-way between the mouths of the Mawddach and Dovey estuaries. At its shallowest point, it forms a ridge of seasonally mobile boulders and cobbles at 1 m depth. Fine sand lies to the north and south, dropping to a maximum of 17 m depth, 16 km offshore.

The southernmost Sarn, Sarn Cynfelyn consists of broad areas of boulders and cobbles up to 2 km wide at 2-3 m depth. The 14 km-long ridge is bisected by a 5 m deep channel approximately half-way along. On the south side of the ridge, the cobble and sand seabed gradually drops to a maximum depth of 15 m.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	6	April 1997	MNCR survey 642
	Habitat (biotope) mapping		May 1996, April-July 1997	CCW surveys 9.26.1, 9.25.1, 9.23.1, 9.22.1, 9.21.1, 9.19.1
	Infaunal sampling - cores	6	April 1997	MNCR survey 642
Sublittoral	Recording (epibiota)	7	Sept 1984	Hiscock (1985)
		20	July 1986	Hiscock (1986)
		6	Sept 1993	Bunker (1994)
		13	July 1995	MNCR survey 630
		7*	August 1998	CCW survey 773
	Infaunal sampling - cores	9	July 1995	MNCR survey 630
	van Veen grab	8	July 1989, July 1991	Mackie, Oliver & Rees (1995)

* Monitoring trials - includes two transects across Sarn Badrig with 31 sampling points (= habitats).

Littoral

Bedrock shores are found only between Clarach Bay and Borth at the southern extreme of Area 7. The shores here are level platforms backed by shale cliffs, with many ridges and undulations produced by the steeply-tilted rock strata. The upper shore consists of broken rock with patches of black lichen *Verrucaria maura* (Ver). The greater part of the shore is dominated by limpets *Patella vulgata* and barnacles *Semibalanus balanoides* (BPat.Sem) with a narrow band of spiral wrack *Fucus spiralis* further up the shore (Fspi). The lower shore is characterised by a covering of serrated wrack *Fucus serratus* (Fser; Fser.R), with a narrow band of kelp *Laminaria digitata* recorded in the sublittoral fringe (Ldig). At the landward end of Sarn Cynfelyn, smooth, rounded pebbles and cobbles form a symmetrical ridge perpendicular to the coast. The mobility of the pebbles and cobbles limits the growth of benthic species, but a small area of stability in the lee (north side) of the ridge is consolidated by the honeycomb reef worm *Sabellaria alveolata*, supporting fucoids such as *Fucus vesiculosus* and *F. serratus* (Salv; FvesX; Fser). Sparse plants of dabberlocks *Alaria esculenta*, a seaweed normally associated with strong wave action, are atypical colonisers of the larger cobbles in the sublittoral fringe of the ridge (Ala).

Between Borth and Tywyn, the west-facing coast consists of extensive plains of clean, mobile sand. The top of the shore comprises barren dry sand and patches of shingle storm beach (BarSnd) that merge with the primary dunes of Ynyslas. There is usually a strandline of seaweed with dense aggregations of talitrid amphipods (Tal). The mid- and lower shores of clean, moderately mobile sand have infaunal communities comprising robust species of amphipods *Pontocrates arenarius*, *Pontocrates altamarinus* and *Bathyporeia* spp. and polychaetes *Nephtys cirrosa* and *Scolelepis squamata* (AP.P). Patches of peat and fossilised wood are exposed on the mid- and lower shore with relict piddock holes and a covering of the relatively sand-scour tolerant alga *Polysiphonia fucoides* (?RPid). The sandy shores further north between Fairbourne and Morfa Dyffryn are characterised by similar communities, although there are higher densities of bivalves, particularly *Angulus tenuis* and *Donax vittatus*. Both species are present in the adjacent shallow sublittoral.

Between Tywyn and Fairbourne, the predominant boulder and cobble habitats have communities that are characteristic of sand-scour conditions. The upper shore is covered by mobile pebbles, with no obvious associated biota (BarSh); patches of *F. spiralis* (Fspi) and *F. vesiculosus* (Fves) are present on the more stable rocks of the upper and mid-shore. Often, the boulders and cobbles on the mid- and lower shore are consolidated by *S. alveolata* reefs, and the sand-bottomed rockpools which form amongst these reefs contain dense stands of sand-tolerant red algae including *Ahnfeltia plicata*, *Polyides rotundus*, *Rhodomela confervoides*, *Polysiphonia fucoides* and *Audouinella* spp. (SwSed). Winkles *Littorina saxatilis* and *Littorina littorea* are found in high abundance throughout these mixed substratum shores (BLlit). At Pen Bwch Point, dense mussels *Mytilus edulis* cover the rocks (MytX) in the deltaic outflow of the Dysynni estuary (*area summary* 9). Some rocks are also covered by

F. serratus (MytFR). The steep sides of these boulders have patches of the sponges *Halichondria panicea* and *Hymeniacidon perleve*, and hydroids *Obelia dichotoma* on the lower shore.

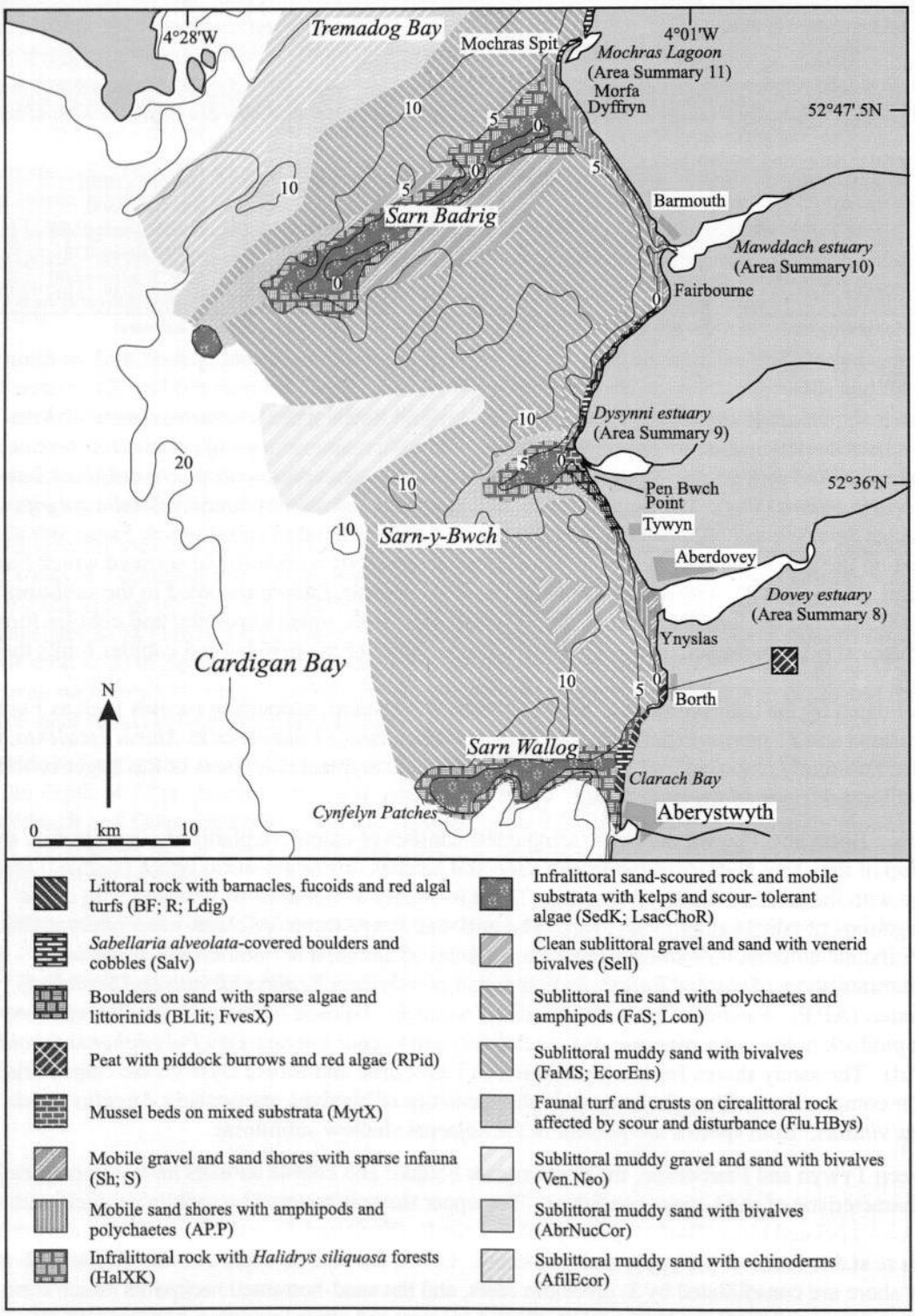

Figure 7.2 Indicative distribution of the main biotopes in the area (based on data from survey sites shown in Figure 7.1, cited literature and additional field observations).

Sublittoral

Long-lived species such as *Laminaria hyperborea* and delicate sessile animals cannot colonise the more unstable and sand-scoured cobble habitats which comprise the bulk of the Sarns. Therefore, communities that develop on the Sarnau typically comprise ephemeral species that grow rapidly during the summer or are very robust species that resist most of the wave-action of winter storms. However, even the most robust species lose against violent winter storms which can shift whole sections of the Sarnau reefs. Sarn Badrig has the shallowest and most extensive rocky habitats of the three Sarnau, although the same biotope types appear to be represented on all three reefs.

Mobile cobbles down to 8 m depth are colonised by dense bootlace weed *Chorda filum* and small barnacles *Balanus crenatus* (LsacChoR). This biotope is found on the boulders and cobbles exposed to a high degree of wave action on the narrow crest of Sarn Badrig and the shallow patches of the other Sarnau at 1 m depth. Where wave action is likely to be moderated by the reefs, as on the landward end of Sarn-y-Bwch (1.5 m depth off Pen Bwch Point) and Cynfelyn Patches (4 m depth on Sarn Wallog) the cobbles with *Chorda filum* are also densely covered by mussels *Mytilus edulis*. Small amounts of the fast-growing sugar kelp *Laminaria saccharina* are found at Mochras Spit, toward the landward end of Sarn Badrig, where there is reduced exposure to wave action. Hiscock (1986) found a greater abundance of *L. saccharina*, as well as *L. hyperborea* and *Laminaria digitata* (XKScrR) at sites throughout the length of Sarn Badrig down to 4 m deep, indicating that the abundance and species present may vary on a yearly basis. Better-developed kelp forests and mixed kelp forests with large *L. hyperborea* (Lhyp.Ft and XKScrR) were found on the western parts of the Sarns during monitoring trials in 1998 (CCW information). On more stable boulders and cobbles at depths greater than 4 m, a more species-rich turf of algae is present, characterised by sea oak *Halidrys siliquosa* and filamentous red algae *Polysiphonia elongata*, *Plocamium cartilagineum* and *Brongniartella byssoides* (HalXK). The algal turf, in places, is densely covered with hydroids such as *Aglaophenia pluma* and the bryozoans *Bowerbankia citrina* and *Amathia lendigera*. This biotope is distributed either side of each Sarn, but is most extensive on the north side of Sarn Badrig. The red algal turf with *H. siliquosa* becomes sparse below 10 m depth and is replaced by a turf of hydroids and bryozoans, including *Hydrallmania falcata*, *Aglaophenia pluma*, *Nemertesia* spp., *Scrupocellaria* spp., *Flustra foliacea*, *Crisia* spp. and *Bugula* spp. (Hiscock 1985, 1986) (SNemAdia; Flu.SerHyd). Some filamentous algae such as *Ceramium* spp., *P. elongata* and the brown alga *Desmarestia* spp., grow down to 10 m depth. Hiscock describes a deeper boulder and cobble habitat with a rich faunal turf of sponges, hydroids and bryozoans between 10 m and 20 m depth, found predominantly off the west end of Sarn Badrig (Flu.HBySS). Patches of boulders and cobbles on both sides of the crest of Sarn Badrig are surrounded by very mobile shell gravel that has no apparent infauna. Patches of sand, mainly on the north side of the Sarn, are more stable and have an infauna characterised by razor shells *Ensis* spp. and the heart urchin *Echinocardium cordatum* (EcorEns). Without more extensive survey of the seabed, the extent of these patches of sediment cannot be established. Transition areas between the dense cobbles and sediment have a sparse flora of *H. siliquosa* and scour-resistant algae such as *Ahnfeltia plicata* and *Halurus equisetifolius* (HalXK).

There are large expanses of clean, well-sorted fine sand between the Sarnau, characterised by the sand mason worm *Lanice conchilega*, razor shells *Ensis* spp. and the heart urchin *Echinocardium cordatum* (EcorEns). To the north of both Sarn Cynfelyn and Sarn-y-Bwch, the fine sand habitat is rich in bivalves; the nationally scarce crab *Thia scutellata* was recorded at these locations. North and south of the mouths of the Dovey and Mawddach estuaries, in less than 10 m depth, the abundance of *L. conchilega* is high and is also associated with the presence of the bivalve *Donax vittatus* (Lcon). Further offshore from the estuary mouths, where there is a small mud fraction in the sediment, *D. vittatus* is replaced by another bivalve *Spisula elliptica* (Sell). To the north of Sarn-y-Bwch, at 15 m depth, muddy gravel is characterised by a species-rich infauna including the polychaetes *Pholoe* spp., *Glycera lapidum*, *Mediomastus fragilis* and *L. conchilega*, the bivalves *Mysella bidentata*, *Abra alba* and *Mya truncata*, holothurians *Neopentadactyla mixta* and *Leptosynapta inhaerens*, and the ascidian *Molgula occulta* (coated with sand), with an epifauna of sparse hydroids *Obelia dichotoma*,

and keel worms *Pomatoceros triqueter* attached to small stones (Ven.Neo). The extent of this mixed sediment is not known.

Off Mochras Point (to the north of Sarn Badrig) and in 10 m depth of water south of Sarn Badrig, the fine sand has an infauna characterised by *L. conchilega*, *Spiophanes bombyx*, *Magelona filiformis*, *Chaetozone setosa*, the bivalves *M. bidentata* and *Ensis ensis*, the brittlestars *Amphiura brachiata* and *Ophiura ophiura*, and the holothurian *Labidoplax digitata* (?EcorEns). North of Sarn-y-Bwch a similar infaunal community is also present inshore, but there is not the same high abundance of *L. conchilega* (FabMag). North of Sarn Badrig, in deeper water up to 23 m depth, Mackie, Oliver & Rees (1995) found muddier sediments with a community characterised by polychaetes including *Nereiphylla lutea*, *Levinsenia gracilis*, *Owenia fusiformis*, the oligochaete *Tubificoides amplivasatus*, the bivalves *M. bidentata* and *A. alba*, brittlestars *Amphiura filiformis* and the holothurian *L. inhaerens* (AfilEcor).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Pen Llŷn a'r Sarnau/Lleyn Peninsula and the Sarnau	cSAC	SH 50 30	Estuaries; Reefs
Ceredigion	HC	SN 586 842 - SN 602 886	Coastal scenery
Cors Fochno and Dyfi	Ramsar	SN 65 95	Migratory birds.
Borth to Clarach	pSSSI	SN 840 587 – SN 900 600	Marine intertidal
Glannau Tonfanau I Friog	pSSSI; GCR	SH 562 033 – SH 610 119	Geological; marine biological (cliffs and intertidal)
Morfa Dyffryn	SSSI	SH 550 250	Ornithological.
Broadwater	SSSI	SH 582 027	Ornithological.
Snowdonia	NP	N/A	

Human influences

Coastal developments and uses

There is little coastal development in mid-Wales; that which is present is restricted to coastal resorts and sea defence walls adjacent to residential areas. The main centres of Borth, Aberdovey, Tywyn and Barmouth are primarily summer resorts which experience a seasonal increase in population. They have sea front promenades and at Aberdovey (population c. 1000) and Barmouth (population c. 2000), some small fishing vessels, yachts and pleasure-boats use quays and moorings at the mouths of the estuaries. The sand dunes at Ynyslas, together with an excellent bathing beach, attract a large number of people to this part of the Area, putting considerable pressure on the relatively sensitive and fragile dunes and wetlands. An active management plan for the dunes is in effect, including the transplanting of marram grass *Ammophila arenaria*. Boardwalks have been constructed on the paths to the beach which reduce trampling on the dune flora thus reducing erosion. There is also a visitors' centre and shop at the reserve. Large expanses of sand dunes are also present north of Aberdovey and at Mochras; both sites are popular for walking.

There are few sewage outfalls due to the low coastal population. Recent years have seen the improvement of most of these outfalls with a greater degree of sewage treatment. At the time of writing, sea outfalls at Aberdovey, Tywyn and Barmouth discharged screened and macerated sewage, whilst sewage outfalls at Fairbourne and Llanbedr also had primary treatment.

Marine uses

Sea angling is popular from Aberystwyth harbour, Aberdovey and Barmouth during the summer, the shallow hard grounds of the Sarnau providing good angling sites. Other boating activities from these harbours include yachting, dinghy sailing and pleasure cruisers. In addition, water skiing and windsurfing are popular activities, although these are generally undertaken within close proximity of the estuary mouths.

Commercial fishing is limited to potting for lobsters *Homarus gammarus* and whelks *Buccinum undatum* over the shallow hard ground of the Sarnau and fixed net fishing for rays *Raja* sp., dogfish *Scyliorhinus canicula*, turbot *Psetta maxima*, brill *Scophthalmus rhombus* and bass *Dicentrarchus labrax* between the Sarnau.

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Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).
Survey 125. July 1986 mid-Wales sarns (reefs): Sarn Badrig, Sarn-y-Bwch and Cynfelyn Patches, sublittoral survey (Hiscock 1986).
Survey 498. September 1993, Sarn Badrig reef, sublittoral survey (Bunker 1994).
Survey 630. 1995 MNCR Sarnau of Cardigan Bay, sublittoral survey (MNCR, unpublished data).
Survey 634. 1989-91 BIOMÔR, benthic biodiversity of the southern Irish Sea, sublittoral survey (Mackie, Oliver & Rees 1995).
Survey 773. 1998 CCW monitoring trials survey in Tremadog Bay and the Sarns reefs, sublittoral survey.

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
642	47	N Clarach Bay, Aberystwyth.	SN 585 840	52°26.1'N 04°04.9'W	BPat.Sem, Fspi, Asc.Asc, Fser.Fser, FK, EntPor, Cor, Fser.Fser.Bo
642	48	Sarn Cynfelyn, Aberystwyth.	SN 585 857	52°27.0'N 04°04.9'W	FvesX, Ala, Salv, Fser.Fser.Bo
642	49	Upper Borth, Aberdyfi.	SN 603 888	52°28.7'N 04°03.4'W	Ver.Por, Pel, BPat, Salv, MytFves, Fser.R, Ldig.Ldig, FK
642	50	Beach near Borth Coast Guard Station, Aberdyfi.	SN 607 891	52°28.9'N 04°03.0'W	RPid, AEur, BarSnd, AP.P
642	51	W of Ynyslas dunes, Aberdyfi.	SN 598 942	52°31.6'N 04°04.0'W	Tal, AP.P
642	52	S Tywyn beach, Aberdyfi.	SN 581 998	52°34.6'N 04°05.6'W	AP.P
642	53	Aber Dysynni, Aberdyfi.	SH 562 031	52°36.3'N 04°07.4'W	BLlit, MytX, MytFR
642	55	Llangelynin beach, Barmouth.	SH 567 063	52°38.1'N 04°07.0'W	BPat.Sem, BarSh, Fves, Fspi, Rho, SwSed, Cor, PolAhn
642	56	N Llwyngwril Beach, Barmouth.	SH 595 017	52°35.6'N 04°04.4'W	BarSh, Fves, SwSed, Salv, EntPor
642	57	Fairbourne beach, Barmouth.	SH 610 133	52°41.9'N 04°03.4'W	BarSh, BarSnd, AP.P
642	58	N of Llanaber (shore), Barmouth.	SH 592 179	52°44.4'N 04°05.1'W	AP.P, Ent
642	59	S Morfa Dyffryn, Harlech.	SH 568 227	52°46.9'N 04°07.4'W	AP.P, Tal

Sublittoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
125	1	Sarn Badrig Causeway Buoy, mid-Wales Sarns.	SH 374 128	52°41.3'N 04°24.3'W	Flu.HByS, SNemAdia, Mob
125	2	Cynfelin Patches, mid-Wales Sarns.	SN 483 861	52°27.1'N 04°13.9'W	Urt.Urt, LsacChoR
125	3	Cynfelin Patches N, mid-Wales Sarns.	SN 488 869	52°27.5'N 04°13.5'W	HalXK
125	4	Sarn Badrig West Prong, mid-Wales Sarns.	SH 395 138	52°41.8'N 04°22.4'W	BarSh, XKScrR, EphR, HalXK, FoR
125	5	Sarn Badrig West End Drying, mid-Wales Sarns.	SH 431 144	52°42.2'N 04°19.3'W	LsacChoR, XKScrR, PolAhn
125	6	Sarn Badrig, NW Centre Reef, mid-Wales Sarns.	SH 482 192	52°44.9'N 04°14.9'W	IGS, HalXK
125	7	Sarn Badrig, Centre Reef, mid-Wales Sarns.	SH 486 188	52°44.7'N 04°14.5'W	LsacChoR, XKScrR, PolAhn, HalXK
125	8	Sarn Badrig, Hollow W of Centre Reef A, mid-Wales Sarns.	SH 453 178	52°44.1'N 04°17.4'W	EcorEns
125	9	Sarn Badrig, hollow W of Centre Reef B, mid-Wales Sarns.	SH 453 178	52°44.1'N 04°17.4'W	IGS, IMS
125	10	Sarn Badrig, hollow W of Centre Reef C, mid-Wales Sarns.	SH 453 178	52°44.1'N 04°17.4'W	LsacX
125	11	N of North Shoals, mid-Wales Sarns.	SH 489 236	52°47.3'N 04°14.4'W	IGS
125	12	North Shoals, mid-Wales Sarns.	SH 493 117	52°40.9'N 04°13.7'W	EcorEns
125	13	North Shoals South Reef, mid-Wales Sarns.	SH 496 210	52°45.9'N 04°13.7'W	Flu.SerHyd, EcorEns, HalXK
125	14	Between West and South Prongs, mid-Wales Sarns.	SH 417 130	52°41.5'N 04°20.5'W	XKScrR, HalXK
125	15	S of West Prong, mid-Wales Sarns.	SH 391 112	52°40.5'N 04°22.7'W	IMS, ErSPbolSH
125	16	N of West Prong, mid-Wales Sarns.	SH 406 144	52°42.2'N 04°21.5'W	XKScrR, HalXK
125	17	Sarn-y-Bwch, West End A, mid-Wales Sarns.	SH 507 017	52°35.5'N 04°12.1'W	Flu.HByS, IGS
125	18	Sarn-y-Bwch, West End B, mid-Wales Sarns.	SH 508 016	52°35.5'N 04°12.1'W	SNemAdia, CMS
125	19	Sarn-y-Bwch, S of Centre Reef, mid-Wales Sarns.	SH 534 021	52°35.8'N 04°09.8'W	Flu.HByS, LsacChoR, EphR, HalXK
125	20	Tail Patch, mid-Wales Sarns.	SH 466 108	52°40.4'N 04°16.0'W	EcorEns

Sublittoral sites continued

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
498	1	Sarn Badrig M1, Sarn Badrig reef.	SH 505 202	52°45.5'N 04°12.8'W	PomByC, LsacChoR
498	2	Sarn Badrig M3, Sarn Badrig reef.	SH 487 192	52°44.9'N 04°14.4'W	HalXK
498	3	Sarn Badrig M5, Sarn Badrig reef.	SH 451 164	52°43.3'N 04°17.5'W	Flu.HBysS
498	4	Sarn Badrig - West Prong East M7, Sarn Badrig reef.	SH 400 129	52°41.4'N 04°21.9'W	Flu.SerHyd, IMS
498	5	Sarn Badrig M9, Sarn Badrig reef.	SH 372 123	52°41.0'N 04°24.4'W	XKScrR
498	6	Sarn Badrig, 2 Km NE of Buoy, Sarn Badrig reef.	SH 399 141	52°42.0'N 04°22.1'W	PomByC, XKScrR
630	1	Outer Patch, Sarn Cynfelyn.	SN 481 844	52°26.1'N 04°14.0'W	LsacChoR
630	2	Cynfelyn Patches, Sarn Cynfelyn.	SN 520 855	52°26.8'N 04°10.6'W	LsacChoR, EphR
630	3	W Four Fathom Bank, Barmouth.	SH 480 156	52°43.0'N 04°14.9'W	Lcon
630	4	S of Sarn Badrig.	SH 451 150	52°42.6'N 04°17.5'W	Lcon
630	5	W of Tywyn, Aberdyfi.	SH 568 009	52°35.2'N 04°06.8'W	EcorEns
630	6	NW Aberdyfi.	SN 586 975	52°33.4'N 04°05.1'W	NcirBat
630	7	S of Llwyngwril Shoal, Sarn-y-Bwch.	SH 559 087	52°39.4'N 04°07.7'W	NcirBat
630	8	SE of Tail Patch, Sarn-y-Bwch.	SH 491 064	52°38.0'N 04°13.7'W	Ven.Neo
630	9	Bwch Buoy, Sarn-y-Bwch.	SH 491 004	52°34.8'N 04°13.5'W	SNemAdia
630	10	NE of Tonfanau, Sarn-y-Bwch.	SH 559 054	52°37.6'N 04°07.6'W	FabMag
630	11	Pen Bwch Point, Sarn-y-Bwch.	SH 551 033	52°36.5'N 04°08.4'W	LsacChoR
630	12	N of Aberdyfi Outer Buoy.	SN 570 953	52°32.2'N 04°06.4'W	Sell
630	13	SW of Craig yr Wylfa, Sarn Cynfelyn.	SN 570 877	52°28.1'N 04°06.3'W	EcorEns
630	14	Sarn Wallog, Sarn Cynfelyn.	SN 567 856	52°27.0'N 04°06.5'W	LsacChoR
630	15	Mid-Cynfelyn Patches, Sarn Cynfelyn.	SN 529 852	52°26.6'N 04°09.8'W	HalXK
630	16	W of Barmouth, Sarn Badrig.	SH 556 166	52°43.6'N 04°08.2'W	EcorEns
630	17	E of Sarn Badrig.	SH 531 216	52°46.3'N 04°10.6'W	HalXK
630	18	Bemar Bank, Sarn Badrig.	SH 558 223	52°46.7'N 04°08.2'W	HalXK
630	19	Barmouth Bay.	SH 588 129	52°41.7'N 04°05.3'W	EcorEns
630	20	Offshore of Borth, Aberdyfi.	SN 548 870	52°27.7'N 04°08.2'W	SNemAdia, EcorEns
630	21	Off Borth Sands, Aberdyfi.	SN 598 920	52°30.4'N 04°03.8'W	EcorEns
634	22	Tremadog Bay, Cardigan Bay.	SH 307 154	52°42.6'N 04°30.3'W	AbrNucCor
634	23	Tremadog Bay, Cardigan Bay.	SH 375 148	52°42.4'N 04°24.2'W	SpiSpi
634	24	Tremadog Bay, Cardigan Bay.	SH 351 186	52°44.4'N 04°26.4'W	AfilEcor
634	25	Tremadog Bay, Cardigan Bay.	SH 395 222	52°46.4'N 04°22.7'W	AbrNucCor
634	26	Tremadog Bay, Cardigan Bay.	SH 451 257	52°48.4'N 04°17.8'W	SpiSpi
634	33	Off Sarn-y-Bwch, Cardigan Bay.	SH 491 048	52°37.2'N 04°13.7'W	SpiSpi
634	34	Off Aberdyfi, Cardigan Bay.	SN 494 940	52°31.4'N 04°13.2'W	SpiSpi
773	1	Sarn Badrig transect A (SW transect)	SH 406 132	52°41.6'N 04°21.5'W	FoR, XKScrR, LsacChoR, Lhyp.Ft, Flu.SerHyd, Flu.HBysS, CGS
773	2	Sarn Badrig transect B (NE transect)	SH 492 197	52°45.2'N 04°14.0'W	HalXK, Mob, LsacChoR, Flu.SerHyd, EcorEns
773	3	Mid-section reef crest, Sarn Badrig	SH 497 190	52°44.8'N 04°13.5'W	LsacChoR
773	4	West Prong, Sarn Badrig	SH 390 131	52°41.5'N 04°22.9'W	XKScrR
773	5	NW drying point, Sarn Badrig	SH 424 149	52°42.5'N 04°20.0'W	XKScrR
773	6	SW section, Sarn Badrig	SH 432 147	52°42.4'N 04°19.2'W	LsacChoR
773	7	Mid-section, Sarn Badrig	SH 439 168	52°43.6'N 04°18.6'W	EcorEns

Compiled by: Paul Brazier & Rohan Holt

8 Dovey estuary (Afon Dyfi)

Location		
Position (centre)	SN 640 950	52°32'N 4°0'W
County/district	Ceredigion; Powys; Gwynedd	Meirionnydd; Montgomery
Conservation agency/area	Countryside Council for Wales	North-west, West and East Areas

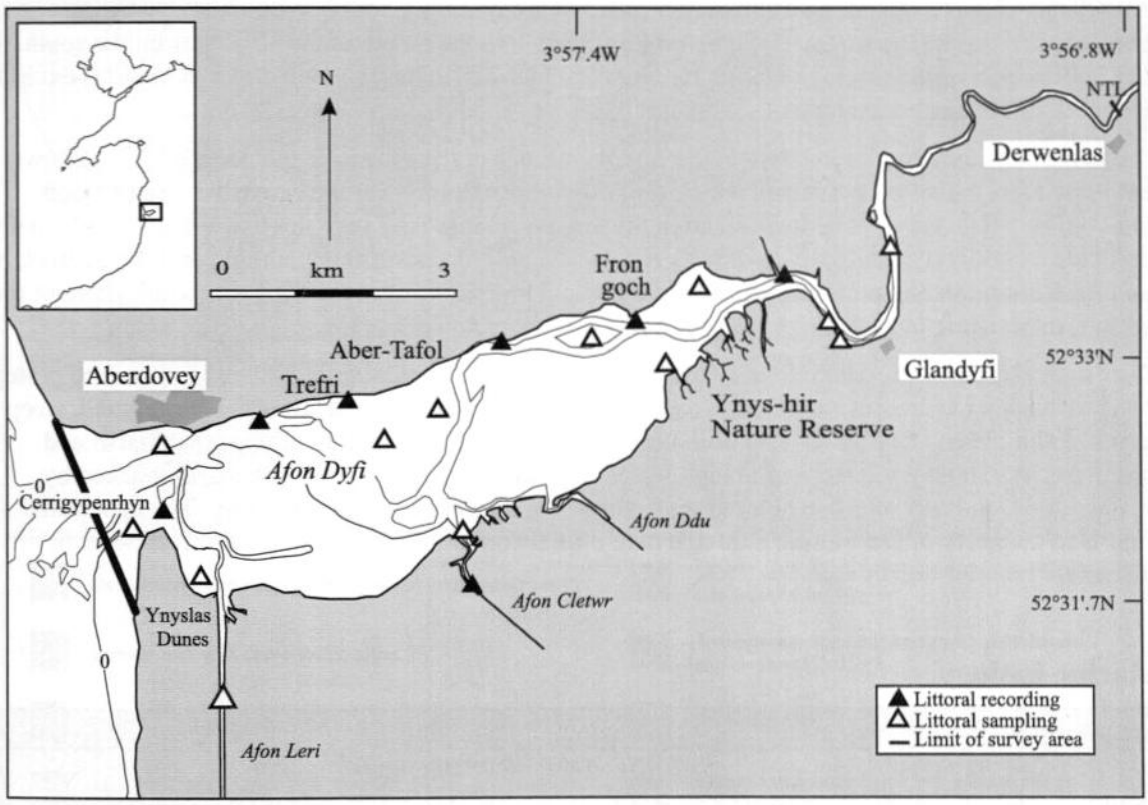

Figure 8.1 Main features of the area and sites surveyed.

Physical features	
Physiographic type	Bar-built estuary
Length of inlet	19.6 km
Area of inlet	1954 ha
Bathymetry	Up to 9.2 m deep in the lower estuary, otherwise a shallow estuary
Wave exposure	Moderately exposed to ultra sheltered
Tidal streams	Strong to negligible
Tidal range	4.3 m springs, 2.1 m neaps (Aberdyfi)
Salinity	Fully marine to low salinity; mainly variable

Introduction

The Dovey (Dyfi) is the largest of the estuaries flowing into Cardigan Bay (*area summary* 7). It is a shallow estuary with extensive intertidal sandflats and large sand dune systems at Ynyslas and Aberdovey (Aberdyfi) either side of the mouth. On the south shore, a floodplain claimed from the estuary is fronted by extensive areas of pioneer saltmarsh dominated by the cord-grass *Spartina* sp.; there are 556 ha of saltmarsh throughout the estuary (Huckbody *et al.* 1992). To the south-east of

Ynyslas lies Cors Fochno (Borth Bog) which has the most extensive area of raised mire vegetation in the UK. There are also small remnant areas of peat bog on the south and north side of the estuary.

The mouth of the estuary is protected by a bar of sand and shingle which deflects the main channel making it run parallel to an extensive system of dunes at Ynyslas, although its course through the highly mobile sediment varies considerably with time. In July 1995 the channel had split into two, running parallel to the north and south banks with a large 'island' of waved sand in the centre of the estuary. To the north of the entrance is a popular beach backed by dunes and golf links, upstream of which the shoreline has been modified and a pier built to create a small harbour at Aberdovey. The town developed as a quiet seaside holiday resort, and today it is a popular watersports centre, attracting many tourists during the summer. The Afon Leri flows into the mouth of the estuary from the south. It was built as part of the drainage system for Cors Fochno. The extensive sand dunes at Ynyslas exhibit a number of different dune types.

The Dovey channel divides into two in the middle reaches of the estuary to the north of Afon Cletwr and Afon Ddu, canalised tributaries which act as drainage channels for the extensive area of flood plain on the south shore. The north shore in the middle reaches is of very steep, wooded hillside, with restricted amounts of saltmarsh. A railway runs adjacent to the north shore, cutting into the bedrock at the top of the shore. An embankment for a disused railway line runs along the entire south shore of the estuary, influencing land drainage patterns along this shore.

The estuary narrows considerably at Glandyfi, where there are a number of breakwaters built to protect the river bank and adjacent road from erosion. The shores in the upper reaches comprise small, steep banks of shingle and fine sand. The land adjacent to the channel is mainly of upper saltmarsh and freshwater marsh which is flooded at high water of spring tides. An area of this marsh, backed by mixed arable land and woodland on the south shore, forms Ynys-hir RSPB reserve. The upper tidal limit is to the north of Derwenlas, although here littoral communities are essentially freshwater in character.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	7	July 1995	MNCR survey 629
	Habitat (biotope) mapping		July 1997	CCW survey 9.24.1
	Infaunal sampling - cores	14	July 1995	MNCR survey 629

Littoral rock

Throughout the estuary the presence of bedrock is fairly limited. Cobbles and sea-walls in the vicinity of Aberdovey are heavily-silted and dominated by fucoid algae (Pel; Fspi; FvesX). The cobble and shingle bank known as Cerrigypenrhyn that lies to the north of Ynyslas is covered by bladder wrack *Fucus vesiculosus* with the barnacle *Elminius modestus* encrusting the cobbles beneath (FvesX). A steep rocky headland at Trefri has an extensive supralittoral zone dominated by yellow and grey lichens (YG). The upper littoral fringe here has dense black lichen *Verrucaria maura* (Ver.Ver) with a dense band of channel wrack *Pelvetia canaliculata* in the lower littoral fringe (Pel). A narrow band of spiral wrack *Fucus spiralis* in the upper eulittoral (Fspi) is restricted to the vertical rock and the rugged, horizontal rock in the mid-eulittoral has a dense cover of knotted wrack *Ascophyllum nodosum* with some *F. vesiculosus* (Asc.VS). Large mussels *Mytilus edulis* occur beneath the algae on the silted rock adjacent to the channel.

Rocky habitats in the middle reaches of the Dovey estuary are limited to small headlands at Aber-Tafol and Fron-Gôch with some cobble banks adjacent to the railway line on the north side. The bedrock shores have similar algal zonation to the rock in the lower reaches, whilst the cobbles are dominated by the wrack *Fucus ceranoides* (FcerX), reflecting the reduced salinity of the adjacent mid-estuarine channel.

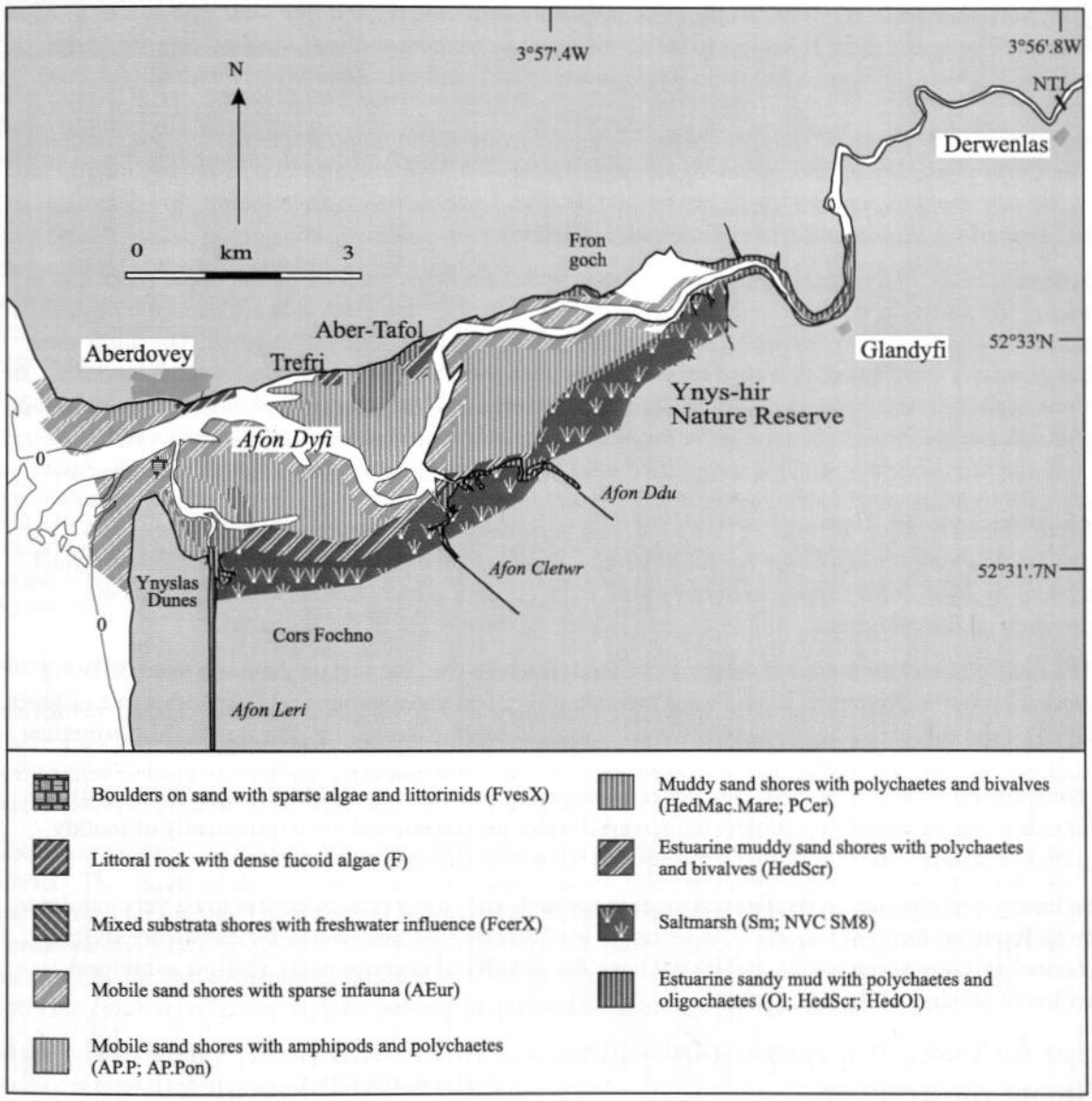

Figure 8.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 8.1, cited literature and additional field observations).

Littoral sediment

The mouth of the estuary is fairly wide and exposed to prevailing winds, although it gains some protection from wave action by the bar and dunes at Ynyslas. Sediment in the lower estuary comprises fine sand which is fairly mobile due to exposure to wave action and strong tidal streams from the river flow. The upper shore adjacent to the dunes is of mobile sand and gravel with talitrid amphipods (Tal). The mid- and lower shores are of fairly mobile fine sand which is sculptured into waves by the tidal streams. The lower shore is extremely mobile and 'quick' in places, with sparse burrowing amphipods (AEur). Areas of soft sediment in the shelter of the dunes supports a sparse polychaete community (AP.P). To the east of Ynyslas the sand has a large number of cockle shells *Cerastoderma edule* on the surface although no live specimens were observed. The Afon Leri drains through an extensive area of cord-grass *Spartina* sp. and pioneer saltmarsh before it flows into the lower reaches

of the Dovey. In the lower reaches of the tributary the upper shore comprises fine sand and mud with glasswort *Salicornia* sp. (NVC SM8). The mid-shore is of soft, rippled fine sand with sparse *C. edule* (PCer). The lower shore is subject to increased water movement and is of medium fine sand with the polychaete *Nephtys cirrosa*, the tellin *Angulus tenuis* and sand-eels *Ammodytes tobianus* (AP.Pon). In the middle reaches of the Afon Leri, with increasing shelter the whole shore is comprised of anoxic sandy mud with very high numbers of the bivalves *Scrobicularia plana* and *Mya truncata* (HedScr). The CCW phase 1 intertidal survey found large numbers of *Mya arenaria* in mid-estuary muddy sand. In the extreme shelter of the upper reaches of the Afon Leri the muddy shores have very dense numbers of the ragworm *Hediste diversicolor* (HedScr).

Sediment in the mid-estuary comprises fine sand which becomes muddier on the upper shore due to shelter from wave action by the sandflats. Sediment shores on the south side are backed by extensive saltmarsh and have a higher mud fraction due to shelter from the dunes at Ynyslas. The north shore has extensive sandflats of fine sand heaped into waves and small dunes by wind and tidal streams. In some areas the sand is very soft and aerated, supporting a few polychaetes and burrowing amphipods (AP.P). Areas of sediment adjacent to the channel are subject to increased tidal streams and consequently, comprise mobile, well-sorted sand with sparse burrowing amphipods (AEur). Areas adjacent to the channel experiencing reduced water movement, such as on the outside of meanders and 'blind' channels, have well sorted fine sand with burrowing errant polychaetes and *A. tenuis* (AP.Pon). The stable muddy banks of the Afon Cletwr and Afon Ddu and on the north bank adjacent to small streams at Aber-Tafol support extremely high numbers of *S. plana* (HedScr). This reflects the presence of flocculent mud, rich in organic matter, on the surface of the sediment.

The main channel narrows and deepens at Glandyfi where the peat bog on the north shore is being eroded by water movement. The shores here are of vertical and overhanging peat with a mat of green algae on the surface. The soft substratum is burrowed by *H. diversicolor*, the amphipod *Corophium volutator* and the shore crab *Carcinus maenas*. The steep muddy banks adjacent to the saltmarsh are characterised by sparse polychaetes, oligochaetes and *Corophium* sp. (HedOl). The banks on the outside of the meanders are subject to increased water movement and are consequently of muddy gravel, characterised by errant polychaetes and some oligochaetes (Ol).

Sediment communities in the river channel in the mid- and lower estuary appear to be very similar to those found on the lower shore. The sediment is of mobile fine sand due to the constantly shifting channel and prevailing winds, and do not have the stability of corresponding shallow sublittoral sediment habitats of the open coast.

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Pen Llŷn a'r Sarnau/Lleyn Peninsula and the Sarnau	cSAC	SH 50 30	Estuaries; Reefs
Dyfi	NNR, Biosphere Reserve, SSSI, , NCR	SN 640 955	Unspoilt estuary; dune system; Unmodified raised bog.
Cors Fochno and Dyfi	Ramsar; cSPA	SN 65 95	Estuary, saltmarsh, raised bog. Wintering wildfowl.
Ynys-hir	RSPB	SN 686 956	Wintering wildfowl; passage migrants.
Ynyslas	SSSI; GCR	SN 610 950	Geomorphological.
Snowdonia	NP	N/A	(North shore of estuary)

Human influences

Coastal developments and uses

Most coastal development in the estuary is situated around Aberdovey, with a resident population of about 1000 people. Here the shoreline has been canalised and sea defences built to form a popular bathing beach and harbour facilities. To the north of Aberdovey are golf links.

The wide range of habitats together with an excellent bathing beach attract a large number of people to Borth and Ynyslas, putting considerable pressure on the whole area. An active management programme for the intensively trampled dunes is in effect; work has included the transplanting of marram grass *Ammophila arenaria*, reinforcement with brushwood, and path construction to reduce erosion. There is a visitor centre and shop at the reserve and in 1994, 8,764 cars used the car park (upper shore) on the site.

The RSPB reserve at Ynys-hir covers 427 ha of saltmarsh, woodland and peat bog. Wildfowling occurs on a large part of the lower estuary, although it is controlled by permit from CCW, and shooting is not permitted at Ynys-hir and the adjoining area.

Since the 1920s over one-third of the intertidal area has been developed for grazing land or for railway construction. The canalisation and diversion of some of the tributaries has also had a significant effect on the estuary. The introduction of the cord-grass *Spartina* sp. stabilised the flood plain and allowed the build-up of saltmarsh which is now used for grazing livestock.

Marine uses

Aberdovey harbour is occasionally dredged to maintain the channel, keeping it open for larger craft. There are 150 moorings in the harbour, mainly for pleasure craft. One commercial fishing boat and two charter vessels for angling are based here. An outdoor centre teaches canoeing and other activities on the estuary; the nearshore water is used for jet-skiing, water-skiing and surfing.

The lower estuary is a nursery area for a number of fish species including the sea bass *Dicentrarchus labrax*. The mouth of the river is netted for salmon *Salmo salar* and trout *Salmo trutta*, although the use of fixed nets within the estuary is banned from March to October. The beds of cockles *Cerastoderma edule* have been intensively exploited. A twelve-month ban on cockle collecting was enforced by the Sea Fisheries Committee in 1995 to enhance stock levels. Bait-digging, winkle *Littorina littorea* collecting and the picking of glasswort *Salicornia* sp. also occurs.

At the time of writing, primary treated sewage was discharged into the estuary at Aberdovey, but water quality is classified at grade A (highest quality).

The natural flow of sediment along the coast to the south of the estuary mouth has been disrupted by the construction of groynes along Borth beach. This has a knock-on effect on the amount of sediment reaching the estuary from the seaward end.

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Sites surveyed

Survey 629. 1995 MNCR Cardigan Bay estuaries, littoral survey (MNCR, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
629	1	Ynyslas, Dyfi estuary.	SN 610 950	52°32.0'N 04°02.9'W	Tal, AP.P, HedOl
629	2	Cerrigypenrhyn, Dyfi estuary.	SN 613 953	52°32.2'N 04°02.7'W	FvesX
629	3	West Beach, Aberdyfi, Dyfi estuary.	SN 613 958	52°32.5'N 04°02.7'W	AEur, AP.P,
629	4	Aberdyfi shore, Dyfi estuary.	SN 617 960	52°32.6'N 04°02.3'W	Fspi, FvesX, Pel
629	5	Afon Leri, Dyfi estuary.	SN 618 943	52°31.7'N 04°02.2'W	PCer, AP.Pon, HedScr
629	6	River Leri Moorings, Dyfi estuary.	SN 617 933	52°31.1'N 04°02.3'W	HedScr
629	7	Trefri Point, Dyfi estuary.	SN 633 963	52°32.8'N 04°00.9'W	YG, Fspi, Pel, Asc.VS, FvesX
629	8	S of Trefri, Dyfi estuary.	SN 635 959	52°32.6'N 04°00.7'W	PCer, AP.Pon, AP.P
629	9	Craig-y-Penrhyn transect, Dyfi estuary.	SN 645 942	52°31.7'N 03°59.8'W	HedMac.Mare, HedMac.Are, HedScr, AP
629	10	S of Railway Bridge, Craig-y-Penrhyn Creek, Dyfi estuary.	SN 646 940	52°31.6'N 03°59.7'W	FcerX, Pel
629	11	W of Aber-Tafol, Dyfi estuary.	SN 648 964	52°32.8'N 03°59.6'W	HedMac.Mare, HedScr, Ol
629	12	Aber-Tafol, Dyfi estuary.	SN 650 968	52°33.1'N 03°59.4'W	YG, Ver.Ver, Pel, Asc.VS, FcerX
629	13	W of Fron-Gôch, Dyfi estuary.	SN 661 967	52°33.0'N 03°58.5'W	AEur, HedScr
629	14	Fron-Gôch, Dyfi estuary.	SN 665 972	52°33.3'N 03°58.1'W	YG, Ver.Ver, FcerX
629	15	Ynys-hir transect, Dyfi estuary.	SN 670 965	52°32.9'N 03°57.7'W	AEur, AP.P, HedScr
629	16	S of Gogarth Hall, Dyfi estuary.	SN 676 974	52°33.4'N 03°57.1'W	HedOl
629	17	S of Penmaen Isa, Dyfi estuary.	SN 684 975	52°33.5'N 03°56.4'W	HedOl
629	18	The Saltings, Ynys-hir, Dyfi estuary.	SN 687 971	52°33.3'N 03°56.2'W	HedOl
629	19	SW Garreg Farm, Dyfi estuary.	SN 695 968	52°33.1'N 03°55.5'W	HedOl
629	20	NW of Glandyfi, Dyfi estuary.	SN 689 967	52°33.1'N 03°56.0'W	HedOl, Ol
629	21	Dyfi Junction, Dyfi estuary.	SN 695 981	52°33.8'N 03°55.5'W	HedOl

Compiled by: Paul Brazier & Eleanor Murray

9 Dysynni estuary (Broad Water)

Location		
Position (centre)	SH 582 027	52°36'N 4°06'W
County/district	Gwynedd	Meirionnydd
Conservation agency/area	Countryside Council for Wales	North-west Area

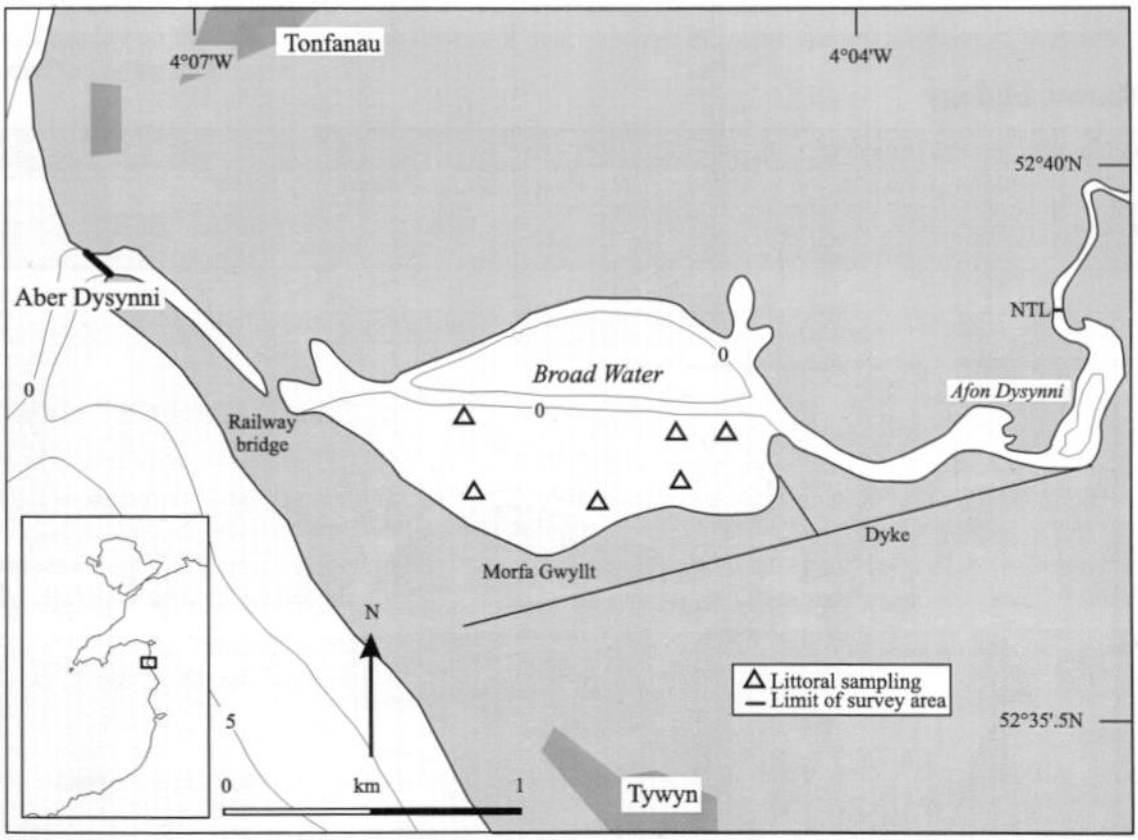

Figure 9.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Bar-built estuary
Length of inlet	4.4 km
Area of inlet	117 ha total, 69 ha intertidal
Bathymetry	Intertidal with a shallow channel
Wave exposure	Extremely sheltered
Tidal streams	Weak
Tidal range	Approximately 1 - 2 m
Salinity	Variable

Introduction

The Dysynni estuary, or Broad Water, is a bar-built estuary at the lower end of the Afon Dysynni. The estuary is small and largely intertidal except for the river channel that flows through the estuary from east to west. The river channel enters the estuary, splits in two and runs down the centre and

along the northern edge. A 1 km long, 50 m-wide channel connects the estuary to the sea at upper shore level at Aber Dysynni, where a shingle spit restricts the mouth of the estuary, reducing its tidal range (Buck 1993). Outside the estuary mouth, the spring tidal range is 4.3 m. The spit extends north from Tywyn and is mostly covered by grassland although there are some areas of bare shingle and pioneer shingle vegetation at the seaward end. The estuary itself is composed of a mixture of sediments ranging from coarse mobile sand near the seaward end to muddy sand in the more sheltered areas. Saltmarsh has developed in the west and north sections of the estuary.

To the south of the Dysynni estuary, Morfa Gwyllt saltmarsh has a dike running along its southern edge which drains the surrounding land for grazing.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Habitat (biotope) mapping		April 1997	CCW survey 9.23.1
	Recording and infaunal core sampling	1	April 1997	MNCR survey 642

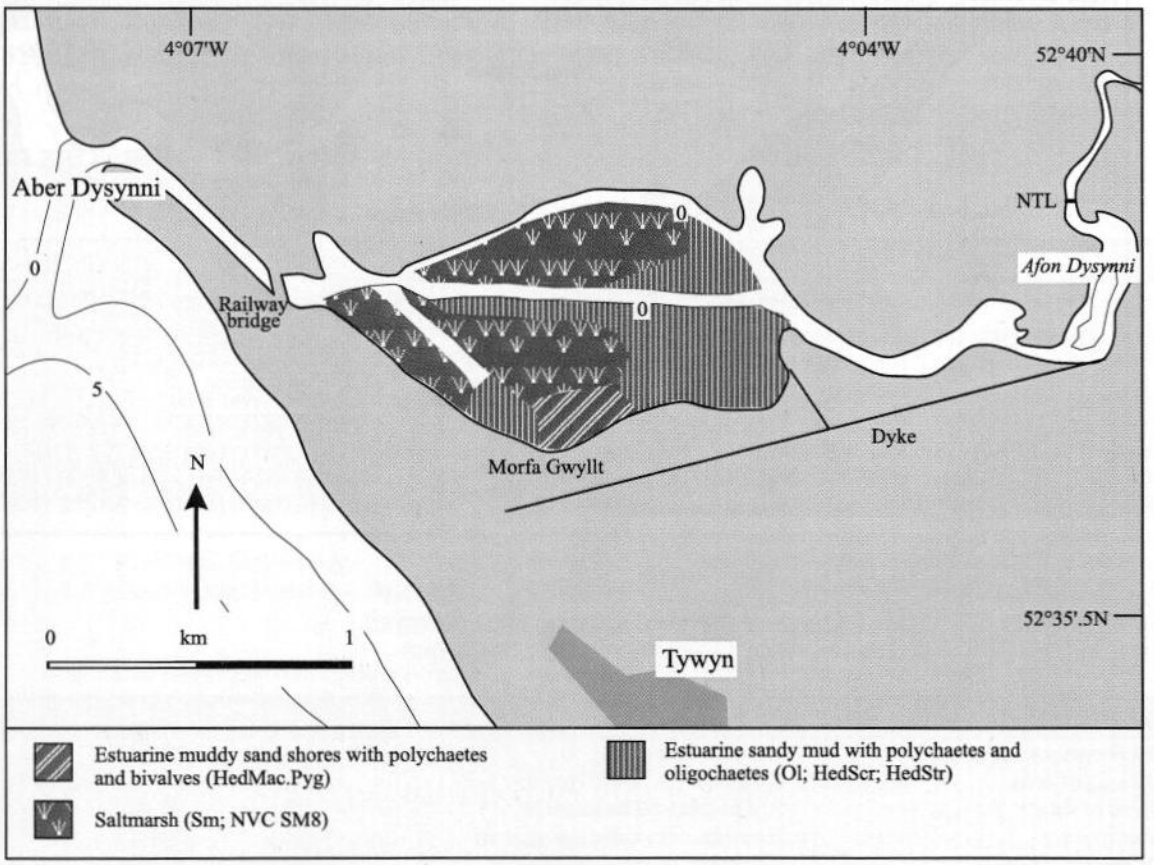

Figure 9.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 9.1).

The entire Dysynni estuary consists of sediment habitats and no hard substrata are present. Much of the estuary is dominated by saltmarsh communities but there are areas of true intertidal marine communities in the south. The muddy fine sand in the upper estuary contains the polychaetes *Hediste diversicolor* and *Pygospio elegans*, enchytraeid oligochaetes, the amphipod *Corophium volutator*, the

mud snail *Ventrosia ventrosa* and mussels *Mytilus edulis* (HedMac.Pyg). At the west end, the sediment consists of coarse sand and gravel, with only a small fraction of mud due to wash out of fine material by the tidal flow. The infauna are low in numbers, dominated by *P. elegans* and enchytraeid oligochaetes, with rare occurrences of other estuarine species such as *H. diversicolor* and *S. shrubsolii*, the isopod *Cyathura carinata* and the sand gaper *Mya arenaria* (Ol). In the most sheltered areas to the south-east where the effects of tidal streams are slight, the sediment comprises fine muddy sand. Near the Afon Dysynni, the mid-shore is dominated by the polychaetes *H. diversicolor* and *Manayunkia aestuarina*, enchytraeid oligochaetes, the oligochaete *Paranais litoralis*, *C. volutator* and abundant peppery furrow shell *Scrobicularia plana* (HedScr). Towards the centre of muddy sandflats, the infaunal community is characterised by *H. diversicolor* and *S. shrubsolii* (HedStr). The sediment is more muddy on the lower shore with the result that, although the same species are present, they are found in higher abundance.

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Broadwater	SSSI	SH 582 027	Biological; ornithological
Snowdonia	NP	N/A	(North shore of estuary)

Human influences

The Dysynni estuary is surrounded by grazing land that has been drained by building sea-walls on the south-eastern part of the estuary. The influence of freshwater on the estuary is restricted by flood defence walls and dykes which divert land drainage from the estuary. Walls on either side of the narrow channel at the seaward end prevent lateral erosion of the channel and support the railway bridge. These walls limit habitat diversity in the lower reaches of the estuary.

There is little recreational use of the estuary, although some walking, birdwatching and canoeing take place. Wildfowling takes place on Morfa Gwyllt saltmarsh.

References and further reading

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Sites surveyed

Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
42	54	Broad Water, Aberdyfi	SH 575 025	52°36.0'N 04°06.2'W	HedStr, HedMac.Pyg, HedScr, HedOl; Ol

Compiled by: Dora Nichols & Paul Brazier

10 Mawddach estuary (Aber Mawddach)

Location		
Position (centre)	SH 640 160	52°43'N 4°01'W
County/district	Gwynedd	Meirionnydd
Conservation agency/area	Countryside Council for Wales	North-west Area

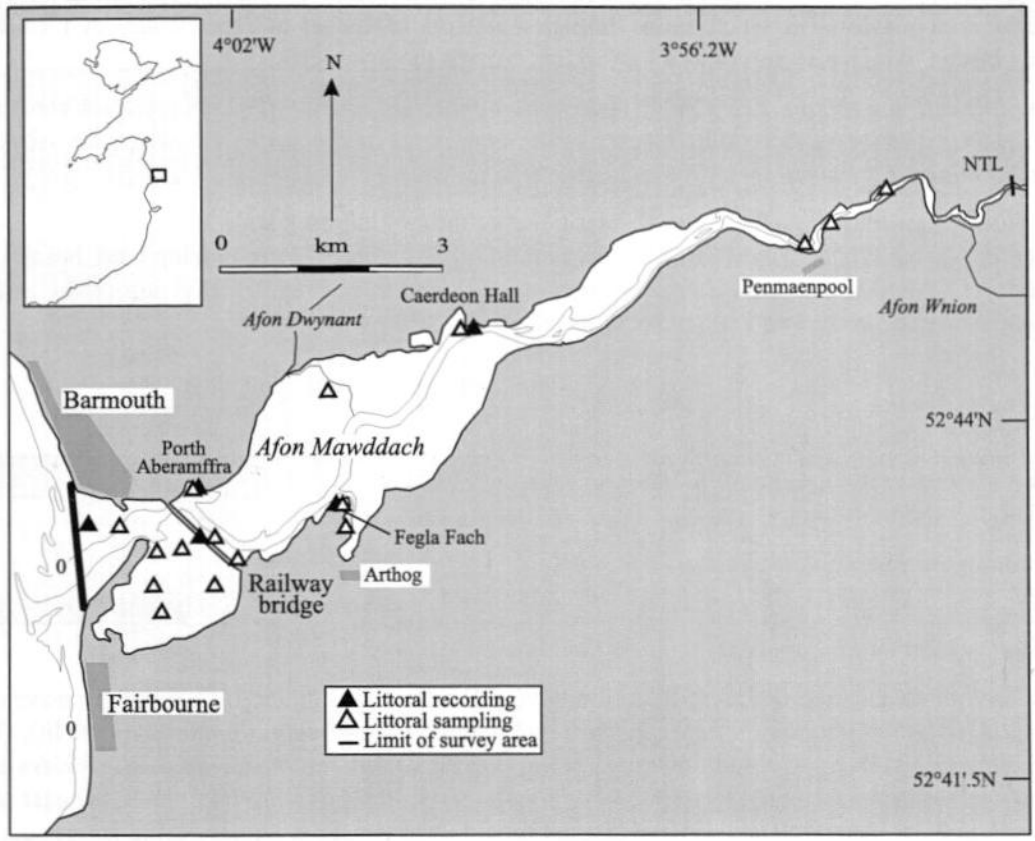

Figure 10.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Bar-built estuary
Length of inlet	37.7 km
Area of inlet	1159 ha
Bathymetry	6.6 m maximum in the lower 1 km of estuary, otherwise very shallow
Wave exposure	Moderately exposed to ultra sheltered
Tidal streams	Moderately strong to very weak
Tidal range	4.3 m springs; 2.2 m neaps (at Barmouth)
Salinity	Full marine to low salinity

Introduction

The Mawddach is a large shallow estuary situated on the west coast of Wales. The Afon Mawddach and its tributary the Afon Wnion, which flows through the market town of Dolgellau, drains into Cardigan Bay (*area summary* 7) to the south of the town of Barmouth (Abermaw). It is a wide

estuary with extensive intertidal sandflats throughout its length and 219 ha of saltmarsh (Huckbody *et al.* 1992). The route of the channel varies seasonally and is charted at less than 1 m below chart datum in the mid- and upper reaches of the estuary. The lower estuary is deeper with a charted depth of up to 6.6 m in the vicinity of Barmouth Harbour.

The mouth of the estuary is fairly wide and exposed to prevailing winds, although it is protected from wave action by a sand and shingle spit running northwards from Fairbourne on the south side and a bank of cobbles to the north of the channel entrance. The mouth of the estuary by the bar and dunes at Fairbourne. Barmouth beach is protected by a number of groynes. The north side of the estuary has been canalised at Barmouth to form a sheltered harbour. Inside the spit on the south side is an extensive area of saltmarsh which drains through a network of ditches into the estuary. A 1 km-long railway bridge, which also serves as a footbridge, crosses the lower estuary.

The middle reaches of the estuary are flanked by steep forested hillside. The main area of cord-grass *Spartina* sp. saltmarsh in the middle reaches of the estuary are on the north side, where the Afon Dwynant joins the estuary.

Above Penmaenpool bridge there was formerly one of the two largest stands of the common reed *Phragmites communis* in Wales; this has now largely been drained to form grazing land, but the remaining reed-bed still supports large numbers of birds, and there is an RSPB visitor centre at the site. The whole estuary, including Penmaenpool Reedbed and Arthog Bog, is notified a SSSI.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	4	July 1995	MNCR survey 629
	Habitat (biotope) mapping		April 1997	CCW survey 9.20.1
	Infaunal sampling (cores)	12	July 1995	MNCR survey 629

Littoral

A low bank of mobile cobbles and pebbles on the north side of the entrance is scoured by wave action and encrusted by sparse mussels *Mytilus edulis* and barnacles *Semibalanus balanoides* (BLlit). The coastal defences at Barmouth and the bridge pilings are encrusted with barnacles *S. balanoides* and *Elminius modestus* and fucoid algae (Pel; Fspi; Fves). Some areas of steep bedrock to the east of Barmouth at Porth Aberamffra also have distinct fucoid algal zonation. Upper littoral fringe rock has a dense cover of the black lichen *Verrucaria maura* (Ver.Ver) while the lower littoral fringe has dense tufts of channel wrack *Pelvetia canaliculata* with the red alga *Catenella caespitosa* beneath (Pel). The upper eulittoral rock has a rich cover of spiral wrack *Fucus spiralis*, and *C. caespitosa* is in greater abundance in this zone (Fspi). The mid-eulittoral bedrock is dominated by knotted wrack *Ascophyllum nodosum*, a species characteristic of sheltered shores, beneath which are large *M. edulis* (Asc.VS). The zone below the *A. nodosum* supports dense large mussels topped with a mosaic of bladder wrack *Fucus vesiculosus* and the green alga *Enteromorpha* sp. (Fves). This zone continues onto muddy rocky outcrops surrounded by fine sand and supports some tattered specimens of *F. vesiculosus*. Lower shore rocky biotopes do not occur because the rock/sediment interface occurs in the mid-eulittoral.

Mobile sand at the narrow entrance of the estuary is forced into waves by the rapid tidal streams. Robust amphipods *Bathyporeia* spp. and isopods *Eurydice pulchra* characterise the infaunal community on the upper shore (AEur), with sparse polychaetes such as *Nephtys cirrosa* on the lower shore (AP.P).

Sediment in the lower estuary comprises fine sand which becomes muddier in areas of extreme shelter. Sheltered sand behind the spit at Fairbourne is backed by extensive saltmarsh, and the upper shore is colonised by the glasswort *Salicornia* sp., with the burrowing amphipod *Corophium volutator*

dominating the infauna (NVC SM8). The sheltered mid-shore has abundant lugworm *Arenicola marina* and the cockles *Cerastoderma edule* and *Cerastoderma glaucum* (?PCer). This is the only site in the estuary at which the estuarine *C. glaucum* was found, although *C. edule* is present in the middle reaches of the estuary. The medium-fine sand of the more exposed mid-shore on the north side and the lower shore is mobile with some areas of quick sand adjacent to the channel. The sand is sculpted into large waves and platforms by tidal streams and has a scattering of empty shells over the surface. Due to the mobility of this sediment, the infauna are very sparse and comprise mainly burrowing amphipods (AEur) or amphipods with polychaetes *N. cirrosa* and tellins *Angulus tenuis* (AP.P; AP.Pon). One area of muddy sand in the extremely sheltered inlet of Porth Aberamffra has dense populations of the burrowing polychaetes *Nephtys hombergii* and *Pygospio elegans* (HedMac.Pyg).

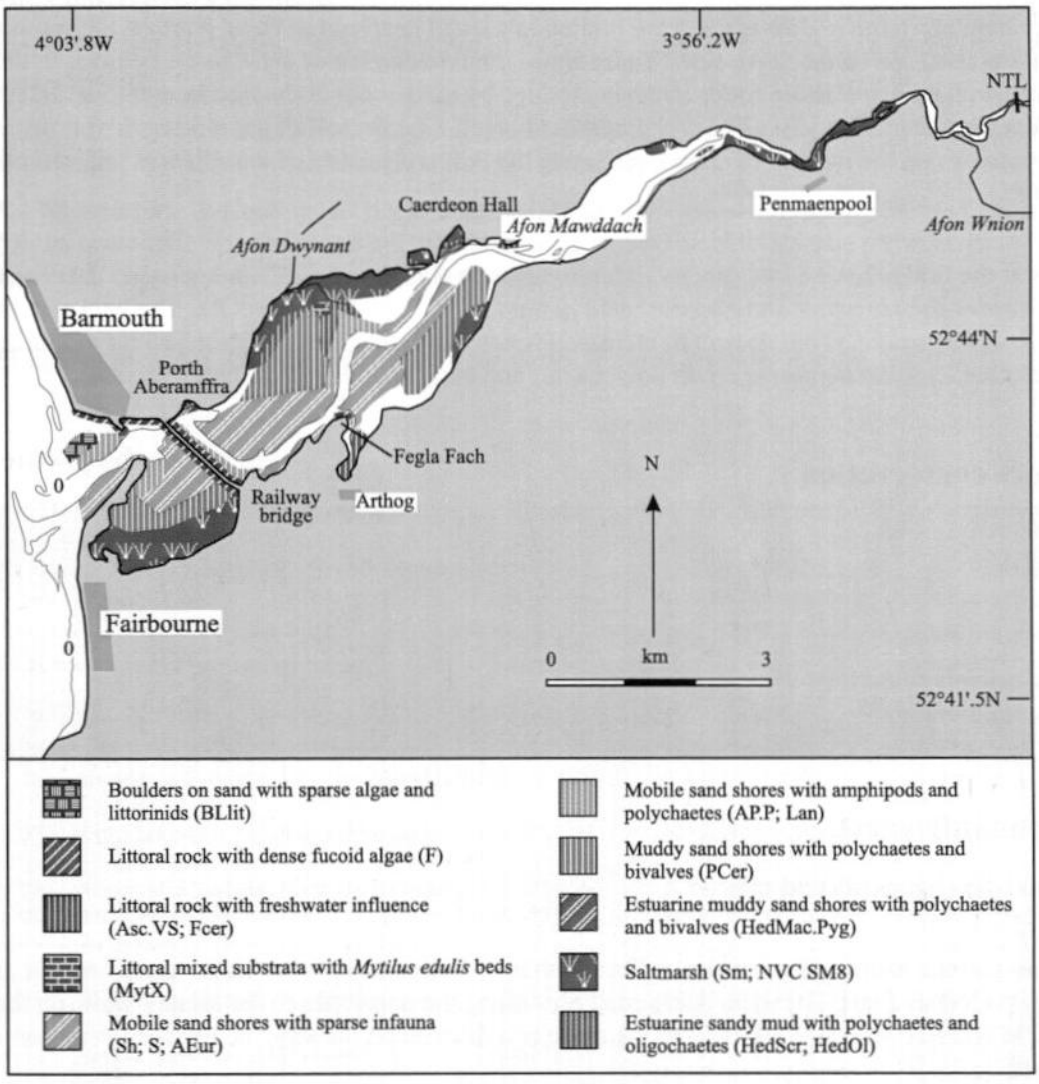

Figure 10.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 10.1 and cited literature).

The main channel in the middle reaches of the estuary flows close to the south bank and a large area of sediment occurs to the north. Two minor tributaries, the Afon Arthog and Afon Dwynant, drain into the main channel creating localised areas of muddy sand alongside the creeks. The extensive sandflat to the north of the channel comprises fine sand backed by a large area of saltmarsh where the

Afon Dwynant drains into the Mawddach. The shore is divided by a number of muddy creeks and channels and there is a lot of standing water and pools amongst the sculptured sandflat. The upper shore pioneer saltmarsh has glasswort *Salicornia* sp. with the mud snail *Hydrobia ulvae* in dense aggregations on the surface of the sediment (NVC SM8). There is a large bed of dense *M. edulis* on the mid-shore (MytX); the thick, muddy pseudofaeces produced by the mussels is burrowed by *H. diversicolor* and *P. elegans* and bivalves including *Macoma balthica* and *Scrobicularia plana* (HedScr). Areas of muddy sand adjacent to the creeks are very stable with an algal mat covering the surface and comprising dense beds of *C. edule* and *S. plana* (PCer). On the south side of the channel the muddy inlet of the Afon Arthog is backed by areas of *Spartina* sp. saltmarsh. The banks of the small tributary are of stable mud and fine sand with some areas of dense *S. plana*, *H. diversicolor* and the oligochaete *Tubificoides benedii* (HedScr).

Rocky habitats in the middle reaches are limited to a small headland at Fegla Fach on the south side and a few outcrops on the north side. These show similar zonation of algae to the bedrock in the lower estuary, with no lower shore rocky biotopes, limited by sand-scour at the interface with sediment (YG; Ver.Ver; Pel; Fspi; Asc.VS). The rocky headland below Caerdeon Hall has a dense cover of *F. ceranoides* on the mid-shore (Fcer), reflecting the reduced salinity of the adjacent mid-estuarine channel.

The estuary narrows considerably at Penmaenpool bridge in the upper estuary. The steep muddy banks at the bridge have a low species richness but high abundance of *H. diversicolor*, the oligochaetes *Tubificoides pseudogaster* and *Heterochaeta costata* and *C. volutator* (HedOl). The banks on the outside of the meanders are subject to increased water movement and are consequently of muddy gravel, characterised by sparse errant polychaetes and enchytraeid oligochaetes (?HedOl).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Pen Llŷn a'r Sarnau/Lleyn Peninsula and the Sarnau	cSAC	SH 50 30	Estuaries; Reefs
Aber Mawddach/Mawddach estuary	SSSI	SH 670 176	Intertidal; saltmarsh; reedbed; estuarine mire
Penmaenpool reed bed	RSPB	SH 363 348	Ornithological.
Snowdonia	NP	N/A	(Middle and upper reaches of the estuary).

Human influences

Coastal developments and uses

Barmouth has a resident population of 2000 and is a popular tourist resort; the beach is protected by groynes and the banks of the estuary at Barmouth have been canalised to form a small harbour used mainly by leisure craft. The main A496 road runs along the north side of the estuary while on the south shore, Morfa Mawddach Walk follows the route of a dismantled railway line between Penmaenpool and Arthog.

Marine uses

Barmouth has 170 permanent moorings for commercial and leisure craft. A ferry runs from Barmouth to Fairbourne on the opposite side of the estuary. The harbour and lower estuary is much used for water-skiing, jet-skiing and surfing, and both Barmouth and Fairbourne are designated bathing beaches. Five fishing vessels and three angling boats operate from Barmouth Harbour, the main fishery being for pelagic and flatfish by netting and trawling. Some potting for lobsters *Homarus gammarus* and crabs *Cancer pagurus* also takes place just outside the mouth of the estuary. The lower estuary is an important nursery area for sea bass *Dicentrarchus labrax* and consequently the use

of fixed nets within the estuary is banned from March to October. Some cockling takes place on the estuary.

There is a long sea outfall at Barmouth and sewage treatment works at Dolgellau and Morfa Mawddach. Water quality throughout the estuary has been classified as grade A (highest quality) but contains high levels of copper, zinc and iron from natural outcrops and abandoned mine workings up-river (Buck 1993).

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Richards, A., Bunker, F. St.P., Foster-Smith, R. 1996. Handbook for marine intertidal Phase 1 and SSSI habitat mapping. *Countryside Council for Wales Natural Sciences Report*, No. 95/6/1.

Sites surveyed

Survey 629. 1995 MNCR Cardigan Bay estuaries, littoral survey (MNCR, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
629	22	Below Ynys y Brawd, Mawddach estuary.	SH 608 152	52°42.9'N 04°03.6'W	BLlit
629	23	N Mouth of Mawddach, Mawddach estuary.	SH 613 152	52°42.9'N 04°03.2'W	AEur, AP.P
629	24	NE of Fairbourne, Mawddach estuary.	SH 619 146	52°42.6'N 04°02.6'W	AEur, AP.Pon, PCer
629	25	N of Ynysgyffylog, Mawddach estuary.	SH 625 146	52°42.6'N 04°02.1'W	AEur, NVC SM8
629	26	Mawddach Footbridge Pylons, Mawddach estuary.	SH 623 151	52°42.9'N 04°02.3'W	Fves, Fspi, Pel
629	27	E of Mawddach Footbridge, Mawddach estuary.	SH 625 150	52°42.8'N 04°02.1'W	AEur, Lan
629	28	Aberamffra Harbour, Mawddach estuary.	SH 623 156	52°43.2'N 04°02.3'W	HedMac.Pyg, HedOl
629	29	Barmouth Bridge NE side, Mawddach estuary.	SH 622 157	52°43.2'N 04°02.4'W	Ver.Ver, Fves, Pel, Fspi, Asc.VS
629	30	N of Fegla Fach, Mawddach estuary.	SH 639 156	52°43.2'N 04°00.9'W	AEur, Tal
629	31	Fegla Fach, Mawddach estuary.	SH 639 155	52°43.1'N 04°00.9'W	YG, Ver.Ver, Pel, Fspi, Asc.VS
629	32	Arthog Inlet, Mawddach estuary.	SH 642 153	52°43.0'N 04°00.6'W	MacAre, AEur, HedScr
629	33	S of Glandwr Hall, Mawddach estuary.	SH 638 168	52°43.8'N 04°01.0'W	MacAre, NVC SM8, AP.Pon, HedScr, MytX
629	34	Caerdeon Hall Beach, Mawddach estuary.	SH 652 176	52°44.3'N 03°59.8'W	HedMac.Pyg, HedScr
629	35	Below Caerdeon Hall, Mawddach estuary.	SH 654 176	52°44.3'N 03°59.6'W	YG, Pel, Fspi, Asc.VS, Fcer
629	36	Penmaenpool, Mawddach estuary.	SH 695 185	52°44.8'N 03°56.0'W	HedOl, Ol
629	37	W of Penmaenpool Bridge, Mawddach estuary.	SH 694 185	52°44.8'N 03°56.1'W	HedOl
629	38	Glan-y-morfa, Mawddach estuary.	SH 702 192	52°45.2'N 03°55.4'W	HedOl

11 Mochras Lagoon (Artro estuary)

Location		
Position (centre)	SH 566 274	52°49'.4N 4°07'.7W
County/district	Gwynedd	Meirionnydd
Conservation agency/area	Countryside Council for Wales	North-west Area

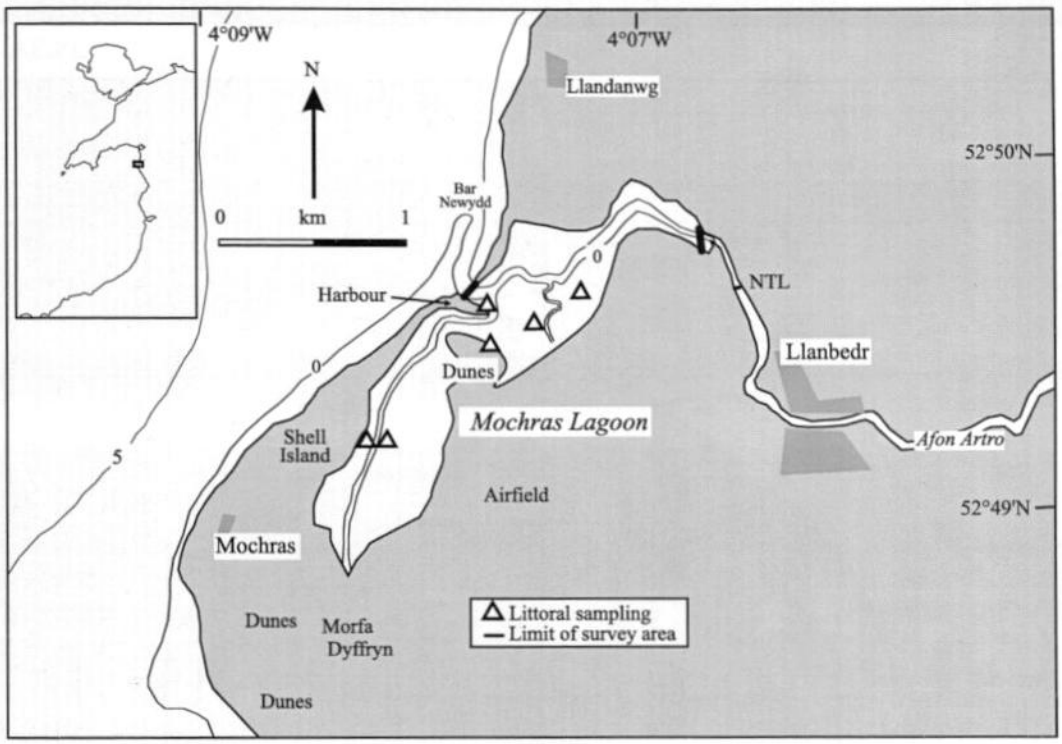

Figure 11.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Bar-built estuary
Length of inlet	1.7 km channel length, 2.7 km length of inlet
Area of inlet	120 ha total, 114 ha intertidal
Bathymetry	Intertidal with a shallow river channel
Wave exposure	Extremely sheltered
Tidal streams	Weak
Tidal range	4.4 m springs; 2.4 m neaps (Porthmadog)
Salinity	Fully marine to variable

Introduction

Mochras Lagoon is a shallow, bar-built estuary which opens out into Tremadog Bay (*area summary* 13) at the north end of Cardigan Bay. The Afon Artro flows along the northern side of the inlet, entering the sea through a narrow channel at Bar Newydd. An extensive muddy sandflat is exposed at low tide leaving only the narrow river channel and several drainage channels up to about 20 m wide. At the southern end of Mochras Lagoon there is an area of saltmarsh, south of which are the extensive Morfa Dyffryn dunes (Buck 1993). There is another small area of saltmarsh to the east

of the mud and sandflats. To the west of the estuary is Shell Island (Mochras), a spit which shelters the estuary from prevailing south-westerly winds.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Habitat (biotope) mapping		April 1997	CCW survey 9.18.1
	Recording and infaunal core sampling	1	April 1997	MNCR survey 642

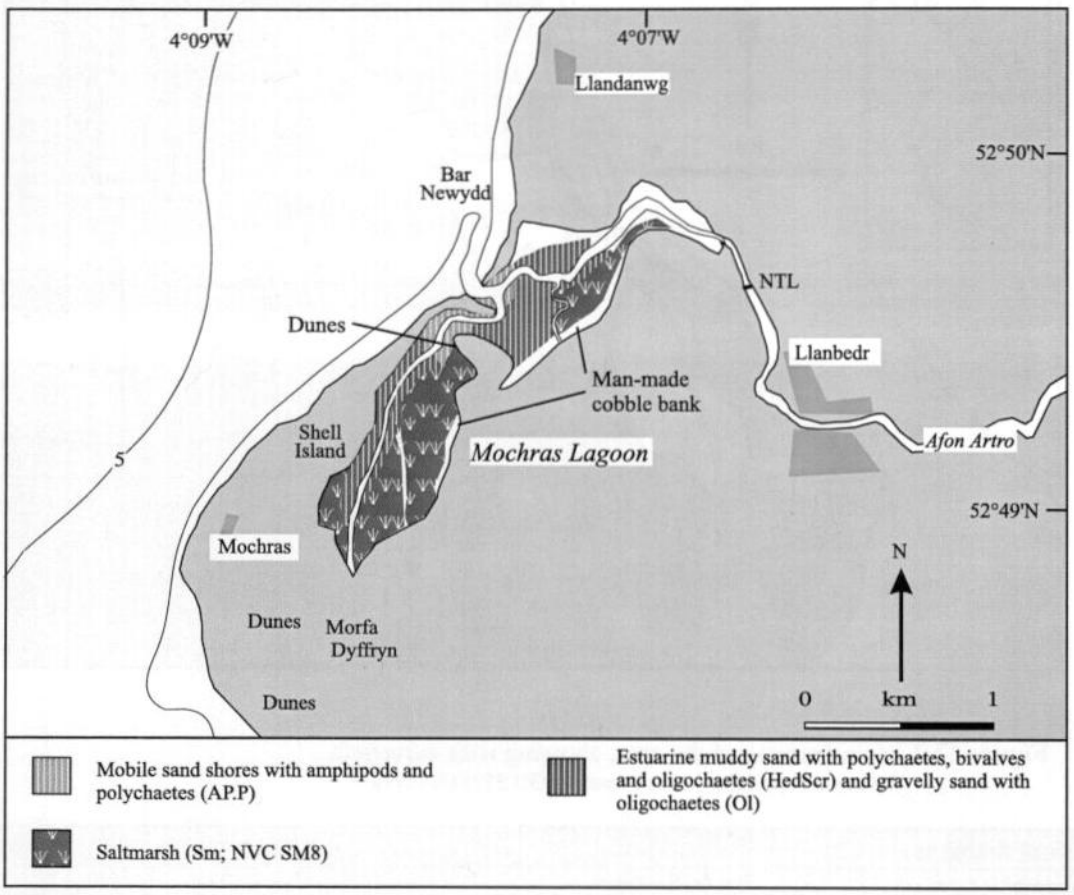

Figure 11.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 11.1, cited literature and additional field observations).

The sediment biotopes in the inlet reflect its extremely wave-sheltered conditions. A large proportion of the southern part of the estuary consists of saltmarsh with a further small area in the east. The eastern fringes of the estuary comprise firm muddy sand with the green alga *Enteromorpha* sp. and sparse saltmarsh flora. Infauna includes enchytraeid oligochaetes, mud snails *Ventrosia ventrosa* and juvenile mussels *Mytilus edulis* (NVC SM8). The upper shore merges with the dense saltmarsh vegetation, above which a small artificial shingle bank next to a road runs parallel to the estuary. Below the pioneer saltmarsh is wet, fine sand with a flocculent muddy surface which contains abundant polychaetes such as *Capitella* sp. and lugworm *Arenicola marina*, oligochaetes *Tubificoides benedii* and bivalves such as *Macoma balthica*, *Cerastoderma edule* and some *Scrobicularia plana*

(HedScr). Well-drained gravelly sand on higher ground throughout the estuary contains oligochaetes dominated by enchytraeids and sparse numbers of polychaetes (O1). The main channel draining the saltmarsh in the south of the estuary has banks of stable anoxic muddy sand and areas of mobile sand with some gravel and mud. The muddy sand on the western bank has dense populations of polychaetes *Hediste diversicolor* and *Pygospio elegans*, oligochaetes *Tubificoides* spp., *Hydrobia ulvae* and abundant bivalves dominated by *S. plana*, *C. edule* and *M. balthica* (HedScr). The more mobile sand on the eastern bank is dominated by polychaetes including *Pygospio elegans* and *Scoloplos armiger*, *Tubificoides* spp. and scattered bivalves including *M. edulis*, *S. plana* and *C. edule* (HedScr). At the entrance to the estuary, where there are strong tidal streams, well-sorted mobile sand on the lower shore has abundant juvenile *M. edulis* and scattered polychaetes dominated by *Nephtys* spp. (AP.P).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Morfa Dyffryn	NNR, SSSI, GCR	SH 550 250	Biological; geomorphological.
Morfa Harlech and Morfa Dyffryn	cSAC	SH 56 34	Dunes
Glannau Harlech	SSSI; NCR	SH 58 27	Biological
Snowdonia	NP	N/A	

Human influences

Coastal developments and uses

The present day features of Mochras Lagoon have been largely shaped by man. A land-claim scheme in 1819 diverted the the Afon Artro river channel from the south of Shell Island to the north through marshy ground, isolating Shell Island and making it a true island. Gradually the southern end of the island silted up, joining it to the mainland once more, and subsequently sand dunes formed (Buck 1993). To the north-east, the extent of the saltmarsh has been reduced by a dyke draining the land.

There are few recent human influences on Mochras Lagoon, and few coastal developments. The saltmarsh to the south of Mochras Lagoon is grazed by livestock. There is a military airfield to the east, at Llanbedr. A railway bridge crosses narrows at the eastern end of the estuary and a track runs along the southern edge of the estuary, crossing creeks via small bridges. Footpaths cross the intertidal areas of the inlet and follow its perimeter. Tourism and leisure are the main activities in the area. There is a visitor centre with camping facilities on Shell Island.

Marine uses

Mochras Lagoon is used for mooring small boats and there is a small marina, quay, and moorings. However, most of the water-based activities, such as sailing and wind-surfing, take place on the open coast. There are no commercial fishing interests in Mochras lagoon but a limited amount of bait-digging takes place.

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Sites surveyed

Survey 642. 1997 MNCR Cardigan Bay littoral survey (MNCR, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
642	61	Mochras Lagoon, Harlech	SH 566 274	52°49.4'N 04°07.7'W	HedScr, NVC SM8, AP.P, Ol

Compiled by: Dora Nichols

12 Traeth Bach (Glaslyn and Dwyryd estuaries)

Location		
Position (centre)	SH 570 360	52°54'N 4°07'.5W
County/district	Gwynedd	Meirionnydd; Dwyfor
Conservation agency/area	Countryside Council for Wales	North-west Area

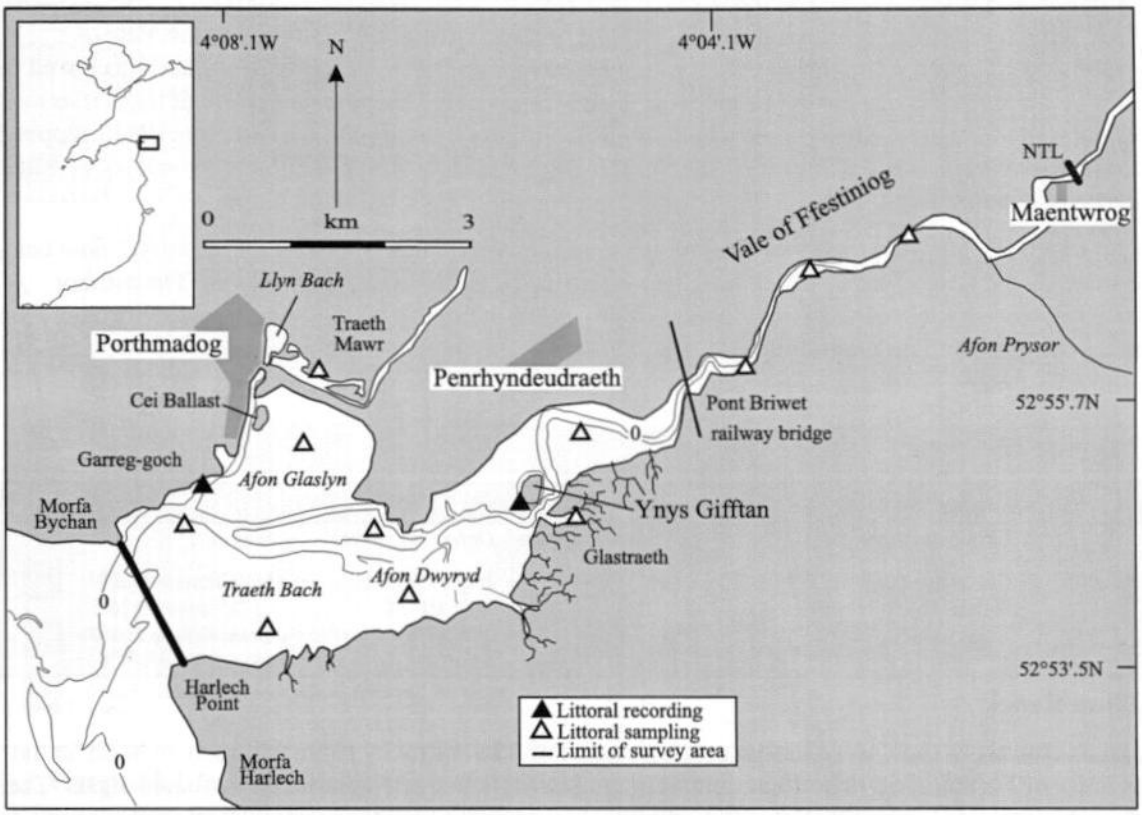

Figure 12.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Bar-built estuary
Length of inlet	15.7 km
Area of inlet	2,050 ha total; 1750 ha intertidal
Bathymetry	Maximum 2.2 m in the lower estuary, otherwise very shallow
Wave exposure	Moderately exposed to ultra sheltered
Tidal streams	Weak to very weak
Tidal range	4.4 m springs; 2.4 m neaps (Porthmadog)
Salinity	Fully marine to low salinity

Introduction

The Glaslyn and Dwyryd estuaries converge to form a common basin, Traeth Bach, which joins Tremadog Bay (*area summary* 13), in the north-east corner of Cardigan Bay. The mouth of Traeth Bach is partly closed by an extensive sand-bar and dune system to the south at Morfa Harlech and a smaller sand-bar and dunes to the north at Morfa Bychan. Morfa Harlech is important

geomorphologically, as an example of an advancing dune system with several ridges aligned to the prevailing wind. The lower estuary is of medium-fine mobile sand with some small areas of saltmarsh to the south and rocky shore to the north.

The Afon Glaslyn runs north-south and joins the Dwyryd south of Porthmadog. A 1.5 km-long embankment south-east of Porthmadog, carrying the railway and A487 road, limits the Glaslyn's intertidal sandflats of Traeth Mawr to the lower estuary, with several brackish pools and extensive areas of marsh occurring upstream of the causeway. Sluice gates on the causeway restrict tidal flow but allow migratory fish to pass through. Much of the Afon Glaslyn in the vicinity of Porthmadog has been canalised to form a harbour.

The Afon Dwyryd runs east-west, the upper tidal limit occurring at Maentwrog in the Vale of Ffestiniog. The main channel is very shallow in the mid-and upper reaches. It formerly followed the north side of the estuary but now runs close to the south bank. There are a few small tributaries to the estuary, including the Afon Prysor which drains from Llyn Trawsfynydd, a reservoir which supplied the now-decommissioned Trawsfynydd Nuclear Power Station. Ynys Gifftan is a small rocky island in the mid-estuary.

Glastraeth is a large area of grazed saltmarsh to the south of Ynys Gifftan on the Dwyryd, now being eroded by the river channel which has diverted naturally to the south of the island. The estuary narrows considerably above Pont Briwet bridge, where the valley becomes steep-sided with only small areas of marshland on the shores.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	2	July 1995	MNCR survey 629
	Habitat (biotope) mapping		May 1997	CCW survey 9.16.1
	Infaunal sampling (cores)	8	July 1978	Cook & Rees (1978)
		3	July 1995	MNCR survey 629

Littoral rock

Hard substrata in the lower Glaslyn estuary consist of 3 km of rocky shore and harbour walls in the vicinity of Porthmadog. The canalised areas are heavily-silted and dominated by fucoid algae. The steep bedrock at Garreg-Goch shows a distinct algal zonation. Rugged supralittoral rock supports a wide range of yellow and grey lichens (YG); upper littoral fringe rock has a dense cover of the black lichen *Verrucaria maura* (Ver.Ver) and the lower littoral fringe rock has dense tufts of channelled wrack *Pelvetia canaliculata* with the red alga *Catenella caespitosa* beneath and the odd plant of spiral wrack *Fucus spiralis* (Pel). The mid-eulittoral bedrock is dominated by the knotted wrack *Ascophyllum nodosum* with the epiphytic red alga *Polysiphonia lanosa*, both species characteristic of sheltered shores (Asc.VS). Beneath the *A. nodosum* the rock is encrusted by dense crusts of barnacles *Elminius modestus* and *Semibalanus balanoides.* The zone below the *A. nodosum* supports a mosaic of bladder wrack *Fucus vesiculosus* (Fves) and the brackish-water fucoid *Fucus ceranoides* (Fcer). Beneath the fucoids, the rock is encrusted with large mussels *Mytilus edulis*. Lower eulittoral rocky biotopes are not present because the rock/sediment interface occurs in the mid-eulittoral.

In the mid-estuary and above the causeway, habitats are more sheltered from wave action. Rocky areas are restricted to the upper eulittoral and littoral fringe with the exception of Ynys Gifftan, which is similar in character to the lower estuary shores, although more silted. A boulder shore at Llyn Bach has a dense cover of *F. ceranoides* and the green alga *Enteromorpha* sp.; common eels *Anguilla anguilla* are found under the boulders (Fcer) (R. Covey, pers. comm.).

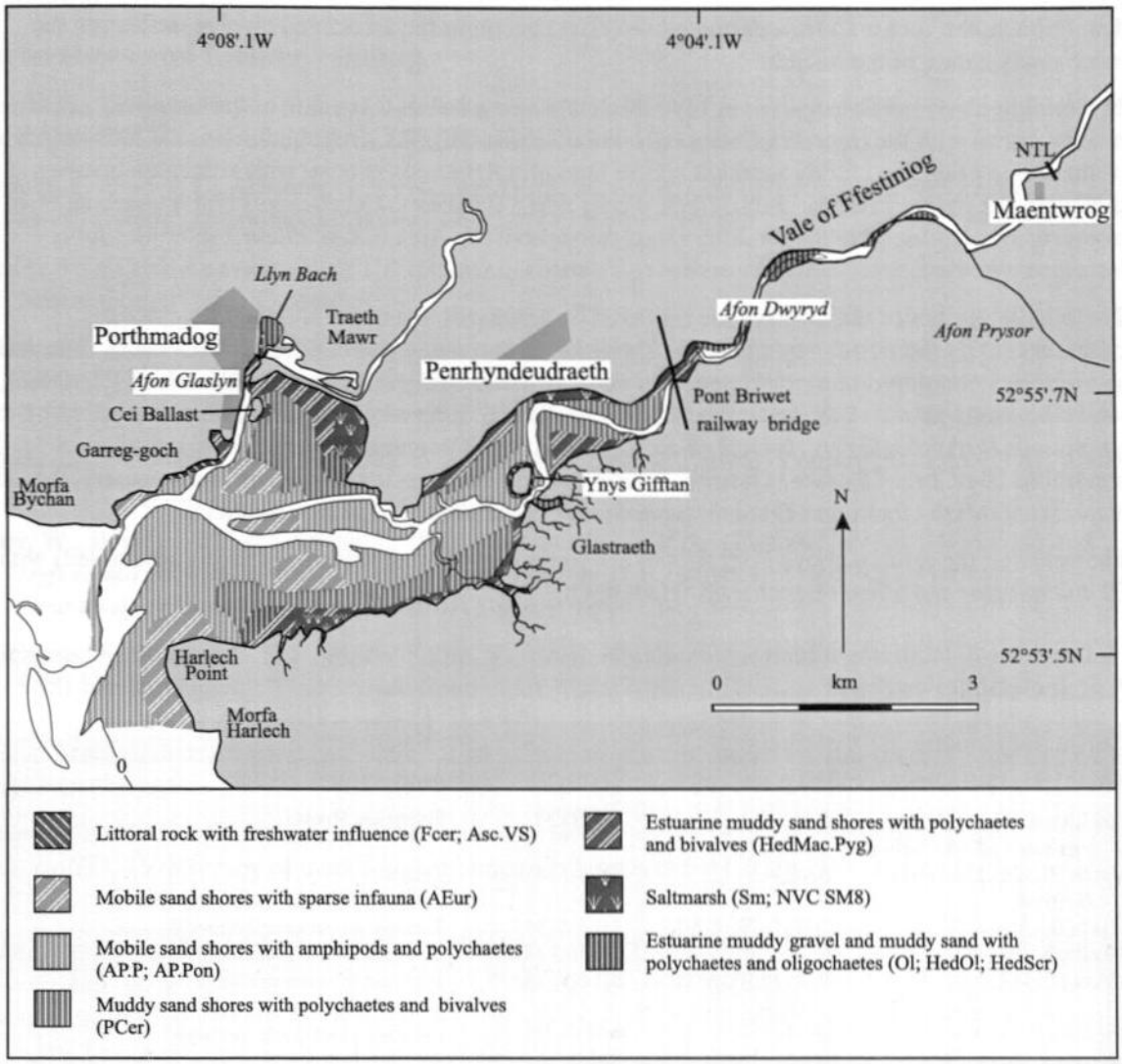

Figure 12.2 Indicative distribution of the main biotopes in the inlet (based on data from survey sites shown in Figure 12.1, cited literature and additional field observations).

Littoral sediment

The lower basin of the inlet comprises well-sorted, mobile, medium-fine sand which is slightly coarser towards the mouth. The extensive sandflats of Traeth Bach are sculptured and waved by rapid tidal streams and support a sparse infauna due to the mobility of the sediment. At the mouth of the estuary, the clean, mobile sands have an infaunal community characterised by burrowing amphipods *Bathyporeia pilosa* and *Haustorius arenarius* and the isopod *Eurydice pulchra* (AEur). The same biotope is present between the main river channels in the lower estuary. Throughout most of the mid- and lower shores of the lower estuary, the sandflats are subject to tidal streams, with a community of polychaetes *Nephtys cirrosa* and *Scolelepis squamata*, *B. pilosa*, *E. pulchra* and the tellin *Angulus tenuis* (AP.Pon; AP.P). The sheltered sediment behind Harlech Point and south-east of Cei Ballast has a higher proportion of mud, is backed by saltmarsh and is dominated by very dense numbers of the mud snail *Hydrobia ulvae*. The upper shore at these sites is characterised by the polychaete *Pygospio elegans* and the tellin *Macoma balthica* (HedMac.Pyg), although towards the central area of

Traeth Bach, the cockle *Cerastoderma edule* (PCer) becomes the associated bivalve, reflecting the more sandy nature of the habitat.

In the mid-estuary, sediment areas at Llyn Bach and along the northern side of the causeway are of muddy gravel with the ragworm *Hediste diversicolor* (HedOl) (R.Covey, pers. comm.). Downstream of the sluice gates, the muddy sand has sparse lugworm *Arenicola marina* with numerous bivalves including the peppery furrow shell *Scrobicularia plana* (HedScr). Other large bivalves such as *Mya arenaria* are also found in the muddier sands throughout the Area (CCW Phase 1 intertidal survey information).

The middle reaches of the Dwyryd are bordered by saltmarsh, the upper shore communities characterised by the burrowing amphipod *Corophium arenarium* and *H. ulvae* (NVC SM8). The mid-shore here is composed of muddy sand with *H. diversicolor*, oligochaetes and *M. balthica* (HedMac), while the sandy nature of the lower shore accounts for the infaunal community being dominated by the amphipods *Bathyporeia* spp., typical of mobile sands, and *Corophium volutator*, typical of estuarine conditions (BatCor). *C. edule* is notably sparse, in contrast to the lower reaches of the estuary. Muddy areas in saltmarsh creeks and channels have dense populations of *S. plana* (HedScr).

The banks of the estuary above Pont Briwet are composed of muddy sand or gravel (unsampled) with *H. diversicolor* and a few oligochaetes (HedOl; Ol).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Pen Llŷn a'r Sarnau/Lleyn Peninsula and the Sarnau	cSAC	SH 50 30	Estuaries; Reefs
Morfa Harlech and Morfa Dyffryn	cSAC	SH 56 34	Dunes
Morfa Bychan	SSSI; GCR; CWT	SH 542 365	Biological; geomorphological
Glaslyn Marshes	SSSI; CWT	SH 582 385	Botanical
Morfa Harlech	NNR; SSSI; NCR; GCR	SH 560 350	Biological; geomorphological
Snowdonia	NP	N/A	(Southern and upper estuary)
Llyn Peninsula	ESA	N/A	Agri-environmental scheme

Human influences

Coastal developments and uses

The embankment across the Glaslyn estuary was constructed in 1811, reducing its area by 50% (Buck 1993). This area of land is used for livestock grazing. Porthmadog is a popular holiday resort, with a number of caravan parks to the west of the town.

Marine uses

The lower estuary is a nursery area for sea bass *Dicentrarchus labrax* and the use of fixed nets within the estuary is banned from March to October. Cockles *Cerastoderma edule* are gathered on the estuary and mussels *Mytilus edulis* were cultivated at Porthmadog prior to the installation of the yacht moorings. Porthmadog has a developed harbour area with over 230 moorings, predominantly for pleasure craft, but with one commercial fishing vessel. The lower estuary is used for a variety of water sports.

There are three sewage treatment works on the Glaslyn/Dwyryd, and the former Nobel's explosives factory at Penrhyndeudraeth had an industrial discharge into the estuary. This site is now being reclaimed and may be used for nature conservation. Most of the water is classified as grade A (highest quality), with the exception of a small area around Porthmadog harbour, which is grade B.

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Richards, A., Bunker, F. St.P., Foster-Smith, R. 1996. Handbook for marine intertidal Phase 1 and SSSI habitat mapping. *Countryside Council for Wales Natural Sciences Report*, No. 95/6/1.

Sites surveyed

Survey 629. 1995 MNCR Cardigan Bay estuaries, littoral survey (MNCR, unpublished data).
Survey 633. 1978 survey of macro-invertebrate populations in the Glaslyn/Dwyryd estuary (Cook & Rees 1978).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
629	39	Garreg-goch, Glaslyn/Dwyryd estuary.	SH 563 372	52°54.7'N 04°08.2'W	YG, Ver.Ver, Asc.VS, Fves
629	40	W shore of Ynys Gifftan, Glaslyn/Dwyryd estuary.	SH 600 371	52°54.7'N 04°04.9'W	YG, Fspi, Pel, Fcer
629	41	Glastraeth Creek, Glaslyn/Dwyryd estuary.	SH 608 365	52°54.4'N 04°04.2'W	HedOl
629	42	S of Pont Tyddyn-Isaf, Glaslyn/Dwyryd estuary.	SH 632 397	52°56.2'N 04°02.1'W	HedOl
629	43	Below Laundry Cottage, Glaslyn/Dwyryd estuary.	SH 643 399	52°56.3'N 04°01.1'W	HedOl
633	1	Garreg-Goch, Glaslyn/Dwyryd estuary.	SH 560 365	52°54.3'N 04°08.4'W	AEur, AP.Pon
633	2	Garth, Glaslyn/Dwyryd estuary.	SH 572 377	52°55.0'N 04°07.4'W	PCer, AP.Pon, HedMac, AP, BatCor
633	3	Traeth Bach West, Glaslyn/Dwyryd estuary.	SH 570 357	52°53.9'N 04°07.5'W	BatCor, HedOl, NVC SM8, HedMac, Ol
633	4	Porthmadog, Glaslyn/Dwyryd estuary.	SH 575 387	52°55.5'N 04°07.2'W	HedOl
633	5	Portmeirion, Glaslyn/Dwyryd estuary.	SH 586 371	52°54.7'N 04°06.1'W	AP.P, HedScr, HedMac, Ol, BatCor
633	6	Traeth Bach East, Glaslyn/Dwyryd estuary.	SH 586 361	52°54.2'N 04°06.1'W	AEur, PCer, AP.Pon, HedMac, AP.P, BatCor
633	7	Glastraeth, Glaslyn/Dwyryd estuary.	SH 606 374	52°54.9'N 04°04.4'W	HedMac.Pyg, HedOl, HedMac, Ol, BatCor
633	8	Vale of Ffestiniog, Glaslyn/Dwyryd estuary.	SH 638 397	52°56.2'N 04°01.6'W	BatCor, HedOl

Compiled by: Paul Brazier & Eleanor Murray

13 Tremadog Bay

Location		
Position (centre)	SH 428 287	52°50'N 4°20'W
County/district	Gwynedd	Dwyfor
Conservation agency/area	Countryside Council for Wales	North-west Area

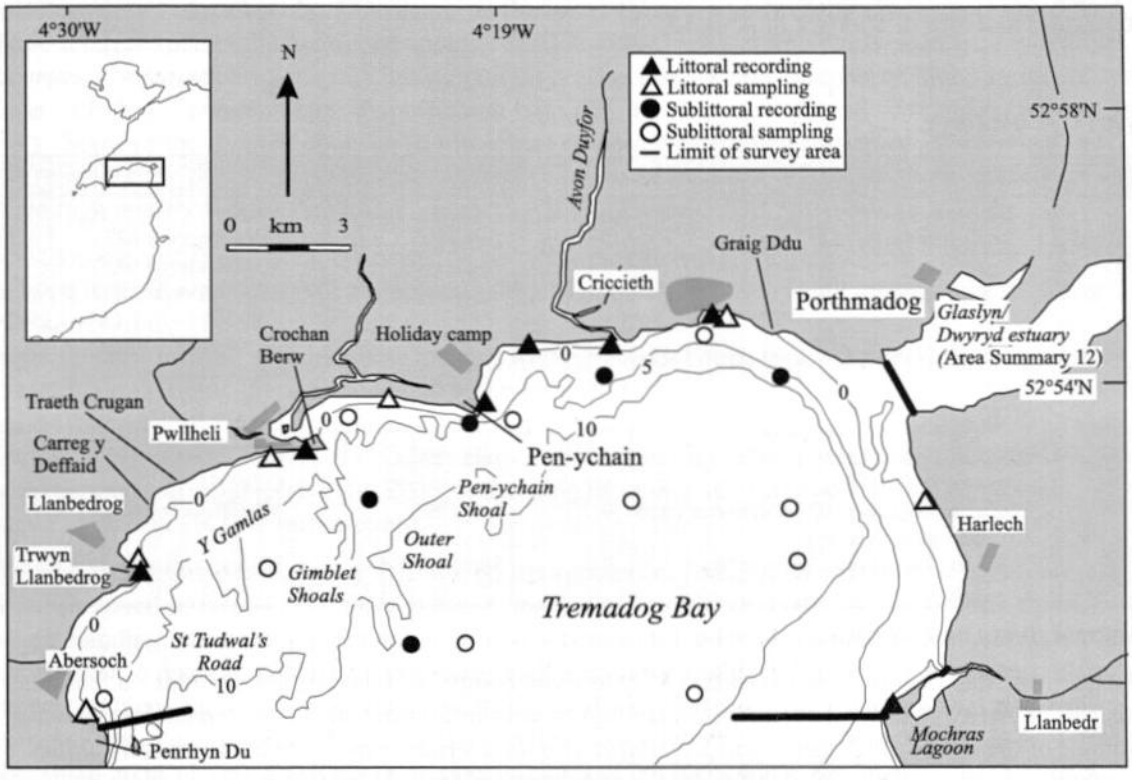

Figure 13.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Semi-enclosed coast
Length of coast	41 km (measured at low water mark, excluding estuaries)
Bathymetry	10 m isobath at 1-3 km offshore, maximum depth in bay 19 m
Wave exposure	Moderately exposed to sheltered
Tidal streams	Weak to negligible
Tidal range	4.3 m springs; 2.2 m neaps (at Pwllheli)
Salinity	Fully marine

Introduction

Tremadog (Tremadoc) Bay is a large, shallow bay at the north end of Cardigan Bay. The Lleyn Peninsula forms the north and west shores of the bay; hills behind Harlech lie to the east, and the shallow reefs of Sarn Badrig (*area summary* 7) partially shelter the bay from the south. The extensive Glaslyn/Dwyryd estuary (*area summary* 12) opens into the north-east corner of Tremadog Bay and there are several smaller river and estuary systems: Afon Soch, which opens into Tremadog Bay at

Abersoch; Afon Erch at Pwllheli Harbour and Afon Artro, which forms Mochras Lagoon (*area summary* 11).

Most of the habitats within Tremadog Bay are of sediment or are sediment-influenced. The shores comprise a series of sandy bays with patches of gravel and cobbles punctuated by low-lying rocky headlands. The seabed slopes very gradually offshore, reaching no more than 19 m depth towards the middle of Tremadog Bay. Despite the lack of great depth and the open nature of the bay, there is a wide range of sediment grades, from clean sands and patches of cobbles and boulders in the shallows through to muddy sands and thick mud in deeper water further offshore. There are no extensive sublittoral outcrops of bedrock in Area 13.

Marine biology

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	5	July 1995	MNCR survey 627
		1	April 1997	MNCR survey 642
	Phase 1 mapping		June-July 1996	CCW surveys 9.18.1, 9.17.1, 9.15.1, 9.14.2, 9.14.1, 9.13.1, 9.12.1, 9.11.1, 9.10.1, 9.9.2, 9.9.1
	Infaunal sampling (cores and granulometry samples)	6	July 1995	MNCR survey 627
Sublittoral	Recording (epibiota)	5	July 1995	MNCR survey 628
	Recording (epibiota)	6	August 1998	CCW survey 773
	Infaunal sampling (10 cm diameter cores and granulometry)	9	July 1995	MNCR survey 628
	Infaunal sampling (0.1m^2 van Veen grab)	3	Summer 1989	Mackie, Oliver & Rees (1995)

Littoral (from east to west)

Outside Mochras Lagoon (*area summary* 11) the shore comprises boulders and cobbles - a feature of this part of Area 13. Littoral communities are highly sand-influenced and characterised by extensive mounds of the honeycomb reef worm *Sabellaria alveolata* which cement the boulders and cobbles together, providing additional stability for the attachment of fucoid algae (Salv).

The sands in the mouth of the Glaslyn/Dwyryd estuary (*area summary* 12) are highly mobile, similar to many of the other sandy beaches around Tremadog Bay. The mobile sand has a sparse infauna of burrowing amphipods and a few polychaetes (AP.P; AEur) and, where slightly more stable, the tellin *Angulus tenuis* is also found (part of AP.P). A bed of the eelgrass *Zostera angustifolia* (Zmar) occurs at extreme low water on the shore between Graig Ddu, at the northern side of the estuary, and the approaches to Criccieth (CCW Phase 1 survey information). Evidently the sediment is fairly stable here, supporting burrowing urchins *Echinocardium cordatum*, razor shells *Ensis* spp. and *A. tenuis* (I. Rees, pers. com.). Slightly further west, at the partially-sheltered sand beach at Criccieth, are dense populations of the polychaetes *Nephtys cirrosa* and *Scolelepis squamata*, and the lugworm *Arenicola marina* (AP).

The rocky shores below Criccieth Castle are rather sand-scoured, particularly on the lower shore, and therefore support little more than the algae typical of the zones found throughout much of the country. The upper shore has small patches of channelled wrack *Pelvetia canaliculata* (Pel) with mats of the black lichen *Lichina pygmaea* and scattered barnacles *Semibalanus balanoides*. Upper and mid-eulittoral steep bedrock below the castle, and tops of large boulders nearby, are dominated by dense crusts of *S. balanoides* and limpets *Patella vulgata* (BPat.Sem). A few scraps of fucoid algae *Fucus spiralis*, *Fucus vesiculosus* and larger patches of *Ascophyllum nodosum* (Asc.Asc) are also found.

At Criccieth, well-rounded cobbles set in mobile sand in the mid-eulittoral support little other than the ephemeral green alga *Enteromorpha* spp., with *Fucus serratus* (Fserr) in the lower eulittoral. Small

clumps of *S. alveolata* also occur on the boulders (Salv). The *Sabellaria* in Area 13 was hit badly by the cold winter of 1984 (Gubbay 1988), although the reefs are now regenerating and are rich in red algae and underboulder and overhang communities (CCW Phase 1 intertidal survey information). This habitat type, colonised by sparse fucoids and *S. alveolata*, extends westwards for 4 km along a straight section of coast, interrupted only by the mouth of the Afon Dwyfor. On the banks of the Dwyfor, just inside the river mouth, clumps of the brown alga *Fucus ceranoides* and *Enteromorpha* spp. (FcerX) are found covering cobbles, a biotope characteristic of brackish and variable salinity conditions.

The small rocky headland Pen-ychain is more rugged than most rocky shores in Tremadog Bay, with many crevices and rockpools. Overhangs on the lower shore are particularly interesting, supporting shade-tolerant species, including the sponges *Halichondria panicea*, *Myxilla incrustans*, *Esperiopsis fucorum*, *Hymeniacidon perleve*, *Ophlitaspongia seriata* and *Grantia compressa*, and a variety of red algae including *Ceramium* spp., *Polysiphonia* spp., *Phyllophora pseudoceranoides* and coralline algae (SR). Some of the shallow pools on this headland contain well-formed masses of *Sabellaria* tubes. Two small sandy coves, on the east of the headland, have sparse *Z. angustifolia* (Zmar), although not at the high density seen to the east of Criccieth (CCW information).

For 4 km west of Pen-ychain, the coastline reverts to an extensive linear sand beach, supporting sand-hoppers (talitrid amphipods) (Tal), but little other sign of life (BarSnd) until reaching the mouth of Pwllheli marina. Here there is another small rocky headland, similar in some respects to Pen-ychain, but it supports little other than sparse mussels *Mytilus edulis*, barnacles *Chthamalus montagui* and *S. balanoides* (BPat.Cht) and ephemeral green algae *Enteromorpha* spp., due to the high degree of scour from the loose coarse sediment on the mid- and lower shore. The gravel beach, Traeth Crugan, continues for over 6 km west of Crochan Berw, again appearing rather barren with few signs of life other than talitrid amphipods (Tal; BarSh) including the nationally rare species *Pectenogammarus planicrurus* (Pec) (CCW information).

West of the headland of Carreg y Deffaid, on the approaches to Llanbedrog, the sand in this more wave-sheltered position is of a finer grade. *A. marina* casts are abundant over much of the shore, where standing water remains for much of time between high tides. Just south of Llanbedrog, on the lower shore, a patch of cobbles on sand surrounds very large sculptured limestone boulders which support sponges such as *H. panicea*, rock-boring piddocks *Hiatella arctica* and colonial ascidians *Morchellium argus* and *Botryllus schlosseri* on their shaded overhanging surfaces (SByAs). There are also small areas of very localised shelter behind lines of boulders where the brown bootlace weed *Chorda filum* is attached to shells and small pebbles, and patches of sand are bound into muddy mats by the fine filamentous red alga *Rhodothamniella* sp. (Rho). The lower shore sand supports communities which continue offshore - characterised by *E. cordatum*, *Ensis* sp., the bivalve *Tapes decussatus* and burrowing amphipods and polychaetes (VsenMtru?, AP.Pon). The anemone *Cereus pedunculatus* and tube worm *Sabella pavonina* are also occasionally exposed at very low water of spring tides on this beach (CCW information).

Bedrock and large boulders in the south-west corner of this bay, shaded by the headland of Trwyn Llanbedrog, support dense layers of *P. canaliculata* with a thick under-layer of *Catenella caespitosa* on the boulder tops (Pel), some *F. spiralis* (Fspi) and a thick curtain of *A. nodosum* (Asc.Asc) hanging down the boulder sides. This typical sheltered algal community gives way to one more typical of moderate exposure at Trwyn Llanbedrog, where fucoid and barnacle mosaics are found on sand-scoured limestone boulders and cobbles (BPat, FvesX and Fser.Fser.Bo).

The most south-westerly shore site surveyed in Area 13 is on the extensive sand beach of Borth Fawr in the south of St Tudwal's Road, just west of Penrhyn Du. The upper shore is of medium-grained sand with coarse gravel beneath and has little visible infauna other than talitrid amphipods (Tal). However, lower down the shore, sand mason worm *Lanice conchilega* tubes and *A. marina* casts are present on the sand surface. Both species are also found at the low water mark with other polychaetes and *A. tenuis* (AP.P).

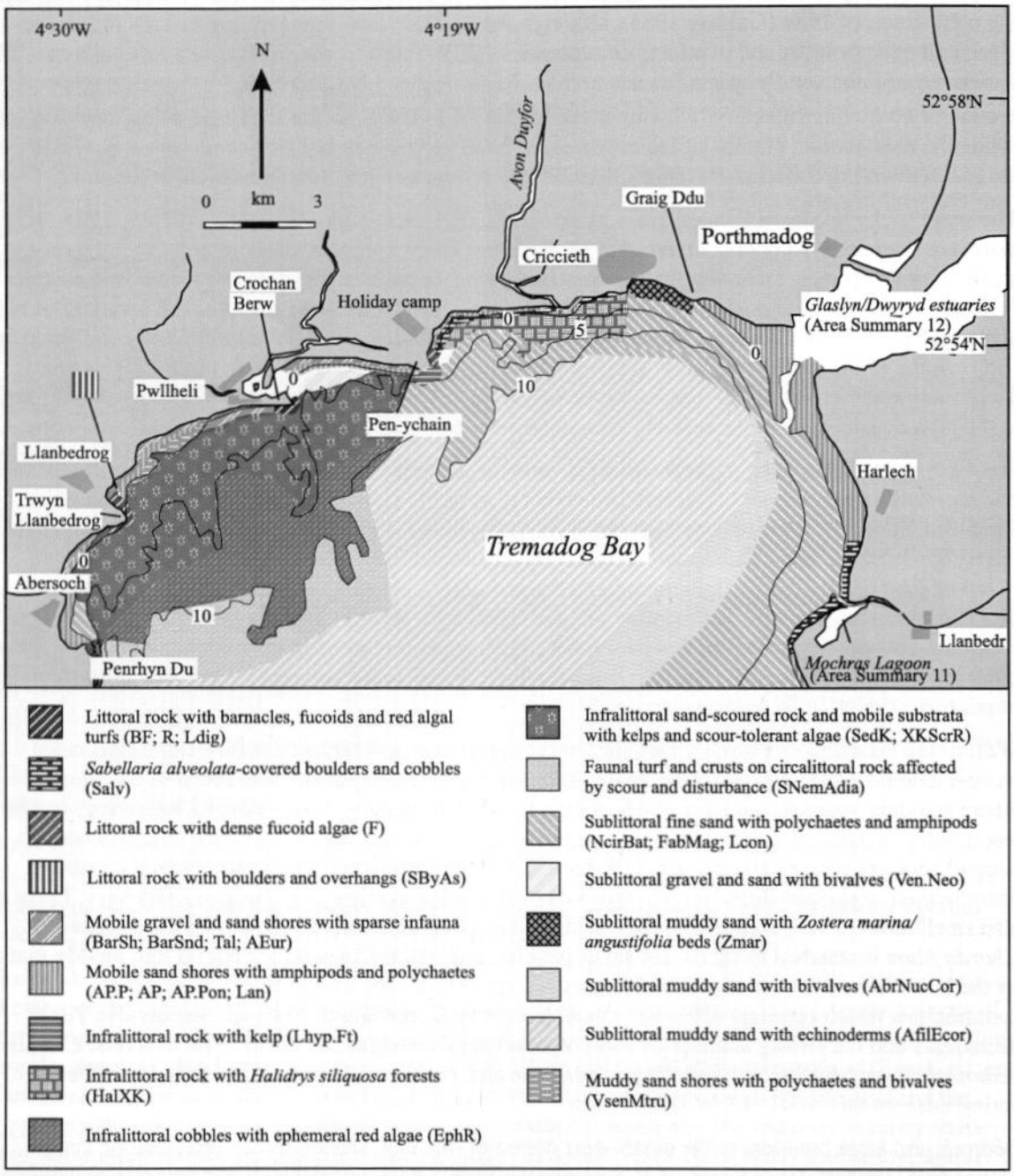

Figure 13.2 Indicative distribution of the main biotopes in the area (based on data from survey sites shown in Figure 13.1, cited literature and additional field observations).

Sublittoral

In summary, Tremadog Bay is a large, sediment-filled, shallow basin, with cobble reefs of the Sarns to the south and south-east (*area summary* 7) and north-west (Gimblet, Outer and Pen-ychain Shoals). There are clean sands and mixtures of sediment and cobbles in the shallows around the margins of the bay which grade into soft sandy mud in the deeper middle section of the bay.

Stable rocky habitats in Tremadog Bay appear to be scarce and were surveyed at only one site in very shallow water, at Pen-ychain. Dense kelp *Laminaria hyperborea* forest on bedrock and the tops of large boulders on sand extends only just below chart datum (less than 3 m depth). Under the kelp canopy and on the sides of the boulders there is a dense mat of the red alga *Phyllophora pseudoceranoides*, overgrown with *Ceramium* spp. and other red algae including *Plocamium cartilagineum*, *Cryptopleura ramosa*, *Hypoglossum hypoglossoides*, *Heterosiphonia plumosa*, *Brongniartella byssoides* and *Halurus equisetifolius* (Lhyp.Ft). Several other species of algae indicative of disturbance and scour, including *Laminaria saccharina*, *Chorda filum*, large sheets of the red alga *Dilsea carnosus*, and *Polyides rotundus*, are present on cobbles and pebbles in sand (XKScrR). Of note at this site were the large numbers of sea bass *Dicentrarchus labrax* seen swimming in shallow water close inshore.

Slightly further offshore, but still in shallow water (3-5 m), there are several areas of cobble and pebble reef which support algal communities similar to those found on the Sarns (*area summary* 7) for example, between Pen-ychain and Criccieth, offshore east of Pwllheli and in parts of St Tudwal's Road (as indicated by RoxAnn survey). Most of the species present are typical of scoured and disturbed conditions. Sea oak *Halidrys siliquosa* forms a dense canopy with *Polyides rotundus*, *Furcellaria lumbricalis* and *Chorda filum* amongst it (HalXK). A dense mat of red algae including *H. hypoglossoides*, *Phycodrys rubens*, *Calliblepharis ciliata* and *Polysiphonia* spp. and sparse *L. hyperborea* occurred on the tops of the boulders (XKScrR). As the larger algae thin out in the slightly deeper (5-10 m) water on Gimblet Shoal and Pen-ychain Shoal, ephemeral species of red algae such as *Naccaria wiggii* and *Scinaia* spp. are found on cobbles and pebbles in the sediment (EphR). Two algae of particular note were found in 1998 in the area between St Tudwal's Road and Pwllheli Bay. The find of *Polysiphonia sanguinea* was the first record of this species in Britain (C. Maggs, pers. com.), while *Anotrichium barbatum*, a fine filamentous red alga, had not previously been recorded in Britain during the 20th century, and never north of the English Channel coast (Maggs & Hommersand 1993). It is listed as a priority species under the UK Biodiversity Action Plan (UK Biodiversity Group 1998).

On Gimblet Shoals the algae thin out with increasing depth and below approximately 10-12 m, animal communities dominate the increasingly silted stony seabed. The tall hydroids *Nemertesia antennina* and *Nemertesia ramosa* and the bryozoan *Flustra foliacea* cover most of the upward-facing surfaces of the larger rocks, although there are a large number of other species recorded amongst the smaller stones and on the undersides of boulders (SNemAdia). Sponges are common, although each species is present in only low abundance, including small *Suberites carnosus*, *Raspailia hispida, Hemimycale columella* and the tiny, stalked calcareous sponge *Clathrina lacunosa*. The star anemones *Epizoanthus couchii* and *Isozoanthus sulcatus* are found in small patches amongst the boulders which also support various calcareous tube worms, saddle oysters and encrusting bryozoans. The undersides of boulders are often covered with the colonial ascidian *Perophora listeri* and also provide shelter for many small mobile crustaceans such as the crabs *Pilumnus hirtellus* and *Pisidia longicornis*.

The shallow, sheltered to moderately exposed sand and slightly muddy sand habitats in Tremadog Bay cover a large proportion of the area surveyed offshore from Harlech, Criccieth and Pen-ychain and around the perimeter of the bay towards Abersoch. The infauna was sampled using cores although many species are conspicuous as epifauna or larger infauna (NcirBat and AfilEcor). The epifaunal community comprise large brittlestars *Ophiura ophiura*, the sand star *Astropecten irregularis*, the opisthobranchs *Philine aperta* and *Acteon tornatilis*, the anemones *Cereus pedunculatus* and *Sagartiogeton undatus* (attached to small buried fragments of shell or stone), the sponge *Suberites ficus* and the holothurian *Labidoplax digitata* which was seen in large numbers protruding from its burrow whilst feeding. Scavenging crustaceans, particularly the hermit crab *Pagurus bernhardus* and the swimming crab *Liocarcinus depurator*, were also recorded regularly. At one site, offshore west of Harlech, the holothurian *Ocnus planci* was found in moderate densities lying on the seabed (Ocn). Ascidians, particularly *Ascidiella aspersa*, *Ascidia mentula* and, just off Pwllheli, *Pyura microcosmus* and *Styela clava* were found attached to fragments of shell and pebbles (?Aasp). Some of these

ascidian aggregations are particularly dense, and amongst these grow filamentous algae including the nationally rare red algae *Anotrichium barbatum* and *Polysiphonia sanguinea* and the more common brown alga *Sporochnus pedunculatus*. Fish, including dragonets *Callionymus lyra*, gobies *Pomatoschistus* spp. and plaice *Pleuronectes platessa*, were recorded at most sites. Protruding siphons marked the location of several species of bivalve below the sand surface. The bivalves *Arctica islandica*, *Mya arenaria*, *Chamelea gallina*, *Donax vittatus* and *Acanthocardia echinata* were recorded by digging in the sand; this action often unearthed large numbers of heart urchins *Echinocardium cordatum* (FabMag).

In the deepest part of Tremadog Bay, at around 17-20 m depth, the sediments comprise well-burrowed soft sandy mud with underlying clayey mud. Turret shells *Turritella communis* and various sponges and ascidians attached to empty shells are found on the sediment surface. Scale worms *Ophiodromus flexuosus*, sea mice *Aphrodita aculeata*, holothurians *Ocnus planci* and ascidians *Molgula* sp. and *Eugyra arenosa* are also present in small numbers on the sediment surface. The infaunal core samples contained large numbers of the brittlestars *Amphiura chiajei* and *Amphiura filiformis* with *E. cordatum* and *M. truncata* (BriAchi). These observations broadly concur with those of Mackie, Oliver & Rees (1995). Hamon grab samples taken to the north and east of the St Tudwal's Islands in 1997 (I. Rees, pers. com.) contained species characteristic of fine muddy sand including the bivalve *Phaxas pellucidus* and the sipunculan worms *Golfingia* spp. Large burrowing crustaceans such as *Upogebia deltaura* were also present.

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Pen Llŷna'r Sarnau/Lleyn Peninsula and the Sarnau	cSAC	SH 50 30	Estuaries; Reefs
Morfa Harlech and Morfa Dyffryn	cSAC	SH 56 34	Dunes
Snowdonia	NP	N/A	(South-east part of Area)
Lleyn Peninsula	AONB	N/A	High scenic quality
Llyn Peninsula	ESA	N/A	Agri-environmental scheme
Lleyn Peninsula	HC	SH 424 514 - SH 324 266	Coastal scenery
Glanllunnau	SSSI; GCR	SH 459 373	Geological
Morfa Harlech	SSSI; GCR	SH 560 350	Biological; geomorphological
Morfa Bychan	SSSI	SH 542 365	Biological
Llyn Ystumllyn	SSSI	SH 526 385	Biological
Criccieth Coastal Section	SSSI; GCR	SH 507 381	Geological

Human influences

Coastal developments and uses

The long sandy beaches attract large numbers of visitors during the summer. Pwllheli is the largest town in Area 13, but Abersoch, and other coastal towns all experience a marked rise in poulation during the season. There is a holiday camp at Pen-y-chain and a few light industrial developments at Porthmadog just inside Traeth Bach (*area summary* 12).

Marine uses

Watersports are particularly popular in the vicinity of Pwllheli, Abersoch and Criccieth. Pwllheli marina has recently been extended involving land-claim of an area of shore, and new training walls have been constructed at the entrance to the marina. Yachts not using the marina often moor or anchor in St Tudwal's Road which is sheltered by St Tudwal's Islands (*area summary* 15), and small boats use Mochras Lagoon (*area summary* 11), on the east side of Tremadog Bay.

Lobster *Homarus gammarus* and crab *Cancer pagurus* potting takes place on the cobble and boulder reefs and angling from commercial and privately-operated boats occurs throughout Area 13. Whelk *Buccinum undatum* potting is also an important, although intermittent, fishery. Some trawling also occurs in Area 13.

The main sewage outfalls and storm overflows in Area 13 are situated at Harlech, Pwllheli and Abersoch. At the time of writing, the main outfalls were screened although there were several outfalls at Llanbedrog, Pwllheli and Criccieth where work was in progress to improve the quality of the discharge. Smaller treated sewage outfalls are situated at the caravan sites around Tremadog Bay and at the holiday camp at Pen-y-chain. Designated EC Bathing Waters Directive 'Bathing Beaches' are at Abersoch and Pwllheli. Between 1986 and 1991 both beaches passed the criteria in most years.

References and further reading

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UK Biodiversity Group. 1998. *Tranche 2 action plans. Volume 1 – vertebrates and vascular plants.* Peterborough, English Nature Publicity & Grants Team, for UK Biodiversity Group.

Sites surveyed

Survey 627. 1995 MNCR North Lleyn Peninsula and Tremadog Bay, littoral survey (MNCR, unpublished data).

Survey 628. 1995 MNCR Lleyn Peninsula and Tremadog Bay, sublittoral survey (MNCR, unpublished data).

Survey 634. 1989-91 BIOMÔR, benthic biodiversity of the southern Irish Sea, sublittoral survey (Mackie, Oliver & Rees 1995).

Survey 642. 1997 MNCR Cardigan Bay, littoral survey (MNCR, unpublished data).

Survey 773. 1998 CCW monitoring trials survey in Tremadog Bay and the Sarns reefs, sublittoral survey (CCW, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
627	1	W Penrhyn Du, Abersoch.	SH 320 267	52°48.6'N 04°29.5'W	Tal, AP.P
627	17	South of Abererch Station, Pwllheli.	SH 400 368	52°54.2'N 04°22.7'W	Tal, AP.P, BarSnd
627	19	West of Criccieth, Tremadog.	SH 484 370	52°54.5'N 04°15.2'W	Fspi, Salv, FvesX, Pel
627	20	River Dwyfor, West of Criccieth.	SH 478 373	52°54.6'N 04°15.8'W	FcerX, HedOl
627	21	Llanbedrog Sand Shore, Pwllheli.	SH 332 313	52°51.1'N 04°28.6'W	VsenMtru, BarSnd, AP.Pon, AP.P, LGS
627	22	Llanbedrog Rocky Shore, Pwllheli.	SH 332 313	52°51.1'N 04°28.6'W	YG, Ver.Ver, BPat, Fspi, Asc.Asc, FvesX, SByAs, Fser.Fser.Bo, Pel
627	23	East Criccieth Castle.	SH 502 378	52°54.9'N 04°13.6'W	BPat.Sem, Ver.Ver, Asc.Asc, Salv, PelB, Fserr
627	24	Criccieth.	SH 505 380	52°55.0'N 04°13.4'W	Tal, AP.P
627	25	Pen-ychain, Pwllheli.	SH 436 353	52°53.5'N 04°19.5'W	BPat.Cht, G, YG, MytB, FK, Cor, IR, Ver.B, Osm, PelB
627	26	South Beach. Pwllheli.	SH 377 342	52°52.8'N 04°24.7'W	BarSh, Tal
627	27	Crochan Berw, Pwllheli.	SH 387 343	52°52.9'N 04°23.8'W	BPat.Cht, , YG, Ver.Ver
642	60	Shell Island, Harlech.	SH 549 263	52°48.8'N 04°09.1'W	Sab, Fves, Fspi, FK, Fser
642	62	Harlech beach.	SH 565 325	52°52.2'N 04°07.9'W	AEur, AP.P

Sublittoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
628	1	N of Penrhyn Du, Abersoch.	SH 321 270	52°48.8'N 04°29.4'W	NcirBat
628	2	E of Pwllheli Marina, Tremadog Bay.	SH 404 334	52°52.4'N 04°22.2'W	XKScrR
628	3	Off Morfa Abererch, Pwllheli.	SH 401 351	52°53.3'N 04°22.6'W	Ven.Neo
628	4	Offshore SSE of Pwllheli, Tremadog Bay.	SH 425 286	52°49.9'N 04°20.2'W	AfilEcor
628	5	SE Gimblet Shoals, Pwllheli.	SH 405 292	52°50.2'N 04°22.0'W	SNemAdia
628	6	SE of Oyster Bank, Tremadog Bay.	SH 379 311	52°51.2'N 04°24.4'W	NcirBat, EphR
628	7	Offshore SE of Pen-ychain, Tremadog Bay.	SH 478 332	52°52.4'N 04°15.6'W	AfilEcor
628	8	SE Butlins Holiday Camp, Tremadog Bay.	SH 444 352	52°53.4'N 04°18.7'W	FabMag
628	9	Inshore S of Llanystumdwy, Tremadog Bay.	SH 472 362	52°54.1'N 04°16.2'W	HalXK
628	10	SE Criccieth.	SH 516 364	52°54.2'N 04°12.3'W	Lcon
628	11	W of Harlech, Tremadog Bay.	SH 517 327	52°52.3'N 04°12.2'W	Ocn
628	12	Criccieth.	SH 500 376	52°54.8'N 04°13.8'W	FabMag
628	13	3.5 N.M. W of Mochras Point, Tremadog Bay.	SH 500 274	52°49.4'N 04°13.5'W	Lcon
628	14	Pen-ychain, Pwllheli.	SH 434 352	52°53.5'N 04°19.6'W	Lhyp.Ft
634	27	Tremadog Bay, Cardigan Bay.	SH 524 309	52°51.3'N 04°11.5'W	AbrNucCor
773	10	E of Penrhyn Du, Abersoch	SH 330 266	52°48.7'N 04°28.6'W	?SubSoAs/Aasp
773	11	St Tudwal's Road, Abersoch	SH 335 280	52°49.4'N 04°28.3'W	EcorEns/Aasp
773	12	NE of Abersoch, Abersoch	SH 344 287	52°49.8'N 04°27.4'W	Aasp
773	13	SE of Trwyn Llanbedrog, Llanbedrog	SH 351 298	52°50.4'N 04°26.9'W	Aasp
773	14	E of Trwyn Llanbedrog, Llanbedrog	SH 361 316	52°51.4'N 04°20.0'W	?Aasp
773	15	Oyster Bank, Pwllheli	SH 373 327	52°52.1'N 04°24.9'W	?Aasp

Compiled by: Rohan H.F. Holt

14 South-west Lleyn Peninsula (Penrhyn Llŷn)

Location		
Position (centre)	SH 284 348	52°33'N 4°33'W
County/district	Gwynedd	Dwyfor
Conservation agency/area	Countryside Council for Wales	North-west Area

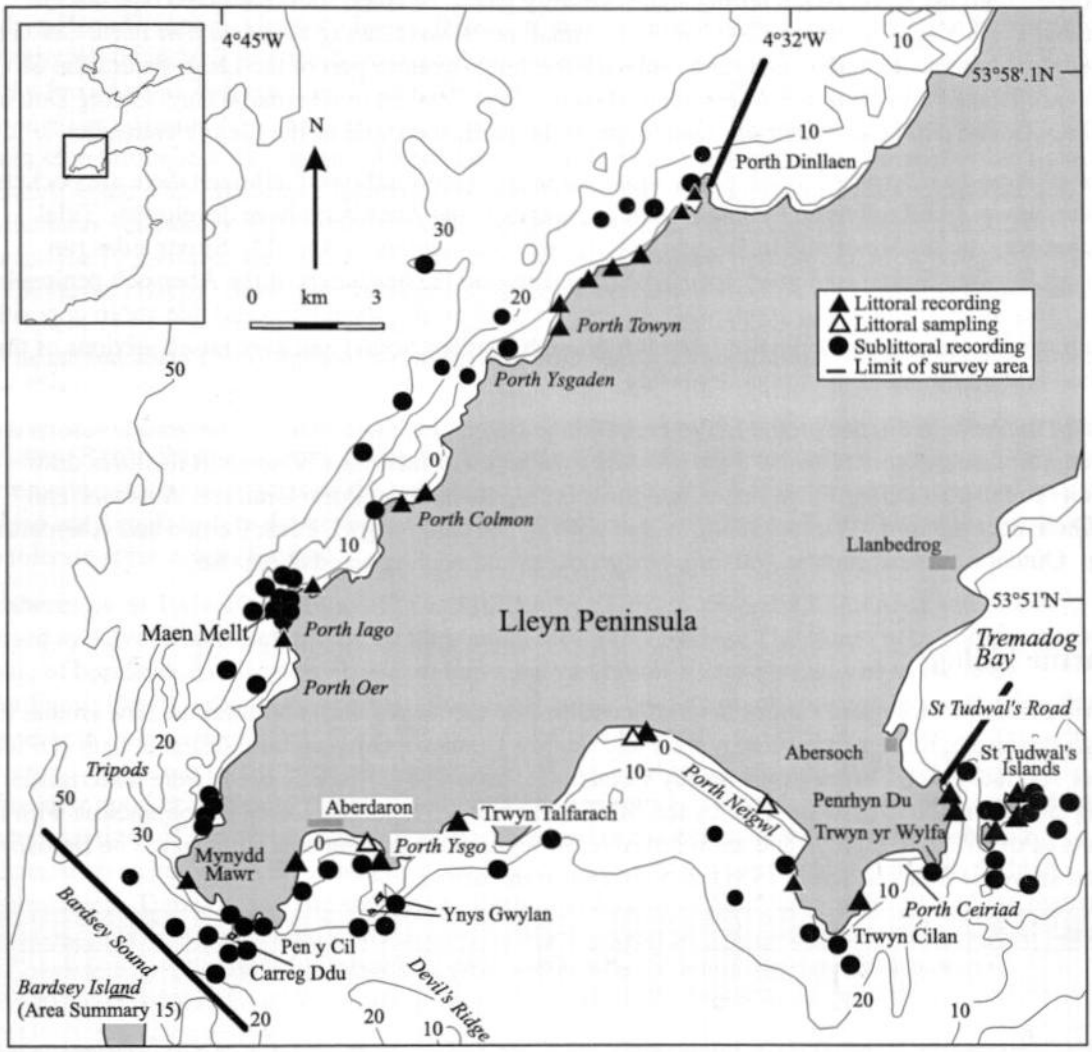


Figure 14.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Open coast with offshore islands and small bays
Length of coast	Approx. 55 km
Bathymetry	30 m isobath between 0.4 and 4 km offshore on the north side of the Lleyn and around 10 km offshore on the south side; 50 m isobath within 2 km of the south-west tip of the Lleyn.
Wave exposure	Very exposed to moderately exposed
Tidal streams	Very strong to negligible
Tidal range	4 m springs; 1.7 m neaps (at Porth Dinllaen)
Salinity	Fully marine

Introduction

The coastline of the Lleyn Peninsula (Penrhyn Llŷn) has been split into three areas for the purposes of these area summary reports. Area 14 and adjoining Bardsey Island (*area summary* 15) are predominantly rocky, in contrast to Tremadog Bay (*area summary* 13) and Caernarfon Bay (*area summary* 16) which have mainly sand and fine sediment-based habitats.

Much of the coastline of Area 14 comprises moderately high cliffs and rugged bedrock slopes down to the shore although there is a 6 km-long strip of sand at Porth Neigwl (Hell's Mouth) where waves are funnelled onto the storm beach during south-westerly gales. Smaller, more sheltered beaches are found at Porth Ysgo, Aberdaron Bay and in the small north-west facing coves such as Porth Oer. There are several groups of small islands and rocks off the south-western part of the Lleyn Peninsula: St Tudwal's Islands lie east of the Abersoch peninsula, Ynys Gwylan in Aberdaron Bay, Carreg Ddu in Bardsey Sound and Maen Mellt off Porth Iago on the north-west side of the Lleyn Peninsula.

Most of Area 14 is exposed to wind and wave action from the south-west although there are pockets of shelter, where small towns and villages such as Abersoch and Aberdaron have developed. Tidal streams play an important role in shaping the benthic communities in Area 14. Strong tides run through Bardsey Sound (see *area summary* 16) and around the headlands of the Abersoch peninsula; most other areas are swept by moderately strong tides. Overfalls when wind and tide are in opposition, which can be a hazard to navigation, develop through Bardsey Sound and over raised sections of the seabed around the tip of the Lleyn Peninsula.

Today, the main industries on the Lleyn Peninsula are agriculture and tourism, the seaside resorts and the adjacent Snowdonia National Park providing the major attractions. Watersport facilities draw visitors to the area during the summer, and the mooring facilities at Porth Dinllaen, Abersoch and Pwllheli are well used. Winter surfing is also popular in Porth Neigwl, Porth Ceiriad and Aberdaron Bay. Outdoor pursuits such as walking, birdwatching and angling are also popular.

Marine biology

Previous marine biological studies have concentrated on the shores and sublittoral habitats around the Lleyn Peninsula; those carried out by the Field Studies Council's Oil Pollution Research Unit (OPRU) under contract to the Nature Conservancy Council (Rostron 1984; Hiscock 1984) were undertaken using similar methods to those used by the MNCR. These two reports are used in conjunction with the results of the MNCR surveys and are referred to throughout the present area summary. The Bardsey Island surveys (Hoare & Jones 1981) also covered some of Area 14.

Marine biological surveys

	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	18	Aug 1983	Rostron (1984)
		6	June 1995	MNCR survey 627
	Habitat (biotope) mapping		April-May 1996 July-Aug 1997	CCW surveys 9.8.1, 9.7.1, 9.6.1, 9.5.1, 9.4.1, 9.3.1, 9.2.1, 10.52.1, 10.51.1, 10.50.1, 10.49.1, 10.48.1
	Infaunal sampling (cores)	2	June 1995	MNCR survey 627
Sublittoral	Recording (epibiota)	1	1977	Hoare & Jones (1981)
		49	Aug 1983	Hiscock (1984)
		5	July 1995	MNCR survey 628
		13	May 1997	MNCR survey 644
		16	July 1998	Bunker (in prep) survey 771
		2	August 1998	CCW survey 773
	Recording (epibiota) monitoring trials	3 zones*	August 1998	CCW survey 772
	AGDS & side-scan survey and video	N part of Area	July 1998	CCW/School of Ocean Science

* Monitoring trials involving 3 m x 50 m transect surveys within three depth zones (total of 61 habitats recorded)

Littoral rock

The rocky shore biotopes in Area 14 follow a characteristic association with wave exposure: barnacle-dominated on the more exposed shores and fucoid-dominated on the more sheltered shores. In addition, sand-scour plays an important role in influencing the characteristics of some biotopes. In the present report describes characteristic biotopes following the coastline clockwise from the more sheltered shores near Abersoch, around the Abersoch peninsula and out to the very exposed headlands at the south-west tip of the Lleyn Peninsula, then north-eastwards along the slightly less exposed north-west-facing side up to Porth Dinllaen.

Penrhyn Du, adjacent to Abersoch beach, faces east into Tremadog Bay. The shore from here south to Trwyn yr Wylfa is fairly sheltered from wave action, supporting zones of lichens (YG and Ver.Ver) and the fucoid algae *Pelvetia canaliculata* (Pel), *Fucus spiralis* (Fspi), *Fucus vesiculosus* (Fves), *Ascophyllum nodosum* (Asc.Asc) and *Fucus serratus* (Fser.Fser) in the typical top-to-bottom zonation pattern seen throughout the region. Where there is a little more wave exposure, the mid-shore fucoids are interspersed with barnacles *Chthamalus montagui* (BPat.Cht) towards the upper mid-shore and *Semibalanus balanoides* (BPat.Sem; FvesB) throughout the mid-shore. On the lower mid-shore, amongst the *F. serratus*, are patches of red algae such as *Osmundea pinnatifida*, *Mastocarpus stellatus* and *Chondrus crispus*. Sand has a marked influence on the biotopes of the rocky shores adjacent to sand beaches by reducing the abundance of the less scour-tolerant animals and plants, allowing species such as the red algae *Cystoclonium purpurea*, *Phyllophora pseudoceranoides*, *Gelidium pusillum* and crabs *Carcinus maenas* to flourish in relatively large numbers. The red alga *Rhodothamniella floridula* is often common on such shores, forming cushions of sand bound together by the fine algal filaments (Rho). Where scouring action is strong enough to prevent most species colonising, perhaps where winter storms bury parts of the rocky shore in sand, only a few fast-growing ephemeral species of algae are found, such as *Enteromorpha* sp. and *Porphyra* sp. and mussels *Mytilus edulis* which can also tolerate some scour (EntPor).

The shores on St Tudwal's Islands, 1 km east of Penrhyn Du, are less sand-influenced and more exposed to wave action, particularly on their south-west facing sides. The steep rocky shores support a mosaic of barnacles and limpets *Patella vulgata* and patches of *Fucus vesiculosus* v. *linearis* (BPat.Fvesl; FvesB). Dense *F. serratus* (Fser.Fser) grows on the lower shore above a sublittoral fringe zone of kelp *Laminaria digitata* (Ldig.Ldig). The kelp supports the red alga *Palmaria palmata* which also grows in patches on the rock where kelp plants have been torn loose. St Tudwal's Islands have particularly good examples of littoral communities in sea caves - a feature uncommon in Area 14 and adjacent sections of the Welsh coast. The species found in the caves are widespread in shaded habitats, such as gullies on the lower shore and the infralittoral, but are found in particularly high densities here. These include the sponges *Clathrina coriacea* and *Stelletta grubii*, turfs of the hydroid *Dynamena pumila*, the ascidian *Dendrodoa grossularia*, anemones *Actinia equina*, *Sagartia elegans* and *Corynactis viridis* inside the caves (SByAs) and patches of encrusting algae including *Hildenbrandia* sp. and coralline crusts nearer to the dimly-lit cave entrances (BPat.Cat).

Wave exposure levels increase dramatically on the south-west facing steep rocky shores around Trwyn Cilan. Fucoid algae cannot retain a hold on the rock surfaces which instead are dominated by barnacles. The rocks of the upper shore and splash zone are covered by the black lichen *Verrucaria maura* and the red alga *Porphyra umbilicalis* and have large numbers of the small gastropod *Melarhaphe neritoides* living in the cracks and crevices (Ver.Por). Small *M. edulis* occur in lines amongst the barnacles on the mid- and lower shore (MytB), finding purchase within fine cracks in the rock, and on these exposed shores, *Patella ulyssiponensis* is the dominant limpet, rather than *P. vulgata*. The transition into the sublittoral fringe is marked by a zone of *Corallina officinalis* on coralline-encrusted rock with dabberlocks *Alaria esculenta* and sparse *L. digitata* being the only large algae capable of attachment (Ala.Myt; Ala.Ldig).

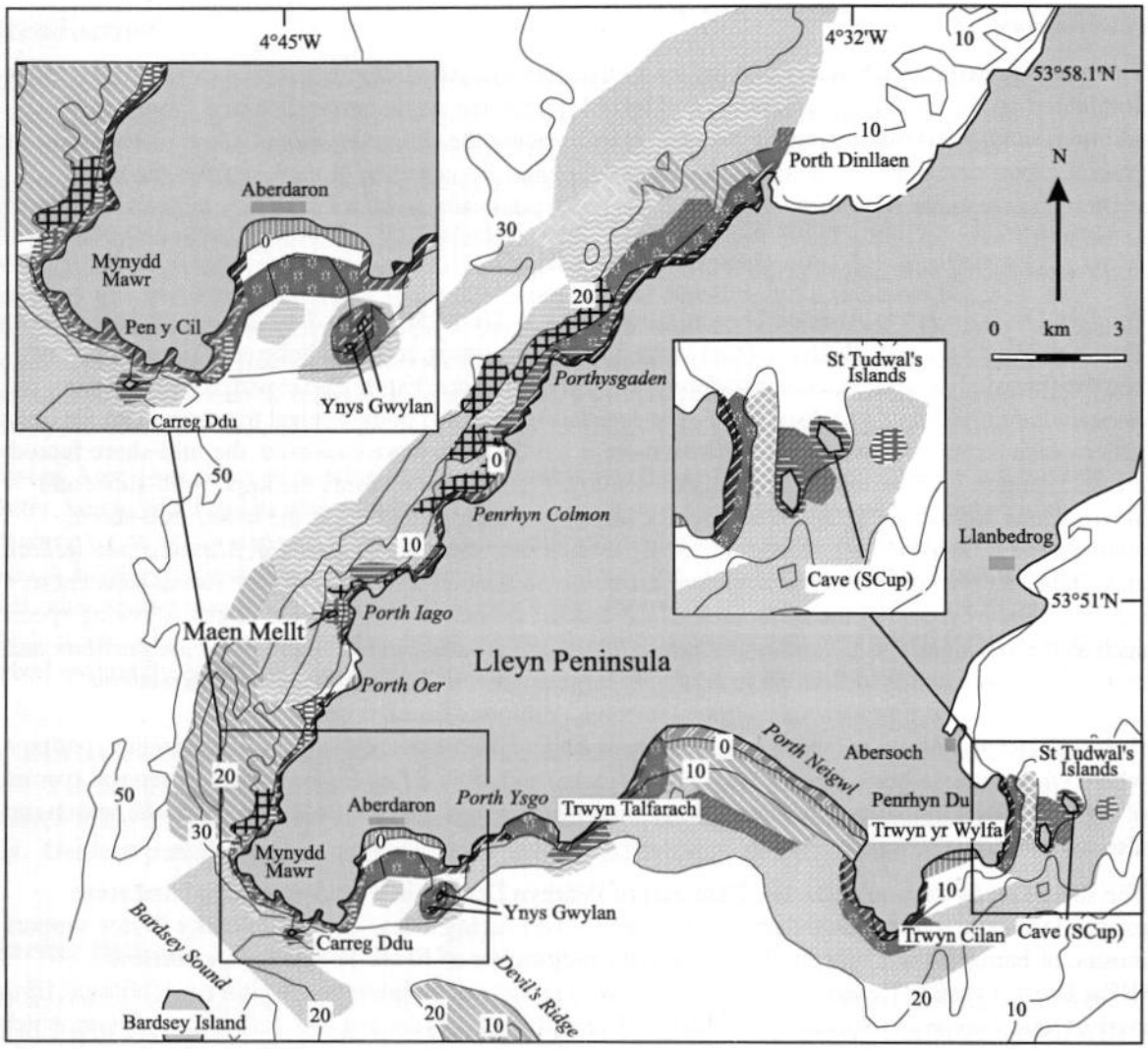
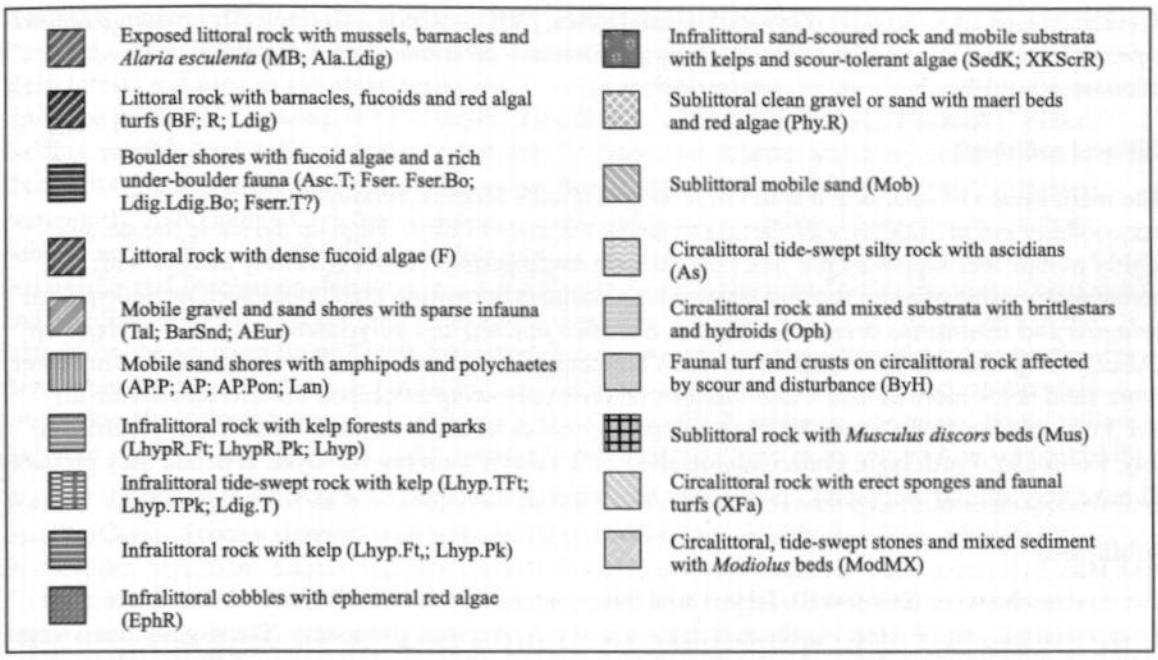


Figure 14.2 Indicative distribution of the main biotopes in the area (based on data from survey sites shown in Figure 14.1, AGDS information, cited literature and additional field observations). (Key to biotopes symbols on next page.)

The well-rounded boulders and cobbles set in sand at each end of Porth Neigwl and Aberdaron Bay have highly characteristic sand-scoured communities with little more than ephemeral algae *Enteromorpha* spp. and *Porphyra* spp. (EntPor), although boulders on rock at these sites have rich underboulder communities (CCW information). Between Trwyn Talfarach and Aberdaron the rocky shores support a mixture of barnacle-dominated and barnacle-fucoid mosaic communities with sand-scour influencing those shores adjacent to the sandy portions of Porth Ysgo and Aberdaron Bay. Fucoid communities with *P. canaliculata*, sparse *F. spiralis* and *F. vesiculosus* occur locally in the pockets of part sheltered south-east facing rocky shores. Fucoid-barnacle mosaics and dense *F. serratus* are found on the lower mid-shore. Similar communities characterise the rocky shores on the east-facing side of Aberdaron Bay. As the coastal aspect once more turns south-west at the entrance to Bardsey Sound, the steep craggy shores have communities characteristic of very wave-exposed conditions. The broad zone of lichens (YG; Ver.Por) indicates the strong influence of blown salt spray high on the shore. The mid-shore supports little more than barnacles, limpets *Patella* sp. and



mussels *M. edulis* (BPat.Sem; MytB) while the sublittoral fringe has *A. esculenta*, a broad band of coralline crusts and *L. digitata* (Ala.Ldig).

Wave exposure conditions are more uniform on the north-west coast of the Lleyn Peninsula, although not quite as exposed as the south-west facing shores. *M. neritoides* and *P. umbilicalis* are present in the *V. maura* zone (Ver.Por), and both *Chthamalus stellatus* and *C. montagui* occur above the mid-shore zone of *S. balanoides* (BPat.Cht). Patches of *Fucus vesiculosus* occur amongst the barnacles and limpets (both *P. vulgata* and *P. ulyssiponensis*) and red algae including *Ceramium* spp., *O. pinnatifida*, *M. stellatus*, *Gastroclonium ovatum* and the green alga *Cladophora rupestris* occur in patches on the mid- and lower shore (Fser.R). The lower shores on this side of the peninsula are characterised by the brown alga *Himanthalia elongata*, often amongst *F. serratus*, although the abundance of both species varies with localised changes in wave exposure. This suite of communities characterises much of the littoral rock along the north-west side of the Lleyn Peninsula although there are a few sheltered sand-influenced communities adjacent to the beaches at Porth Oer, Porth Colmon and Porth Towyn.

Extensive bedrock platform shores are found between Porth Ysgadan and Trwyn Porth Dinllaen. The rocky platforms themselves break up wave action, allowing the development of communities characterised by species more often associated with sheltered shores. On the upper shore, *P. canaliculata* has a dense layer of *Catenella caespitosa* growing amongst its holdfasts (Pel) and on shaded vertical rock faces; *F. spiralis* forms a more well-defined zone than elsewhere in Area 14, and the mid-shore has a dense cover of *A. nodosum* mixed with *F. vesiculosus* and red algae (Asc.Asc). Littorinid molluscs such as *Littorina obtusata*, *L. mariae* and *L. littorea* are common amongst the algae, particularly in the dense *A. nodosum* and *F. serratus* on the lower mid-shore. Stretches of boulder shore in Area 14 have rich mixtures of the above fucoids and barnacles on their upper surfaces and sponges, anemones, hydroids, ascidians and bryozoans on their undersides (Asc.T, Fser.Fser.Bo, Ldig.Ldig.Bo).

Rockpools are present on most of the shores, usually containing species found lower down the shore or in the shallow sublittoral of the immediate surrounding area. The extensive boulder and bedrock-floored pools to the west of Trwyn Porth Dinllaen are notably species-rich with large numbers of anemones *Anemonia viridis*, *Cereus pedunculatus* and gastropods such as *L. littorea* and *Gibbula cineraria*. Algal diversity is also high with abundant coralline crusts and *C. officinalis*, red algae

Bonnemaisonia asparagoides, *Gastroclonium ovatum*, *Dilsea carnosa*, *Callophyllis cristata*, *Halurus equisetifolius*, the brown algae *Chorda filum* and *Dictyota dichotoma* and the green alga *Bryopsis plumosa* (Cor; FK).

Littoral sediment

The main stretch of sand beach is in Porth Neigwl (Hell's Mouth), although here the sand is occasionally swept aside by wave action to reveal outcrops of clay. High up the shore the sand is highly mobile and supports little other than talitrid amphipods (Tal) but gradually merges with permanently damp sand on the mid-shore which contains burrowing amphipods such as *Bathyporeia pelagica* and *Haustorius arenarius*, isopods *Eurydice pulchra* and polychaetes such as *Scolelepis* sp. (AEur). Oligochaetes are found where small amounts of freshwater runoff cross the sand. The lower shore sand holds more moisture and supports another burrowing amphipod *Pontocrates arenarius* (AP.Pon). Although the sandy beaches and smaller coves of Porth Ceiriad, Porth Ysgo, Aberdaron Bay, Porth Oer, Porth Iago, Porth Colmon and Porth Towyn were not surveyed in detail, they probably all have very similar amphipod - polychaete infaunal communities (AP.P) (Allen *et al.* 1983).

Sublittoral

The channel between St Tudwal's Islands and the mainland, south of St Tudwal's Road, is the most wave sheltered part of Area 14, situated in the lee of the Abersoch peninsula. The slightly tide-swept sediment-floored channel contains small pebbles, cobbles and sparse fragments of *Phymatolithon calcareum* maerl which support a rich variety of opportunistic red algae including *Schmitzia hiscockiana*, *Schmitzia neapolitana* and *Scinaia* spp., brown algae *Laminaria saccharina* and *Halidrys siliquosa* (Phy.R) (see also *area summary* 13). The anemones *Cereus pedunculatus*, *Cerianthus lloydii* and *Sagartiogeton laceratus* protrude from the sediment surface and razor clams *Ensis* sp. burrow into the sediment. In contrast, St Tudwal's Islands and the headland of Trwyn yr Wylfa are exposed to wave action entering Tremadog Bay from the south-west. *Alaria esculenta* (Ala.Ldig) grows above the kelp *Laminaria hyperborea* forests and dense turfs of red algae, particularly *Plocamium cartilagineum*, grow on the open rock faces and in slightly deeper water (Lhyp.Ft). Some of the kelp forest shows signs of disturbance; loose rocks on the seabed are probably mobilised during winter storms, tearing up patches of kelp and preventing kelp development, allowing opportunistic scour-tolerant species to colonise. Hence, the kelps *L. saccharina* and *Saccorhiza polyschides* (XKScrR) and other brown algae such as *Desmarestia ligulata* and red algae such as *Calliblepharis ciliata* are more common on these boulders and cobbles than *L. hyperborea*. In deeper water below 12 m, red algae are less numerous and fast-growing sponges, in particular *Esperiopsis fucorum* cover a high proportion of the rock surface 'cementing' the cobbles and pebbles together. Other sponges such as *Phorbas fictitius*, *Hemimycale columella*, *Haliclona simulans* and *Dysidea fragilis* are recorded frequently and a few branching sponges, *Stelligera* spp. and *Raspailia* spp., are found on larger boulders and bedrock outcrops where the substratum is more stable (ErSPbolSH).

Some of the caves on St Tudwal's Islands extend underwater. The communities in the cave surveyed by Hiscock (1984) are characteristic of the surge conditions: the calcareous sponge *Clathrina coriacea* and the ascidian *Dendrodoa grossularia* cover the walls and ceilings, particularly towards the blind-ending back of the cave (SCAs.DenCla), various encrusting sponges and mussels *Mytilus edulis* are found towards the lower parts of the cave walls and the floors themselves are largely scoured clean by boulders hurled around in the heavy surge (CC.Mob).

In deeper water (> 20 m) offshore from Trwyn yr Wylfa, silted pebbles are covered by silt- and scour-tolerant animals forming a short turf on the rock surface. The bulk of the turf comprise bryozoans such as *Flustra foliacea*, *Scrupocellaria* spp. and *Bowerbankia* spp. with an underlying crust of barnacles *Balanus crenatus*. *D. grossularia* is also common at this site, although other ascidians such as *Polycarpa pomaria*, *Distomus variolosus* and *Molgula manhattensis* are more common in aggregations in similar habitats (see sites with Flu.HByS & MolPol).

Around the more wave-exposed headland Trwyn Cilan and across Porth Neigwl to the tip of the Lleyn Peninsula, wave exposure is high, and tidal stream strengths tend to increase around Bardsey Sound. Kelp forests and turfs of red algae predominate in the shallower areas in the clearer water towards the tip of the peninsula (growing to 13 m depth, compared to < 8 m on St Tudwal's Islands). Filter feeding animals form turfs on plains of bedrock, boulders and cobbles which are generally less silted than those found further east towards Tremadog Bay (Lhyp.TFt; Lhyp.TPk). Species richness is particularly high around Ynys Gwylan where small boulders and cobbles sit in a matrix of clean pebbles and shell gravel, supporting mobile species such as crustaceans *Pagurus bernhardus*, *Galathea intermedia* and *Inachus phalangium* living amongst turfs of sponges, hydroids, anemones, bryozoans and ascidians (SNemAdia; Flu.HByS; MolPol). The most tide-swept areas of seabed around the islands, on the southern tip of Ynys Gwylan-bâch, are covered in a dense bed of dead man's fingers *Alcyonium digitatum* with a rich faunal turf including several species of sponge such as the vivid green-blue *Hymedesmia paupertas*, elephant's hide sponge *Pachymatisma johnstonia*, bright yellow *Aplysilla sulfurea* (mainly found under boulders) and branching sponge *Raspailia ramosa* (AlcMaS).

West of Ynys Gwylan, the seabed comprises pebbles and cobbles covered by brittlestars *Ophiothrix fragilis* (Oph). Species richness within the brittlestar bed is low, mainly comprising barnacles *B. crenatus*, bryozoans *Bugula* spp. and anthozoans such as *Urticina felina*, *Sarcodictyon roseum* and *Epizoanthus couchii*. The sponges *Ciocalypta penicillus* and *Polymastia mamillaris* are found on bedrock and large boulders partially covered in sediment (Urt.Cio). Both species have chimney-like structures allowing the sponges to circulate water despite being part covered in silt and sand.

Aberdaron Bay is partially sheltered by headlands either side of the bay. RoxAnn information indicates that the sea floor is a mixture of cobbles and boulders, supporting similar ephemeral algal-dominated communities to those in St Tudwal's Road interspersed with sand plains. The infauna of the sand was not sampled, but is probably similar to that elsewhere on the Lleyn Peninsula with a mixture of polychaetes, bivalves including *Ensis* spp., the burrowing urchin *Echinocardium cordatum* and the ascidian *Molgula occulta* living just under the surface (EcorEns).

Kelp forests dominate the shallows around Pen y Cil and into Bardsey Sound with dense turfs of red algae as described above. Short vertical faces in the infralittoral are dominated by bryozoans, particularly *Chartella papyracea*, *Bugula plumosa*, *Crisia eburnea* and sponges, such as *Dysidea fragilis* (Bug). A tunnel (a submerged cave open at both ends) was surveyed in this area by Hiscock (1984) who described a more fully-developed *Clathrina-Dendrodoa* community than found in the caves on St Tudwal's Islands, with abundant *Sagartia elegans* and small *Metridium senile* (SCAs.DenCla). Outside the tunnel, bedrock in the circalittoral supported dense turfs of *F. foliacea* and *Crisia* spp. mixed with clumps of *C. papyracea* and a range of encrusting and branching sponges, including *Axinella infundibuliformis* and *A. dissimilis*.

Carreg Ddu, a small rocky island in Bardsey Sound approximately 200 m offshore from the tip of the Lleyn Peninsula, is fully exposed to a combination of wave action and 6-knot tidal streams. The species dominating this habitat are well adapted for clinging to rock, their growth forms being either squat and crustose or highly flexible with strong holdfasts. Below dense forests of kelp *L. hyperborea* (Lhyp.TFt), *B. crenatus* forms a crust on the tops and sides of huge boulders overgrown with dense hydroids *Tubularia indivisa* and *Sertularia argentea* (BalTub). Adjoining the barnacle crusts, thin sheets of the sponge *Halichondria panicea* cover large sections of the rock, with *T. indivisa* and the anemone *Sagartia elegans* growing through it. *P. johnstonia* is also found in the shallows, becoming increasingly common with depth (AlcMaS). Jewel anemones *Corynactis viridis* form large multi-coloured patches on the walls of shaded overhangs and the black sponge *Dercitus bucklandi* fills small crevices. There are also prominent ridges with dense growths of *A. digitatum*, while more sheltered spaces amongst and under the boulders have sparse growths of the branching sponge *Haliclona oculata*.

An extensive plain of rounded cobbles and boulders was surveyed by drift diving over the seabed for approximately 1 km through the middle of Bardsey Sound (see also *area summary* 16). Information from the echo sounder, AGDS (W. Cook & I. Rees, pers. comm.) and Admiralty charts indicates that this seabed type extends throughout much of Bardsey Sound. The number of animals attached to the stones broadly reflects the size and stability of each individual piece of rock, although generally the biotope is characteristic of tide-swept and unstable scoured conditions, supporting *B. crenatus*, crustose bryozoans, erect bryozoans *F. foliacea* and scour-tolerant hydroids such as *S. argentea* (Flu.SerHyd). *U. felina* is common, and the larger boulders often support a similar suite of animals to bedrock elsewhere in Area 14 with patches of *Polyclinum aurantium* (StoPaur). Heading north out of Bardsey Sound the seabed rises over a bank of highly mobile sand and gravel known as the Tripods. Very sparse fauna inhabit this area, although further north and east, where there is less tide, a 'deep *Venus*' community has probably developed in the slightly muddy gravel. Towed-video records taken off Porth Ysgadan (W. Cook pers. comm.) show how the effects of tide and wave action have created large waves in the surface of the gravel, although epifauna is sparse in this habitat comprising little other than scattered tube worms *Sabella pavonina*, anemones *U. felina* and the bryozoan *F. foliacea*.

The mobile sands of the Tripods grade into reefs of cobbles and boulders with small outcrops of bedrock towards Porth Oer and Porth Iago. The most sand-influenced low-lying outcrops support *F. foliacea* and other scour tolerant and ephemeral bryozoans such as *Vesicularia spinosa* and *Alcyonidium diaphanum* and hydroids *Hydrallmania falcata* (Flu.SerHyd). Further away from the sand-rock interface, ascidians cover the uppers surfaces of the rock; *P. pomaria*, *Polyclinum aurantium* and *M. manhattensis* bind silt and sand to their tests (MolPol). The least sand-influenced and most strongly tide-swept rocky habitats in this part of Area 14, around headlands and small islands (e.g. Maen Mellt off Porth Iago), support abundant sponges *Esperiopsis fucorum* and *H. panicea*, anemones *S. elegans* and *C. viridis* and the hydroid *T. indivisa*. Less robust branched and cushion sponges, such as *Raspailia* spp., *Stelligera* spp., *Axinella dissimilis*, *Axinella infundibuliformis*, *Polymastia boletiformis*, *Tethyspira spinosa* and *Tethya aurantium* (ErSPbolSH) are more common on the moderately tide-swept bedrock and boulder reefs away from the immediate influence of the sand. Two species associated with this biotope but normally found in south-west Britain and south to the Mediterranean are found in the area below Mynedd Mawr: the cup coral *Caryophyllia inornata*, which occurs on overhanging rock faces, and the bright orange colonial ascidian *Polysyncraton lacazei*. Also of note here, and throughout Area 14 in general, were large numbers of a 'pin-head' clavelinid ascidian as yet undescribed by taxonomists, and the small cushion star *Asterina phylactica*, which was previously believed to be 'rare' in Wales (CCW information).

Other sand-influenced communities occur on the north side of the Lleyn Peninsula adjacent to the small beaches and sand-filled coves. Sand-tolerant species such as the brown alga *Taonia atomaria* and the sponge *Ciocalypta penicillus* are more common at the sand-rock interface just below kelp forests near Porth Colmon and approaching Trwyn Porth Dinllaen. Scarce species of 'gelatinous' red algae were found in these habitats: *S. hiscockiana*, *Scinaia* sp. and *Helminthocladia calvadosii* (see XKScrR, EphR, Urt.Urt and Urt.Cio). On rock spanning the lower infralittoral and upper circalittoral (10-20 m depth) in this part of Area 14 the mussel *Musculus discors* (Mus) were found in dense aggregations by Hiscock (1984) and during CCW's 1998 monitoring trails around Porth Colmon. The small mussels produce fine silty pseudofaeces which are bound together by their fine byssus threads. The result is a uniform-looking muddy mat with the mussel siphons protruding, interspersed with aggregations of ascidians such as *Polycarpa pomaria*.

A series of bedrock ridges and narrow gullies just off Porth Ysgadan are of interest for the wide range of habitats present in a small area. Kelp forest on the tops of the ridges close to shore (Lhyp.Ft) shade deep gullies with *S. elegans*, *A. digitatum* and bryozoans *Bugula* spp. and *Scrupocellaria* spp. turfs growing on the walls (AlcByH). *M. edulis* (MytHAs) are common on the floors of these gullies, sometimes forming patchy beds. Similarly-shaped tide-swept ridges, further offshore from Porth Ysgadan, support a variety of faunal communities characterised by dense aggregations of ascidians.

P. pomaria (MolPol) tends to be the most common species although several ridges at around 20 m depth were found with an almost complete covering of *Distomus ?variolosus* (possibly an undescribed species which closely resembles *D. variolosus*).

Most of the seabed offshore (roughly beyond the 25 m isobath) from Porth Colmon and Porth Ysgadan comprises mixed gravel and sand with broken and whole shells. Patchy brittlestar *Ophiothrix fragilis* beds (Oph) were found at several sites on these offshore mixed sediments, some of which overlapped with the edges of dense horse mussel *Modiolus modiolus* beds. The *Modiolus* beds form waves in the seabed (~ 5 m between crests) and cover an area of several square kilometres (CCW/School of Ocean Science side-scan sonar survey information). The shells support dense hydroids and bryozoans and large number of *Chlamys varia* live between them (?ModMx/ModCvar). RoxAnn™ acoustic ground discrimination system (AGDS) and video studies of this area (I. Rees & W. Cook pers. comm.) have shown the *Modiolus* bed to have slowly decreased in size over a number of years. A wide variety of species have been found in the sediment matrix of the mussel bed by taking samples with a Hammon grab. Burrowing crustaceans such as *Upogebia deltaura*, *Callianassa subterranea* and *Callianassa tyrrhena* and sipunculan worms such as *Golfingia elongata* and *Golfingia vulgaris* were common in the mussel-stabilised sediment. In depths of around 30 m, on mixed sediment and broken shell, areas of seabed are covered with tubes of the sand reef worm *Sabellaria spinulosa* which form nodules and crusts of bound sediment (SspiMx). Sparse hydroids *Abietinaria abietina* and bryozoans *F. foliacea* were found growing on the tubes.

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau	cSAC	SH 50 30	Estuaries; Reefs
Porth Dinllaen	SSSI	SH 270 410	Rocky shore habitats
Glannau Aberdaron	SSSI; GCR	SH 167 263	Botanical, ornithological and geological
Ynysoedd y Gwylanod	SSSI	SH 184 245	Ornithological & botanical; grey seals
Mynydd Penarfynydd	SSSI; GCR	SH 225 265	Geological and ornithological
Porth Ceiriad	SSSI; GCR	SH 290 252	Botanical, ornithological and geological
Porth Neigwl	SSSI; GCR	SH 273 269	Geological
Llyn Peninsula	ESA	N/A	Agri-environmental scheme
Glannau Aberdaron and Ynys Enlli (Aberdaron Coast and Bardsey Island)	SPA	SH 120 220	Ornithological
Llanengan	NT	SH 290 249	Cliffs
Penrallt Neigwl	NT	SH 248 287	Cliff and farmhouse
Mynydd-y-Graig	NT	SH 230 270	Coastal summit
Penarfynydd, Rhiw	NT	SH 217 265	Cliff top rough and farmland
Porth Ysgo	NT	SH 208 266	Beach and cliffs
Pen-y-Cil	NT	SH 158 240	Cliff top and common land
Mynydd Bychestyn	NT	SH 150 245	Common land
Braich-y-Pwll	NT	SH 140 254	Coastal habitats
Porth Llanllawen	NT	SH 145 265	Cliffs
Porth Orion	NT	SH 156 285	Cliffs
Dinas Bach & Dinas Fawr	NT	SH 156 285	Island and cliffs
Carreg Farm	NT	SH 162 292	Headland
Porth Gwylan	NT	SH 215 365	Coastal habitats
Porth Dinllaen	NT	SH 275 415	Coastal rocky and sediment habitats
Lleyn Peninsula	AONB	N/A	High scenic quality
Lleyn Peninsula	HC	SH 424 514-SH 324 266	Coastal scenery

Human influences

Coastal developments and uses

The Lleyn Peninsula is mainly rural, and is a major tourist area close to Snowdonia National Park, but the main holiday centres lie to the east of Area 14. Walking, birdwatching and angling are popular.

Marine uses

Although watersports continue to increase, the main marinas and safe mooring areas are in Pwllheli, Abersoch and Morfa Nefyn, just outside Area 14.

There are no major fishing ports around the Lleyn Peninsula although small fishing vessels work out of minor ports such as Pwllheli (outside Area 14), Porth Dinllaen (bordering Area 14) and Abersoch. Herring *Clupea harengus* was historically the most important fishery in Cardigan Bay, but lobster *Homarus gammarus* and crab *Cancer pagurus* potting are now most important, with whelk *Buccinum undatum* potting also having an important role. Some trawling for scallops *Pecten maximus* and *Aequipecten opercularis* occurs off the north coast of the Lleyn Peninsula and a seasonal fixed net fishery exists on the south coast of the peninsula. Target species include rays *Raja* spp., turbot *Scophthalmus maximus*, brill *Scophthalmus rhombus* and, more recently, bass *Dicentrarchus labrax*. Bass netting is controlled through restricting the type of fishing gear and protecting nursery areas.

The main sources of sewage in Area 14 are at Porth Dinllaen, Nefyn and Llanbedrog with smaller discharges from the villages scattered around the Lleyn Peninsula. There are no industrial effluent discharges in the Area.

References and further reading

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Sites surveyed

Survey 186. 1983 Bardsey and the Lleyn Peninsula, sublittoral survey (Hiscock 1984).
Survey 205. 1983 Bardsey and the Lleyn Peninsula littoral survey (Rostron 1984).
Survey 228. 1977 marine biological survey of Bardsey Island (Hoare & Jones 1981).
Survey 627. 1995 MNCR North Lleyn Peninsula and Tremadog Bay, littoral survey (MNCR, unpublished data).
Survey 628. 1995 MNCR Lleyn Peninsula and Tremadog Bay, sublittoral survey (MNCR, unpublished data).
Survey 644. 1997 MNCR Bardsey Island and SW Lleyn Peninsula, sublittoral survey (MNCR, unpublished data).
Survey 771. 1998 survey of Maen Mellt to Porth Ysgadan, north Lleyn Peninsula, sublittoral survey (Bunker in prep.)
Survey 772. 1998 CCW monitoring trials survey on the north Lleyn Peninsula, sublittoral survey (CCW, unpublished data).
Survey 773. 1998 CCW monitoring trials in Tremadog Bay and the Sarns reefs, sublittoral survey (CCW, unpublished data).

Littoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
205	1	Traeth Penllech	SH 200 343	52°52.5'N 04°40.5'W	Ver.Ver, Fspi, Asc.Asc, FvesX, EntPor, Pel
205	2	Careg y Defaid	SH 193 344	52°52.5'N 04°41.1'W	BPat.Sem, Ver.Ver, BPat, Fser.Fser, Ldig.Ldig, Ver.B
205	3	By Ogof Newry, Bardsey	SH 164 312	52°50.8'N 04°43.6'W	Him, YG, Ver.Ver, FvesB, Ala.Ldig, BPat.Fvesl
205	4	W of Porth Felin, Bardsey	SH 169 322	52°51.3'N 04°43.1'W	BPat.Sem, G, YG, Asc.Asc, XR, Ala.Ldig, BPat.Cat, FK, Cor, IR, Ver.B
205	11	St. Tudwal's Island E	SH 343 258	52°48.2'N 04°27.5'W	BPat.Sem, YG, MytB, Fspi, Ldig.Ldig, Cor, Ver.B
205	12	St. Tudwal's Island W	SH 335 256	52°48.1'N 04°28.2'W	BPat.Sem, YG, FvesB, Fspi, Fser.R, Fser.Fser, Ldig.Ldig, Ver.B
205	13	S of Trwyn y Ffosle	SH 287 243	52°47.3'N 04°32.4'W	Pra, MytB, BPat, Ala.Myt, BPat.Cht, FK, Cor
205	14	S of Porth Bach	SH 327 261	52°48.3'N 04°28.9'W	Fves, Fspi, Fser.R, Fser.Fser, SwSed, PelB
205	15	Porth Bach.	SH 326 264	52°48.5'N 04°29.0'W	Fves, Fspi, Fser.R, Fser.Fser, XKScrR, PelB
205	16	E of Penrhyn Cwmistir	SH 252 397	52°55.5'N 04°36.0'W	YG, BPat, Fves, Asc.Asc, SwSed, Pel
205	17	Rhos y Llan N	SH 237 387	52°54.9'N 04°37.3'W	BPat.Sem, Ver.Ver, Ldig.Ldig, Mas, Ver.B
205	18	Rhos y Llan S	SH 237 386	52°54.9'N 04°37.3'W	BPat.Sem, YG, Fves, Fser.Fser, Ldig.Ldig, Fser
205	20	W of Porth Dinllaen	SH 274 418	52°56.7'N 04°34.1'W	BPat.Sem, Ver.Ver, FvesB, Ala.Ldig, FK, Cor, Coff, Ver.B
205	21	Borth Wen.	SH 272 411	52°56.3'N 04°34.3'W	FK, Cor

Littoral sites continued

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
205	22	Porth Meudwy	SH 164 255	52°47.7'N 04°43.4'W	BPat.Sem, YG, Ver.Ver, BPat, Ala.Ldig, PelB
205	23	Trwyn y Gwyddel	SH 140 250	52°47.4'N 04°45.5'W	Ver.Ver, Ver.Por, BPat, XR, Ala.Ldig, FK, Cor
205	24	Cave on St. Tudwal's Island E	SH 343 258	52°48.2'N 04°27.5'W	SByAs, BPat.Cat
627	10	Pentowyn Dunes beach, Aberdaron.	SH 283 264	52°48.4'N 04°32.8'W	Tal, AP.Pon, AP.P
627	11	East of Mynydd Gilan, Abersoch.	SH 302 238	52°47.0'N 04°31.0'W	BPat.Sem, BPat.Cht, YG, Fser.R
627	12	Northwest Porth Neigw, Aberdaron.	SH 250 280	52°49.2'N 04°35.8'W	BPat, BLlit, EntPor, Cor, PelB
627	13	NW Porth Neigw Sand beach, Aberdaron.	SH 282 242	52°47.2'N 04°32.8'W	AEur, AP.P
627	14	East of Aberdaron Bay.	SH 185 258	52°47.9'N 04°41.5'W	AP.P
627	15	Ogof Ddeuddrws, Aberdaron.	SH 186 255	52°47.7'N 04°41.4'W	BPat.Sem, MytB, FK, Cor, IR, Ver.B, Fser.Fser.Bo
627	16	Porth Ysgo, Aberdaron.	SH 209 264	52°48.3'N 04°39.4'W	BPat.Cht, YG, EntPor, Cor, Ver.B
627	31	NW Bryn Gwydd, Morfa Nefyn.	SH 259 400	52°55.7'N 04°35.4'W	BPat.Cht, YG, Ver.Ver, BPat, Fser.R, FK, Ver.B
627	32	E of Penrhyn Cwmistir, Morfa Nefyn.	SH 246 397	52°55.5'N 04°36.5'W	Fves, Asc.Asc, Fser.R, FK, Cor

Sublittoral sites

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
186	1	Offshore Hell's Mouth	SH 280 243	52°47.3'N 04°33.0'W	Flu.SerHyd
186	2	NW of Trwyn Cilan	SH 289 235	52°46.8'N 04°32.2'W	Flu.HBySS, IGS, MytHAs, XKScrR, Lhyp
186	3	Trwyn Cilan	SH 293 227	52°46.4'N 04°31.8'W	EphR
186	4	Trwyn Llech-y-Doll	SH 301 223	52°46.2'N 04°31.1'W	XKScrR
186	5	NW of Porth Ysgadan	SH 222 379	52°54.5'N 04°38.6'W	XKScrR
186	6	Offshore Porth Gwylan	SH 208 374	52°54.2'N 04°39.8'W	Mus
186	7	Nearshore Porth Gwylan	SH 212 371	52°54.0'N 04°39.5'W	FoR.Dic, Bug, EphR
186	8	N Porth Ysgadan	SH 221 384	52°54.7'N 04°38.7'W	MytHAs
186	15	Offshore Maen Mellt	SH 161 318	52°51.1'N 04°43.8'W	MytHAs, MolPol
186	16	W Maen Mellt	SH 161 317	52°51.0'N 04°43.8'W	ErSPbolSH
186	17	N Maen Mellt	SH 162 317	52°51.0'N 04°43.7'W	SCAs.ByH, Bug, EphR, FoR
186	18	Penrhyn Mawr	SH 166 322	52°51.3'N 04°43.4'W	MytHAs, Lhyp.Ft, FoR
186	19	Braich-y-Pwll	SH 134 254	52°47.6'N 04°46.0'W	Bug, MolPol, LhypR.Ft, SCAs.ByH, EphR, LhypR.Pk
186	20	Carreg Ddu.	SH 148 239	52°46.8'N 04°44.7'W	Flu.HBySS, Urt.Urt, MolPol, LhypR.Ft, Ala.Ldig, FoR
186	21	Carreg Ddu - Offshore	SH 147 241	52°46.9'N 04°44.8'W	TubS, BalTub
186	22	Ogof Goch - Nearshore	SH 146 268	52°48.3'N 04°45.0'W	LhypR.Ft, CC.BalPom, SCAn, SCAs
186	23	Ogof Goch - Offshore	SH 145 268	52°48.3'N 04°45.1'W	Mus
186	24	Carreg Allan	SH 147 278	52°48.9'N 04°45.0'W	Lhyp.Ft
186	34	Trwyn Talfarach	SH 214 257	52°47.9'N 04°38.9'W	MolPol, Bug, EphR, Lhyp.Pk,
186	35	E Ynys Gwylan-Fawr	SH 185 244	52°47.1'N 04°41.5'W	SNemAdia, Ala.Ldig, XKScrR, EphR, Bug
186	36	Outer Aberdaron Bay	SH 177 241	52°47.0'N 04°42.2'W	Urt.Cio

Sublittoral sites continued

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
186	37	Inner Aberdaron Bay	SH 172 256	52°47.7'N 04°42.7'W	XKScrR
186	38	Porth Cloch	SH 164 250	52°47.4'N 04°43.3'W	Bug, Ala.Ldig, XKScrR, EphR
186	39	Cave W of Pen-y-Cil	SH 156 241	52°46.9'N 04°44.0'W	CC.BalPom, SCup, SCAs.DenCla
186	40	Offshore St. Tudwal's Island W	SH 340 242	52°47.3'N 04°27.7'W	Flu.HByS, PomByC,
186	41	E of St. Tudwal's Island E	SH 346 253	52°47.9'N 04°27.2'W	SNemAdia,
186	42	SE of St. Tudwal's Island E	SH 343 258	52°48.2'N 04°27.5'W	Ala.Ldig, Lhyp.Ft, FoR
186	43	Cave, St Tudwal's Island E	SH 343 258	52°48.2'N 04°27.5'W	SCAs.DenCla,
186	44	Between St. Tudwal's Islands	SH 338 257	52°48.1'N 04°27.9'W	EphR
186	45	St. Tudwal's Sound	SH 331 259	52°48.2'N 04°28.5'W	SNemAdia, Phy.R
186	46	Below Cim.	SH 326 255	52°48.0'N 04°29.0'W	Ldig.Ldig
186	47	S St. Tudwal's Road	SH 328 268	52°48.7'N 04°28.8'W	IMS
186	53	Offshore Aber Geirch (1)	SH 248 412	52°56.3'N 04°36.4'W	Flu.SerHyd, Urt.Cio,
186	54	Offshore Aber Geirch (2)	SH 256 408	52°56.1'N 04°35.7'W	EphR
186	55	Aber Geirch	SH 264 405	52°56.0'N 04°35.0'W	XKScrR
186	56	Offshore Trwyn Porth Dinllaen	SH 273 418	52°56.7'N 04°34.2'W	XKScrR
186	57	Nearshore Trwyn Porth Dinllaen	SH 275 417	52°56.6'N 04°34.0'W	XKScrR
186	58	Offshore Porth Colmon	SH 189 350	52°52.8'N 04°41.5'W	Flu.HByS, Oph, PomByC, Mus,
186	59	W Penrhyn Colmon	SH 189 338	52°52.2'N 04°41.4'W	Mus
186	60	Offshore Traeth Penllech	SH 198 349	52°52.8'N 04°40.7'W	Mus
186	61	NE of Trwyn Talfarach	SH 225 261	52°48.1'N 04°38.0'W	Flu.HByS, LhypR.Ft, XKScrR, ErSPbolSH
186	62	Trwyn-y-Ffosle	SH 286 247	52°47.5'N 04°32.5'W	Bug, Flu.HByS, FoSwCC, SCAs.ByH,
186	63	Hell's Mouth	SH 268 253	52°47.8'N 04°34.1'W	EphR
628	15	E of Carreg-y-Trai, Abersoch.	SH 349 257	52°48.2'N 04°26.9'W	FoR
628	16	Trwyn-yr-Wylfa, Abersoch.	SH 320 245	52°47.5'N 04°29.4'W	XKScrR, Bug
628	17	S of West St. Tudwal's Island, Abersoch.	SH 335 250	52°47.7'N 04°28.1'W	SNemAdia, XKScrR
628	18	Offshore Porth Ysgadan, Morfa Nefyn.	SH 205 402	52°55.7'N 04°40.2'W	SNemAdia
628	28	W of Carreg-y-Trai, Abersoch.	SH 347 257	52°48.2'N 04°27.1'W	SNemAdia
644	17	S of Ynys Gwylan-Bach, Aberdaron.	SH 184 243	52°47.1'N 04°41.5'W	Flu.HByS, MolPol
644	18	SW Ynys Gwylan-Fawr, Aberdaron.	SH 183 252	52°47.6'N 04°41.7'W	AlcMaS
644	19	Pen-y-Cil, Aberdaron.	SH 153 241	52°46.9'N 04°44.2'W	Lhyp.TPk, Bug, ErSPbolSH
644	20	Mid-Bardsey Sound, Aberdaron.	SH 139 231	52°46.4'N 04°45.4'W	StoPaur, Flu.SerHyd
644	21	Carreg Ddu, Aberdaron.	SH 149 239	52°46.8'N 04°44.6'W	Flu.HByS, AlcMaS, BalTub
644	22	W side of Porth Felen, Aberdaron.	SH 140 247	52°47.2'N 04°45.4'W	Flu.SerHyd, Flu.HByS, Urt.Urt, Bug
644	23	N Mynydd Mawr, Aberdaron.	SH 135 259	52°47.9'N 04°45.9'W	SCup, ErSPbolSH
644	24	Porth Llanllawen, Aberdaron.	SH 141 264	52°48.2'N 04°45.4'W	EphR, Lhyp.TPk, ErSPbolSH
644	25	S Braich Anelog, Aberdaron.	SH 145 275	52°48.7'N 04°45.1'W	Lhyp.TPk
644	26	Dinas Bach, Aberdaron.	SH 155 293	52°49.7'N 04°44.2'W	Lhyp.TFt, Bug
644	27	Maen Mellt, Morfa Nefyn.	SH 161 316	52°51.0'N 04°43.8'W	Lhyp.TFt, Lhyp.TPk, Bug
644	28	N side of Maen Mellt, Morfa Nefyn.	SH 162 317	52°51.1'N 04°43.8'W	SCup, Lhyp.TFt, ErSPbolSH
644	29	Penrhyn Colmon, Morfa Nefyn.	SH 164 318	52°51.1'N 04°43.6'W	ErSPbolSH
771	1	Off Penrhyn Cwmistir, Porth Colmon - Porth Dinllaen.	SH 236 405	52°55.9'N 04°37.4'W	MolPol
771	2	Porth Ysgadan, Porth Colmon - Porth Dinllaen.	SH 213 377	52°54.4'N 04°39.4'W	MolPol
771	3	Off Porth Ferin, Porth Colmon - Porth Dinllaen	SH 166 328	52°51.7'N 04°43.4'W	MolPol
771	4	Penrhyn Mawr (NE of Maen Mellt)	SH 165 321	52°51.3'N 04°43.5'W	StoPaur
771	5	Off Penrhyn Colmon, Porth Colmon - Porth Dinllaen.	SH 184 346	52°52.6'N 04°41.8'W	Oph

Sublittoral sites continued

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
771	6	Penrhyn Colmon, Porth Colmon - Porth Dinllaen	SH 190 344	52°52.6'N 04°41.3'W	MolPol
771	7	Off Porth Ychain, Porth Colmon - Porth Dinllaen.	SH 203 364	52°53.7'N 04°40.2'W	Sspi
771	8	Off Porth Ysgadan, Porth Colmon - Porth Dinllaen.	SH 205 379	52°54.5'N 04°40.1'W	Flu.SerHyd
771	9	Off Penrhyn Melyn, Porth Colmon - Porth Dinllaen.	SH 191 351	52°53.0'N 04°41.3'W	Mus
771	12	N of Penrhyn Cwmistir, Porth Colmon - Porth Dinllaen.	SH 246 403	52°55.9'N 04°36.5'W	MolPol
771	13	Porth Dinllaen, Porth Colmon - Porth Dinllaen.	SH 278 414	52°56.5'N 04°33.7'W	Zmar
771	14	E of Porth Dinllaen Moorings, Porth Colmon - Porth Dinllaen	SH 279 414	52°56.5'N 04°33.6'W	Zmar
771	15	N of Porth Ysgaden, Porth Colmon – Porth Dinllaen.	SH 219 417	52°56.6'N 04°39.0'W	MolPol
771	16	WSW Penrhyn Cwmistir, Porth Colmon - Porth Dinllaen	SH 218 395	52°55.4'N 04°39.0'W	Flu
771	17	W of Porth Ysgaden, Porth Colmon - Porth Dinllaen.	SH 210 375	52°54.3'N 04°39.6'W	MolPol
771	18	NE Porth Ysgadan, Porth Colmon - Porth Dinllaen.	SH 225 383	52°54.7'N 04°38.4'W	MolPol
772	1	Porth Colmon transect, Inshore section.	SH 188 337	52°52.1'N 04°41.5'W	Mus, Oph, XKScrR, MolPol, Lhyp.Ft, Lhyp.Pk, Mob, EphR, SCR
772	2	Porth Colmon transect, mid-section.	SH 170 340	52°52.3'N 04°43.1'W	PomByC, Flu.HBySerHyd, MolPol, Mus, MolPol.Sab, Oph, ErSPbolSH, Ven.Neo
772	3	Porth Colmon transect, offshore section.	SH 165 360	52°53.3'N 04°43.6'W	Flu.SerHyd, CGS, Sspi, MolPol.Sab
773	8	W St Tudwal's Island channel, Abersoch.	SH 331 255	52°48.1'N 04°28.5'W	XKScrR
773	9	N East St Tudwal's Island, Abersoch.	SH 341 261	52°48.4'N 04°27.6'W	XKScrR, KSwMx

Compiled by: Rohan H.F. Holt

15 Bardsey Island (Ynys Enlli)

Location		
Position (centre)	SH 120 215	52°44'.5N 4°47'W
County/district	Gwynedd	Dwyfor
Conservation agency/area	Countryside Council for Wales	North-west Area

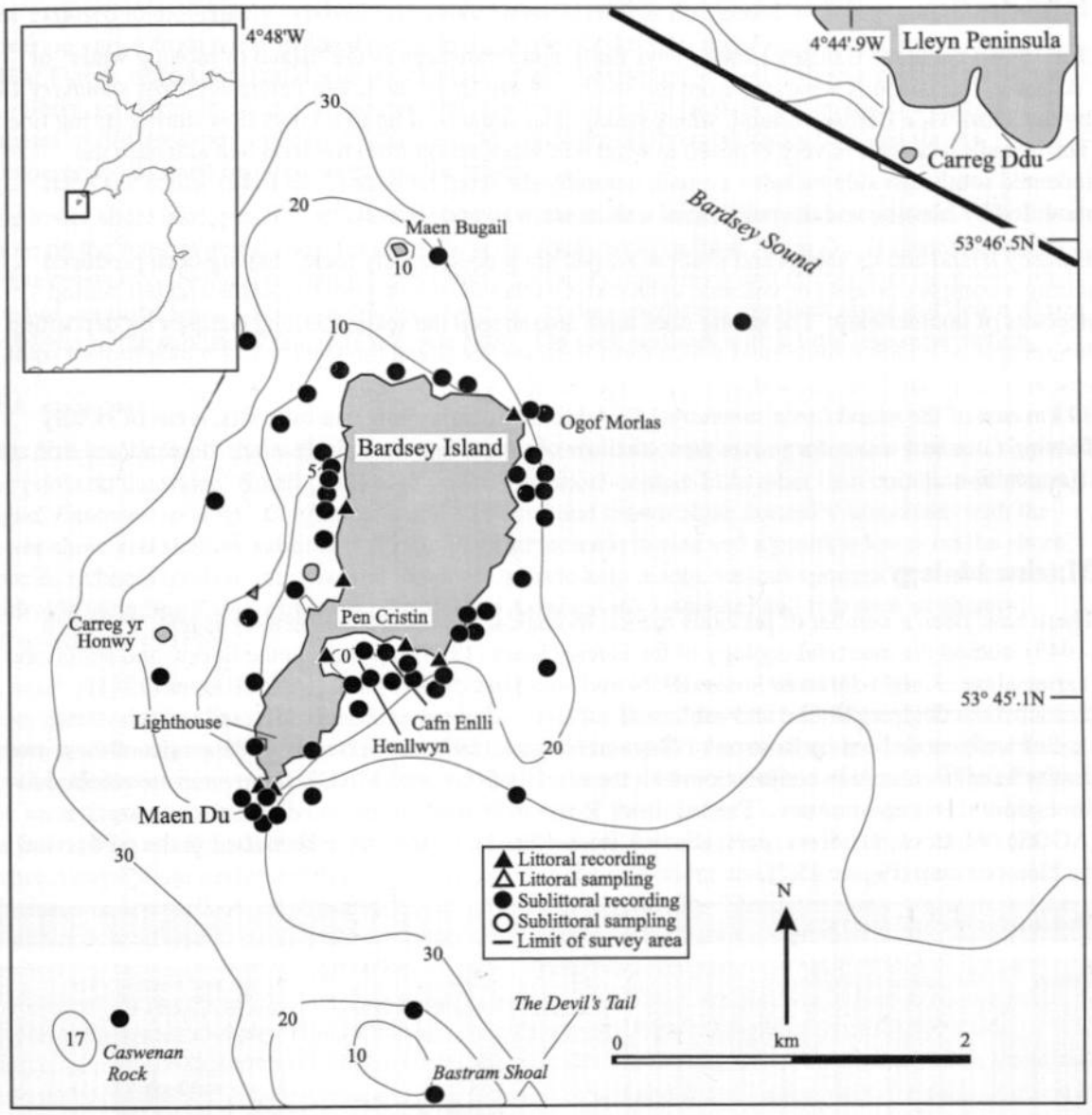

Figure 15.1 Main features of the area, showing sites surveyed.

Physical features	
Physiographic type	Offshore island
Length of coast	7.5 km
Bathymetry	30 m isobath between 0 and 1.5 km; 50 m isobath within 2.5 km
Wave exposure	Very exposed to moderately exposed
Tidal streams	Very strong to weak
Tidal range	3.7 m springs; 2 m neaps (Bardsey Island)
Salinity	Fully marine

Introduction

The Welsh name for Bardsey Island, Ynys Enlli, aptly translates as the 'island of moving water' or 'surges'. The island is separated from the south-western tip of the Lleyn Peninsula (*area summary* 14) by the 3 km-wide Bardsey Sound, where strong tidal streams of up to 6 knots flow during spring tides. The island's west side is very exposed to wind and wave action from the Irish Sea although the indented south-east side includes a small, naturally sheltered harbour (Cafn Enlli) which has been modified by blasting and the building of a short sea wall and slipway.

Bardsey Island and its shores and shallow seabed are predominantly rocky, having been produced during a complex process of volcanic upheaval. Glaciation rounded the landscape and left behind deposits of boulder clay. The strong tides have also shaped the seabed around Bardsey by depositing long ridges of highly mobile sand which form Bastram Shoal and the Devil's Tail which project south-east around 15 km from the southern tip of the island. A similar shoal, Devil's Ridge, is situated about 12 km east of the island (*area summary* 14). Admiralty charts show that overfalls, areas of swiftly flowing turbulent water, form over these shallow obstructions, particularly when the wind and tide are in opposition.

Marine biology

There have been a number of previous marine biological studies around Bardsey Island. Pyefinch (1943) studied the intertidal ecology of the island; Jones (1955) reported on the littoral and sublittoral marine algae; Knight-Jones & Jones (1955) and later Hoare (1978) and Hoare & Jones (1981) presented results from littoral and sublittoral surveys. More recent detailed littoral and sublittoral studies were carried out by Rostron (1984) and Hiscock (1984) respectively. The results of these two studies have been used in conjunction with the results of the latest MNCR survey and are referred to throughout this area summary. The results of RoxAnn™ acoustic ground discrimination studies (AGDS) (W. Cook & I. Rees, pers. comm.) around Bardsey Island have been used in the production of the biotopes map (Figure 15.2).

Marine biological surveys				
	Survey methods	*No. of sites*	*Date(s) of survey*	*Source*
Littoral	Recording (epibiota)	19	1977	Hoare and Jones (1981)
		7	Aug 1983	Rostron (1984)
		1	Mar 1996	MNCR/CCW survey 638
Sublittoral	Recording (epibiota)	12	Aug 1983	Hiscock (1984)
		12	1977	Hoare and Jones (1981)
		16	May 1997	MNCR survey 644
		2	September 98	CCW monitoring trials
	RoxAnn AGDS	Whole Area	Summer 1998	Cook & Rees (unpublished data)

Littoral

Perhaps the most obvious feature of many of the west-facing and steep east-facing shores around Bardsey Island is the broad zone of barnacles *Chthamalus montagui*, *Semibalanus balanoides*, limpets *Patella vulgata* and small patches of fucoid algae covering a large proportion of the available rock on the mid-shore. These barnacle-dominated biotopes (BPat.Cht; BPat.Sem) are highly characteristic of wave-exposed conditions and usually have zones of the black lichen *Verrucaria maura* (Ver) and

yellow and grey lichens (YG) growing above the barnacles in the splash zone. Small gastropods *Melarhaphe neritoides* and *Littorina saxatilis* are often found in large numbers at this level high on the shore, occupying small cracks, crevices and empty barnacle shells.

The barnacles which live amongst the lower fringes of the *V. maura* zone on the upper mid-shore are mainly *C. montagui* and all but the most exposed and uniformly steep sites have a few small clumps of the fucoid *Pelvetia canaliculata* (PelB) and, a little lower on the shore, *Fucus spiralis* (Fspi), amongst them. A thin red alga *Porphyra umbilicalis* and patches of the black lichen *Lichina pygmaea* also occur amongst the barnacles on the upper mid-shore of the more exposed shores.

The exposed to moderately exposed mid-shore barnacle zone is dominated by *S. balanoides*. Fucoid cover on varies from a few isolated plants to a mosaic of barnacles and *Fucus vesiculosus* v. *linearis* (BPat.Fvesl), reflecting small localised changes in wave-exposure around different parts of the island. Similarly, red algae including *Ceramium shuttleworthianum* and *Gastroclonium ovatum* and small patches of *Mastocarpus stellatus* (Mas) are more abundant on the moderately exposed shores compared to the most exposed shores on the island.

The lower shore biotopes also reflect the changes in wave exposure around Bardsey Island. The lower shore on the most exposed sites, for example at the south-western tip at Maen Du, is characterised by dense crusts of *S. balanoides* and limpets (both *Patella ulyssiponensis* and *P. vulgata*) merging with a zone of coralline algae *Corallina officinalis* which overlies encrusting coralline algae and dense *Alaria esculenta* in the sublittoral fringe (Coff; Ala.Myt). On rock surfaces with a little less surge action, thong weed *Himanthalia elongata* and dense patches of *M. stellatus* (Him) occur just above the zone of *A. esculenta*.

The flora and fauna in the rockpools around Bardsey Island vary depending upon the size and height of the pools on the shore. Small pools high on the mid-shore contain little other than coralline encrusting algae, *Enteromorpha* sp., *C. officinalis* and a few red and brown algae normally associated with the lower shore and shallow sublittoral (Cor). With an increase in size and a position lower on the shore, species richness tends to increase and the pools include kelp plants, various sponges and anemones, hydroids including *Tubularia larynx*, brittlestars *Amphipholis squamata* and fish such as shanny *Lipophrys pholis* (FK).

A small proportion of Bardsey Island's coastline, particularly in Henllwyn and the Cafn, is protected from direct wave action. The rugged bedrock and boulder shores provide a highly cryptic environment where a wide variety of plants and animals are found compared to the more exposed shores less than a few hundred metres away. The upper shore has a far denser turf of *Pelvetia canaliculata* (Pel) than on the more open coast and there are also dark fuzzy mats of the red alga *Catenella caespitosa* on shaded surfaces. Fucoid algae dominate the shore with zones of *F. spiralis* (Fspi) on the upper mid-shore, dense *Ascophyllum nodosum* (Asc.Asc) over much of the mid-shore and *Fucus serratus* mixed with *H. elongata* and turfs of red algae on the lower mid-shore (Fser.R). The invertebrate fauna under the boulders is particularly rich with a wide range of sponges including *Clathrina coriacea*, *Leuconia nivea, Grantia compressa, Halichondria panicea, Hymeniacidon perleve*, *Ophlitaspongia seriata*, *Haliclona cinerea* and *Halisarca dujardini* (Fser.Fser.Bo). There are also anemones *Actinia equina*, *Sagartia elegans* and *Aulactinia verrucosa*, porcelain crabs *Pisidia longicornis* and *Porcellana platycheles* under almost every boulder, large numbers of the opisthobranch *Berthella plumula* and colonial ascidians *Sidnyum turbinatum*, *Botryllus schlosseri* and *Botrylloides leachi*. Evidently there is sufficient water movement around the boulders to encourage filter-feeding animals but not enough to regularly disturb the boulders and prevent them colonising.

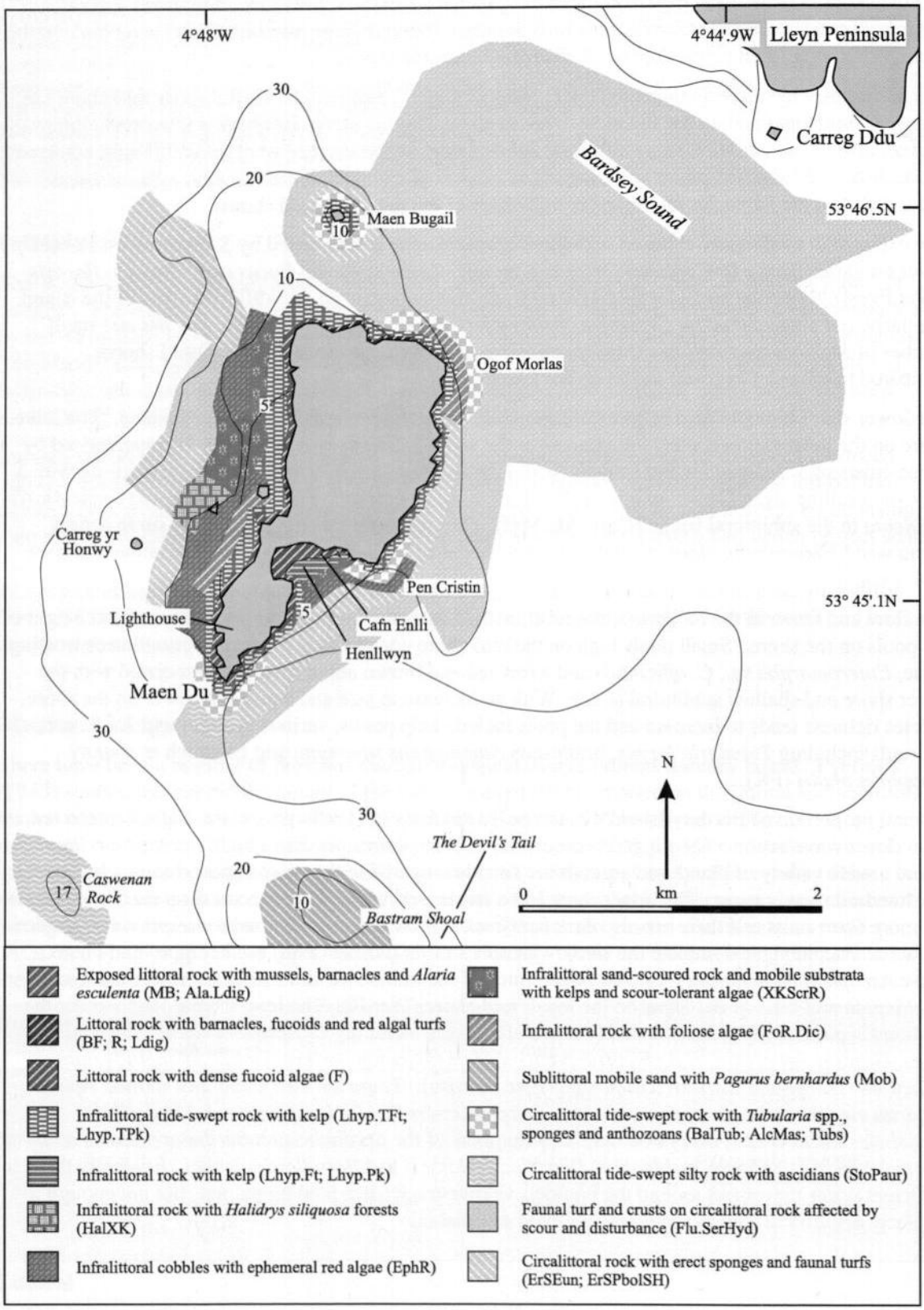

Figure 15.2 Indicative distribution of the main biotopes in the area (based on data from survey sites shown in Figure 15.1, AGDS results, cited literature and additional field observations).

Sublittoral

Sublittoral rock

Practically all the sublittoral rocky biotopes around Bardsey Island are influenced by strong tides and therefore have many characteristics in common. Whether in the shallower regions, where light levels are strong enough to support kelps forests, or in the deeper, animal-dominated circalittoral zone, filter feeding animals form a dense turf over most surfaces. The most visually-obvious species include the hydroids *Tubularia indivisa* and *Nemertesia antennina*, large sponges such as *Pachymatisma johnstonia* and *Esperiopsis fucorum* and anemones *Sagartia elegans* and *Corynactis viridis*. However, localised variation in the biology does occur and seems mainly related to exposure to wave action which is generally higher on the west-facing side of the island than the east. These differences can be highlighted by describing the sublittoral habitats travelling clockwise around the island, starting from the southern tip, Maen Du.

Off the south-west tip of Bardsey Island, the seabed comprises outcrops of undercut bedrock worn smooth at their base by the grinding action of cobbles and sand mobilised by winter storms. There is very little sediment or silt on the rock which gives this part of the island a very 'clean' appearance. The banks of stones between these bedrock outcrops are well-rounded and support very little life other than a few crustose bryozoans and coralline algae (CC.Mob). In shallow water *Alaria esculenta* is found above the *Laminaria hyperborea* kelp forest and dense patches of *C. viridis* and *S. elegans* are present on the rock (Ala.Ldig; LhypFa). There are also dense tufts of *T. indivisa* growing amongst the kelp on the strongly tide-swept sides and upper edges of these rocky ridges (Lhyp.TFt). In slightly deeper water below the kelp forests (> 15 m) the faunal turfs which completely cover the more stable bedrock and boulders comprises mainly rock-hugging colonies of the colonial ascidian *Polyclinum aurantium* with patches of *C. viridis*, hydroids and bryozoans (StoPaur).

To the south-west of Bardsey Island there is a small group of ridges and pinnacles known as Caswenan Rock where the seabed rises steeply from over 40 m up to 17 m. The biotopes here are characteristic of a combination of strong tides and moderate scouring action from silt and sediment in suspension. Dense colonial ascidians, mainly *P. aurantium*, with *T. indivisa* and the bryozoan *Alcyonidium diaphanum* growing between them, cover much of the rock surface (StoPaur). Other opportunistic species capable of attachment in the strong tides are found in large numbers, particularly mussels *Mytilus edulis* and tube-building amphipods *Jassa* sp.

A long rocky platform, around 0.5 km wide, flanks the west side of Bardsey Island between the shore and the 10 m isobath. This area, including the seabed around the small off-lying rocks Carreg yr Honwy, is strongly tide-swept on the ebb and is covered in kelp forest and park (Lhyp.TFt; Lhyp.TPk) growing on bedrock. Adjacent large boulders sitting in coarse gravel and sand support mixed kelps and turfs of red algae typical of the more unstable substrata (FoR.Dic, XKScrR). Some of the bedrock and boulders appear rather scoured although sponges, such as *Polymastia boletiformis* and *Hemimycale columella* and turfs of hydroids *Aglaophenia* spp., *Gymnangium montagui* and *T. indivisa* and bryozoans *Bugula* spp., *Flustra foliacea* and *Scrupocellaria* spp. are found amongst the forests, particularly on vertical faces in the gullies and on large boulders in deeper water (ErSPbolSH, Flu.HByS). The fan worm *Bispira volutacornis* is also present, often protruding its tentacles from beneath boulders and cracks in the rock. In deeper water in this area Hiscock (1984) found that some vertical faces supported dense aggregations of the anemone *Parazoanthus axinellae* (?ErSEun). Although this area was not studied during the MNCR survey, *P. axinellae* was found on the east side of the island; the biotope in which it was found is described below.

Maen Bugail, a rock just off the north-west tip of Bardsey Island, is exposed to the full force of the tide flowing into Bardsey Sound. Below the dense kelp forest which grows around the steeply-sloping first 10 m of rock, most surfaces are covered by a dense layer of *T. indivisa* growing through a thick layer of sponge - mainly *Halichondria panicea* and *Myxilla* sp. (TubS). Some areas of rock are scoured almost clean with only a layer of barnacles *Balanus crenatus* and sparse *Tubularia* able to remain attached in the strong tidal streams (BalTub). A little deeper (> 14 m) the extreme tidal

streams are reduced and species richness increases. A variety of massive sponges, such as *Cliona celata* and *Pachymatisma johnstonia*, branching sponges, such as *Stelligera stuposa* and *Raspailia ramosa* and anemones such as *C. viridis* and *M. senile* and hydroids are found here (CorMetAlc, AlcMaS) although these biotopes are better represented on the east side of Bardsey Island. Small caves near the base of Maen Bugail contain several species characteristic of deeply shaded habitats. These include the sponges *Thymosia guernei* and *Aplysilla sulfurea* and the nationally rare cup coral *Caryophyllia inornata*. There are also large numbers of the more common Devonshire cup coral *Caryophyllia smithii* and the squat lobster *Galathea strigosa* (SCup).

A plain of cobbles and boulders extends in all directions from the base of Maen Bugail similar to that found throughout the seabed in most of Bardsey Sound (see also *area summary* 14). The number of animals attached to the stones broadly reflects the size and stability of each individual piece of rock, although overall the biotope is characteristic of tide-swept and rather unstable scoured conditions with *B. crenatus*, crustose bryozoans, erect bryozoans *F. foliacea* and scour-tolerant hydroids such as *Sertularia argentea* (Flu.SerHyd). *U. felina* is common, and the larger boulders often support a similar suite of animals as bedrock elsewhere in Area 15 with patches of *P. aurantium* (StoPaur).

On the north and north-east sides of Bardsey Island, dense kelp forests extend down the bedrock slopes to around 6-8 m below chart datum, thinning out completely by around 12 m. This is shallower than the less shaded south- and west-facing parts of the island where dense kelp forest grows to around 10 m and thins out at 15 m, leaving mainly anemones and sponges dominating vertical surfaces (CorMetAlc, AlcMaS, AlcByH). Circalittoral biotopes around the north-east corner of the island are dominated by *T. indivisa* and a range of scour-tolerant hydroids and bryozoans similar to those found on the seabed in Bardsey Sound. However, around Ogof Morlas several very large limestone boulders sitting on the igneous bedrock support a somewhat different suite of animals. The most striking difference is that the vertical faces of these boulders are deeply pitted by rock-boring piddocks (apparently mainly *Hiatella arctica*) with other animals, such as the ascidian *Ciona intestinalis*, occupying empty holes and the black sponge *Dercitus bucklandi* filling cracks and crevices (AlcByH.Hia and SCup).

From Ogof Morlas southwards down the east side of Bardsey Island to a point east of the lighthouse, steep infralittoral rock supports dense kelp forest (Lhyp.TFt) to around 6 m depth, dropping quickly to circalittoral rock with greater numbers of branching sponges such as *Axinella dissimilis*, *Stelligera stuposa*, *Raspailia ramosa* and *Raspailia hispida* than the more exposed west side of the island as well as very large colonies of *C. celata* and *P. johnstonia*. There are also several vertical and overhanging bedrock faces, for example at Pen Cristin and directly east of the lighthouse, where dense aggregations of the yellow star anemone *Parazoanthus axinellae* are found along-side patches of the sponge *Thymosia guernei*. Both these areas have been chosen as potential sites for fixed-point monitoring stations by CCW, primarily to study *P. axinellae*. There are large numbers of two species of cup coral *C. smithii* and *C. inornata* and, although not found recently, Hiscock (1984) recorded the anthozoan *Alcyonium glomeratum* here. Small clumps of the bryozoan *Pentapora foliacea* are present on upward-facing surfaces. This biotope is very similar in character to ErSEun, which is characterised by the pink sea-fan *Eunicella verrucosa*, a species which has a south-western distribution in the British Isles, and has yet to be found further north in the Irish Sea than the Pembrokeshire Islands.

Slopes of cobbles and small boulders on the south-east side of Bardsey Island are particularly species-rich, especially at the transition between the infralittoral and circalittoral where the tops of the stones support dense turfs of red algae such as *Plocamium cartilagineum* and *Bonnemaisonia asparagoides* mixed with a wide variety of sponges including large amounts of *Esperiopsis fucorum* and *Hemimycale columella*. It is likely that these stones are periodically disturbed by winter storms which prevent larger animals or plants from settling. Of interest are two species of less common red algae characteristic of this type of disturbance, *Schmitzia hiscockiana* and *Scinaia turgida*, which are found at the deeper limit of the red algae (approximately 16 m) just outside Henllwyn (EphR).

Sublittoral sediment

Very little sediment occurs close inshore around Bardsey Island, although there are pockets of muddy shell-gravel and sand at the base of the bedrock slopes on the east side of the island. However, there is a long sandbank, forming Bastram Shoal and the Devil's Tail, which stretches over 10 km south of the southern tip of the island. Here the seabed seems to comprise entirely of clean sand kept highly mobile by the ebb and flood tides which sweep across the banks at high speed. There are no obvious fauna living in the sand on the shallower parts of the bank although a few hermit crabs *Pagurus bernhardus*, plaice *Pleuronectes platessa* and sand-eels *Ammodytes tobianus* can be seen on the surface (Mob).

Nature conservation

Conservation sites

Site name	*Status*	*Location*	*Main features*
Pen Llŷn a'r Sarnau / Lleyn Peninsula and the Sarnau	cSAC	SH 50 30	Estuaries; Reefs
Ynys Enlli: Bardsey Island	NNR; SSSI	SH 120 220	Sub-maritime grassland and coastal heath; seabirds; Grey seals.
Glannau Aberdaron and Ynys Enlli (Bardsey Island and Aberdaron Coast)	pSPA	SH 120 220	Ornithological
Llyn Peninsula	ESA	N/A	Agri-environmental scheme
Lleyn Peninsula	AONB	N/A	High scenic quality
Lleyn Peninsula	HC	SH 424 514 - SH 324 266	Coastal scenery

Human influences

Coastal developments and uses

Bardsey Island is owned and managed by the Bardsey Island Trust who use traditional farming methods to maintain a balance between grazing and the regeneration of the more natural habitats on the island. Bardsey Island is of ornithological importance, both for its breeding seabirds and because it lies in the centre of the west coast migration route. There has been a bird observatory on the island since 1953.

The coastline of Bardsey Island is largely undeveloped, the only man-made structures on the shores being the small area blasted out to make a slipway, the gabions and the sea-wall in the small bay, Cafn Enlli, on the east side of the island. Visitors and supplies for the resident population arrive by boat on a regular basis, although the maximum size of vessel which can safely use the Cafn is limited. Cattle and sheep are transported to and from the island by 'sea truck'; a landing-craft style boat run by the islanders.

Marine developments and uses

The main local fishery is potting for crabs *Cancer pagurus* and lobsters *Homarus gammarus*, and crayfish *Palinurus elephas* when in season (mid-late summer). Queen scallop *Aequipecten opercularis* dredging and fixed netting for bass *Dicentrarchus labrax* and other fish species occurs sporadically to the south of Bardsey Island, but most fishing effort around the Island is by local inshore small boat-users.

References and further reading

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Sites surveyed

Survey 186. 1983 Bardsey and the Lleyn Peninsula, sublittoral survey (Hiscock 1984).
Survey 205. 1983 Bardsey and the Lleyn Peninsula littoral survey (Rostron 1984).
Survey 228. 1977 marine biological survey of Bardsey Island (Hoare & Jones 1981).
Survey 638. 1996 MNCR/CCW Bardsey Island, littoral survey (MNCR, unpublished data).
Survey 644. 1997 MNCR Bardsey Island and SW Lleyn Peninsula, sublittoral survey (MNCR, unpublished data).

Littoral sites

Survey	Site	Place	Grid reference	Latitude/longitude	Biotopes present
205	5	Maen Du, Bardsey/Lleyn Peninsula.	SH 109 201	52°44.7'N 04°48.1'W	Him, YG, BPat, FvesB, Ala.Ldig, FK, Coff, Ver.B
205	6	Pen Cristin, Bardsey/Lleyn Peninsula.	SH 120 209	52°45.1'N 04°47.1'W	BPat.Sem, BPat, Ala.Ldig, Ver.B, BPat.Fvesl, PelB
205	7	N of Ogof Morlas, Bardsey/Lleyn Peninsula.	SH 126 224	52°45.9'N 04°46.6'W	BPat.Sem, YG, Ver.Ver, FvesB, Ala.Myt, PelB, XR
205	8	S of Ogof Trwyn-yr-Hwch, Bardsey/Lleyn Peninsula.	SH 114 218	52°45.6'N 04°47.7'W	Cor.Bif, Him, YG, Ver.Ver, FvesB, Ala.Ldig, FK, Cor, Ver.B
205	9	Porth Solfach, Bardsey/Lleyn Peninsula.	SH 114 214	52°45.4'N 04°47.7'W	Ldig.Ldig, Cor
205	10	Maen Du (Sheltered Area), Bardsey/Lleyn Peninsula.	SH 109 200	52°44.6'N 04°48.1'W	BPat.Sem, Ver.Por, Fser.R, BPat.Fvesl, XR
205	25	Henllwyn Bay, Bardsey/Lleyn Peninsula.	SH 114 209	52°45.1'N 04°47.6'W	Him, Ver.Ver, Fspi, Asc.Asc, Fser.Fser, Rho, FK, SwSed, Cor, Pel
228	A	Maen Du, Ynys Enlli	SH 109 201	52°44.7'N 04°48.1'W	PelB
228	B	E of Maen Du, Ynys Enlli	SH 111 201	52°44.7'N 04°47.9'W	BPat, Cor
228	C	S of Henllwyn, Ynys Enlli	SH 115 206	52°44.9'N 04°47.5'W	BPat, Cor, PelB
228	D	Bae Henllwyn, Ynys Enlli.	SH 114 209	52°45.1'N 04°47.6'W	BPat, Asc, Pel, Fser
228	E	E of Cafn Enlli (1), Ynys Enlli.	SH 117 209	52°45.1'N 04°47.4'W	Him, BPat, Asc.Asc
228	F	E of Cafn Enlli (2), Ynys Enlli.	SH 118 210	52°45.2'N 04°47.3'W	Him, BPat, FK, Cor
228	G	East Coast, North of Pen Cristin, Ynys Enlli.	SH 124 214	52°45.4'N 04°46.8'W	BPat.Sem, BPat.Cht, Cor
228	H	Bae Felen, Ynys Enlli.	SH 125 219	52°45.7'N 04°46.7'W	BPat, R
228	I	Bae'r Nant, Ynys Enlli.	SH 122 225	52°46.0'N 04°47.0'W	BPat
228	J	E side of Trwyn y Gorlech, Ynys Enlli.	SH 117 226	52°46.0'N 04°47.4'W	BPat.Sem, BPat.Cht,
228	K	Bae y Rhigol, Ynys Enlli.	SH 118 226	52°46.0'N 04°47.4'W	BPat, Cor, PelB
228	L	N of Ogof Hir, Ynys Enlli	SH 115 224	52°45.9'N 04°47.6'W	BPat, FK, Cor
228	M	N of Ogof Trwyn-yr-Hwch-Fawr, Ynys Enlli.	SH 115 219	52°45.6'N 04°47.6'W	BPat, Fser.R, Cor, Bli, PelB
228	N	N of Porth Solfach (1), Ynys Enlli.	SH 114 215	52°45.4'N 04°47.7'W	BPat, Cor
228	O	N of Porth Solfach (2), Ynys Enlli.	SH 114 214	52°45.4'N 04°47.7'W	BPat, Cor
228	P	Porth Solfach, Ynys Enlli.	SH 114 213	52°45.3'N 04°47.7'W	Asc, Pel, Fserr
228	Q	Porth Hadog, Ynys Enlli.	SH 112 209	52°45.1'N 04°47.8'W	Asc
228	R	N of Ogof Lladron (1), Ynys Enlli.	SH 109 203	52°44.8'N 04°48.1'W	Him, BPat, FvesB, PelB
228	S	N of Ogof Lladron (2), Ynys Enlli.	SH 109 202	52°44.7'N 04°48.1'W	BPat, Cor
638	1	Cafn Enlli, Bardsey.	SH 116 209	52°45.1'N 04°47.5'W	Him, YG, Fspi, Asc.Asc, FK, SwSed, Pel, XR

Sublittoral sites

Survey	Site	Place	Grid reference	Latitude/longitude	Biotopes present
186	25	Pen Cristin, Ynys Enlli	SH 120 208	52°45.1'N 04°47.1'W	MolPol, AlcMaS, SNemAdia, EphR, ErSPbolSH
186	26	Henllwyn, Ynys Enlli	SH 116 207	52°45.0'N 04°47.5'W	Bug, EphR, ErSPbolSH, Lhyp.Ft
186	27	Maen Du, Ynys Enlli	SH 110 200	52°44.6'N 04°48.0'W	Bug, LhypR.Ft, LhypR.Pk, ErSPbolSH
186	28	NW of Bardsey Lighthouse (1), Ynys Enlli	SH 108 208	52°45.0'N 04°48.2'W	Bug, FoR.Dic, EphR
186	29	NW of Bardsey Lighthouse (2), Ynys Enlli	SH 103 210	52°45.1'N 04°48.6'W	CorCri, ErSPbolSH

Sublittoral sites continued

Survey	*Site*	*Place*	*Grid reference*	*Latitude/longitude*	*Biotopes present*
186	30	NE Point Bardsey, Ynys Enlli	SH 126 224	52°45.9'N 04°46.6'W	TubS, CorCri, CuSH, BalTub, FoR.Dic, Bug, Lhyp.Ft, FoR
186	31	Briw Gerig, Ynys Enlli	SH 127 219	52°45.7'N 04°46.5'W	Bug, Flu.SerHyd, CorCri
186	32	Inner Henllwyn, Ynys Enlli	SH 115 209	52°45.1'N 04°47.6'W	LsacChoR
186	33	Outer Henllwyn, Ynys Enlli	SH 116 207	52°45.0'N 04°47.5'W	XKScrR
186	48	NW Bardsey, Ynys Enlli	SH 112 224	52°45.9'N 04°47.9'W	Flu.HByS, Urt.Urt, Ala.Ldig, XKScrR, EphR, Lhyp.Ft
186	49	Offshore NW Bardsey, Ynys Enlli	SH 108 229	52°46.2'N 04°48.2'W	CorCri, ErSEun
186	50	N Pen Cristin, Ynys Enlli	SH 122 210	52°45.2'N 04°46.9'W	ErSEun, SNemAdia
186	51	SE Bardsey, Ynys Enlli	SH 113 203	52°44.8'N 04°47.7'W	CorCri, ErSEun
186	52	N Maen Du, Ynys Enlli	SH 111 201	52°44.7'N 04°47.9'W	CorCri, ErSEun, AlcTub
228	1	Caswenan Rock, Ynys Enlli	SH 106 188	52°43.9'N 04°48.3'W	TubS, AlcMaS
228	2	Maen Du, Ynys Enlli	SH 110 200	52°44.6'N 04°48.0'W	TubS, CorCri, ErSPbolSH
228	3	Ogof Diban, Ynys Enlli	SH 112 202	52°44.7'N 04°47.8'W	CorCri, Bug, Lhyp.TFt
228	4	Bae Henllwyn, Ynys Enlli	SH 116 209	52°45.1'N 04°47.5'W	ErSPbolSH
228	5	Ogof Cristin, Ynys Enlli	SH 119 209	52°45.1'N 04°47.2'W	CorCri, ErSPbolSH
228	6	Pen Cristin, Ynys Enlli	SH 121 209	52°45.1'N 04°47.0'W	Bug, AlcMaS, Lhyp.TFt, ErSPbolSH
228	7	Ship Ledge, Ynys Enlli	SH 126 208	52°45.1'N 04°46.6'W	Flu.HByS
228	8	Ogof Barcut, Ynys Enlli	SH 124 214	52°45.4'N 04°46.8'W	SNemAdia, CorCri, Lhyp.TFt, Bug, SCAn, ErSPbolSH
228	9	NE Corner, Ynys Enlli	SH 125 224	52°45.9'N 04°46.7'W	TubS, LhypR.Ft, CorCri, BalTub, Lhyp.TFt
228	10	Ogof Trwyn-yr-Hwch Bach, Ynys Enlli	SH 115 219	52°45.6'N 04°47.6'W	XKScrR
228	11	W of Ogof Las	SH 109 221	52°45.7'N 04°48.1'W	ErSPbolSH, Ven.Neo
228	12	Due West of Cristin, Ynys Enlli	SH 104 216	52°45.5'N 04°48.6'W	ErSPbolSH
228	13	Carreg yr Honwy, Ynys Enlli	SH 109 213	52°45.3'N 04°48.1'W	ErSPbolSH
634	31	SE of Ynys Enlli, Cardigan Bay.	SH 183 175	52°43.5'N 04°41.4'W	ModMx
634	32	Far SE of Ynys Enlli, Cardigan Bay.	SH 237 101	52°39.6'N 04°36.4'W	AbrNucCor
644	1	Bastram Shoals, Ynys Enlli.	SH 131 152	52°42.1'N 04°45.9'W	Mob
644	2	Bastram Shoal N, Ynys Enlli.	SH 118 183	52°43.7'N 04°47.2'W	Mob
644	3	Near Caswenan Rock, Ynys Enlli.	SH 117 186	52°43.9'N 04°47.2'W	StoPaur
644	4	Maen Du, Ynys Enlli.	SH 108 200	52°44.6'N 04°48.1'W	StoPaur, SCAn.Tub, CC.Mob
644	5	W of Cristin, Ynys Enlli.	SH 111 215	52°45.4'N 04°47.9'W	HalXK
644	6	W Penrhyn Gogor, Ynys Enlli.	SH 110 223	52°45.9'N 04°48.1'W	Lhyp.TPk
644	7	Maen Bugail, Ynys Enlli.	SH 121 231	52°46.3'N 04°47.1'W	BalTub, AlcMaS, SCup, ErSPbolSH
644	8	E of Bae y Rhigol, Ynys Enlli.	SH 122 226	52°46.0'N 04°46.9'W	AlcMaS, Lhyp
644	9	SE Baer Nant, Ynys Enlli.	SH 123 224	52°45.9'N 04°46.9'W	SNemAdia, Ala, Lhyp.TFt
644	10	NE corner of Bardsey, Ynys Enlli.	SH 125 220	52°45.8'N 04°46.7'W	SNemAdia, Lhyp.TPk
644	11	S of Ogof Morlas, Ynys Enlli.	SH 125 222	52°45.8'N 04°46.6'W	SCup, Lhyp.TFt, AlcByH.Hia, ErSPbolSH
644	12	N of Ogof Braichyfwyall, Ynys Enlli.	SH 124 216	52°45.5'N 04°46.7'W	Lhyp.TPk
644	13	Pen Cristin, Ynys Enlli.	SH 121 210	52°45.2'N 04°47.0'W	Lhyp.TFt, SCup, HalXK, Bug
644	14	NW Pen Cristin, Ynys Enlli.	SH 121 210	52°45.2'N 04°47.0'W	Flu.HByS, SCup
644	15	E of Bardsey Lighthouse, Ynys Enlli.	SH 112 203	52°44.8'N 04°47.8'W	ErSEun, Lhyp.TPk, ErSPbolSH
644	16	Ogof Diban, Ynys Enlli.	SH 110 203	52°44.8'N 04°47.9'W	SNemAdia, Lhyp.TPk
644	20	Mid-Bardsey Sound, Aberdaron.	SH 139 231	52°46.4'N 04°45.4'W	StoPaur, Flu.SerHyd

Compiled by: Rohan H.F. Holt