



Marine Nature Conservation Review

Sector 5

South-east Scotland and north-east England

Area summaries

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Coasts and seas of the United Kingdom

Marine Nature Conservation Review series

Area summaries

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 is drawing 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 includes a major field survey programme of the shores and nearshore subtidal 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 below.

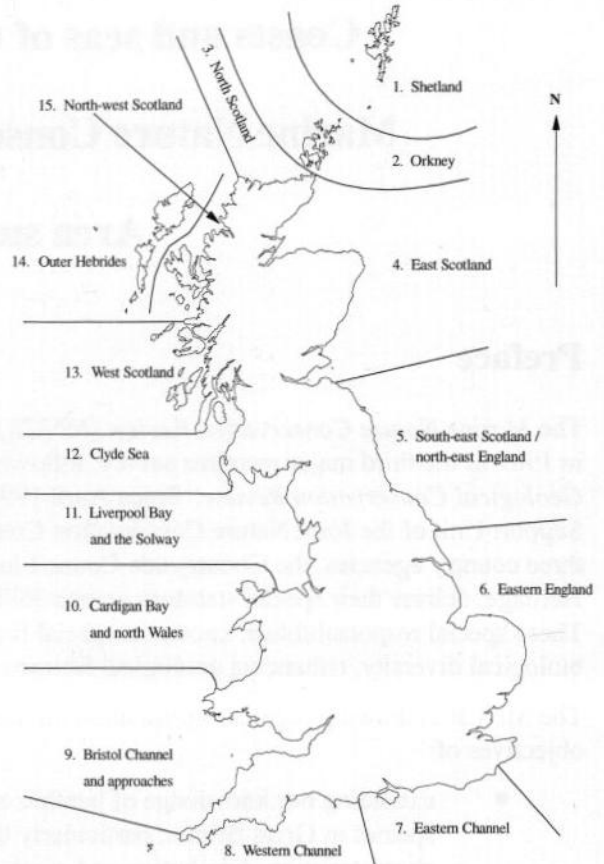
A full list of MNCR and other JNCC marine reports is available from the Marine Enquiry Officer, JNCC. JNCC publications can be purchased from NHBS Ltd, 2-3 Wills Road, Totnes, Devon, TQ9 5XN (tel. 01803 865913; fax. 01803 865280; e-mail nhbs@nhbs.co.uk).

Dr Keith Hiscock

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, <i>ed.</i>	1996
1-15	Benthic marine ecosystems: a review of current knowledge for Great Britain and the north-east Atlantic	Hiscock, <i>ed.</i>	1998
Biotope classification			
1-15	Marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes (<i>JNCC Report, No. 229</i>)	Connor, Brazier, Hill & Northen	1997
1-15	Marine biotope classification for Britain and Ireland. Volume 2. Sublittoral biotopes (<i>JNCC Report, No. 230</i>)	Connor, Dalkin, Hill, Holt & Sanderson	1997
Area summaries			
1	Shetland	Howson	Due 1998
2	Orkney	Murray, Dalkin, Fortune & Begg	Due 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	Smith, Moore & Northen	Due 1998
9	Inlets in the Bristol Channel and approaches	Smith, Moore, Northen & Little	Due 1998
10	Cardigan Bay and north Wales	Brazier, Holt, Murray & Nichols	Due 1998
11	Liverpool Bay and the Solway Firth	Covey	Due 1998
1-2	Lagoons in Shetland & Orkney	Thorpe	Due 1998
3, 4, 12, 13, 15	Lagoons in mainland Scotland & the Inner Hebrides	Covey, Fortune, Nichols & Thorpe	Due 1998
14	Lagoons in the Outer Hebrides	Thorpe, Dalkin, Fortune & Nichols	Due 1998

Other volumes in the series are also in preparation.

Marine Nature Conservation Review

Sector 5: South-east Scotland and north-east England

Area summary

Synopsis

The coast from North Berwick in Lothian (south-east Scotland) to Flamborough Head in the East Riding of Yorkshire (north-east England) has been studied as part of the Marine Nature Conservation Review programme (MNCR Sector 5: South-east Scotland and north-east England). The studies included field surveys of the shores and nearshore subtidal zone to describe the marine habitats and communities (together referred to as biotopes) and to assess their marine natural heritage importance. Comparable data from other organisations have been added to provide information on over 1,000 sites within the region and analysed to classify the biotopes present. Information on the designated conservation sites and main human activities in the region has also been compiled.

The information available for MNCR Sector 5 is presented as 24 *area summaries*:

- | | |
|-----------------------------------------------|-----------------------------------|
| 1. Bass Rock | 13. Coquet estuary |
| 2. Gin Head to Dunbar | 14. Alnmouth to Newbiggin Point |
| 3. Tynninghame Bay | 15. Newbiggin Point to Hartlepool |
| 4. Dunbar to Fast Castle Head | 16. Wansbeck estuary |
| 5. Fast Castle Head to Eyemouth | 17. Blyth estuary |
| 6. Eyemouth to the Tweed estuary | 18. Tyne estuary |
| 7. Tweed estuary | 19. Wear estuary |
| 8. Tweed estuary to Bamburgh | 20. Tees Bay |
| 9. Budle Bay | 21. Tees estuary |
| 10. Holy Island (N & E) and the Farne Islands | 22. Saltburn to Filey Bay |
| 11. Bamburgh to Alnmouth | 23. Esk estuary |
| 12. Aln estuary | 24. Flamborough Head |

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

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

MNCR Sector 5 extends from North Berwick in Lothian to Flamborough Head in the East Riding of Yorkshire (Figure 1). This coastline is relatively linear compared to Britain's more complex west coast, but nevertheless has representative examples of a wide range of coastal features, including embayments, headlands, islands and estuaries. The region is also an area of contrast between the undeveloped countryside in south-east Scotland, north Northumberland and North Yorkshire and the heavily industrialised conurbations around the Tyne, Wear and Tees estuaries.

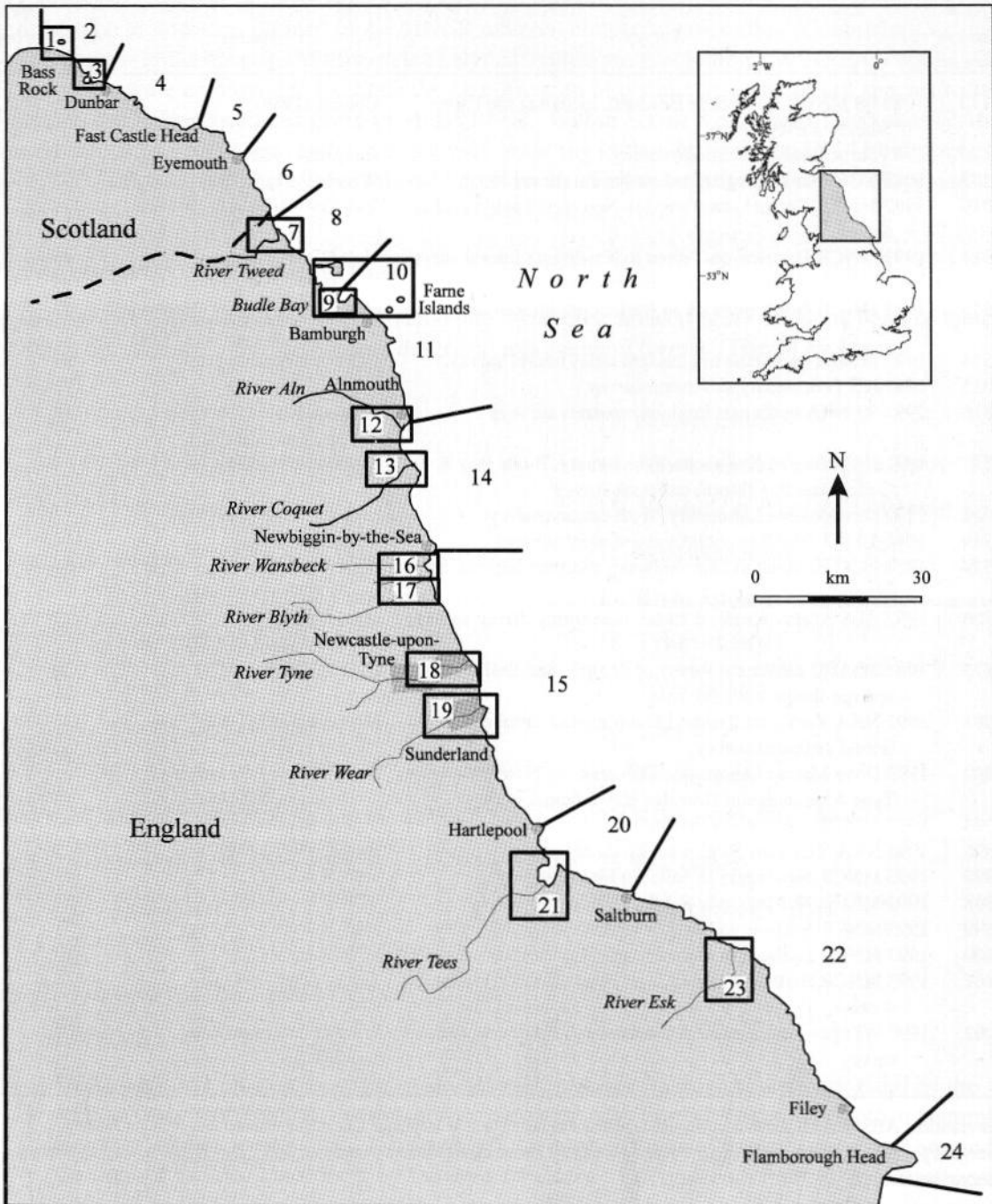


Figure 1 Location of the 24 reporting areas (*area summaries*) for MNCR Sector 5.

Field surveys were undertaken in 1992 and 1993, as part of the Marine Nature Conservation Review programme, to describe the marine biology of the shores and nearshore subtidal zone of MNCR Sector 5 and to assess their marine natural heritage importance. These surveys complemented surveys carried out by other organisations, including the Environment Agency (formerly the National Rivers Authority), Imperial Chemical Industries, the University of Newcastle's Dove Marine Laboratory, Analytical and Environmental Services and Wimpey Environmental, who made data available to the MNCR. Together the data from these surveys provide an extensive and geographically detailed dataset to describe the marine biology of the region. A summary of these surveys is given in Table 1.

Table 1 Sources of field survey data.

MNCR database survey no.	Survey	Source	No. of sites	No. of habitats surveyed
112	1987-88 MNCR Berwick to Beadnell, including the Farnes Islands, survey	Connor (1989)	86	302
120	1982 Farnes Islands sublittoral survey	Edwards (1983)	4	10
145	1987 NCC Flamborough Head sublittoral survey	Wood (1988)	61	125
310	1992 MNCR Berwick-on-Tweed to Newbiggin sublittoral survey	Holt (1994), Davies (1994)	74	103
311	1992 MNCR Berwick-on-Tweed to Newbiggin littoral survey	Holt (1994), Davies (1994)	48	270
312	1992 MNCR North Berwick to Burnmouth sublittoral survey	Holt (1994), Davies (1994)	48	99
313	1992 MNCR North Berwick to Burnmouth littoral survey	Holt (1994), Davies (1994), Brazier & Murray (1994)	47	274
314	1992 MNCR north-east England estuaries littoral survey	Brazier & Murray (1994)	63	178
315	1991 ICI Tees estuary sublittoral survey	Tapp <i>et al.</i> (1992)	76	76
316	1992-93 NRA north-east England estuaries surveys	National Rivers Authority (unpublished data)	16	19
317	1991 University of Newcastle Tyne estuary, Budle Bay & Cullercoats Bay littoral sediment survey	Evans <i>et al.</i> (1994)	3	18
318	1990 Dove Marine Laboratory Blyth estuary survey	Frid & Garwood (1991)	2	12
319	1981-90 ICI Tees Bay sublittoral sediment surveys	Shillabeer (1991)	114	114
324	1987 NCC Beadnell to Dunstanburgh, Northumberland, littoral survey	Foster-Smith & Foster-Smith (1987)	34	118
356	1992 AES Northumberland outfall monitoring diving surveys	Johnston (1992a, b, 1993), Woolmington (1994)	9	13
375	1991 SOAFD sublittoral survey of St Abbs and Bell Rock sewage sludge dumping sites	Hull & Webster (1991)	20	20
391	1991 NRA Yorkshire Region EC designated bathing beaches littoral sediment survey	Morris & Bird (1992)	21	58
392	1993 Dove Marine Laboratory, University of Newcastle-upon-Tyne Alnmouth and Druridge Bay infaunal survey	Dove Marine Laboratory (unpublished data)	21	22
393	1993 AES Berwickshire coast sublittoral sediment survey	Turner <i>et al.</i> (1993b)	16	16
395	1991 NRA Yorkshire Region rocky shore surveys	Bird & Morris (1992)	7	77
397	1993 MNCR Newbiggin to Saltburn littoral survey	MNCR survey	42	187
398	1993 MNCR Newbiggin to Saltburn sublittoral survey	MNCR survey	51	72
399	1993 MNCR Saltburn to Flamborough Head littoral survey	MNCR survey	37	91
400	1993 MNCR Saltburn to Flamborough Head sublittoral survey	MNCR survey	70	95
461	1993 MNCR Blyth to Flamborough Head sublittoral sediment survey	Turner <i>et al.</i> (1993a)	25	25
462	1990 Wimpey Environmental Scarborough sublittoral sediment survey	Wimpey Environmental (1993)	68	68
Total			1,063	2,462

Abbreviations: AES = Analytical and Environmental Services; ICI = Imperial Chemical Industries; NCC = Nature Conservancy Council; NRA = National Rivers Authority (now Environment Agency); MNCR = JNCC's Marine Nature Conservation Review.

Data collection and the classification of biotopes

Data on the nature of the marine habitats and their associated communities (together referred to as biotopes) were collected through a series of MNCR field surveys and from data made available by other organisations (Table 1). For MNCR surveys, sites were selected to sample a wide range of substrata and different environmental conditions, such as differing wave exposure and salinity regimes in the littoral and sublittoral zones. Sites were surveyed following standard MNCR recording and infaunal sampling techniques (Connor & Hiscock 1996). Data from other organisations, collected with compatible techniques, increased the volume of information available and its geographical coverage. Species recorded from the surveys are listed in Appendix A.

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 dataset, using the procedures given in Mills (1994). Within Sector 5 data from 1,063 sites (2,462 different habitat records) were used in the analyses, resulting in the identification of 141 biotopes or sub-biotopes from the national classification (Appendix B). Full descriptions of each biotope and the general approach to biotope classification are given in Connor *et al.* (1997a, b).

Area summaries and their format

The coast of MNCR Sector 5 has been divided into 24 discrete areas (Figure 1) on the basis of their physiographic character, and each area is described in a standard format. The 24 areas are:

- | | |
|-----------------------------------------------|-----------------------------------|
| 1. Bass Rock | 13. Coquet estuary |
| 2. Gin Head to Dunbar | 14. Alnmouth to Newbiggin Point |
| 3. Tynninghame Bay | 15. Newbiggin Point to Hartlepool |
| 4. Dunbar to Fast Castle Head | 16. Wansbeck estuary |
| 5. Fast Castle Head to Eyemouth | 17. Blyth estuary |
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| 7. Tweed estuary | 19. Wear estuary |
| 8. Tweed estuary to Bamburgh | 20. Tees Bay |
| 9. Budle Bay | 21. Tees estuary |
| 10. Holy Island (N & E) and the Farne Islands | 22. Saltburn to Filey Bay |
| 11. Bamburgh to Alnmouth | 23. Esk estuary |
| 12. Aln estuary | 24. Flamborough Head |

Each *area summary* is structured as follows:

Location

The geographic location is given as the central Ordnance Survey grid reference and by the appropriate county/region, district, conservation agency (English Nature or Scottish Natural Heritage) and its local office. A map shows the main features of the area, key locations and the limit of the area considered by the *area summary*. The upstream limit of the survey area of estuaries and tidal inlets is usually the normal tidal limit (noted as 'ntl' on the location maps).

The sites surveyed are shown according to five main types of survey:

- ▲ recording on littoral rock/hard substrata
- recording on sublittoral rock/hard substrata
- △ sampling by cores in littoral sediment
- sampling by cores in sublittoral sediment
- ⊕ sampling by grab in sublittoral sediment

Marine biological surveys

Marine biological surveys of the shores and sublittoral zone that have been used in compiling the *area summary* are listed to include the survey type (littoral/sublittoral), survey method, number of sites, date of survey and reference source. The distribution of survey sites is shown on the location map and sites are listed at the end of each area summary.

Introduction

This serves as a pen picture of the coastline, describing the physical characteristics of the area and the main human influences and activities.

Physical features

A summary of the main physical features includes: the type of physiographic feature as defined in Connor & Hiscock (1996) or, for estuary types, in Davidson *et al.* (1991); the length of coastline and bathymetry summarised from Admiralty charts; the areas and lengths of inlets, taken from Buck (1993), the length being from the mouth of the inlet to the limit of tidal influence; wave exposure and tidal stream ranges taken from Admiralty chart information and additional field observations, as defined in Connor & Hiscock (1996); tidal range figures are for maximum spring and minimum neap tidal range, quoted for the nearest secondary port, and taken from Admiralty tables; and the salinity range is from estimates made in the field or available literature, with categories as in Connor & Hiscock (1996). All heights and depths given are corrected to chart datum.

Marine biology

The biological nature of the area is described with reference to the biotopes present and their distribution within each area. A full listing of the biotopes is given in Appendix B and a summary of biotopes present within each area is presented in Appendix C. Species nomenclature follows Howson & Picton (1997); that for lichens follows Purvis *et al.* (1992).

A map has been assembled, aided by interpretation on a Geographical Information System, to illustrate the distribution of the main biotopes within the area. **NOTE:** This map gives an indication of the *likely* distribution and extent of biotopes, based on the data available, cited literature and information on Admiralty charts. In some areas especially data are sparse and additional data would enable more accurate maps to be drawn.

Nature conservation

A summary of statutory and non-statutory wildlife and landscape conservation designations for marine and coastal parts of the area is shown (from Barne *et al.* 1995a, b, 1997, where further information on the types of designation can be found).

Key to conservation site designations in Sector 5:

AONB	Area of Outstanding Natural Beauty
CP	Country Park
HC	Heritage Coast
LNR	Local Nature Reserve
MCA	Marine Consultation Area
NNR	National Nature Reserve
NP	National Park
NT	National Trust
NTS	National Trust for Scotland
Ramsar	Ramsar site
RSPB	Royal Society for the Protection of Birds reserve
cSAC/pSAC	candidate/proposed Special Area of Conservation
SMA	Sensitive Marine Area
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
VMNR	Voluntary Marine Nature Reserve
WT	County Wildlife Trust
WWT	Wildfowl and Wetlands Trust

Human influences

This section describes the main uses and activities of the area, including urbanisation, industrial or commercial activities that have (or potentially have) an impact within the area described. The possible human activities include sewage discharges, industrial effluents, development, dredging, spoil dumping, commercial fishing, recreation and shipping.

References and further reading

This lists cited references and other relevant literature.

Sites surveyed

This provides a listing of the sites surveyed within the area with additional information on the location of each site (OS grid reference and Latitude/Longitude) and an inventory of the biotopes known to be present at the time of survey.

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David Connor	Clare Eno
Roger Covey	Helen Fletcher
David Donnan (Scottish Natural Heritage)	Toby Flint

Bob Foster-Smith (University of Newcastle-upon-Tyne)	Jenny Loring (English Nature)
Judy Foster-Smith (University of Newcastle-upon-Tyne)	Jonathan Martin (Independent)
Sarah Fowler	Tom Mercer
Matthew Frost	David Mills
Ian Fuller (Scottish Natural Heritage)	Jim Munford (Scottish Natural Heritage)
Paul Gilliland (English Nature)	Noelle Murphy (Independent)
Jason Hall-Spencer (University Marine Biological Station, Millport)	Dale Rostron (SubSea Services)
Gavin Hardy (Independent)	Bruce Smith
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Keith Hiscock	Chris Stevens
Sue Hiscock	Timothy Venes (Flamborough Heritage Coast)
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Dan Laffoley	John Woolford (Independent)
	Tim Worsfold

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1

Bass Rock

Location

<i>Position (centre)</i>	NT 602 873
<i>Administrative area</i>	East Lothian
<i>Conservation agency/area</i>	Scottish Natural Heritage Lothian and Borders

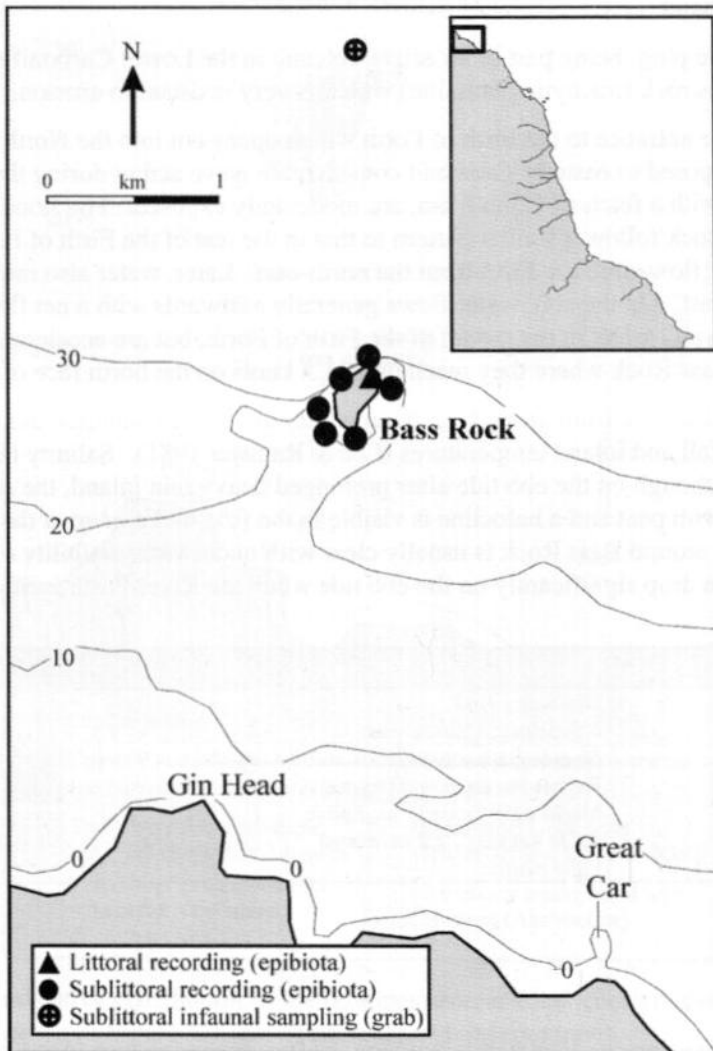


Figure 1.1 Location of area showing sites surveyed and main bathymetric features.
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Marine biological surveys

	<i>Survey methods</i>	<i>No. of sites</i>	<i>Date of survey</i>	<i>Source</i>
<i>Littoral</i>	Recording	1	June 1992	Davies (1994)
<i>Sublittoral</i>	Recording	6	June 1992	Davies (1994)
	Sampling (infauna/granulometry) (Day grab)	1	February 1993	Turner <i>et al.</i> (1993)

Introduction

Bass Rock is a small island located 2.3 km north of the East Lothian coastline and 11 km north-west of Dunbar. The long axis of the island has a south-west to north-east orientation and the centre of the island rises to more than 75 m above sea level. Near-vertical cliffs surround most of the island and access can be gained only at the southern end of the island via a small landing stage where there is a steep cliff path. A lighthouse stands above the landing stage. Bass Rock retains one of the largest seabird colonies in the Firth of Forth and has a nationally important gannet colony which supports approximately 8% of the Great Britain breeding population (SSSI citation); the gannet *Sula bassana* was named after the island.

Bass Rock is a volcanic plug, being part of an active volcano in the Lower Carboniferous period, and comprises hard igneous rock (trachytic phonolite) which is very resistant to erosion.

The island stands at the entrance to the Firth of Forth which opens out into the North Sea. The east side of the island is exposed to easterly gales and considerable wave action during the winter, but the south and west sides, with a fetch of 1.5 to 8 km, are moderately exposed. The flood and ebb tidal streams around Bass Rock follow a similar pattern to that in the rest of the Firth of Forth. At the start of the flood tide, water flows into the Firth from the north-east. Later, water also moves in on the flood from the south-east. On the ebb, water flows generally eastwards with a net flow south and east. Tidal streams are generally weak in the mouth of the Firth of Forth, but are accelerated around obstructions such as Bass Rock where they reach up to 1.5 knots on the north face of the island.

Surface temperatures fluctuate from around 5.5 °C in winter to 12 °C in summer, although this can vary according to rainfall and inland temperatures (Lee & Ramster 1981). Salinity in the region is generally of 34.5‰, although on the ebb tide after prolonged heavy rain inland, the surface water becomes discoloured with peat and a halocline is visible in the first metre or so at the surface (Davies, pers. obs.). The water around Bass Rock is usually clear with underwater visibility often in excess of 10 m, although this can drop significantly on the ebb tide when the River Forth is in spate.

Physical features

<i>Physiographic type</i>	Offshore island
<i>Size of feature</i>	450 m long x 250 m wide
<i>Bathymetry</i>	30 m isobath adjacent to island, 50 m isobath at 9 km offshore
<i>Wave exposure range</i>	Exposed to moderately exposed
<i>Tidal stream range</i>	Moderately strong to negligible
<i>Tidal range</i>	4.5 m (springs), 2.2 m (neaps)
<i>Salinity range</i>	Fully marine

Marine biology

Littoral

Littoral habitats comprise near-vertical bedrock which is often subject to considerable eutrophication from seabird guano. Only one site has been surveyed in detail but the biotopes recorded are represented throughout the island. Due to the high wave exposure, the splash zone is very extensive and characterised by black lichens *Verrucaria* spp. and the green alga *Prasiola stipitata*; *P. stipitata* is particularly common in habitats subject to eutrophication by guano. *Prasiola stipitata* is most abundant in the supralittoral zone and the upper littoral fringe (Pra), with *Verrucaria maura* and the red alga *Porphyra umbilicalis* forming a distinct band in the lower littoral fringe (Ver.Por). Eulittoral bedrock is characterised by sessile animals with scattered clumps of algae tolerant of wave-exposed conditions. Rock surfaces are dominated by mussels *Mytilus edulis* and barnacles with patches of the red algae *P. umbilicalis* and *Aglaothamnium sepositum* (MytB). Sublittoral fringe habitats support a dense forest of the kelps *Alaria esculenta* and *Laminaria digitata*. *Alaria esculenta* (Ala.Myt) is most abundant on the more exposed north and east coasts of the island with *L. digitata* present on the more sheltered west coast. Where the species co-occur, *A. esculenta* generally forms a dense band above the *L. digitata*.

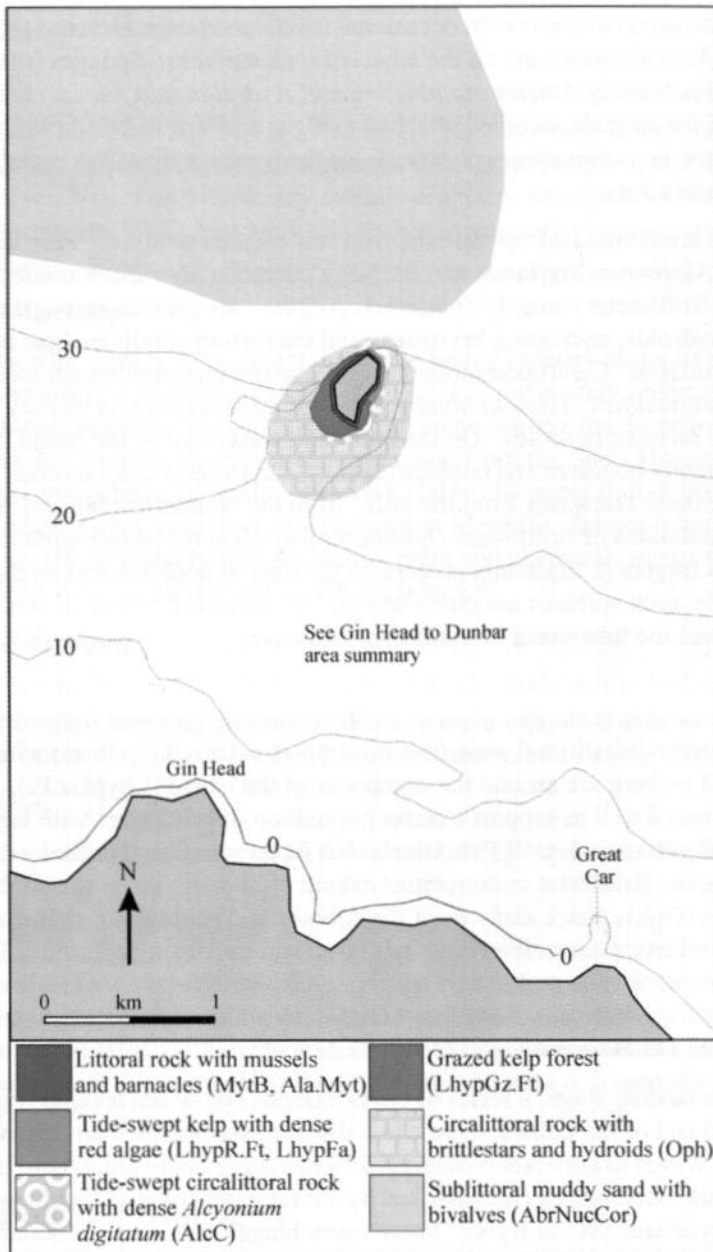


Figure 1.2 Indicative distribution of the biotopes around Bass Rock (based on data from survey sites shown in Figure 1.1 and additional field observations).

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Sublittoral

Vertical, stepped cliffs extend into the sublittoral around the whole island although the lower limit varies with location. At the northern end of the island, the cliffs extend to a depth of 40 m decreasing to 19 m along the western coast, and further decreasing to 14 m along the southern and eastern coast. At most locations, rather than a single vertical face, these submarine cliffs are divided into steps by a series of small, horizontal ledges. A dense kelp *Laminaria hyperborea* forest covers all rock surfaces, and in particular small, horizontal ledges, down to a depth of approximately 5 m (LhypR.Ft; LhypGz.Ft). Filamentous and foliose red algae form a lush turf on the kelp stipes and on the rock surfaces between kelp plants. This red algal assemblage is characterised by *Polysiphonia* spp. with *Delesseria sanguinea*, *Ptilota gunneri* and *Phycodryis rubens*. Open rock surfaces not covered with erect algae have a dense covering of encrusting coralline algae. Animal assemblages are characterised

by anemones, mainly *Sagartia elegans* with occasional dahlia anemones *Urticina felina*, which are most abundant within kelp holdfasts and on the adjacent rock surfaces. Sponges (mainly *Myxilla incrustans*) and hydroids (mainly *Abietinaria abietina* and *Hydrallmania falcata*) are recorded on rock and algal surfaces. Of the animals recorded attached to algae and within kelp holdfasts, the urchin *Echinus esculentus* is the most commonly observed. At the northern tip of the island, a kelp park extended to approximately 9 m.

Vertical bedrock walls are dominated by animals, with few records of algae. Very dense populations of dead-man's fingers *Alcyonium digitatum* and the large anemone *Metridium senile* form a carpet over the rock face (AlcC). Brittlestars - mainly *Ophiothrix fragilis* - are present amongst the fingers of *A. digitatum*. Sponges, hydroids, encrusting bryozoans and encrusting coralline algae cover the remaining open rock surfaces. Gastropod molluscs, and in particular nudibranch molluscs, are common amongst the animal turf; *Tritonia hombergii* is recorded feeding on its prey *A. digitatum*, and *Doto* spp. are common on erect hydroids. On the north and west coast of the island, the habitats at the base of the cliffs are mainly boulders and cobbles (EphR). On the east coast a series of bedrock ridges, some up to 2 m high, extend eastwards from the cliff. Both the boulder/cobble and bedrock habitats support very dense populations of brittlestars *Ophiothrix fragilis* and *Ophiocolina nigra*, with large colonies of dead-man's fingers *A. digitatum* present on the tops of boulders and on the crests of ridges (Oph). Where available, rock surfaces are characterised by encrusting epifaunal species, mainly encrusting bryozoans and the tubeworm *Pomatoceros triqueter*.

Inshore off the southern end of the island, the sea bed is much shallower and comprises a boulder slope from 2 to 8 m leading to a gently sloping plain of small cobbles and pebbles that extends offshore. Boulders and cobbles in the infralittoral zone (0-4 m) support a dense kelp forest which is similar to the kelp forest recorded on bedrock around the remainder of the island (LhypGz.Ft). Circalittoral boulders and cobbles from 4 to 8 m support a dense population of brittlestars with large colonies of dead-man's fingers *A. digitatum*. A wolf fish *Anarhichas lupus* was found in the spaces between the small boulders in this area. Brittlestar communities extend offshore to cover the cobbles and pebbles, albeit at lower densities (Oph). Rock surfaces of the cobbles and pebbles are characterised by encrusting bryozoans and calcareous tubeworms with frequent encrusting coralline algae. Between the stones, in muddy sediment, bivalve molluscs *Modiolus modiolus*, *Clausinella fasciata* and *Ensis* sp. and tubicolous polychaetes *Lanice conchilega* and *Chaetopterus variopedatus* are present. In the deepest part of this zone, the swimming crab *Liocarcinus depurator* is common.

To the north-east of the landing stage, a series of caves extends below sea level to form submarine gullies. At the seaward end of the gullies, there a less diverse assemblage than that at the landward end. The gullies focus waves to generate considerable wave surge landward, where the vertical rock faces have rich epifaunal assemblages characterised by solitary and colonial ascidians, sponges, encrusting and erect bryozoans (SCAs.ByH). These assemblages, as a result of scour by gravel and small stones, are less diverse at the base of the gullies.

Offshore to the north and north-west of the island, sublittoral muddy sand with bivalves has been recorded (AbrNucCor).

Nature conservation

Conservation sites

Site name	Designation	Centre grid ref.	Main features
Bass Rock	SSSI	NT 602 873	Ornithology
Firth of Forth Islands	SPA, SSSI	NT 207 805	Ornithology

Human influences

Sewage discharge

As Bass Rock is uninhabited (the lighthouse is no longer manned) there is no direct discharge of sewage from the island. However, there are numerous discharges in the Firth of Forth from sewage treatment plants. Leven Valley and Kirkcaldy outfalls discharge sewage after preliminary treatment, Dunfermline, Edinburgh and Wallyford works discharge sewage after primary treatment and Alloa and Stirling works discharge sewage after secondary treatment.

Industrial effluent discharge

The Forth receives a wide variety of pollutants from the heavy industry along its shores. The effects of dispersal and dilution ensure that the sea around Bass Rock is not acutely polluted but there is a possibility of a pollution event such as an oil spill from ships visiting the oil refineries in the Firth. The most significant industrial discharges in the area come from the Shell Mossmorran and Exxon Mossmorran outfalls (petrochemical works), Inveresk Caldwells paper mill at Inverkeithing, Kilbagie paper mill at Kincardine, Quest yeast factory discharge at Menstrie, Zeneca (chemical works) at Grangemouth and the BP oil refinery (gas separation plant and chemicals plant) which is also at Grangemouth. Ballast water is discharged by BP at Dalmeny.

Dredging and spoil dumping

There are no dredging operations carried out near Bass Rock, although some occur much higher up the estuary. There are no spoil dumping grounds charted near the island but there is a sewage sludge disposal site further out in the Firth of Forth. There is an ammunition dump east of the Isle of May.

Commercial fisheries

The area is potted for lobsters and crabs and a few small fishing boats from North Berwick and Dunbar visit the area.

Recreation

Bass Rock attracts boats from nearby North Berwick on sightseeing and bird watching trips. Some boats land on the small jetty at the south side of the island, although access on foot is limited to footpaths on the top of the island and in the area around the lighthouse. Boats from North Berwick and Dunbar also bring sport anglers just off the island, and the area is frequently visited by divers during the summer.

References and further reading

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Sites surveyed

Surveys

- 312: 1992 MNCR sublittoral survey of south-east Scotland (Davies 1994).
 313: 1992 MNCR littoral survey of south-east Scotland (Davies 1994).
 393: 1993 AES grab sampling survey of south-east Scotland (Turner *et al.* 1993).

Littoral sites

Survey Site	Site name	Grid reference	Latitude & longitude	Biotopes present
313 11	NE shore, Bass Rock, North Berwick.	NT 603 875	56°04.7'N 02°38.2'W	Pra; Ver.Por; MytB; Ala.Myt

Sublittoral sites

Survey Site	Site name	Grid reference	Latitude & longitude	Biotopes present
393 1	ENE of Bass Rock, North Berwick.	NT 606 893	56°05.7'N 02°37.9'W	AbrNucCor
312 17	SW of Bass Rock, North Berwick.	NT 600 874	56°04.7'N 02°38.5'W	LhypGz.Ft; FoR; AlcC; Oph
312 18	E of Bass Rock, North Berwick.	NT 605 874	56°04.6'N 02°38.0'W	LhypR.Ft; AlcC; Oph
312 19	N face of Bass Rock, North Berwick.	NT 604 875	56°04.7'N 02°38.1'W	LhypFa; AlcC; Oph
312 20	S of Bass Rock, North Berwick.	NT 601 862	56°04.0'N 02°38.4'W	LhypGz.Ft; AlcC; Oph
312 21	Caves at Bass Rock, North Berwick.	NT 603 871	56°04.5'N 02°38.1'W	LhypFa; SCAs.ByH
312 22	W of Bass Rock, North Berwick.	NT 600 871	56°04.5'N 02°38.5'W	LhypGz.Ft; EphR; Oph

Compiled by: Jon Davies & Rohan Holt

2

Gin Head to Dunbar

Location

Position (centre/limits)	NT 632 817	NT 594 854 - NT 669 795
Administrative area	East Lothian	
Conservation agency/area	Scottish Natural Heritage	Lothian and Borders

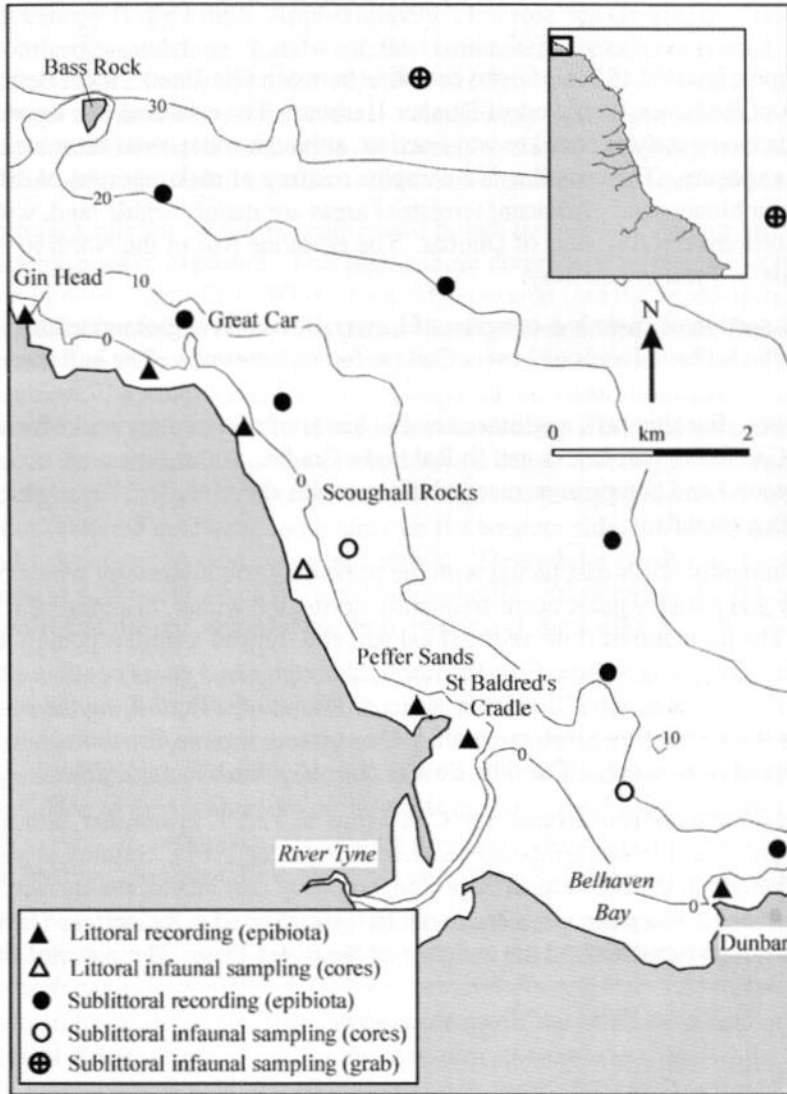


Figure 2.1 Location of area showing sites surveyed and main bathymetric features.
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Marine biological surveys				
	Survey methods	No. of sites	Date of survey	Source
<i>Littoral</i>	Recording	6	July 1992	Davies (1994)
	Infaunal cores and granulometry	1	July 1992	Davies (1994)
<i>Sublittoral</i>	Recording	7	August 1992	Davies (1994)
	Infaunal cores and granulometry	2	August 1992	Davies (1994)
	Infaunal grab samples (0.1 m ² Day grab) and granulometry	2	February 1993	Turner <i>et al.</i> (1993)

Introduction

This area covers approximately 10 km of open coastline between Gin Head, North Berwick to the shore platform east of Belhaven Bay, west of Dunbar Harbour. The coastline has a north-easterly aspect and overall is moderately exposed to wave action, although some areas have localised increased or decreased wave exposure. The coastline is a complex mixture of rock outcrops of differing geology and expanses of clean blown sand. Adjacent terrestrial areas are mainly arable land, with woodland behind Tynninghame/Belhaven Bay west of Dunbar. The estuarine part of the North River Tyne is considered in section 3. Tynninghame Bay.

The geology of this section of coast is a complex of Lower Devonian agglomerate and volcanic ash, Carboniferous basaltic tuff and bands of Lower Carboniferous limestone. The softer rocks have eroded to form broad rock platforms, while the harder rocks of volcanic origin form outcrops with steep or vertical edges. Basaltic tuff, agglomerates and bands of sedimentary rocks form the rocky platforms at Great Car, Scoughall Rocks and St Baldred's Cradle. Softer limestone outcrops occur just offshore at Lady Ground and comprise terraced platforms with short, vertical faces which support a variety of rock-boring animals.

This coast is predominantly north-east facing with the prevailing south-westerly winds from offshore, but strong northerly and easterly gales occur frequently during the winter, bringing heavy wave action onto these shores. The direction of flow on the flood and ebb follows a similar pattern as seen on Bass Rock (Area 1). The flood starts to flow from the north, although some water continues to flow from the west out of the Forth. Later in the flood tide, water flows into the Forth from the east and eddies around this sea area with a net flow from the north. The currents reverse direction on the ebb, flowing generally eastwards and northwards. The tidal flow is normally weak to negligible.

Surface temperatures fluctuate from around 5.5 °C in winter to 12.5°C in summer, although this can vary according to rainfall and inland temperatures (Lee & Ramster 1981). Salinity is generally of the order of 34.5‰ although on the ebb tide, after prolonged heavy rain inland, the surface becomes discoloured with peat and a halocline is visible in the first metre or so at the surface (Davies pers. obs.). Salinity is locally reduced around the entrance of the River Tyne. The water of this coastline is usually clear, with underwater visibility often in excess of 10 m, although this can drop significantly on the ebb tide when the Rivers Forth and Tyne are in spate.

Physical features

<i>Physiographic type</i>	Open coast
<i>Length of coast</i>	10 km
<i>Bathymetry</i>	30 m isobath at 4 km, 50 m isobath at 15 km offshore
<i>Wave exposure range</i>	Moderately exposed to sheltered
<i>Tidal stream range</i>	Weak to negligible
<i>Tidal range</i>	4.5 m (springs), 2.2 m (neaps)
<i>Salinity range</i>	Fully marine

Marine biology

Littoral

At Gin Head there is a broad, moderately exposed sandstone platform eroded to form a series of ridges with pools between. Littoral habitats are a mosaic of furoid algae and sessile animals; eulittoral habitats have furoid algae on horizontal surfaces (Fspi; FvesB) with the barnacle *Semibalanus balanoides* and the limpet *Patella vulgata* on vertical surfaces. Lower shore habitats are characterised by red algae with *Himanthalia elongata* and *Osmundea pinnatifida* forming a low turf. Kelp *Laminaria digitata* forms a dense forest in the sublittoral fringe with a turf of red algae on the rocks beneath the algal canopy (Ldig.Ldig). Approximately 2 km east lies Great Car, a basalt outcrop backed by Carboniferous sandstone. Landward, the sedimentary rocks have eroded, leaving the basalt as a distinct headland that extends approximately 500 m offshore, with a sheltered sandy bay to the west. Rock outcrops within the bay are subject to considerable sand scour and the communities recorded are characterised by ephemeral algae, in particular the red alga *Porphyra purpurea* and the green alga *Enteromorpha* sp., which together form a dense mat over the rock surface (EntPor).

Great Car is a complex mixture of ridges, gullies and broad, flat, upward-facing bedrock subject to wide local variations in wave exposure. This high habitat diversity is reflected in a high biotope diversity with ten biotopes identified. Where rock ridges extend into the supralittoral and littoral fringe, a narrow band of lichens (YG) with a narrow band of channelled wrack *Pelvetia canaliculata* below (Pel) is present on the tops of the highest ridges, with patches of spiral wrack *Fucus spiralis* on the lower ridges (Fspi). Most of the eulittoral zone supports mosaics of bladder wrack *Fucus vesiculosus*, barnacles and limpets, with the barnacles dominating steep and vertical surfaces. Lower eulittoral habitats at the seaward end of the outcrop have a dense covering of serrated wrack *Fucus serratus* and red algae (Fser.R), with sponges and ascidians covering vertical and overhanging surfaces (SR). At the more sheltered landward end mainly on the western side, the lower eulittoral comprises boulders and bedrock subject to sand scour (see above). Throughout Great Car, the troughs between ridges have extensive rockpools which have rich communities characterised by the coralline alga *Corallina officinalis* and the red alga *Mastocarpus stellatus* (Ldig.Ldig).

South-east of Great Car extends Scoughall Rocks where the coastline adopts a more easterly aspect and the rock type changes from basalt to tuffs. Scoughall Rocks has an extensive rock platform comprising a series of low ridges interspersed with patches of boulders and cobbles overlying bedrock. Littoral communities are similar to those recorded on Great Car although the habitat and biotope diversity is lower. Due to the level nature of the platform, sublittoral fringe habitats are more extensive than at Great Car, being characterised by a well-developed wrack *Laminaria digitata* assemblage with encrusting red coralline algae covering the rock beneath the canopy.

Littoral areas from Scoughall Rocks to Dunbar are predominantly sediment with a rock outcrop at St Baldred's Cradle, which separates Peffer Sands from Tynninghame/Belhaven Bay. Peffer Sands is an extensive sandy beach approximately 1.5 km long, backed by sand dunes. Throughout the beach, the sand is mobile which has resulted in a low species richness of the infaunal assemblage. Upper shore habitats are the most stable, characterised by the lugworm *Arenicola marina*, whilst mid-shore habitats are characterised by amphipods with occasional sand-eels *Ammodytes* spp. present (AP.P). Sand on the lower shore is the most mobile with no fauna visible, although a few specimens of the polychaete *Scolecopsis squamata* and the amphipod *Bathyporeia pelagica* are found in core samples.

St Baldred's Cradle is composed of basalt on the northern side and Carboniferous limestone on the southern side. The harder volcanic rock is more resistant to weathering and has resulted in a steep shore, while the sedimentary limestone rock has eroded to form a broad, flat platform. On the northern side, the shore displays a characteristic zonation pattern with lichens in the supralittoral, a mosaic of furoid algae (Fser.R) and sessile animals on the horizontal/vertical surfaces (MytB) in the eulittoral and a kelp forest in the sublittoral fringe. On the southern side, the platform has boulders overlying the bedrock which creates extensive rockpools across the shore. These pools have very rich assemblages of algae with *Corallina officinalis* and the green filamentous algae *Cladophora* spp. most common (Cor).

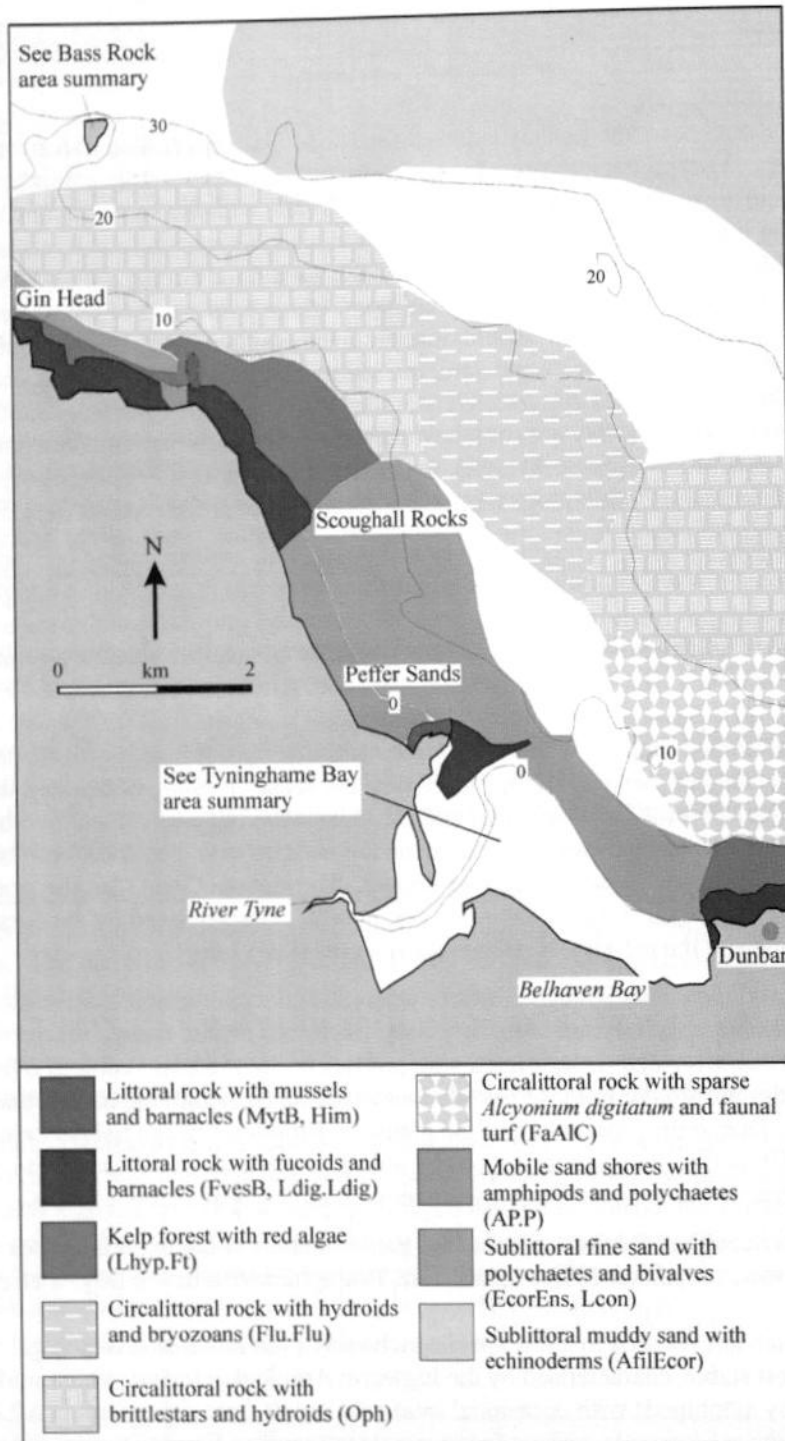


Figure 2.2 Indicative distribution of the biotopes within the area (based on data from survey sites shown in Figure 2.1 and additional field observation).

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Eelgrass *Zostera marina* is also present within the pools on the mid-shore. On the lower mid-shore, an area of flat bedrock has an extremely dense population of the common periwinkle *Littorina littorea*. In the sublittoral fringe, the rock has been eroded to form a rugged mixture of broken bedrock and boulders which creates a series of microhabitats between and under the stones. Upward-facing rock surfaces are characterised by algae with rich epifaunal and mobile epibenthic assemblages. In

particular sponges, tubeworms and ascidians characterise the epifaunal assemblages, and crustaceans and brittlestars characterise the epibenthic assemblages.

The estuary of the North River Tyne and the adjacent Tynninghame and Belhaven Bays are described in section 3. Tynninghame Bay.

To the east of Belhaven Bay is a broad, flat, rock platform of Carboniferous limestone with a volcanic dyke and agglomerates on the lower shore. Sedimentary rocks of the upper shore are soft and friable which has restricted the development of epibenthic assemblages. Supralittoral habitats are characterised by orange and yellow lichens with the littoral fringe of black lichens and gastropods (YG; Ver.Ver). Mid-shore habitats comprise a broad, flat, rock platform with mussel-bound sediment covering much of the shore (MytFR; MytFves). Rock surfaces in the eulittoral zone have a mosaic of furoid algae with barnacles, limpets and mussels; many juvenile mussels are present, mainly confined to small cracks and crevices. Lower shore habitats on the harder volcanic rock are more rugged and support a dense kelp forest of *Laminaria digitata*, *L. hyperborea*, *L. saccharina* and *Alaria esculenta*, the last species more characteristic of wave-exposed conditions (Lhyp.Ft).

In summary, littoral zones from Gin Head to Dunbar are either moderately exposed bedrock or mobile clean sediment. Variations in the underlying hard geology are mirrored in the structure and composition of the biotopes present on the shore. Steep and/or more exposed rock are characterised by epifaunal assemblages, while horizontal and more sheltered rock have a dense covering of furoid algae. Sediment habitats are characterised by crustaceans and polychaetes but, overall, species richness is much reduced due to the mobility of the sediment.

Sublittoral

Like the adjacent littoral habitats, nearshore sublittoral habitats between Gin Head and Dunbar are strongly influenced by the geology. In general, where there are platforms of hard volcanic rock, the platforms terminate abruptly leaving a vertical drop into a sublittoral flat sea bed of mixed stones and/or sediment. Where there are sedimentary rock platforms, these extend more gradually into the sublittoral resulting in shallow, stepped rock reefs. Offshore from the sandy bays, nearshore habitats (up to 1 km offshore) also comprise sediment. Offshore habitats from 1 to 2 km offshore are a mixture of sedimentary rock outcrops and mixed boulders, cobbles and pebbles lying on, or occasionally overlain with, sediment. Beyond the 30 m isobath approximately 3 km offshore, the substratum comprises mainly muddy sediment with occasional patches of stones.

At Gin Head, although no nearshore sites have been surveyed, the rock platform drops steeply into the water to approximately 2 m below sea level, beyond which is a sand plain. Infralittoral rock habitats are characterised by a kelp forest. Foster-Smith & Carrie (1992) described the area: to a depth of approximately 5 m rock habitats support a dense kelp forest with a lush red algal turf on kelp stipes and adjacent rock. Infralittoral zones are varied with a series of rocky reefs interspersed with sediment. In areas of localised shelter, the sugar kelp *Laminaria saccharina* is recorded on sediment-influenced rock. Lower infralittoral habitats support a sparse kelp park and appear to be subject to heavy grazing by urchins *Echinus esculentus*. Boulder slopes are present at the base of bedrock reefs. Sediment habitats are predominantly medium-fine sand characterised by sand mason worms *Lanice conchilega*, lugworms *Arenicola marina* and razor shells *Ensis siliqua* with numerous crabs, starfish *Asterias rubens* and juvenile flatfish (Foster-Smith & Carrie 1992). Offshore in the sound between Bass Rock and the mainland, the sea bed comprises a level plain of mixed stones on sandy mud with dense aggregations of the tubeworm *Pomatoceros triqueter*, whilst dense populations of brittlestars *Ophiothrix fragilis*, *Ophiocomina nigra* and *Ophiura albida* cover the sea bed (Oph). On the tops of larger stones there are large colonies of dead-man's fingers *Alcyonium digitatum* and frequently there are hydroids including *Thuiaria thuja*, a species with a northern distribution. In the spaces between the stones, there are many mobile crustaceans including hermit crabs, squat lobsters and swimming crabs (Foster-Smith & Carrie 1992).

Great Car terminates abruptly with steep and vertical bedrock habitats extending approximately 7 m to a level sediment plain. Steep rock habitats are characterised by a very dense kelp forest dominated by *Laminaria hyperborea* with some *L. saccharina* at the lower limit of the forest (Lhyp.Ft). Under the

kelp canopy, kelp stipes and adjacent rock surfaces are covered with a dense turf of foliose and filamentous red algae. Under this red algal turf, rock surfaces are covered with encrusting red algae, encrusting bryozoans and tubeworms. Some parts of the habitat have a sparse algal turf probably as a consequence of the grazing activities of the urchin *Echinus esculentus* and gastropod molluscs. A diverse assemblage of nudibranch molluscs, including *Archidoris pseudoargus*, *Goniodoris nodosa*, *Limacia clavigera*, *Polycera quadrilineata*, *Cadlina laevis* and *Onchidoris bilamellata*, are found within the kelp forest. At the base of the rock adjacent to the sand plain, the density of kelp decreases to form a kelp park with an associated decrease in the density of the algal turf (XKScrR). Rock surfaces are covered with sand tubes (constructed by the polychaete *Sabellaria spinulosa*) and the solitary ascidian *Asciidiella aspersa*. Where the rock walls are vertical or overhanging, kelp plants are absent and the rock is covered with a dense assemblage of sponges (*Myxilla incrustans* and unidentified encrusting species), colonial ascidians (*Sydneyum turbinatum* and *Morchellium argus*), encrusting and erect bryozoans and dead-man's fingers *Alcyonium digitatum* (AlcByH). Sediment habitats at the base of the rock have many casts of lugworm *Arenicola marina*, and the surface of the sediment is covered with a diatom film.

To the south-east of the sedimentary rock platform of Scoughall Rocks, infralittoral habitats are mainly stepped rocky reefs which support an extremely dense kelp forest with a well developed algal turf. Within this forest, kelp plants are absent from the short (<1 m high) vertical steps, and the rock faces retain epifaunal assemblages more typical of circalittoral habitats (see below). Upward-facing rock surfaces have a very dense covering of encrusting coralline and brown algae, mainly the *Aglaozonia* phase of *Cutleria multifida*. Rock reefs are interspersed by sand gullies and the rock terminates at a sand plain at approximately 7 m depth. Foster-Smith & Carrie (1992) recorded rock platforms with pockets of sand extending approximately 1.5 km offshore. However, they describe a change in rock texture below 10 m: shallower than 10 m, the reefs are composed of numerous gullies, rock mills and areas of boulders; deeper than 10 m, the rock forms an extensive, almost horizontal platform, broken only by fissures and small steps. Approximately 2 km offshore and extending inshore into Belhaven Bay, the limestone terraces at Lady Ground outcrop from the predominantly sediment sea bed and provide an interesting habitat. Upward-facing rock has large colonies of dead-man's fingers *Alcyonium digitatum*, the hydroid *Abietinaria abietina* and the erect bryozoan *Flustra foliacea*, all species characteristic of tide-swept habitats (Flu.Flu). In less tide-swept areas, the rock is covered by brittlestars, urchins and non-calcareous encrusting red algae (FaAlC). The rock is extensively bored by bivalve molluscs including *Hiatella arctica* and *Pholas dactylus*. The bored holes provide shelter for a variety of other species including the brittlestar *Ophiopholis aculeata*. Overall, diverse assemblages of epifaunal and epibenthic species are recorded on the rock surfaces. Adjacent to the rock, the sea bed comprises sediment, including patches of coarse 'pea-gravel' colonised by clumps of the ascidian *Asciidiella aspersa* with few other species present, probably due to the mobility of the gravel in tidal streams (CGS).

Sublittoral habitats adjacent to the sandy beaches of Peffer Sands and Tynninghame/Belhaven Bay comprise level plains of medium-fine sand with a diatom film on the surface. Few epibenthic species are recorded, with only the edible crab *Cancer pagurus* and two-spotted goby *Gobiusculus flavescens* noted frequently. Infaunal communities are characterised by sand mason worms *Lanice conchilega*, razor shells *Ensis* sp. and heart urchins *Echinocardium cordatum* (Lcon; EcorEns; FabMag). Occasional sand-eels *Ammodytes* sp. are observed burrowing in the sediment. At approximately 2 km offshore there are level plains of cobbles and pebbles with occasional boulders. This habitat is likely to be a continuation of the habitat offshore of Gin Head in the sound between Bass Rock and the mainland (described above).

On the extensive rock platform to the east of Belhaven Bay, volcanic rocks on the lower shore are resistant to erosion and the platform ends abruptly with a steep drop into the infralittoral, similar to that described at Great Car. Infralittoral habitats are a mixture of very steep and overhanging bedrock in a complex series of gullies which cut landward into the platform. Kelp forests are restricted to the less steep rock faces at the top of the gullies, while the vertical and overhanging walls are covered with encrusting sponges, erect and encrusting bryozoans, and solitary and colonial ascidians (AlcByH), a habitat similar to that described at Great Car. At approximately 6 m depth, there is an abrupt transition

from vertical bedrock to a level plain of medium-fine sand characterised by lugworms *Arenicola marina* and heart urchins *E. cordatum*. On the sand plain there is a patch of boulders and cobbles which appears to be subject to periodic smothering by sediment and a community consisting of mainly ephemeral species such as the brown alga *Desmarestia aculeata* and the sea squirt *Asciidiella scabra*.

Throughout the area between Gin Head and Dunbar, the furthest offshore habitats surveyed (at >6 km offshore - the limit of the survey) comprised muddy sediment (AfilEcor) which was sampled by grab (Turner *et al.* 1993). Rich infaunal assemblages were recorded, characterised by polychaetes.

Nature conservation

Conservation sites

Site name	Designation	Centre grid ref.	Main features
North Berwick Coast	SSSI	NT 601 848	Coastal habitats, flora, ornithology, geology
Tynninghame Shore	SSSI	NT 640 800	Coastal habitats, flora, ornithology
Dunbar Coast	SSSI	NT 661 793	Geology, coastal habitats, flora, ornithology
John Muir Country Park	CP	NT 640 800	Recreation

Human influences

Sewage discharge

This area may be affected by sewage or other pollutants discharged further upriver in the Firth of Forth. Leven Valley and Kirkcaldy outfalls discharge sewage after preliminary treatment, Dunfermline, Edinburgh and Wallyford works discharge sewage after primary treatment and Alloa and Stirling works discharge sewage after secondary treatment. Sewage sludge from the Edinburgh area is dumped at sea outside this area in the Firth of Forth.

There are a few outfalls within this area where partially treated or untreated sewage is discharged into the sea. One of the most noticeable is the outfall that discharges into the Biel Water in Belhaven Bay near Dunbar (Forth River Purification Board 1981).

Commercial fisheries

A small number of fishing boats are based in Dunbar and North Berwick. Small-scale salmon-netting occurs in the area and most rocky reefs in the area are potted for crabs and lobsters.

Recreation

Dunbar harbour is used by anglers, yachtsmen and divers particularly during the summer, and there are a few shallow dive sites accessible from the shore to the west of Dunbar harbour. There are several long stretches of unspoilt sandy beach between Gin Head and Dunbar, but these beaches are relatively quiet, even during the summer, and are used primarily by walkers and bathers.

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- Tynninghame Technical Working Party. 1976. *John Muir Country Park: descriptive management plan*. 1st ed. Haddington, East Lothian District Council.

Sites surveyed

Surveys

- 313: MNCR littoral survey of south-east Scotland, 1992 (Davies 1994).
 312: MNCR sublittoral survey of south-east Scotland, 1992 (Davies 1994).
 393: Grab sampling survey of south-east Scotland, Analytical and Environmental Services 1993 (Turner *et al.* 1993).

Littoral sites				
Survey Site	Site name	Grid reference	Latitude & longitude	Biotores present
313 26	E of Belhaven Bay, Dunbar.	NT 662 794	56°00.3'N 02°32.5'W	YG; Ver.Ver; Ent; PelB; MytFves; XR; MytFR; Cor; FK; Ldig.Ldig.Bo; Lhyp.Ft
313 32	Scoughall Rocks, North Berwick.	NT 619 837	56°02.6'N 02°36.7'W	YG; Ver.Ver; Fspi; FvesB; Fser.Fser.Bo; G; Ldig.Ldig
313 33	W Peffer Sands, North Berwick.	NT 622 828	56°02.2'N 02°36.4'W	AP.P
313 34	Great Car, North Berwick.	NT 610 849	56°03.3'N 02°37.5'W	Pra; Pel; Fspi; MytB; FvesB; Fser.R; EntPor; Him; BLlit; FK; SR; Ldig.Ldig
313 39	N of St Baldred's Cradle, Dunbar.	NT 637 815	56°01.5'N 02°34.9'W	Ver.B; MytB; Fser.R; FK; Ldig.Ldig
313 40	E of St Baldred's Cradle, Dunbar.	NT 638 812	56°01.3'N 02°34.8'W	Fspi; Fves; G; Cor; Ldig.Ldig
313 45	Gin Head, nr. North Berwick.	NT 595 853	56°03.5'N 02°39.0'W	Ver.B; Pel; Fspi; FvesB; Fser.R; Cor; FK; Ala.Ldig

Sublittoral sites

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>
312 16	N of Lady Ground, Dunbar.	NT 656 825	56°02.0'N 02°33.0'W	Oph
312 24	Lady Ground NW of Dunbar.	NT 657 812	56°01.3'N 02°33.0'W	AlcByH.Hia; FaAIC
312 41	Scoughall Rocks, North Berwick.	NT 631 829	56°02.2'N 02°35.5'W	EcorEns
312 42	NE of Satan Bush, North Berwick.	NT 645 852	56°03.5'N 02°34.2'W	Flu.Flu; CGS
312 44	W of Dunbar Harbour.	NT 666 795	56°00.4'N 02°32.1'W	LhypGz.Ft; XKScrR; EcorEns
312 45	N of the Gegan, North Berwick.	NT 608 865	56°04.2'N 02°37.7'W	Oph
312 46	Scoughall Rocks, North Berwick.	NT 621 837	56°02.7'N 02°36.5'W	XKScrR
312 47	NE tip of Great Car, North Berwick.	NT 610 850	56°03.4'N 02°37.5'W	Lhyp.Ft; XKScrR; AlcByH; IGS
312 48	Belhaven Bay, Dunbar.	NT 656 801	56°00.8'N 02°33.0'W	Lcon; FabMag
393 2	NE of Great Car, North Berwick.	NT 639 877	56°04.8'N 02°34.7'W	AfilEcor
393 3	N of Dunbar Harbour.	NT 677 856	56°03.7'N 02°31.1'W	AfilEcor

Compiled by:

Jon Davies & Rohan Holt

3

Tynningame Bay

Location

<i>Position (centre)</i>	NT 640 793
<i>Administrative area</i>	East Lothian
<i>Conservation agency/area</i>	Scottish Natural Heritage Lothian and Borders

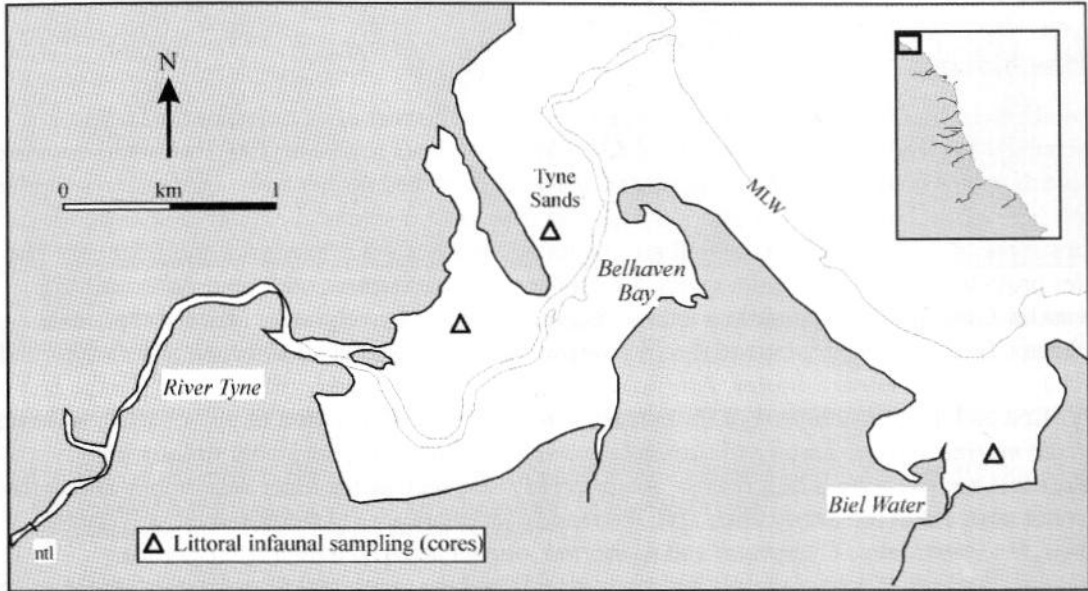


Figure 3.1 Location of area showing sites surveyed and main bathymetric features.

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Marine biological surveys

	<i>Survey methods</i>	<i>No. of sites</i>	<i>Date of survey</i>	<i>Source</i>
<i>Littoral</i>	Infaunal cores and granulometry	3	July 1992	Brazier & Murray (1994)

Introduction

Tynningame Bay, also known as Belhaven Bay, includes the sedimentary delta of the River Tyne and that of Biel Water in the smaller bay to the east; the two embayments are separated by an area of sand dunes. The lower shores of the Bay are exposed to wave action from the north-east, but the extensive sandflats present dissipate the wave energy; as a consequence the innermost parts of the Bay are much more sheltered. This site is separated from area 2, Gin Head to Dunbar by the rocky outcrops to the north and south of the Bay.

Physical features

<i>Physiographic type</i>	Embayment with sediment delta
<i>Length of coast</i>	9.5 km
<i>Area of inlet</i>	507 ha
<i>Length of tidal channel</i>	5.9 km
<i>Bathymetry</i>	Intertidal with shallow streams
<i>Wave exposure range</i>	Moderately exposed to very sheltered
<i>Tidal stream range</i>	Weak to negligible
<i>Tidal range</i>	3.9 m (springs), 1.6 m (neaps)
<i>Salinity range</i>	Fully marine to variable

Marine biology

The moderately exposed shores in the outer parts of the bay consist of clean, medium-fine sand characterised by the polychaetes *Paraonis fulgens* and *Scolecopsis squamata* (AP.P). Muddy sands on the eastern shores of Belhaven Bay and immediately south of, and sheltered by, St Baldred's Cradle, support beds of mussels *Mytilus edulis* (MytX). On the seaward side of the Sandy Hirst spit on the western shore of Belhaven Bay is a level area of stable, poorly sorted muddy sand and gravel. The pebbles provide substrata for bladder wrack *Fucus vesiculosus* to grow, with abundant common periwinkles *Littorina littorea*, and the sediment is characterised by eelgrasses *Zostera* spp., the polychaetes *Hediste diversicolor* and *Apelochaeta marioni*, the amphipod *Corophium volutator* and the oligochaetes *Heterochaeta costatus*, *Tubificoides benedii* and *T. pseudogaster* (Znol). To the east of Sandy Hirst and in the south-west of the estuary, a more diverse population of polychaetes, including *Arenicola marina*, *Eteone longa* and *Capitella capitata*, is found in more stable slightly muddy sandflats that are swept by tidal streams. At sheltered sites, such as the inner eastern bay and in the backwater adjacent to the Sandy Hirst spit, the muddy sandflats are characterised by polychaetes *E. longa*, *H. diversicolor*, *C. capitata* and *A. marina*, oligochaetes *Heterochaeta costatus*, *Tubificoides benedii*, *T. pseudogaster* and enchytraeids and the amphipod *C. volutator* (HedMac.Are; MacAre), reflecting the increased shelter and freshwater influence of the inner estuary.

Nature conservation**Conservation sites**

<i>Site name</i>	<i>Designation</i>	<i>Centre grid ref.</i>	<i>Main features</i>
Tynninghame Shore	SSSI	NT 640 800	Coastal habitats, flora, ornithology
John Muir Country Park	CP	NT 640 800	Recreation

Human influences**Coastal developments and uses**

The upper estuary of the Tyne is bordered by reclaimed land behind an embankment to the south and west and by a saltmarsh to the north (Davidson *et al.* 1991). The whole of this area has open access through the John Muir Country Park. Part of the beach on the north side of the bay is popular with day trippers and a small amount of bait-digging occurs on the south side of the bay.

A sewage outfall discharges into the Biel Water, which flows into Belhaven Bay.

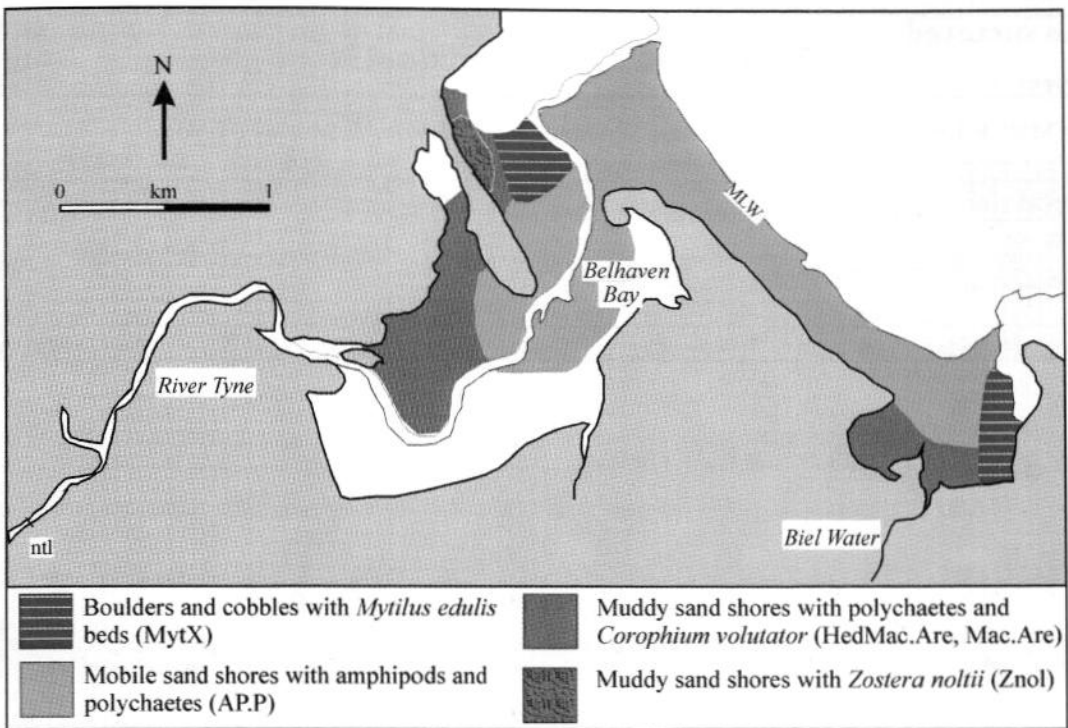


Figure 3.2 Indicative distribution of the biotopes within the area (based on data from survey sites shown in Figure 3.1 and additional field observation).

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Sites surveyed

Surveys

313: MNCR littoral survey of south-east Scotland, 1992 (Brazier & Murray 1994).

Littoral sites				
Survey Site	Site name	Grid reference	Latitude & longitude	Biotopes present
313 27	Belhaven Bay Sands.	NT 661 789	56°00.1'N 02°32.6'W	HedMac.Are; MytX; AP.P
313 35	Tyne Sands, Belhaven Bay.	NT 638 802	56°00.8'N 02°34.8'W	ZnoI; MytX; AP.P
313 36	Upper Tyne Estuary, Belhaven Bay.	NT 634 792	56°00.2'N 02°35.2'W	MacAre; HedMac.Are

4

Dunbar to Fast Castle Head

Location

<i>Position (centre/limits)</i>	NT 760 735	NT 669 795 - NT 860 710
<i>Administrative area</i>	East Lothian	
<i>Conservation agency/area</i>	Scottish Natural Heritage	Lothian and Borders

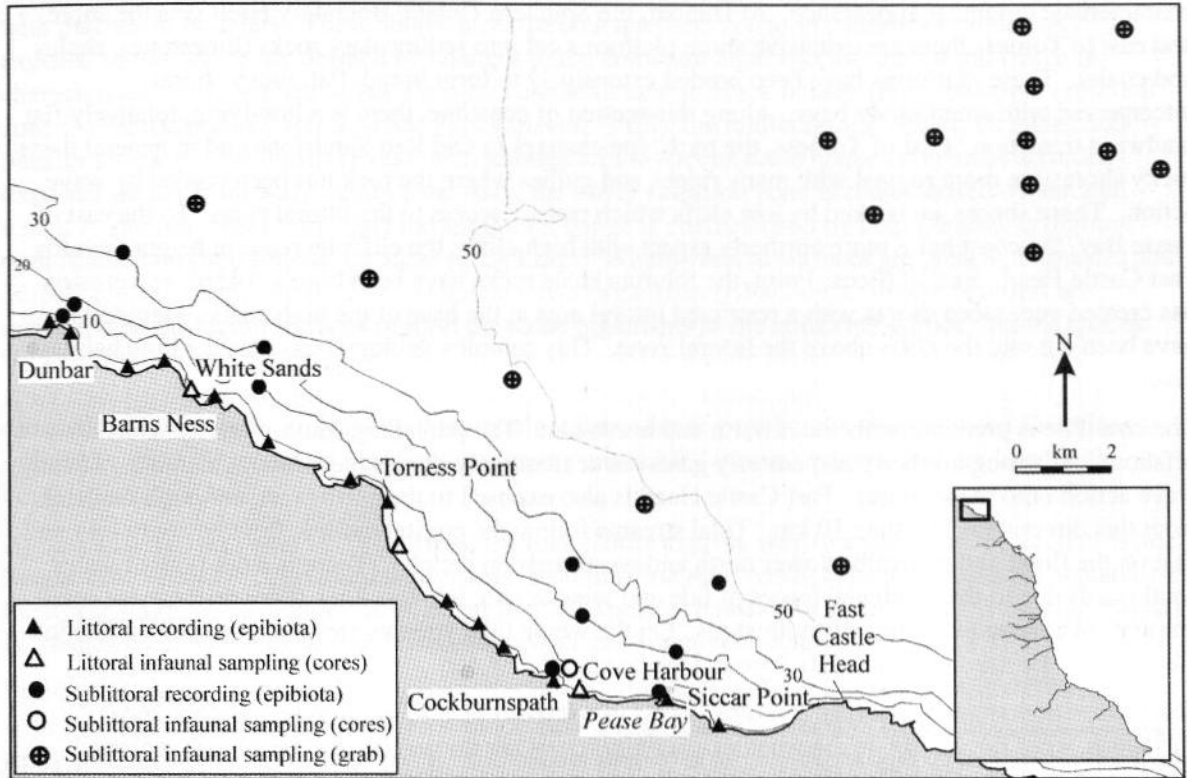


Figure 4.1 Location of area showing sites surveyed and main bathymetric features.

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Marine biological surveys

	<i>Survey methods</i>	<i>No. of sites</i>	<i>Date of survey</i>	<i>Source</i>
<i>Littoral</i>	Recording	14	June-July 1992	Davies (1994)
	Infaunal cores and granulometry	3	June-July 1992	Davies (1994)
<i>Sublittoral</i>	Recording	11	June-August 1992	Davies (1994)
	Infaunal cores and granulometry	4	June-August 1992	Davies (1994)
	Infaunal grab samples (0.1 m ² Day grab) and granulometry	16	February 1993	Turner <i>et al.</i> (1993)

Introduction

Dunbar to Fast Castle Head is a predominantly rocky coastline with occasional small sandy bays. It has a north-easterly aspect and is, for the most part, moderately exposed to wave action. With Dunbar the only urban area, the shore is predominantly rural with the only coastal developments being a nuclear power station at Torness, a cement works to the east of Dunbar and a caravan park at Pease Bay.

The coastal geology from Dunbar to Torness is complex and is reflected in the structure of the shores and their landward transition. A basalt outcrop at Dunbar Harbour results in steep shores which have a characteristic columnar appearance. At Dunbar, the Southern Upland Boundary Fault cuts the shore, and east to Torness there are extensive shore platforms cut into sedimentary rocks (limestones, shales and coals). These platforms have been eroded extensively to form broad, flat, rocky shores interspersed with small sandy bays. Along this section of coastline, there is a low-lying, relatively flat landward transition. East of Torness, the rock type changes to Old Red Sandstone and in general these rocky shores are more rugged with many ridges and gullies where the rock has been eroded by wave action. These shores are backed by low cliffs which restrict access to the littoral zone. To the east of Pease Bay, the coast has a more northerly aspect with high cliffs; the cliffs increase in height towards Fast Castle Head. East of Siccar Point, the Silurian shale rocks have been highly folded, and erosion has created very steep shores with a restricted littoral area at the base of the high cliffs. Many caves have been cut into the cliffs above the littoral zone. This complex geology has created a high habitat diversity on the shores in the area.

The coastline is predominantly faces north and north-east. The prevailing south-westerly wind is offshore, but strong northerly and easterly gales occur frequently during the winter which brings heavy wave action onto these shores. Fast Castle Head is also exposed to the north-west, although the fetch from this direction is less than 10 km. Tidal streams follow the coastal outline, flowing south-east and east on the flood and generally slower north and westwards on the ebb. There is a net flow of water southwards due to the combined forces of tide and wind action, and this long-shore drift carries small amounts of suspended sediment southwards. On the whole tidal streams are weak, but at Fast Castle Head tidal flow rates are accelerated around the headland.

Sea surface temperatures vary from around 5.5°C in winter to 12.5°C in summer, although local variations occur depending on the weather. Salinity levels are normal for the open coast at around 34.5‰ although the River Tyne can reduce salinity levels close to Dunbar. The water in this area is relatively clear compared to other locations in the south of Sector 5. During surveys in 1992 underwater visibility was around 10 m, although close to shore it was occasionally much less.

Physical features

<i>Physiographic type</i>	Open coast
<i>Length of coast</i>	22 km
<i>Bathymetry</i>	30 m isobath within 1 km of Fast Castle Head, 50 m isobath within 1.5 km
<i>Wave exposure range</i>	Moderately exposed
<i>Tidal stream range</i>	Moderately strong to negligible
<i>Tidal range</i>	4.5 m (springs), 2.2 m (neaps)
<i>Salinity range</i>	Fully marine

Marine biology

Littoral

At Dunbar harbour, the basalt columns create very steep and vertical habitats in the littoral fringe and eulittoral zone, but the sedimentary rocks underneath have eroded to form a platform and outlying rock outcrops in the sublittoral fringe. Littoral fringe and upper eulittoral zones are characterised by black lichens and scattered barnacles and limpets (Ver.B). Small pits and crevices provide shelter for dense populations of the periwinkles *Littorina neglecta* and *L. saxatilis*. Mid eulittoral zones are

characterised by dense populations of barnacles and limpets with occasional clumps of the red algae *Ceramium* sp., *Callithamnion* sp. and *Mastocarpus stellatus* (MytB). Vertical, low eulittoral basalt has a rich turf of red and brown algae with encrusting coralline algae, sponges and encrusting bryozoans on rock surfaces beneath the turf (SR). Epifaunal species are more abundant under overhangs at the base of the basalt columns. A dense forest of kelp *Laminaria digitata* covers the rock platform in the sublittoral fringe (Ldig.Ldig). A mosaic of a turf of red algae, predominantly *M. stellatus* and *Osmundea pinnatifida*, and limpets and barnacles cover the tops of the rock outcrops seaward of the basalt (XR).

From Dunbar eastwards for approximately 3 km, the shores are broad, flat rock platforms overlain with patches of boulders. These shores have the characteristic zonation patterns of moderately exposed shores which are defined by changes in the dominant algal species: the littoral fringe is characterised by channelled wrack *Pelvetia canaliculata* with black lichens (Pel); the upper eulittoral zone is characterised by spiral wrack *Fucus spiralis* (Fspi); the mid-eulittoral zone is characterised by bladder wrack *F. vesiculosus* (Fves), with knotted wrack *Ascophyllum nodosum* in areas afforded localised shelter from wave action (Asc.Asc); the lower eulittoral zone is characterised by serrated wrack *F. serratus* (Fser.Fser); and the sublittoral fringe is characterised by kelp *Laminaria digitata* with filamentous and foliose red algae (Ldig.Ldig). Where vertical surfaces are present, barnacles and limpets replace furoid algae as the dominant cover organisms (BPat.Sem). Where boulders are present, upward-facing surfaces support the same organisms as the adjacent bedrock, but the spaces between the stones provide a permanently damp refuge for a wide variety of other organisms (Fser.Fser.Bo). Due to the horizontal nature of these shores, numerous shallow pools of varying dimensions are present. In general, these pools support dense populations of coral weed *Corallina officinalis*, green filamentous algae and common periwinkle *Littorina littorea*, and are lined with coralline crusts (Cor).

Approximately 1 km west of Barns Ness, the rock platform gives way to a small sandy beach at White Sands. The sediment is predominantly clean, medium-fine sand which appears mobile, particularly on the lower shore. This mobility is reflected in a low species richness for the infaunal assemblage which is characterised by the lugworm *Arenicola marina* and amphipods *Bathyporeia* spp. (AP.P).

From White Sands south-east to Torness, the rock platforms have been heavily eroded and overlain with boulders to create complex shores which have a high habitat diversity. Community structure on stony shores (including boulder, cobble and pebble shores) is largely dependent on the stability of the stones. Where stones are regularly disturbed, species assemblages are characterised by ephemeral species and mobile animals. Where stones are stable, species assemblages are similar to those recorded on bedrock, although species richness is often higher in stony habitats due to the increased microhabitat diversity between and under the stones. In general, stability is dependent on the size of the stones and the prevailing wave exposure: increased size and lower wave exposure result in higher stability. East of White Sands, the shore comprises a mixture of broken bedrock and stable boulders which have a dense cover of algae. A number of large pools are present although some are filled with sand which appears to reduce species richness. At Barns Ness the shore is an extremely complex mixture of boulders, cobbles, pebbles and broken bedrock outcrops. Upper shore habitats comprise unstable small cobbles and pebbles with a sparse covering of algae. Small crustaceans, mainly gammarid amphipods, are common under the stones. Mid-shore habitats are a mixture of bedrock ridges characterised by barnacles and limpets and large stable boulders with furoid algae. Extensive areas of shallow (<15 cm) standing water are present, which results in many species characteristic of the lower shore occurring within the mid-shore zone. Lower shore habitats are a similar mixture of bedrock and boulders although both habitats are characterised by furoid algae, with kelp *Laminaria digitata* in the sublittoral fringe. These lower shore habitats have a rich assemblage of filamentous and foliose algae growing on the kelp stipes and on adjacent rock surfaces. To the south-east of Barns Ness, the shore has a similar character although the upper shore habitats are less stable and characterised by sparse clumps of furoid algae and the ephemeral red alga *Porphyra* sp. (EntPor). Upper and mid eulittoral boulders are characterised by barnacles and limpets with furoid algae dominating the remainder of the shore. Large rockpools occur on the lower shore.

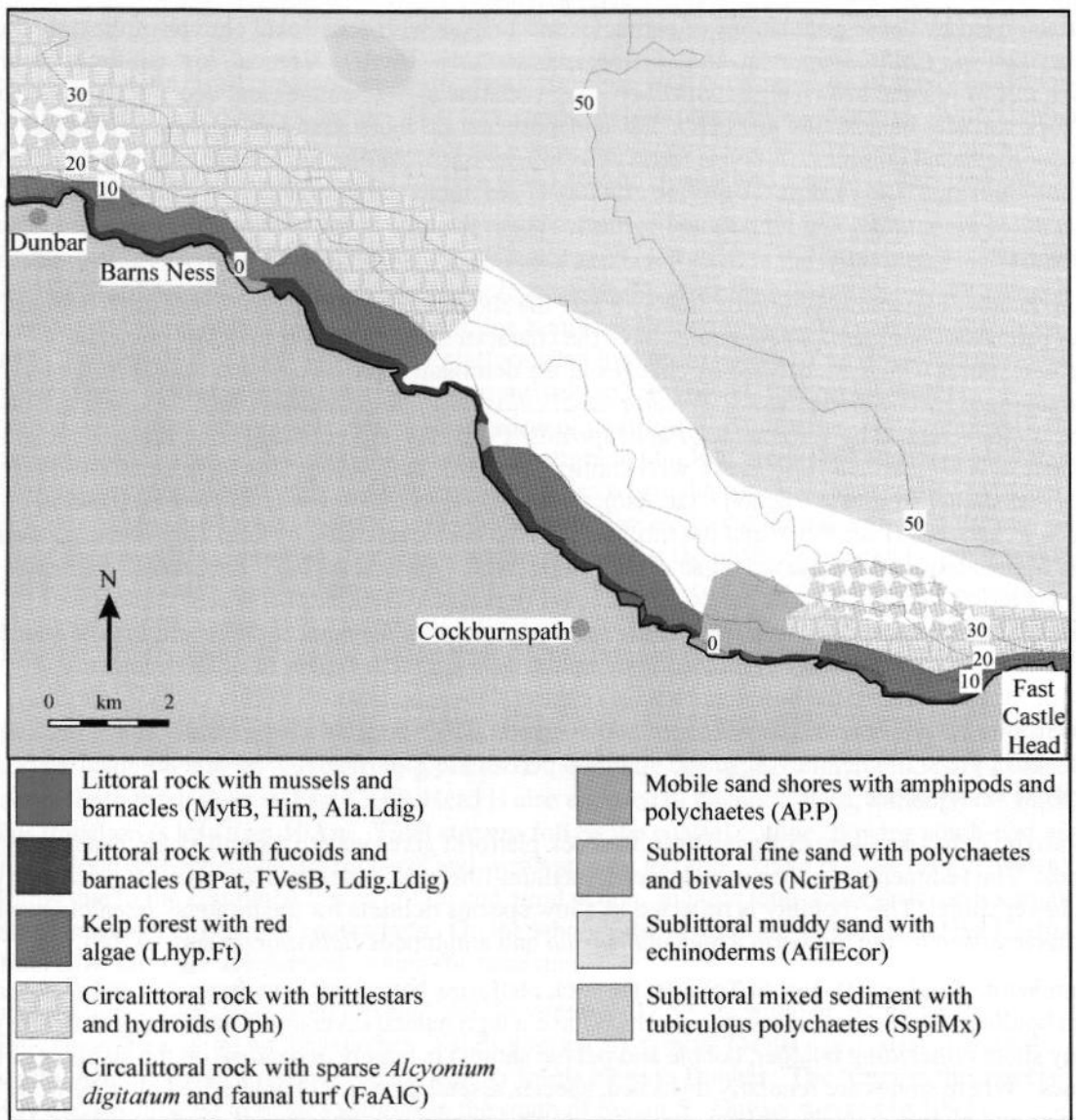


Figure 4.2 Indicative distribution of the biotopes within the area (based on data from survey sites shown in Figure 4.1 and additional field observations).

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At Torness, extensive bedrock platforms either side of the nuclear power station display a characteristic zonation pattern as described above, namely clear zones dominated by different fucoid alga. A sandy beach with boulder outcrops extends approximately 1 km south-east from Torness. Sediment habitats are medium-fine sand characterised by polychaetes and amphipods. Infaunal samples contain the polychaetes *Paraonis fulgens*, *Scolecopsis squamata* and *Arenicola marina*, and the amphipods *Bathyporeia pelagica*, *Urothoe elegans* and *Pontocrates arenarius* (AP.P). Boulder outcrops are subject to sand scour and the communities recorded are characterised by ephemeral species. Upper shore boulders are characterised by the red alga *Porphyra purpurea* and the green alga *Enteromorpha* sp. (EntPor); mid-shore boulders are characterised by sea lettuce *Ulva* sp. and mats of the sand-binding filamentous red alga *Audouinella* sp. Lower shore boulders appear more stable and less scoured, and typical lower eulittoral/sublittoral fringe assemblages characterised by brown algae are present (Fser.Fser.Bo).

South-eastwards towards Pease Bay, the shores comprise broad, flat sandstone platforms with occasional patches of boulders and cobbles. Littoral communities are similar to those recorded on the bedrock platforms to the west. At West Gutchers Hole and Cove Harbour, small freshwater streams drain onto the upper shore and the communities present reflect the lower salinity. Rock surfaces have a dense covering of *Enteromorpha* sp. and occasional clumps of the wrack *Fucus ceranoides*, a species characteristic of lower salinity habitats. At West Gutchers Hole, the sandstone on the lower shore has been heavily eroded to form a complex series of gullies, pools and rockmills. During periods of heavy wave action, surge increases the local wave exposure, resulting in the shallow sublittoral assemblage being characterised by a dense kelp forest of *Laminaria hyperborea* rather than *L. digitata*. East of Cove Harbour, the sandstone has been eroded to form a series of ridges and boulder-filled gullies. Upward-facing surfaces are characterised by dense furoid algal assemblages and very steep and vertical faces of the ridges support limpet/barnacle assemblages.

Pease Bay is a small sandy bay bounded by rocky shores to the east and west. Most of the beach comprises clean, medium-fine sand. A small stream crosses the beach and the adjacent lower shore sediment contains a low density of lugworm *Arenicola marina* casts. Infaunal sampling reveals populations of the polychaete *Capitella capitata* and enchytraeid oligochaetes, both taxa characteristic of organically-enriched habitats. It is likely that the stream is subject to some organic enrichment, possibly as a result of the proximity of a caravan park at the head of the beach. Infaunal communities on the lower shore of the remainder of the beach are characterised by polychaetes and amphipods (AP.P). To the east of the beach there is an extensive rock platform eroded to form a series of ridges which have small boulders and cobbles in the troughs. A typical zonation pattern is recorded with the shore dominated by furoid algae, with limpets and barnacles on the more exposed tops of ridges. Large immobile boulders are present on the lower shore.

From Pease Bay east to Fast Castle Head, the littoral zone comprises bedrock platforms backed by high cliffs. Access to the shore is extremely difficult and restricted to boat access for most of the coastline. East of Siccar Point, a rock platform approximately 50 m wide is characterised by furoid algae. Upper shore habitats have sparse algal cover possibly due to the easily-eroded nature of the soft rock. Upper shore pools are characterised by coralline algae and are fringed with the encrusting brown alga *Ralfsia* sp. Lower eulittoral habitats retain a dense turf of red algae with the kelps *Alaria esculenta* and *Laminaria hyperborea* present within the sublittoral fringe (Ala.Ldig); both the turf and these kelp species indicate increased wave exposure. Further east, Hirst Rocks is a series of irregular igneous rock outcrops divided by gullies containing stones with shingle on the upper shore; both the stones and the shingle appear to be mobile under the influence of wave action. Stable rock surfaces in the mid-shore are dominated by limpets and barnacles with furoid algae dominating the lower shore and sublittoral fringe. The mobile stones have a sparse species assemblage characterised by the ephemeral green algae *Ulothrix flacca* and *Enteromorpha* spp.

In summary, the coastline between Dunbar and Fast Castle Head is a complex mixture of bedrock and boulder shores interspersed with sandy bays. Littoral communities on the rocky shores are representative of moderately exposed conditions, characterised by furoid algae. Habitats subject to localised increases in wave exposure are characterised by sessile animals in the mid-shore, a red algal turf on the lower shore, and a change in the dominant kelp species in the sublittoral fringe. Species assemblages on boulder shores vary with boulder stability but, in general, boulder habitats have a higher species richness than adjacent rock habitats, owing to increased microhabitat diversity created by the interstices between the stones.

Sublittoral

Between Dunbar and Fast Castle Head, habitats slope gently from the sublittoral fringe to offshore areas. There is no deep water close inshore along the western part of this area, but along the cliffed coast at Fast Castle Head the 50 m isobath is approximately 1.5 km offshore. In general, the nearshore sublittoral habitats form a continuation of the adjacent littoral habitats, i.e. the rock platforms continue into the shallow sublittoral and the sandy bays continue as sediment plains into the sublittoral zone.

Off Dunbar Harbour, there is a series of small rock outcrops approximately 500 m offshore where infralittoral bedrock habitats are characterised by a dense forest of kelp *Laminaria hyperborea* (Lhyp.Ft). Rock surfaces under the algal canopy have a covering of silt that reduces the species richness of the understory assemblage, which is characterised by a sparse turf of small red algae including *Lomentaria orcadensis* and *Phyllophora crispa*, and erect bryozoans, mainly *Scrupocellaria* sp. and *Crisia* sp. Within the kelp forest there are short vertical steps which are devoid of the main cover algae where the rock surfaces are dominated by dense populations of the tubeworm *Pomatoceros triqueter*. Throughout the kelp forest, the lower kelp stipes and adjacent rock surfaces are grazed by the urchin *Echinus esculentus*; this grazing may explain the low species diversity of the algal turf. Approximately 2 km offshore at a depth of 18 m, the sea bed comprises a plain of medium and small boulders with bedrock outcrops which have small cobbles and pebbles between the larger rocks. These stones are embedded in coarse sediment. Rock surfaces have a covering of fine silt but nevertheless are heavily encrusted with tubeworms *P. triqueter* and red and brown algal crusts (Oph). Echinoderms are the dominant taxa with many urchins and starfish on open rock surfaces and brittlestars are abundant within the interstices between the stones. Large isolated colonies of dead-man's fingers *Alcyonium digitatum* and erect hydroids (mainly *Abietinaria abietina*) are present on the tops of the largest boulders and bedrock outcrops. Overall species richness is high although most species are recorded in low abundance. At 3 km offshore, at a depth of 35 m, the sea bed comprises a gravelly sediment plain formed into waves and ripples, with occasional boulders and cobbles. Hard substrata support a variety of large anemones including *Urticina eques* and *Metridium senile* (FaAIC). Sediment epibenthic assemblages are characterised by brittlestars and starfish with occasional pelican's foot shells *Aporrhais pespelecani* (AfilEcor).

A similar structure to the littoral zone is present off Barns Ness where a gentle slope of mixed boulders, cobbles and pebbles embedded in coarse sediment occurs offshore for approximately 3 km to a depth of 28 m. Rock surfaces are encrusted with tubeworms *Pomatoceros triqueter* and encrusting red and brown algae; epibenthic assemblages are dominated by echinoderms, mainly the brittlestar *Ophiothrix fragilis*. Occasionally the boulders are limestone and extensively bored by piddocks and the boreholes provide a refuge for the brittlestars *Ophiopholis aculeata* and *Ophiactis balli*. Small scallops *Chlamys varia* and *C. distorta* are occasionally present on the undersurfaces of the stones. The overall species richness is high although most species are recorded in low abundance.

At Cove Harbour, a dense kelp forest is present on Little Hurker, a rock outcrop approximately 500 m offshore. The rock has eroded to form a series of steep-sided gullies which are overhanging in places. Horizontal surfaces support a dense kelp *Laminaria hyperborea* forest with a sparse red and brown algal turf on the stipes and the adjacent rock surfaces. Between the erect algae, encrusting red and brown algae cover all available rock surfaces. Vertical and overhanging surfaces are dominated by sessile animals, principally tubeworms with encrusting sponges, encrusting bryozoans, solitary and colonial ascidians. At approximately 1.5 km offshore the sea bed comprises a mixture of soft sedimentary bedrock, boulders covered with silt, and large patches of muddy sand. Species assemblages of hard substrata are similar to those described above (Oph), with the soft bedrock extensively bored by piddocks. Few epibenthic species are recorded on the sediment, while the infaunal assemblage is characterised by razor shells *Ensis* sp. and heart urchins *Echinocardium cordatum*. Mixed stones on sediment are also recorded 5 km offshore at a depth of 30 m, where the numbers of epibenthic species are dominated by large numbers of the brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra*. A diverse assemblage of anemones is present which including the less common *Bolocera tuediae* (a large northern species) and *Stomphia coccinea*.

In Pease Bay, the sand on the shore extends into the nearshore sublittoral zone as a plain of rippled, well-sorted sand (NcirBat). Very few epibenthic organisms are obvious, such as a few small shrimp and some sand-eels *Ammodytes* sp. To the east, approximately 200 m off Siccar Point, a plain of medium fine sand is present at a depth of 14 m which supports a rich infaunal community characterised by dense populations of razor shells *Ensis* spp. and heart urchins *Echinocardium cordatum*. Large numbers of the masked crab *Corystes cassivelaunus* are present on the surface of the sediment. Landward of the sediment plain is a rugged bedrock outcrop which has a fine covering of silt with a patchy epifaunal assemblage characterised by erect hydroids and dead-man's fingers

Alcyonium digitatum (FaAIC); large areas of barren uncolonised rock are also present. Approximately 1.5 km offshore to the north-east at a depth of 22 m, there is a level plain of mixed boulders, cobbles and pebbles lying on muddy sediment. Epibenthic communities are similar to equivalent habitats further west (see above), characterised by tubeworms *Pomatoceros triqueter* and brittlestars (Oph). Approximately 4 km offshore at a depth of 41 m, a level sea bed of muddy gravel with boulders subject to moderately strong tidal streams is present. Species assemblages are characterised by large colonies of dead-man's fingers *A. digitatum* and the large anemones *Urticina eques* and *Bolocera tuediae* (FaAIC). Few other species were recorded on or within the sediment although the depth restricted the time available for the diving survey.

In summary, sublittoral habitats along the coastline from Dunbar to Fast Castle Head are relatively uniform. Nearshore infralittoral habitats are characterised by dense forests of kelp *Laminaria hyperborea* with a sparse red algal turf underneath the canopy; algal communities appear to be heavily grazed, probably by the urchin *Echinus esculentus*. Lower infralittoral and circalittoral habitats comprise mixed stones and bedrock outcrops on silty coarse sand or gravel. Species assemblages are characterised by tubeworms and echinoderms, mainly brittlestars. Occasional plains of clean sand are present, primarily as a continuation of sediment shores. Thus habitat diversity is low throughout the area, although the mixed nature of the substrata results in a high species richness but low species abundance.

Nature conservation

Conservation sites

Site name	Designation	Centre grid ref.	Main features
Dunbar Coast	SSSI	NT 661 793	Geology, coastal habitats, flora, ornithology
Barns Ness Coast	SSSI	NT 696 781	Coastal habitats, flora, geology
Pease Bay Coast	SSSI	NT 781 718	Geology, coastal habitats and flora
Siccar Point	SSSI	NT 811 709	Geology
St Abb's Head to Fast Castle	SSSI	NT 880 699	Ornithology, coastal habitats and flora
Berwickshire Marine Consultation Area	MCA	NT 915 705	Marine biology

Human influences

Sewage discharge

This area has a small population and therefore little sewage is discharged directly into the sea. The caravan site at Pease Bay has its own treatment plant on site, although the polychaete *Capitella* sp., known indicators of organic enrichment, are known to occur here in relatively high concentrations in comparison to other small sandy beaches in the area. There are also small sewage discharges at Cove (untreated) and Cockburnspath (sedimentation tank treatment).

Industrial effluent discharge

Torness nuclear power station discharges warm water effluent at a temperature just above that of normal sea water.

Mineral extraction

There is a quarry and cement works to the east of Dunbar. Effluent is pumped out of the quarry via a local outfall.

Commercial fishery

The harbour at Dunbar retains a small inshore fishing fleet. Most of the local inshore fishing boats that use this area are based in the Firth of Forth and shellfish pots are set on virtually all the rocky reefs along this stretch of coast. In 1992 local fishermen blamed the unusually low catches of lobsters and

crabs on "swarms" of octopus *Eledone cirrhosa* eating the catch in the pots. However, there was no evidence of higher than normal numbers of octopus from the survey data.

Recreation

Dunbar is the nearest centre of tourism in the area. Caravan sites in the area are busy during the summer; access to the sandy beaches is easy throughout most of the area and many attract large numbers of visitors during the summer months. There are harbours at Dunbar and Cove, which are used by leisure craft particularly during the summer months.

References and further reading

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Sites surveyed

Surveys

- 313: MNCR littoral survey of south-east Scotland, 1992 (Davies 1994).
- 312: MNCR sublittoral survey of south-east Scotland, 1992 (Davies 1994).
- 375: SOAFD sublittoral survey of St. Abbs and Bell Rock sewage sludge dumping sites, 1991 (Hull & Webster 1991).
- 393: Grab sample survey of south-east Scotland, Analytical and Environmental Services, 1993 (Turner *et al.* 1993).

Littoral sites

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>
313 7	Barns Ness, Torness.	NT 720 775	55°59.3'N 02°26.9'W	Pel; Fspi; BPat.Sem; AscX; FvesX; Osm; Fser.Fser; Ldig.Ldig
313 8	W of Gutchers Hole, Cockburnspath.	NT 774 726	55°56.7'N 02°21.7'W	Fspi; MytB; Fves; Fcer; Ent; Him; Ldig.Ldig
313 9	E of Lagoon Pool, Dunglass, Torness.	NT 772 727	55°56.8'N 02°21.9'W	Fspi; Fves; Fser.R; LhypR.Ft
313 10	Cove Harbour, Cockburnspath.	NT 787 718	55°56.3'N 02°20.4'W	Ent; Fspi; BPat.Sem; Fcer; Ldig.Ldig
313 22	Pease Bay Shore, Cockburnspath.	NT 797 710	55°55.9'N 02°19.4'W	YG; Pel; Fspi; BPat.Sem; Fves; Him; Fser.R; Cor; Ldig.Ldig; Lhyp.Ft; AP.P
313 23	S of Torness Power Station.	NT 754 745	55°57.7'N 02°23.6'W	EntPor; Rho; Fser.R; Ldig.Ldig.Bo; AP.P
313 25	E of Siccar Point, Cockburnspath.	NT 817 708	55°55.8'N 02°17.5'W	Pel; Fspi; FvesB; Him; Cor; Ala.Ldig
313 28	White Sands, Torness.	NT 715 775	55°59.3'N 02°27.4'W	Fves; Fser.Fser; FK; Ldig.Ldig; AP.P
313 29	Mill Stone Neuk, Dunbar.	NT 707 783	55°59.8'N 02°28.1'W	Pel; Fspi; FvesB; Asc.Asc; Fser.Fser.Bo
313 30	Broadhaven, Dunbar.	NT 682 795	56°00.4'N 02°30.6'W	Ver.B; MytB; XR; Mas; Cor; SR; Lhyp.Ft
313 31	Dunbar Golf Course.	NT 690 785	55°59.9'N 02°29.8'W	Fspi; BPat.Sem; Fves; Fser.R; Mas; Cor; Ldig.Ldig
313 37	Chapel Point, Torness.	NT 742 758	55°58.4'N 02°24.8'W	Ver.B; Fspi; BPat.Sem; FvesB; Fser.R; Cor; Ldig.Ldig
313 38	S of Barns Ness, Torness.	NT 732 762	55°58.6'N 02°25.7'W	Fspi; FvesB; Fser.Fser.Bo; FK; Ldig.Ldig
313 47	Hirst Rocks, Cockburnspath.	NT 828 704	55°55.5'N 02°16.5'W	BPat.Sem; Fser.R; Osm; Cor

Sublittoral sites

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>
312 7	NNE of Siccar Point, Cockburnspath.	NT 829 735	55°57.2'N 02°16.3'W	FaAIC
312 8	NE of Cargill Rock, Cockburnspath.	NT 816 719	55°56.4'N 02°17.6'W	Oph
312 9	Siccar Point, Cockburnspath.	NT 810 713	55°56.0'N 02°18.1'W	FaAIC; EcorEns
312 10	NNE of Cove Harbour, Cockburnspath.	NT 795 737	55°57.4'N 02°19.6'W	Oph
312 11	Offshore from Cove Harbour, Cockburnspath.	NT 793 726	55°56.8'N 02°19.8'W	Flu.Flu; Oph; EcorEns
312 12	Little Hurker, Cockburnspath.	NT 789 718	55°56.3'N 02°20.2'W	Lhyp.Ft
312 13	Pease Bay, Cockburnspath.	NT 793 713	55°56.0'N 02°19.8'W	NcirBat
312 14	NE of Dunbar.	NT 697 815	56°01.5'N 02°29.1'W	FaAIC; IGS
312 15	N of Barns Ness, Torness.	NT 730 789	56°00.1'N 02°25.9'W	Oph
312 23	NE of Ruddystone, Torness.	NT 731 779	55°59.6'N 02°25.8'W	Oph
312 25	NE of Dunbar harbour.	NT 687 800	56°00.7'N 02°30.0'W	Oph
312 43	Meikle Spiker, Dunbar.	NT 683 796	56°00.5'N 02°30.4'W	Lhyp.Ft
375 1	St Abbs Sewage sludge dumping ground.	NT 924 906	56°06.5'N 02°07.2'W	AfilEcor
375 2	St Abbs Sewage sludge dumping ground.	NT 924 887	56°05.5'N 02°07.2'W	AfilEcor
375 3	St Abbs Sewage sludge dumping ground.	NT 881 875	56°04.8'N 02°11.3'W	AfilEcor
375 4	St Abbs Sewage sludge dumping ground.	NT 906 875	56°04.8'N 02°09.0'W	AfilEcor
375 5	St Abbs Sewage sludge dumping ground.	NT 923 875	56°04.8'N 02°07.4'W	AfilEcor
375 6	St Abbs Sewage sludge dumping ground.	NT 940 875	56°04.8'N 02°05.7'W	AfilEcor
375 7	St Abbs Sewage sludge dumping ground.	NT 961 869	56°04.5'N 02°03.6'W	AfilEcor
375 8	St Abbs Sewage sludge dumping ground.	NT 923 854	56°03.7'N 02°07.4'W	AfilEcor
375 9	St Abbs Sewage sludge dumping ground.	NT 923 838	56°02.8'N 02°07.4'W	AbrNucCor

Sublittoral sites - continued

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>
375 10	St Abbs Sewage sludge dumping ground.	NT 946 906	56°06.5'N 02°05.2'W	AfilEcor
375 11	St Abbs Sewage sludge dumping ground.	NT 893 844	56°03.1'N 02°10.3'W	AfilEcor
393 4	E of Meikle Spiker, Dunbar.	NT 708 833	56°02.5'N 02°28.0'W	AfilEcor
393 5	NNE of Barns Ness, Dunbar.	NT 744 814	56°01.5'N 02°24.6'W	SspiMx
393 6	N of Reeds Point, Cockburnspath.	NT 785 795	56°00.4'N 02°20.6'W	AfilEcor
393 7	N of Siccar Point, Cockburnspath.	NT 813 766	55°58.9'N 02°17.9'W	AfilEcor
393 8	N of Nick Cove, Cockburnspath.	NT 851 755	55°58.3'N 02°14.3'W	AfilEcor

Compiled by:

Jon Davies & Rohan Holt

Fast Castle Head to Eyemouth

Location

Position (centre)/limits	NT 915 695	NT 860 710 - NT 950 645
Administrative area	East Lothian, Borders	
Conservation agency/area	Scottish Natural Heritage	Lothian and Borders

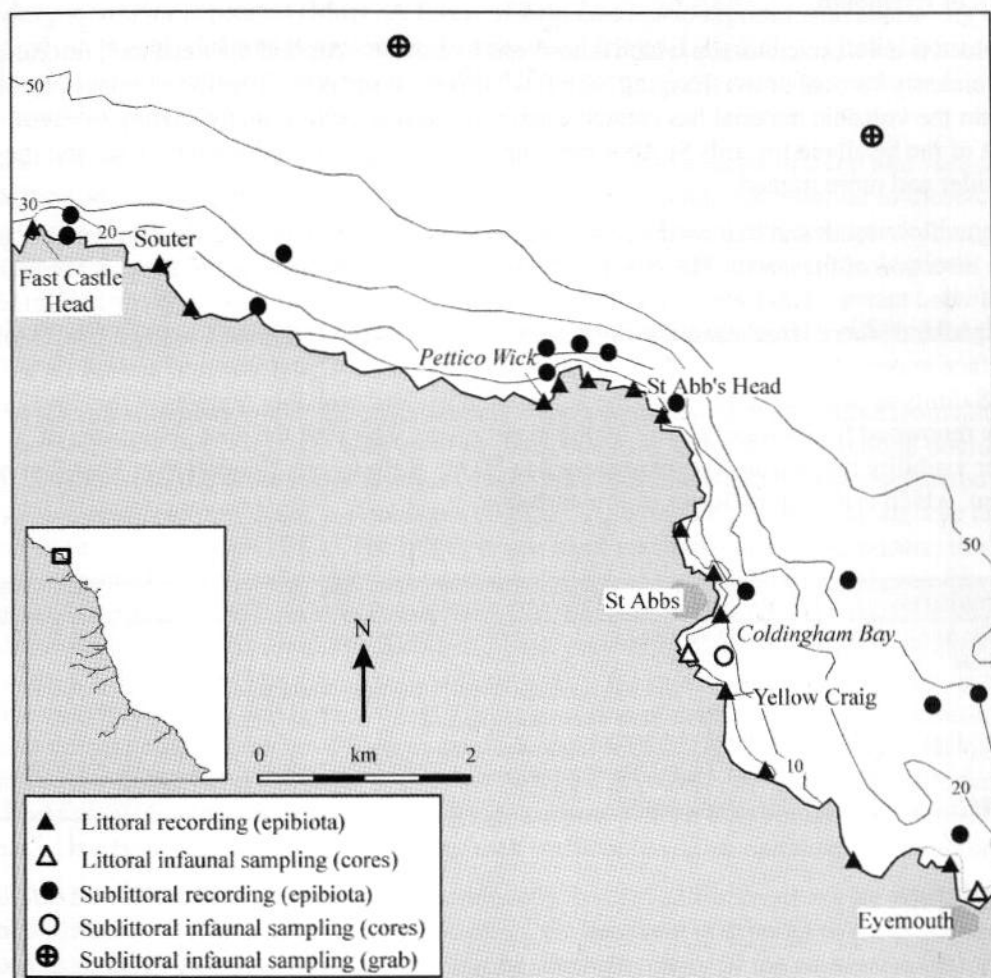


Figure 5.1 Location of area showing sites surveyed and main bathymetric features.

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Marine biological surveys

	Survey methods	No. of sites	Date of survey	Source
Littoral	Recording	15	July 1992	Davies (1994)
	Infaunal cores and granulometry	2	July 1992	Davies (1994)
Sublittoral	Recording	14	August 1992	Davies (1994)
	Infaunal cores and granulometry	1	August 1992	Davies (1994)
	Infaunal grab samples (0.1 m ² Day grab)	2	February 1993	Turner <i>et al.</i> (1993)
	and granulometry			

Introduction

Dramatic cliffs with steep rocky shores at their base dominate the coastline from Fast Castle Head to Eyemouth. These cliffs are broken only by small bays, where there is access to the shore via steep roads or tracks. From Fast Castle to St Abb's Head, the coastline has a northerly aspect and is moderately exposed to wave action; from St Abb's Head to Eyemouth the aspect of the coastline is north-easterly and, in general, is moderately exposed to wave action. At a local level, wave exposure is greater on the headlands and the small bays are more sheltered. Throughout the area, the coastal hinterland is mainly rural with the only urban developments at the small village of St Abbs and the small town of Eyemouth.

St Abb's Head is a volcanic outcrop which is resistant to erosion. Around the headland, littoral zones are predominantly vertical or overhanging with few horizontal surfaces. Erosion of intrusions of soft rocks within the volcanic material has created a series of narrow gullies, many leading to caves. South-east of the headland towards St Abbs harbour, the geology is of sedimentary rock and the shores become wider and more rugged.

Tidal streams flow south and east on the flood and generally slower north and west on the ebb, and follow the direction of the coast. There is a net flow of water southwards due to the combined forces of tide and wind action. Tidal speeds are normally less than one knot, but are accelerated around the St Abb's headland where large standing waves form when the wind is opposed to the direction of tidal flow. Surface water temperatures in the winter drop to around 5.5°C and warm to around 13°C in summer. Salinity appears to be fully marine at around 35‰ and probably remains at that level all year. St Abb's is renowned for its water clarity by the many divers who visit the area. Estimates of underwater visibility range from approximately 2 to 20 m. Kelp forests flourish to at least 8 m below chart datum, which is a good indicator of low turbidity.

Physical features

<i>Physiographic type</i>	Open coast
<i>Length of coast</i>	14 km
<i>Bathymetry</i>	30 m and 50 m isobaths within 1 km of St Abb's Head
<i>Wave exposure range</i>	Exposed and moderately exposed
<i>Tidal stream range</i>	Moderately strong to negligible
<i>Tidal range</i>	4.1 m (springs), 3.1 m (neaps)
<i>Salinity range</i>	Fully marine

Marine biology

Littoral

Littoral zones from Fast Castle Head to St Abb's Head comprise steep, rugged shores eroded to form many stacks, ridges and gullies. At the headlands of Fast Castle, Souter and St Abb's, wave exposure is apparently higher than the adjacent coastline which results in localised changes to the littoral assemblages. At Fast Castle Head, the littoral zone forms a series of stacks with very steep, flat faces subject to considerable wave surge. Extensive supralittoral and littoral fringe zones are present, owing to the wave surge sending salt spray high up the cliffs. Littoral fringe and eulittoral zones are characterised by lichens and sessile animals; furoid algae are largely absent, probably owing to the high wave exposure. Rock surfaces in the littoral fringe support a dense cover of black lichens with many small gastropods crowded into crevices and pits (Ver.Ver). Eulittoral rock supports very dense populations of barnacles and mussels *Mytilus edulis* (MytB) with a band of the red alga *Mastocarpus stellatus* on the lower shore. In the sublittoral fringe, the wave surge promotes the development of a dense forest of edible kelp *Alaria esculenta* (Ala.Ldig; Ala.Myt). In areas afforded localised shelter, for example the landward side of stacks, *Laminaria digitata* replaces *A. esculenta* as the dominant kelp species in the sublittoral fringe.

To the south-east of Souter Point (1 km east of Fast Castle Head) the shore is wider and flatter and comprises a series of igneous rock ridges extending seaward; the troughs between the ridges contain mobile boulders. Due to the flatter nature of the shore, wave energy is dissipated gradually which results in localised shelter for upper shore habitats. Scattered plants of channelled wrack *Pelvetia canaliculata* and black lichens characterise the littoral fringe (Pel), while the eulittoral zone is characterised by limpets and barnacles (BPat.Sem). Small pools lined with calcareous red algae are present within the eulittoral zone (Cor). In the lower eulittoral, the dominant organism varies with wave exposure: in the most exposed areas, the rock surfaces are covered with encrusting coralline algae; where rock surfaces are afforded some shelter, a turf of the red algae *Mastocarpus stellatus* and *Osmundea pinnatifida* is present (Mas). A forest of kelp *Laminaria digitata* with encrusting coralline algae on adjacent rock surfaces is present in the sublittoral fringe (Ldig.Ldig). Gullies between the ridges funnel and concentrate the prevailing wave energy; here *Alaria esculenta* replaces *L. digitata* as the dominant kelp species.

From Souter to Pettico Wick, the shores are very rugged and form a series of steep and vertical bedrock faces separated by short horizontal steps. Littoral communities are similar to those described for Fast Castle Head, i.e. characterised by sessile animals and lichens with a few sparse clumps of red and brown algae. Sublittoral fringe habitats support dense kelp forest although the dominant kelp species varies with the local wave exposure. Where overhangs and crevices are present, epifaunal assemblages are characterised by sponges, hydroids and colonial ascidians (e.g. at Step Heugh, east of Fast Castle Head).

Pettico Wick is a small bay where the cliffs are less steep and the shore is accessible from land. Within the bay, the shore comprises a series of bedrock outcrops surrounded by mobile boulders and cobbles. To the west, the shore forms a series of uplifted sandstone bedrock ridges separated by long, narrow pools which support dense assemblages of algae, including kelp *Laminaria digitata* and *Alaria esculenta* in the deepest pools (FK). The ridges create local variations in wave exposure; the landward sides appear more sheltered and support isolated populations of furoid algae on a shore otherwise characterised by limpets and barnacles (BPat.Sem). In the centre of the bay, the boulders and cobbles are unstable and appear to be regularly disturbed by the prevailing wave action. This disturbance restricts the development of epibenthic assemblages so that the rock surfaces are covered with little other than ephemeral green and brown algae. On the east side of the bay, there are a series of rock stacks and vertical cliffs which have been undercut by pebbles and cobbles. Vertical rock surfaces are characterised by limpets and barnacles with many dog whelks *Nucella lapillus*, a barnacle predator. Bedrock and stable boulders in the sublittoral fringe support a dense kelp forest characterised by *A. esculenta* (Ala.Myt). Vertical and overhanging rock surfaces have rich epifaunal communities.

Around St Abb's Head, littoral zones are predominantly vertical and/or overhanging with few horizontal surfaces. Due to its geographical position, the headland is exposed to wave action from all directions from north-west to south-east. In addition, the bathymetry of the adjacent sublittoral area results in deep water close inshore which does not dissipate the wave energy, thus exposing the littoral zones to considerable wave surge. The supralittoral zone extends almost to the top of the cliffs (40-60 m above sea level). Due to the large breeding seabird populations on the adjacent cliffs, littoral fringe habitats are subject to eutrophication from bird guano and the rocks are covered with the green alga *Prasiola stipitata* (Pra), with abundant littorinid gastropods in pits and crevices. Eulittoral zones support very dense populations of barnacles and mussels (MytB) and extremely dense aggregations of juvenile mussels *Mytilus edulis* are recorded in the lower eulittoral zone. Attached to the mussels and barnacles are tufts of the filamentous red algae *Ceramium shuttleworthianum* and *Callithamnion* spp. Erosion of soft intrusions within the volcanic rock has created a series of narrow gullies, many leading to caves where shaded rock surfaces support a dense mat of red algae, mainly *Plumaria plumosa* and *Membranoptera alata* (SR). Rock surfaces in the sublittoral fringe support very dense kelp forests characterised by *Alaria esculenta* (Ala.Myt) and *Laminaria hyperborea* (Lhyp.Ft). South-east of the headland towards St Abbs harbour, the coastal geology reverts to sedimentary rock and the shores become wider and more rugged.

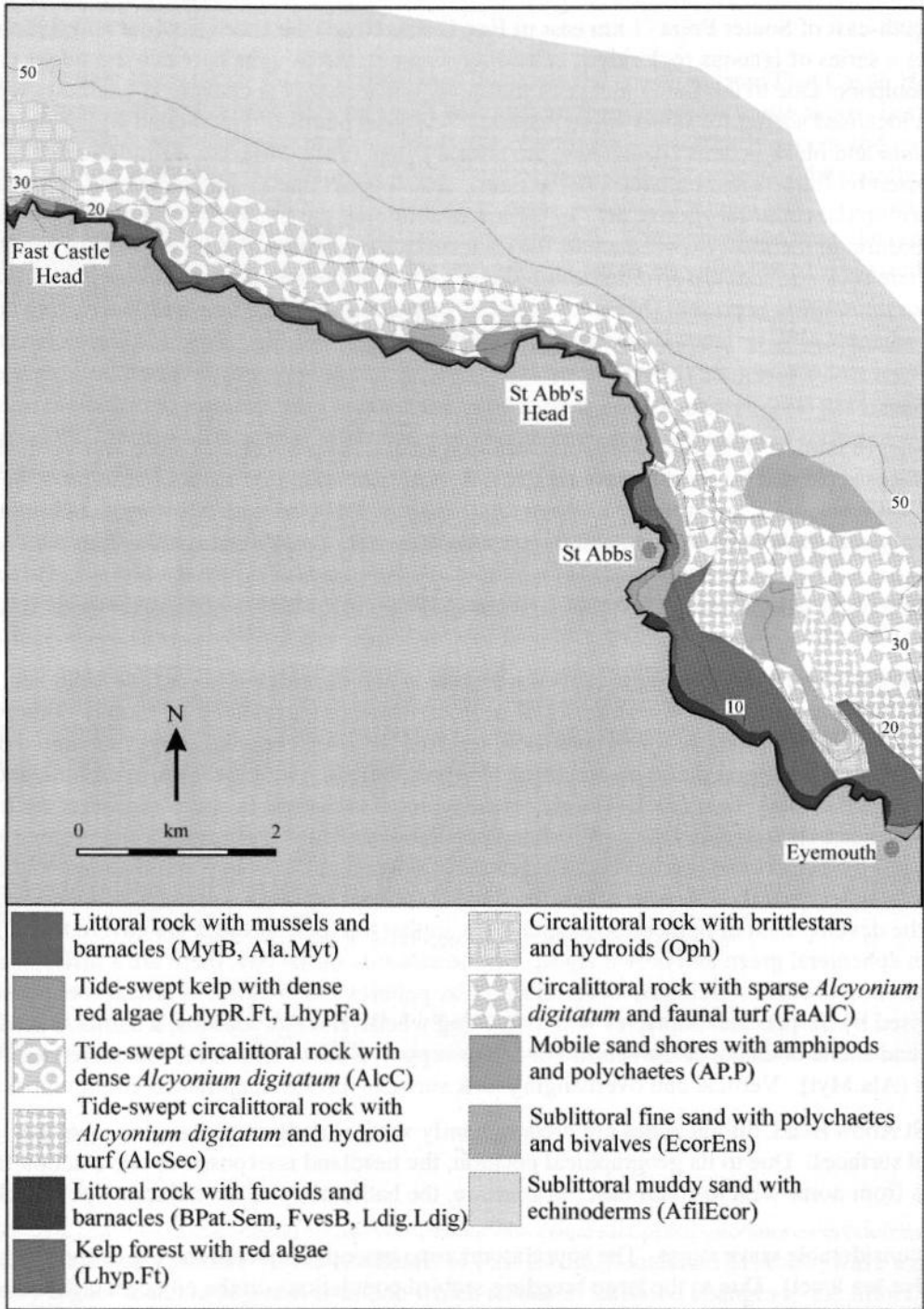


Figure 5.2 Indicative distribution of the biotopes within the area (based on data from survey sites shown in Figure 5.1 and additional field observations).
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Shores in the vicinity of St Abbs harbour comprise rugged bedrock with many fissures and crevices. To the north of the harbour, a series of offshore rock outcrops that shelter the mainland shore have well developed fucoid algal communities on steep and horizontal surfaces (Pel; FvesB). Vertical eulittoral rock supports a limpet/barnacle assemblage (BPat.Sem). On the lower shore, shaded vertical walls in narrow gullies have a dense turf of filamentous red algae with *P. plumosa* abundant and many purse sponges *Grantia compressa* (SR). To the south of the harbour, the shore is not afforded

protection by outlying rocks and the eulittoral zone supports dense populations of limpets and barnacles with only occasional clumps of algae. In the littoral fringe on the sheltered landward side of a bedrock outcrop, a dense band of the tufted, erect black lichen *Lichina pygmaea* is present (BPat.Lic), a species not recorded at any other site within the 1992 survey area. On the lower shore/sublittoral fringe a dense turf of the red algae *Osmundea pinnatifida* and *Chondrus crispus* (Him) forms a band above the kelp forest. A series of small, deep pools is present throughout the eulittoral zone and supports dense populations of encrusting and erect coralline algae (Cor). These rugged, rocky shores extend for approximately 1 km south to Coldingham Bay where there is an expanse of clean, mobile medium-fine sand.

A series of rock outcrops are present within Coldingham Bay although their presence can alter seasonally, depending on the movement of sand within the bay. The rock surfaces are subject to considerable sand scour and smothering and the associated biotic assemblages are characterised by ephemeral red and green algae: dense mats of the red alga *Porphyra purpurea* are recorded over the rock surface (EntPor). Sediment infaunal communities have a low species richness and are characterised by sparse robust polychaetes (AP.P).

Rugged, moderately exposed rocky shores extend south-east from Coldingham Bay to Eyemouth and have a similar structure to that described above for south of St Abbs Harbour. Habitats afforded localised shelter support furoid algal assemblages rather than limpet/barnacle assemblages. This effect is most apparent around the headland to the north of Eyemouth Harbour where littoral zones vary in their composition depending on orientation and inclination to prevailing wave action. Where the rock platforms have been heavily eroded, the shore south of Yellow Craig comprises a series of large, stable boulders where species richness is higher due to the greater microhabitat diversity created by boulder interstices. Extensive lichen assemblages are recorded in the littoral fringe of this area (YG), except where rocks provide a roosting site for seabirds and eutrophication from guano results in the rocks supporting a dense covering of the green alga *Prasiola stipitata* (Pra).

A small, sandy beach is present on the northern side of the harbour entrance at Eyemouth. The beach is predominantly medium-fine sand although there are large patches of coarse sand and pebbles. Infaunal samples are characterised by polychaetes and amphipods with the presence of the polychaete *Capitella capitata* indicating that the shore may be subject to some organic enrichment (AP.P). Eyemouth Harbour is enclosed by two small piers and the main channel is bounded by concrete walls. Inside the north pier there is a patch of rock that extends from the upper to the mid-shore. Sheltered conditions result in the rock surface supporting very dense furoid algal assemblages (Fspi; Fves; Fser.R).

In summary, the shores between Fast Castle Head and Eyemouth are predominantly exposed or moderately exposed, rugged, rocky shores with marked zonation patterns. Extensive supralittoral lichen and littoral fringe zones are present at the most exposed sites. Eulittoral zones are generally characterised by sessile animals except in areas afforded shelter, where furoid algal assemblages are recorded. Rock in the sublittoral fringe supports dense forests of kelp although the dominant species varies with wave exposure; *Alaria esculenta* is most abundant at the high-energy sites. Sediment habitats are present in Coldingham Bay and at Eyemouth, but the high sediment mobility reduces the diversity of infaunal communities.

Sublittoral

Sublittoral habitats from Fast Castle Head to Eyemouth vary considerably due to the change in bathymetry along the coastline. At Fast Castle Head, the 50 m isobath is approximately 2 km offshore whilst at St Abb's Head, the 50 m isobath is less than 0.5 km offshore, and at Eyemouth the 50 m isobath is approximately 4 km offshore. In parallel to this variation in nearshore depth, the rate of nearshore tidal streams is highest around St Abb's Head, and decreases with increasing distance north-west and south-east from the headland. These variations in bathymetry and tidal streams, combined with the geology of the sea bed, have a major influence on the community structure of sublittoral habitats.

At Fast Castle Head, steep bedrock continues from the littoral into the infralittoral zone where a stepped bedrock wall extends to a depth of 4 m and supports a dense kelp *Laminaria hyperborea* forest with a dense turf of red algae below the kelp canopy (LhypR.Ft). At the base of the wall, a gentle boulder slope extends offshore to a depth of 12 m. At the top of the slope, the upper surfaces of the boulders have scattered kelp plants and occasional tufts of red algae (LhypGz.Pk). Boulder surfaces appear to be grazed by the urchin *Echinus esculentus* which reduces the abundance of the algae. In the circalittoral zone, upward-facing surfaces of the boulders are heavily encrusted with the tubeworm *Pomatoceros triqueter* and encrusting brown and red algae. Brittlestars are common throughout the habitat but are most abundant between the stones (Oph). At a depth of 12 m, the boulder slope leads to a level plain of coarse, rippled sand where few epibiota are present: only the burrowing anemone *Cerianthus lloydii* was observed on the surface of the sediment. Approximately 1 km offshore, at a depth of 20 m, the sea bed comprises bedrock outcrops on a level, rippled sediment plain, which is probably an extension of the inshore sediment. On the bedrock there are many large anemones (*Urticina eques* and *Metridium senile*), and occasional clumps of hydroids, mainly *Abietinaria abietina*. Most of the bedrock habitat is covered with a bed of brittlestars, with encrusting non-calcareous red algae on the rock itself (FaAIC; Oph).

Approximately 3 km east of Fast Castle Head, the infralittoral zone has a similar structure to that described above: steep bedrock with a series of vertical and horizontal surfaces extending to a depth of 7 m, with flatter, more extensive bedrock terraces extending offshore to a depth of 9 m. In the sublittoral fringe/infralittoral, the rock supports a dense forest of kelp *Laminaria digitata* and *Alaria esculenta* with the rock beneath the canopy covered with juvenile mussels *Mytilus edulis* (Ala.Myt). Upward-facing rock in the infralittoral is characterised by a dense kelp *L. hyperborea* forest with the rock under the kelp canopy covered by a rich epifaunal assemblage of sponges, hydroids and ascidians. Crevices in the rock provide a refuge for cryptic species, in particular the wrinkled rock borer *Hiatella arctica*, the sea squirt *Ascidia conchilega* and the brittlestar *Ophiopholis aculeata*. Vertical faces are devoid of kelp and characterised by large colonies of dead-man's fingers *Alcyonium digitatum*, patches of the light-bulb sea squirt *Clavelina lepadiformis* and encrusted with tubeworms *Pomatoceros triqueter* (AlcC). A similar assemblage characterises the rugged bedrock terraces in the circalittoral, except that encrusting bryozoans and the encrusting brown alga *Pseudolithoderma extensum* are more abundant (FaAIC). Approximately 1.5 km offshore, at a depth of 32 m, the sea bed comprises a plain of duned stone gravel with some pebbles and the whole sea bed is coated with a fine layer of silt. A very sparse epibiota is present with occasional starfish *Asterias rubens*. Infaunal assemblages also have a low species richness with only scattered sand mason worms *Lanice conchilega* and a few bivalves present (IGS).

Sublittoral habitats at Pettico Wick are similar to those of sites further west (described above) except that the stronger tidal streams result in some differences in the community structure. Infralittoral bedrock is characterised by a dense kelp forest. Shallow bedrock reefs extend offshore at a depth of 11 m, separated by steep-sided gullies at a depth of approximately 7 m, filled with mobile sand. Upward-facing surfaces on the tops of the reefs have large colonies of dead-man's fingers *Alcyonium digitatum* with abundant brittlestars *Ophiothrix fragilis* in cracks and crevices. Vertical faces on the walls of the gullies are encrusted with tubeworms *Pomatoceros triqueter* which provide a matrix for other species including the bivalves *Pododesmus patelliformis* and *Hiatella arctica*. Approximately 1 km offshore at a depth of 26 m, the sea bed comprises a level plain of cobbles and pebbles subject to moderately strong tidal streams. Epibenthic assemblages are characterised by hydroids including *Hydrallmania falcata*, *Sertularia argentea*, *Tubularia* spp. and *Thuiaria thuja*, with large colonies of dead-man's fingers *A. digitatum* on the largest stones (Flu.SerHyd). Mobile crustaceans are common between the stones, including many spider crabs *Hyas coarctatus*. In the sediment under the stones, the polychaetes *Chaetopterus variopedatus* and *Chone infundibuliformis* are present.

At the base of the high cliffs at St Abb's Head, the infralittoral zone is mainly very steep bedrock leading to large, stable boulders at a depth of 7 m. In the transition zone from sublittoral fringe to infralittoral, rock surfaces have a dense covering of juvenile mussels which extends to a depth of approximately 2 m. Infralittoral rock supports a dense forest of kelp *Laminaria hyperborea* with a rich turf of filamentous and foliose red algae on the kelp stipes and rock surfaces below (LhypFa). Under

the algal turf, the rock has a dense epifaunal assemblage of the colonial ascidians *Diplosoma listerianum* and *Lissoclinum perforatum*, the encrusting bryozoans *Umbonula littoralis* and *Parasmittina trispinosa*, the erect bryozoans *Scrupocellaria scruposa*, *Alcyonidium diaphanum* and *Crisia eburnea*, and the anemone *Sagartia elegans*; this epifaunal assemblage is more diverse in the deeper parts of the kelp forest. Further to the south-east at the base of the cliffs below the lighthouse, similar infralittoral communities are recorded. A kelp park extends from a depth of 7 to 12 m where a sparse algal turf is present, and the rock is covered with encrusting coralline algae (LhypGz.Pk). At this site, rugged bedrock reefs extend into the circalittoral and are characterised by large colonies of dead-man's fingers *Alcyonium digitatum* and abundant brittlestars *Ophiothrix fragilis*, with many encrusting bryozoans (FaAIC). Approximately 500 m offshore, at a depth of 25 m, the sea bed comprises a level plain of tide-swept cobbles and pebbles characterised by hydroids, predominantly *Hydrallmania falcata*, and encrusting bryozoans. A moderately diverse epibenthic assemblage is present although species abundance is low (FaAIC).

South of St Abbs Harbour, the sublittoral zone has a similar character to that described above. Upward-facing infralittoral habitats support dense kelp forests with a rich algal turf under the kelp canopy; vertical bedrock has a rich epifaunal community characterised by dead-man's fingers *A. digitatum*, encrusting and erect bryozoans, and ascidians. Lower infralittoral habitats comprise large, stable boulders with a kelp park on upward-facing surfaces and rich epifaunal and epibenthic assemblages on and between the stones. Further offshore, the sea bed is a level plain of boulders, cobbles and pebbles subject to moderate tidal streams with the large, erect bryozoans *Flustra foliacea* and *Securiflustra securifrons* present; both species are characteristic of habitats subject to moderate tidal streams (AlcSec).

Littoral sediment habitats in Coldingham Bay extend offshore into the sublittoral where there is a sand plain at a depth of 13 m. Infaunal communities are characterised by the razor shell *Ensis siliqua* and the heart urchin *Echinocardium cordatum* (EcorEns). A large specimen of the common otter shell *Lutraria lutraria* and occasional sand-eels *Ammodytes* spp. were recorded here. South-east of Coldingham Bay approximately 1 km offshore there is a large sublittoral rock outcrop, Fold Buss, which rises 10 m above the surrounding sea floor; at its shallowest point, the rock is at a depth of approximately 13 m. The outcrop is rugged in form with many short vertical steps, and the rock surface itself has many fissures and crevices. Epibenthic communities are characterised by dead-man's fingers *A. digitatum*, hydroids and encrusting bryozoans, with foliose algae present in the shallower parts of the zone (AlcSec). Large tufts of erect hydroids, particularly *Nemertesia ramosa* and *N. antennina*, are present.

Off the entrance to Eyemouth Harbour is a series of offshore rocks, the Hurkers, which descend into the sublittoral as a series of rugged steps. Here infralittoral habitats are very scenic with a series of steep-sided gullies with large kelp plants providing a 'roof'. Nevertheless, the overall character of the sublittoral zone is similar to that described off St Abb's Head. Upward-facing infralittoral bedrock supports a dense kelp forest (Lhyp.Ft) which decreases in density at a depth of approximately 9 m to form a kelp park. Within the infralittoral, vertical surfaces retain a rich epifaunal turf of sponges, erect bryozoans and colonial ascidians. At a depth of approximately 12 m, bedrock reefs are overlain with large boulders, the interstices of which provide a refuge for brittlestars and crustaceans. Approximately 1.5 km offshore, at a depth of 34 m, the sea bed comprises a level plain of small boulders, cobbles and pebbles, covered with a dense brittlestar bed. Epifaunal communities are characterised by tubeworms *Pomatoceros triqueter* and hydroids, mainly *Hydrallmania falcata* and *Thuiaria thuja* (AlcByH). Occasional limestone boulders are bored by the yellow sponge *Cliona celata*. Further offshore below depths of around 40 m, the sea bed comprises muddy sand with echinoderms (AfilEcor).

In summary, sublittoral habitats between Fast Castle Head and Eyemouth have a similar character throughout. Nearshore habitats are generally steep or vertical rugged bedrock that supports a dense kelp forest on steep and upward-facing surfaces and a rich epifaunal turf on vertical surfaces. Offshore habitats are either bedrock terraces with large colonies of dead-man's fingers *A. digitatum* and dense populations of echinoderms (predominantly brittlestars) or level plains of mixed stones with

hydroids and bryozoans. In general these offshore habitats are subject to strong tidal streams which sweep the habitat free of silt and appears to increase species richness in comparison to adjacent areas. Overall species richness throughout the area was higher than areas further west or south.

Nature conservation

Conservation sites			
Site name	Designation	Centre grid ref.	Main features
St Abb's Head to Fast Castle	SSSI	NT 880 699	Ornithology, coastal habitats and flora
St Abb's Head	pSPA, NNR, NTS, WT	NT 914 689	Ornithology, coastal habitats and flora
Berwickshire & North Northumberland Coast	cSAC	NT 980 575	Marine habitats, seals
Berwickshire Marine Consultation Area	MCA	NT 915 705	Marine biology
St Abb's	VMNR, WT	NT 920 700	Marine biology

Human influences

Sewage discharge

The coast between Fast Castle and St Abb's Head has no sewage outfalls. However, there is an outfall to the north of St Abbs harbour which discharges untreated sewage onto the shore at the access point for one of the popular dive sites in the voluntary Marine Nature Reserve. There is also a low-output outfall in Coldingham Bay. The outfall at Eyemouth releases a relatively large amount of untreated sewage into the sea. A large influx of visitors results in a seasonal increase in the pressure on the local infrastructure, particularly sewage and waste disposal.

Industrial effluent discharge

There is a vegetable processing plant at Eyemouth which may account for the number of peas which were found underwater at some of the survey sites!

Commercial fishery

There are harbours at St Abbs and Eyemouth which both support commercial fisheries. Eyemouth is the larger of the two harbours, has a fish market and accommodates boats engaged in offshore fishing. At St Abbs there is a smaller harbour with a modest fleet fishing mainly inshore for shellfish and handlining. Most of the reefs in the area are potted for lobsters and crabs.

Recreation

Tourism is a major industry throughout the area and the dramatic scenery, important wildlife habitats, deep, clear water close inshore and the small beaches attract many visitors with varied interests. The leisure industry makes use of St Abbs Harbour, particularly the sport diving community and the voluntary Marine Nature Reserve at St Abb's Head attracts a great many divers. Diving is also popular from the shore and from boats around Pettico Wick, St Abb's Head and Eyemouth (Weasel Loch).

Eyemouth and Coldingham Bay have sandy beaches with caravan sites situated on the cliffs above them. Eyemouth in particular is a centre for sea angling, both from the shore and from boats.

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Sites surveyed

Surveys

313: MNCR littoral survey of the south-east coast of Scotland, 1992 (Davies 1994).

312: MNCR sublittoral survey of south-east Scotland, 1992 (Davies 1994).

393: Grab sampling survey of south-east Scotland, Analytical and Environmental Services, 1993 (Turner *et al.* 1993).

Littoral sites				
Survey Site	Site name	Grid reference	Latitude & longitude	Biotores present
313	1	S of Hairy Ness, Eyemouth.	NT 941 650	55°52.6'N 02°05.6'W PelB; BPat.Sem; FvesB; Fser.R; FK; Ldig.Ldig
313	2	Eyemouth Beach.	NT 945 645	55°52.4'N 02°05.2'W Pel; Fspi; EntPor; BPat.Sem; Fser.R; Cor; Ldig.Ldig; AP.P
313	3	NE of Pettico Wick, St Abb's Head.	NT 908 695	55°55.1'N 02°08.8'W Pra; BPat.Sem; MytB; Ala.Myt
313	4	W side of Pettico Wick, St Abb's Head.	NT 907 691	55°54.8'N 02°08.9'W YG; Ver.Ver; BPat.Sem; MytB; Fser.R; FK; Ala.Ldig; Lhyp
313	5	N of St Abbs Harbour.	NT 919 675	55°54.0'N 02°07.7'W YG; Pra; PelB; BPat.Sem; FvesB; Him; Ldig.Ldig
313	6	S of St Abbs Harbour.	NT 921 673	55°53.9'N 02°07.5'W PelB; BPat.Lic; BPat.Sem; Him; Ldig.Ldig
313	13	Eyemouth Harbour.	NT 947 645	55°52.4'N 02°05.0'W Fspi; BPat.Sem; Fves; Fser.R
313	14	W of Killedraught Bay, Eyemouth.	NT 934 650	55°52.6'N 02°06.3'W YG; Ver.Ver; Pel; Fspi; BPat.Sem; FvesB; Fser.Fser.Bo; Cor; Ldig.Ldig
313	17	N of Coldingham Bay.	NT 917 667	55°53.6'N 02°07.9'W YG; Ver.Ver; Pel; EntPor; BPat.Sem; Fser.R; BLlit; Ldig.Ldig.Bo; Lhyp.Ft; AP.P
313	19	Yellow Craig, near Coldingham Bay.	NT 924 662	55°53.3'N 02°07.2'W Pra; Ver.Ver; Ver.B; MytB; XR; Ala.Ldig; Lhyp
313	20	S of Yellow Craig.	NT 922 661	55°53.2'N 02°07.4'W YG; Pel; Fspi; FvesB; Fser.Fser.Bo; Cor; Ldig.Ldig.Bo; Lhyp.Ft
313	21	West of Fast Castle Head.	NT 861 711	55°55.9'N 02°13.3'W MytB; Mas; Ala.Ldig; LhypR.Ft
313	24	Step Heugh, E of Fast Castle Head.	NT 881 699	55°55.3'N 02°11.4'W Ver.B; MytB; Cor; Ala.Ldig
313	41	St Abb's Head Lighthouse.	NT 915 694	55°55.0'N 02°08.1'W Pra; Ver.Ver; MytB; Ala.Myt
313	42	St Abbs Nunnery, St Abb's Head.	NT 910 694	55°55.0'N 02°08.6'W MytB; SR; SCAn.Tub
313	43	E of St Abb's Head Lighthouse.	NT 913 693	55°55.0'N 02°08.3'W MytB; LhypR.Ft
313	46	Brander, St Abb's Head.	NT 874 706	55°55.7'N 02°12.1'W Ver.Ver; BPat.Sem; XR; Cor; G; Ldig.Ldig

Sublittoral sites

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>	
312	1	NW of St Abb's Head.	NT 940 693	55°55.0'N 02°05.7'W	Flu.SerHyd
312	2	Pettico Wick.	NT 908 696	55°55.2'N 02°08.8'W	AlcByH.Hia; AlcC; IGS
312	3	N of Mawcarr Stells, St Abb's Head.	NT 887 707	55°55.8'N 02°10.8'W	IGS
312	4	Mawcarr Stells, St Abb's Head.	NT 883 700	55°55.4'N 02°11.1'W	Ldig.Ldig; Lhyp.Ft; AlcC; FaAIC
312	5	Fast Castle Head.	NT 859 733	55°57.2'N 02°13.5'W	LhypR.Ft; Oph; IGS
312	6	N of Fast Castle Head.	NT 861 715	55°56.2'N 02°13.3'W	FaAIC; Oph
312	26	Offshore of St Abb's Head.	NT 917 694	55°55.1'N 02°07.9'W	FaAIC
312	27	St Abb's lighthouse, St Abb's Head.	NT 915 689	55°54.8'N 02°08.1'W	LhypFa; LhypGz.Pk; FaAIC
312	28	St Abb's Head nunnery.	NT 910 696	55°55.2'N 02°08.6'W	Ala.Myt; LhypR.Ft; Lhyp.Ft; LhypGz.Ft
312	29	NE of Gunsreen Point, Eyemouth.	NT 954 652	55°52.8'N 02°04.4'W	Oph
312	30	Fold Buss, Eyemouth.	NT 942 659	55°53.2'N 02°05.4'W	AlcSec
312	31	Offshore Ebb Carrs, St Abb's Head.	NT 935 672	55°53.9'N 02°06.2'W	AlcSec
312	32	The Hurkers, Eyemouth.	NT 947 650	55°52.7'N 02°05.0'W	Lhyp.Ft; AlcByH; FaAIC
312	33	Coldingham Bay.	NT 922 667	55°53.6'N 02°07.4'W	EcorEns
312	34	Ebb Carrs, St Abb's Head.	NT 925 670	55°53.8'N 02°07.1'W	Lhyp.Pk; Lhyp.Ft; AlcByH
393	9	NE of Brander, St Abbs.	NT 885 738	55°57.4'N 02°10.9'W	AfilEcor
393	10	NE of St Abb's Head.	NT 929 728	55°56.9'N 02°06.8'W	AfilEcor
393	11	NE of St Abbs.	NT 964 702	55°55.5'N 02°03.4'W	AbrNucCor

Compiled by: Jon Davies & Rohan Holt

6

Eyemouth to the Tweed estuary

Location

<i>Position (centre)/limits</i>	NT 975 585	NT 950 645 - NU 011 524
<i>Administrative areas</i>	Borders Northumberland	Berwick-upon-Tweed Lothian and Borders
<i>Conservation agency/area</i>	Scottish Natural Heritage English Nature	Northumbria

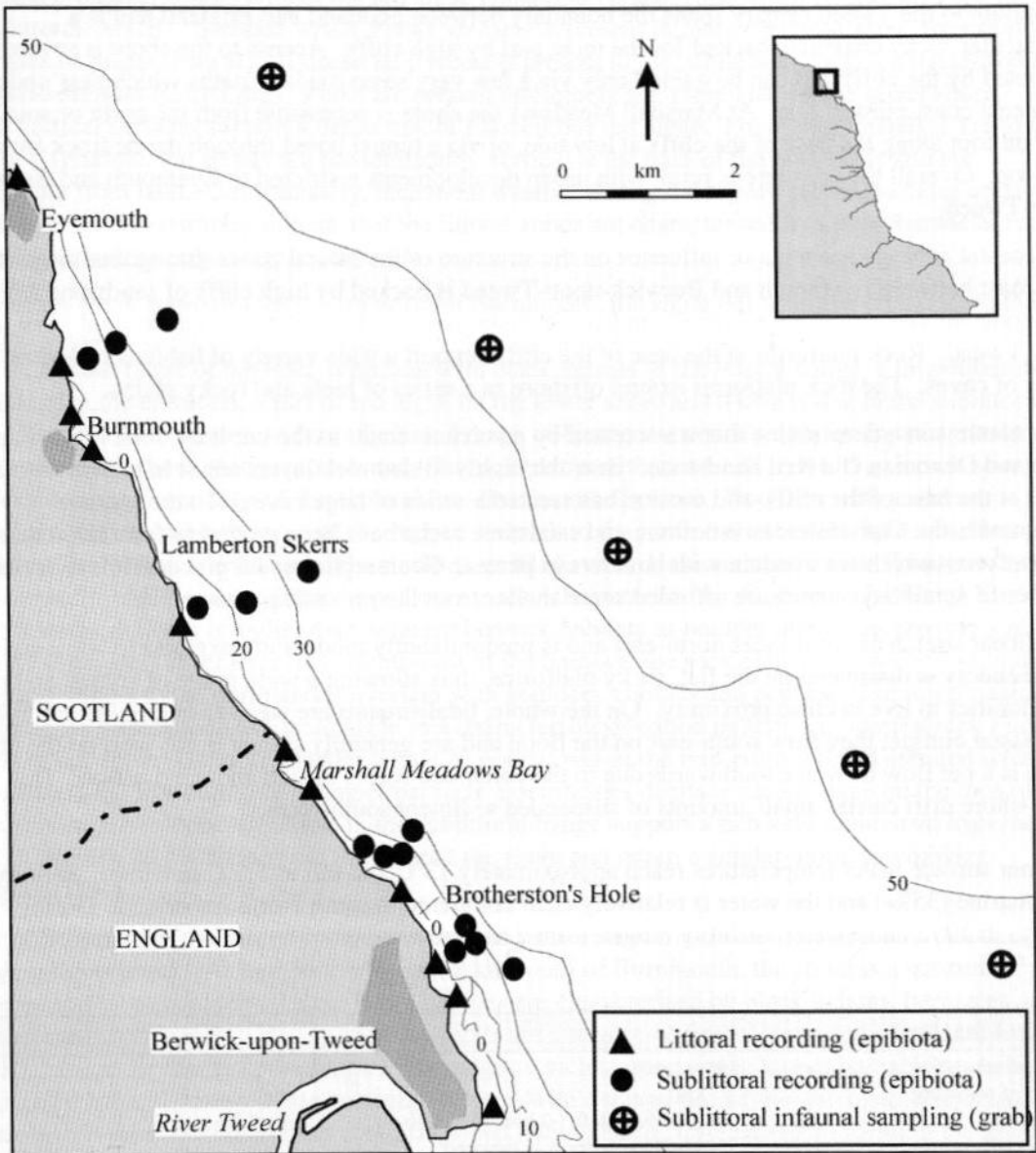


Figure 6.1 Location of area showing sites surveyed and main bathymetric features.
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Marine biological surveys				
	Survey methods	No. of sites	Date of survey	Source
Littoral	Recording	11	June-July 1992	Davies (1994); Holt (1994)
	Infaunal cores and granulometry	3	June 1992	Davies (1994); Holt (1994)
Sublittoral	Recording	14	July 1992	Davies (1994); Holt (1994)
	Infaunal grab samples (0.1 m ² Day grab) and granulometry	5	February 1993	Turner <i>et al.</i> (1993)

Introduction

Eyemouth to the Tweed estuary spans the boundary between Scotland and England and is a spectacular rocky coastline, backed for the most part by high cliffs. Access to the shore is severely restricted by the cliffs and can be gained only via a few very steep roads or paths which pass under the main east coast railway line. At Marshall Meadows the shore is accessible from the north or south only on foot along the base of the cliffs at low tide, or via a tunnel bored through the bedrock from the cliff-top. Overall the coastline is rural, with urban developments restricted to Eyemouth and Berwick-upon-Tweed.

The coastal geology has a major influence on the structure of the littoral zones throughout the area. The coast between Eyemouth and Berwick-upon-Tweed is backed by high cliffs of sandstone and limestone and the shores are relatively undisturbed compared to those further south around Berwick-upon-Tweed. Rock platforms at the base of the cliffs support a wide variety of habitats including a series of caves. The rock platforms extend offshore as a series of reefs and rocky plains.

Burnmouth is in a deep ravine that was created by a volcanic fault; to the north the rock is Silurian shale and Devonian Old Red Sandstone. Here the highly folded rock layers result in narrow littoral zones at the base of the cliffs, and erosion has created a series of large caves. To the south of Burnmouth, the Carboniferous limestone and sandstone rocks have been eroded to form large wave-cut platforms which are overlain with boulders in places. Geomorphological processes have created a number of small bays which are afforded some shelter from the prevailing wave action.

This linear stretch of coast faces north-east and is predominantly moderately exposed to wave action. Wave energy is dissipated on the flat, rocky platforms, thus allowing a wide range of animal and plant communities to live in close proximity. On the whole, tidal streams are weak to negligible and follow the coastal outline; they flow south-east on the flood and are generally slower north-west on the ebb. There is a net flow of water southwards due to the combined forces of tide and wind action. This along-shore drift carries small amounts of suspended sediment southwards.

Summer surface water temperatures reach approximately 13°C and fall to 5.5°C in winter. Salinity is fully marine (35‰) and the water is relatively clear compared to south Northumberland. During surveys in 1992 underwater visibility ranged from 2 to 8 m.

Physical features

<i>Physiographic type</i>	Open coast
<i>Length of coastline</i>	17 km
<i>Bathymetry</i>	30 m isobath at 0.5-2 km, 50 m isobath at 2-5 km offshore
<i>Wave exposure range</i>	Exposed to moderately exposed
<i>Tidal stream range</i>	Moderately strong to negligible
<i>Tidal range</i>	4.1 m (springs), 2.5 m (neaps)
<i>Salinity range</i>	Fully marine

Marine biology

Littoral

On the headland to the south-east of Eyemouth Harbour, the very rugged rocky shores are more exposed to wave action than the shores to the north. The rugged nature of the shore forms a series of ridges and gullies which result in local changes in wave exposure with corresponding changes in the communities present. In the littoral fringe, rock surfaces have dense black lichen communities with abundant gastropod molluscs in small pits and crevices (Ver.Ver). Where upper shore habitats are sheltered from wave action by large ridges, a narrow band of channelled wrack *Pelvetia canaliculata* characterises the lower littoral fringe (Pel). Eulittoral habitats support dense populations of limpets, mussels and barnacles with tufts of the red algae *Dumontia contorta* and *Mastocarpus stellatus* in the low eulittoral (MytB). Serrated wrack *Fucus serratus* is present in more sheltered areas, for example at the base of ridges (Fser.R). A dense kelp forest is present in the sublittoral fringe, characterised by *Laminaria digitata* (Ldig.Ldig). Pools are present throughout the shore and, on the lower shore, shaded vertical surfaces support a dense mat of filamentous red algae. For approximately 3 km to the south of Eyemouth, the shores are predominantly vertical at the base of the high cliffs and are inaccessible from land. Unfortunately, inclement weather during the survey prevented close access by sea but general observations indicate that the littoral zones are characterised by limpet/barnacle/mussel assemblages with red algae on the lower shore.

At Breeches Rock approximately 1 km north of Burnmouth, the shore has a similar character to the headland south of Eyemouth, i.e. a rugged shore comprising a series of ridges running parallel to the coast. A similar range of biotopes is present with black lichens in the littoral fringe, a limpet/barnacle assemblage in the eulittoral, a turf of red algae on the lower shore and a kelp forest in the sublittoral fringe. This shore formation and its associated range of biotopes extends south for approximately 500 m, where the shore changes to a broad, flat rock platform that extends seaward as a rock spur; this spur forms the northern edge of the channel into Burnmouth Harbour. Boulders with a sparse limpet/barnacle assemblage separate the rugged bedrock to the north from the rock spur. On the spur, the mid-eulittoral has a dense limpet/barnacle assemblage with dense serrated wrack *Fucus serratus* in the lower eulittoral. Lower eulittoral boulders are also characterised by *F. serratus*, although the overall species richness is higher than adjacent bedrock habitats as boulder interstices provide a refuge for many organisms (Fser.Fser.Bo). South-east of the harbour, the rock platform is wider and much flatter than shores to the north and is overlain with boulders, cobbles and pebbles. Eulittoral habitats support dense populations of furoid algae in a characteristic zonation pattern, i.e. spiral wrack *Fucus spiralis* in the upper eulittoral, bladder wrack *F. vesiculosus* in the mid-eulittoral and serrated wrack *F. serratus* in the low eulittoral. Limpet/barnacle assemblages displace furoid algae on the tops of ridges and large boulders. Boulders in the sublittoral fringe support a rich kelp *Laminaria hyperborea* forest (Lhyp.Ft). Pools are present throughout the shore and retain a similar biotic assemblage throughout (FK).

South of Burnmouth, the shores comprise wave-cut platforms with occasional patches of boulders overlying the bedrock. At Lamberton Skerries, 2 km south of Burnmouth, the shore is a mixture of rock platforms and large boulders. Upper shore habitats are characterised by black lichens, barnacles and littorinid molluscs (Ver.B). Mid eulittoral habitats are a mosaic of furoid algae and sessile animals (FvesB), except the more exposed tops of the ridges which support dense limpet/barnacle assemblages. Lower shore habitats have a dense covering of algae with a mixed turf of the red algae *Mastocarpus stellatus* and *Osmundea pinnatifida* and thongweed *Himantalia elongata* (Him) forming the lowest eulittoral zone.

Marshall Meadows Bay at the national boundary is a predominantly boulder and mobile sand beach with a bank of small cobbles and pebbles at the base of high cliffs. Between the boulders are smaller stones and occasionally coarse sand. Boulders appear stable, with distinct and characteristic zones present from the top to the bottom of the shore delineated primarily by a change in the dominant furoid algal species. Upper eulittoral boulders support a sparse assemblage of spiral wrack *F. spiralis* and

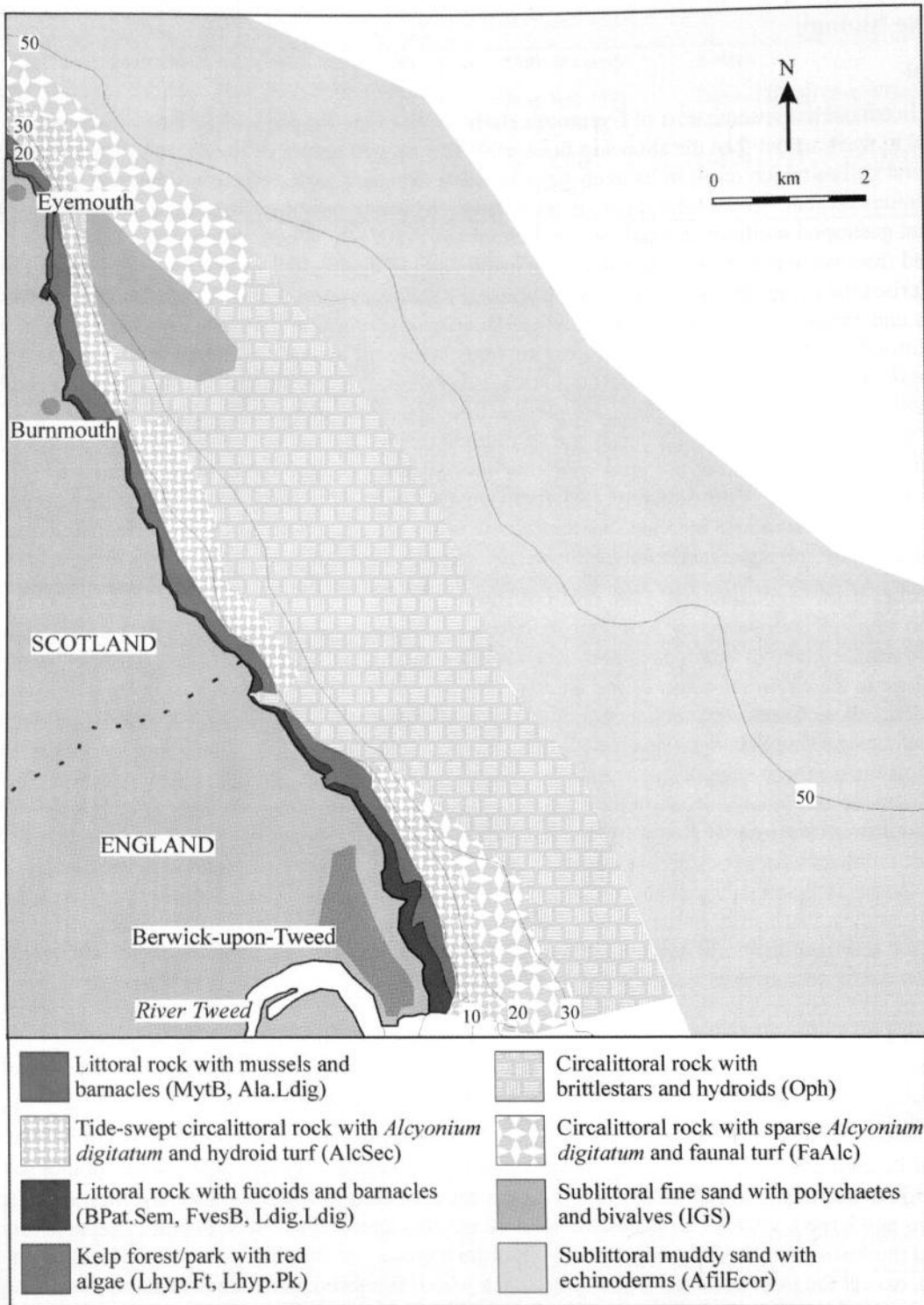


Figure 6.2 Indicative distribution of the biotopes within the area (based on data from survey sites shown in Figure 6.1 and additional field observations).

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limpets with occasional pools. Some pools have a lowered salinity due to freshwater runoff from the cliffs and they retain dense mats of the green alga *Enteromorpha* sp. The mid eulittoral zone is a mosaic of bladder wrack *F. vesiculosus* and limpet/barnacle assemblages, with the latter more common on the sides of rocks. Serrated wrack *F. serratus* forms a dense cover on lower eulittoral boulders and there is an extensive kelp *L. digitata* forest in the sublittoral fringe. Areas of the shore more sheltered from the prevailing wave action have large clumps of knotted wrack *Ascophyllum nodosum* (AscX). On the south side of the bay there are large, flat bedrock reefs in addition to the boulders which increase the habitat diversity of the shore. Rich algal communities are recorded on the boulders including an area of standing water that supports a dense population of the foliose red alga *Palmaria palmata*.

Broad shore platforms extend southwards to Berwick-upon-Tweed and have similar zonation patterns and associated biotic assemblages to those described above. At Brotherston's Hole approximately 2 km south of Marshall Meadows Bay, the rock platform is low-lying and forms an extensive low eulittoral zone; the mid- and upper shore zones occur on the vertical rock of the cliff that backs the shore. Caves are a common feature of the cliffs between Marshall Meadows Bay and Berwick-upon-Tweed. A survey of a large cave at Brotherston's Hole revealed that the biotic assemblage is characterised by a turf of red algae (mainly *Plumaria plumosa* and *Erythrodermis trillii*), encrusting coralline algae and the purse sponge *Grantia compressa* (SR).

At the southern limit of the area, the shores are very broad and comprise a complex mixture of rock platforms, ridges, gullies and boulders overlying rock; patches of coarse sediment have filled some of the gullies and smothered some low-lying reefs. This sediment is very mobile and has sparse infaunal communities. Where the sediment has been deposited in more sheltered areas, generally behind rock reefs, sediment stability has increased and an anoxic black layer has developed at a depth of approximately 2 cm. Here infaunal communities are characterised by polychaete worms (MacAre). Biotic assemblages on the rock habitats are characterised by furoid algae with limpets and barnacles on vertical faces and on the more exposed horizontal surfaces, e.g. the tops of ridges. Lower eulittoral rock adjacent to sediment has a dense mat of the sand-binding red alga *Audouinella* sp. over the rock surface. Due to the complex nature of these shores, the habitat and associated biotope diversity is high, giving rise to rich and varied shores which have a high educational interpretative value.

In summary, the littoral zone between Eyemouth and the Tweed estuary comprises rocky shores with characteristic zonation patterns. Between Eyemouth and Burnmouth, the shores are steep or vertical and characterised by limpet/barnacle assemblages. To the south of Burnmouth, the shores comprise more extensive wave-cut platforms overlain with occasional patches of boulders. Littoral assemblages are characterised by furoid algae with dense kelp forests in the sublittoral fringe. Caves are present at the top of the shore and retain distinct biotic assemblages.

Sublittoral

From Eyemouth to the Tweed estuary, the sublittoral zone generally slopes gently offshore from the sublittoral fringe. At Eyemouth the 50 m isobath is approximately 3 km offshore whereas at the Tweed estuary, the 50 m isobath is more than 15 km offshore. Throughout the area, inshore habitats are predominantly rocky, becoming sediment habitats further offshore in deeper water (30 m). At Eyemouth, infralittoral habitats support a dense kelp forest (Lhyp.Ft) with a sparse, grazed kelp park (LhypGz.Pk) in the lower infralittoral. Offshore, the sea bed comprises a level plain of boulders, cobbles and pebbles with tube-worms, hydroids and bryozoans. Epifaunal communities are characterised by tubeworms *Pomatoceros triqueter* and hydroids, mainly *Hydrallmania falcata* and *Thuiaria thuja* (AlcSec).

North of Burnmouth Harbour there are a series of skerries approximately 300 m offshore which comprise rugged bedrock, with many fissures and crevices, descending in a series of steps to a coarse sand plain at 17 m. Upper infralittoral bedrock from 3.5 to 9 m deep supports a very dense forest of kelp *L. hyperborea* which has a rich turf of red algae on the kelp stipes and adjacent rock surfaces beneath the algal canopy (Lhyp.Ft). Encrusting bryozoans are abundant on the rock and on the fronds of the algae. A rich assemblage of sponges, colonial ascidians and erect bryozoans are present

amongst the kelp holdfasts. In the lower infralittoral, the density of the kelp decreases to form an open kelp park where the rock surfaces between the kelp plants support a turf of filamentous red algae (Lhyp.Pk; LhypGz.Pk). At approximately 12 m depth, the kelp park ceases and the rock surfaces in the upper circalittoral zone have large colonies of dead-man's fingers *Alcyonium digitatum* and are encrusted with tubeworms *Pomatoceros triqueter* and coralline algae (FaAIC). At the base of the rocky slope is a plain of mixed shell and stone gravel swept into ridges about 10 cm high. Few fauna are recorded, with occasional peacock worms *Sabella pavonina* and sand-eels *Ammodytes* sp. Empty razor shells *Ensis* spp. are present on the surface of the sediment although no live specimens were observed. Approximately 200 m further offshore there is a bedrock reef extending from 14 to 21 m depth and leading to a plain of shell and stone gravel. The bedrock is eroded sandstone with many pits, crevices and short vertical steps; a fine layer of silt covers all rock surfaces. Epibenthic assemblages are characterised by hydroids and the erect bryozoans *Flustra foliacea* and *Securiflustra securifrons*, with the light-bulb sea squirt *Clavelina lepadiformis* near the sediment (AlcSec). At approximately 2 km offshore, a level plain of shelly medium-coarse sand is present at a depth of 37 m. A sparse epibiota was observed with only occasional starfish *Asterias rubens*. Within the sediment, infaunal assemblages are characterised by heart urchins *Echinocardium cordatum*, razor shells *Ensis* sp. and sand-eels *Ammodytes* sp. (IGS).

South of Burnmouth, infralittoral habitats comprise rugged sedimentary bedrock with a dense kelp forest that extends to 10 m depth. Within the kelp forest there are a series of short vertical faces which are extensively bored by the wrinkled rock borer *Hiatella arctica* (AlcByH.Hia). Vertical rock surfaces have a rich epifaunal turf characterised by the sponge *Myxilla incrustans* and solitary ascidians. At a depth of 18 m, there are a series of low-lying rocky reefs in the lower circalittoral which support a dense assemblage of erect bryozoans and colonial ascidians (AlcSec). The bedrock, particularly short vertical steps, is extensively bored by piddocks. These reefs are interspersed with patches of large cobbles and small boulders which support a dense population of the brittlestar *Ophiotrix fragilis* (Oph). Approximately 2 km offshore, the sea bed comprises a level plain of angular limestone boulders set into a mixed stony and muddy sediment at a depth of 30 m. Large colonies of dead-man's fingers *Alcyonium digitatum* and the bottlebrush hydroid *Thuiaria thuja* are present on the tops of the boulders, whilst the sides of the boulders are extensively bored by *H. arctica*. These holes provide a refuge for many small squat lobsters *Galathea* spp. and the brittlestar *Ophiopholis aculeata*. Solitary ascidians, mainly *Ciona intestinalis* and *Polycarpa scuba*, are occasionally found between the stones. At Marshall Meadows Bay, a similar suite of biotopes can be found from the nearshore to approximately 3 km offshore. Close inshore, the sea bed is predominantly low-lying bedrock reef which changes to a plain of mixed stones on sediment further offshore (Oph).

The most southerly site surveyed within this area forms a transect offshore from Seal Carr, located approximately 2 km north of the Tweed estuary. The general character of the sea bed follows that described above except that the bedrock is more rugged and the bedding plains more eroded to form a series of overhangs and gullies. A dense kelp forest characterises the infralittoral zone, with a lush turf of foliose red algae under the kelp canopy. Circalittoral rock is characterised by dead-man's fingers *A. digitatum* and hornwrack *Flustra foliacea* with occasional clumps of the hydroids *Nemertesia antennina* and *Hydrallmania falcata* (Flu.Flu; AlcSec). This species assemblage suggests that these habitats are subject to moderate tidal streams. Further offshore, the sea bed comprises a level plain of mixed stones as described above and in deeper water the diversity of polychaetes, bivalves and echinoderms is greater, reflecting the increased stability of the substratum (AfilEcor).

In summary, sublittoral areas from Eyemouth to the Tweed estuary slope gradually offshore from the sublittoral fringe and are predominantly rocky. Infralittoral habitats are mainly rugged bedrock characterised by a dense kelp forest with a kelp park in the lower infralittoral. Circalittoral habitats are a mixture of low-lying rocky reefs inshore leading to plains of mixed stones on sediment further offshore. Interspersed between these rocky habitats are patches of coarse sediment. South of Burnmouth, the relatively soft sedimentary rocks are often extensively bored by piddocks. Overall, the biotope diversity is lower than areas further north (see Davies 1994) although the mixed nature of the sea bed results in a high species richness for most habitats.

Nature conservation

Conservation sites			
Site name	Designation	Centre grid ref.	Main features
Burnmouth Coast	SSSI	NT 960 610	Geology
Northumberland Shore	SSSI, pSPA	NT 980 575 - NU 010 525	Ornithology, coastal habitats
Tweed Estuary	SSSI	NT 990 553	Ornithology
Berwickshire & North Northumberland Coast	cSAC	NT 980 575	Marine habitats, seals
Northumberland Coast	AONB	NU 185 355	Landscape
North Northumberland	HC	NT 979 576 - NZ 297 933	Landscape
Berwickshire Marine Consultation Area	MCA	NT 915 705	Marine biology

Human influences

Sewage discharge

Overall the coastline is set in a rural area with urban developments restricted to Eyemouth and Berwick-upon-Tweed. Raw sewage is discharged to the sea at Eyemouth (which has a population of approximately 3,500) and there are several storm and emergency overflow outfalls situated north of Berwick-upon-Tweed near the golf course and the holiday camp. During a field visit to Berwick-upon-Tweed recognisable sewage was present on the shore, particularly below the holiday camp and caravan site. There is also a small discharge at Burnmouth (Tweed River Purification Board, pers. comm.).

Industrial effluent discharge

There are no direct industrial discharges into the sea in this survey area, although agricultural chemicals, such as fertilisers and pesticides, may have localised effects on cliff and rocky shore communities.

Commercial fishery

At Burnmouth there is a small fishing community associated with a small harbour, but boat traffic is limited as the harbour is shallow and the entrance is passable only at mid- to high water. Trawlers operate from Eyemouth and Berwick-upon-Tweed. Salmon drift-netting is popular during the summer months in this area and some unlicensed salmon fishing also occurs. Most of the rocky reefs surveyed along this stretch of coastline are potted for lobsters and crabs.

Recreation

Tourism is one of the main industries within the area and large caravan parks are present on the cliff-top at Eyemouth, Marshall Meadows Bay and at Berwick-upon-Tweed. Access to the shore is somewhat limited in this area, although there is a path which runs continuously along the shoreline and cliff-tops.

References and further reading

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Sites surveyed

Surveys

- 313: MNCR littoral survey of south-east Scotland, 1992 (Davies 1994).
- 311: MNCR littoral survey of north-east England, 1992 (Holt 1994).
- 312: MNCR sublittoral survey of south-east Scotland, 1992 (Davies 1994).
- 393: Grab sampling survey of south-east Scotland and north-east England; Analytical and Environmental Services, 1993 (Turner *et al.* 1993).
- 310: MNCR sublittoral survey of north-east England, 1992 (Holt 1994).

Littoral sites					
Survey Site	Site name	Grid reference	Latitude & longitude	Biotores present	
313	12	E of Burnmouth Harbour.	NT 961 609	55°50.4'N 02°03.7'W	Ver.B; Fspi; BPat.Sem; Fves; FK; Ldig.Ldig
313	15	S of Lamberton Skerrs, Burnmouth.	NT 972 589	55°49.4'N 02°02.6'W	Fspi; BPat.Sem; FvesB; Him; Fser.R; FK
313	16	Breeches Rock, Burnmouth.	NT 957 622	55°51.1'N 02°04.1'W	Ver.B; BPat.Cat; BPat.Sem; Him; FK; Ldig.Ldig
313	18	N of Partonhall, Burnmouth.	NT 960 615	55°50.8'N 02°03.8'W	Fser.Fser.Bo
313	44	Nestends, Eyemouth.	NT 950 647	55°52.5'N 02°04.7'W	Ver.B; Pel; BPat.Lic; BPat.Sem; MytB; Fser.R; G; Ldig.Ldig
311	8	N side of Fisherman's Haven, Berwick-upon-Tweed.	NU 004 539	55°46.7'N 01°59.6'W	YG; Pra; Fspi; FvesB; Cor; Ldig.Ldig; MacAre
311	9	N of Ladies Skerrs, Berwick-upon-Tweed.	NU 006 536	55°46.5'N 01°59.4'W	BPat.Sem; Fves; Fser.R; Him; FK; Ldig.Ldig
311	10	Shore at Marshall Meadows Bay, Berwick-upon-Tweed.	NT 984 567	55°48.2'N 02°01.5'W	Pel; Fspi; MytB; FvesB; Him; Cor; Ala.Ldig; Ldig.Ldig

Littoral sites - continued

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotores present</i>
311 11	N of Marshall Meadows Bay, Berwick-upon-Tweed.	NT 983 573	55°48.5'N 02°01.6'W	Fspi; BPat.Sem; AscX FvesX; Cor; Ldig.Ldig
311 21	S of Brotherston's Hole, Berwick-upon-Tweed.	NU 002 547	55°47.1'N 01°59.8'W	Ver.Ver; Fspi; BPat.Sem; Him; Fser.R; FK; SR; SByAs; Ldig.Ldig
311 22	N of Brotherston's Hole, Berwick-upon-Tweed.	NU 000 548	55°47.1'N 02°00.0'W	Fspi; Fves; Ldig.Ldig.Bo

Sublittoral sites

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotores present</i>
312 35	Offshore from Hilton Bay, Burnmouth.	NT 985 590	55°49.4'N 02°01.3'W	Oph
312 36	SE of Hilton Bay, Burnmouth.	NT 974 588	55°49.3'N 02°02.4'W	Lhyp.Ft; LhypGz.Pk; AlcByH.Hia
312 37	E of Ross Carrs, Burnmouth.	NT 964 618	55°50.9'N 02°03.4'W	AlcSec; IGS
312 38	E of Hilton Bay, Burnmouth.	NT 977 590	55°49.4'N 02°02.1'W	AlcSec; FaAlC; Oph
312 39	Offshore Ross Carrs, Burnmouth.	NT 976 621	55°51.1'N 02°02.2'W	IGS
312 40	Ross Carr, Burnmouth.	NT 962 616	55°50.9'N 02°03.6'W	Lhyp.Ft; Lhyp.Pk; FaAlC
393 12	NE of Gungreen Point, Eyemouth.	NT 982 659	55°53.2'N 02°01.7'W	AfilEcor
393 13	ENE of Burnmouth.	NU 009 637	55°52.0'N 01°59.1'W	SspiMx
393 14	E of Ross Point, Eyemouth.	NU 031 604	55°50.2'N 01°56.9'W	AfilEcor
393 15	ENE of Seal Carr, Eyemouth.	NU 058 572	55°48.5'N 01°54.4'W	AfilEcor
393 16	E of Seal Carr, Berwick-upon-Tweed.	NU 059 550	55°47.3'N 01°54.3'W	AfilEcor
310 27	Offshore Marshall Meadows, Berwick-upon-Tweed.	NT 999 571	55°48.4'N 02°00.0'W	Oph
310 28	Offshore Seal Carr, Berwick-upon-Tweed.	NU 017 550	55°47.3'N 01°58.3'W	Oph
310 29	E of Marshall Meadows Bay, Berwick-upon-Tweed.	NT 995 567	55°48.2'N 02°00.4'W	AlcSec
310 30	Marshall Meadows, Berwick-upon-Tweed.	NT 990 567	55°48.2'N 02°00.9'W	FaAlC
310 31	Seal Carr, Berwick-upon-Tweed.	NU 006 545	55°47.0'N 01°59.3'W	Lhyp.Ft; AlcByH
310 32	E of Marshall Meadows, Berwick-upon-Tweed.	NT 997 568	55°48.2'N 02°00.2'W	AlcSec
310 33	NE of Seal Carr, Berwick-upon-Tweed.	NU 007 548	55°47.2'N 01°59.3'W	AlcSec
310 34	NNE of Seal Carr, Berwick-upon-Tweed.	NU 007 546	55°47.1'N 01°59.2'W	Flu.Flu

Compiled by: Rohan Holt

Tweed estuary

Location

<i>Position (centre)</i>	NT 980 530	
<i>County/District</i>	Northumberland	Berwick-upon-Tweed
<i>Conservation agency/area</i>	English Nature	Northumbria

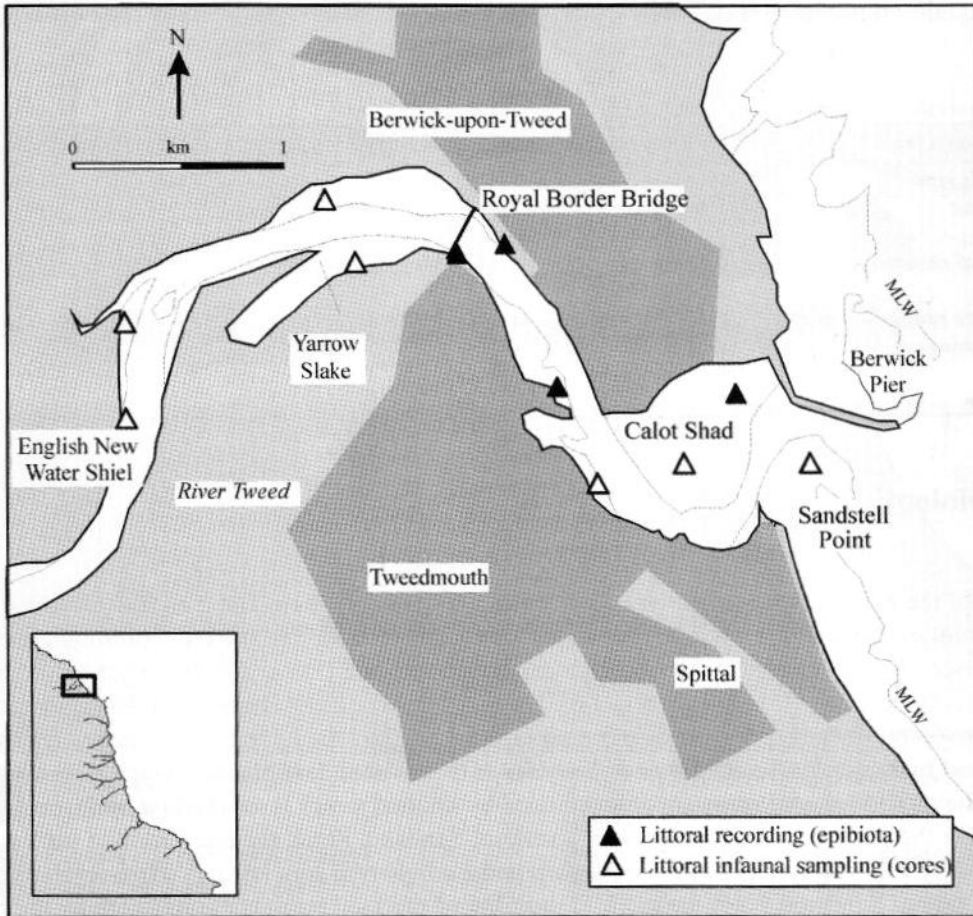


Figure 7.1 Location of area showing sites surveyed and main bathymetric features.

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Marine biological surveys

	<i>Survey methods</i>	<i>No. of sites</i>	<i>Date of survey</i>	<i>Source</i>
<i>Littoral</i>	Recording	4	September 1992	Brazier & Murray (1994)
	Infaunal cores and granulometry	7	September 1992	Brazier & Murray (1994)

Introduction

The Tweed is a long, narrow estuary with substantial sandbanks at the mouth and banks of intertidal cobbles extending upstream from the mouth of the estuary. Two kilometres upstream from the estuary mouth there are road and railway bridges, upstream of which the river is fairly shallow at low tide. Downstream of the bridges shipping access to the small dock is maintained by dredging and therefore a deep channel is present in the centre of the estuary. The tidal streams are highly variable throughout the estuary, although most of the intertidal areas experience high tidal streams during tidal change and currents from the fast-flowing river.

The water quality throughout the Tweed estuary has been classified as grade 'A' by the National Rivers Authority.

Physical features

<i>Physiographic type</i>	Complex estuary
<i>Length of coast</i>	26 km
<i>Area of inlet</i>	230 ha
<i>Length of tidal channel</i>	13.3 km
<i>Bathymetry</i>	Shallow river
<i>Wave exposure range</i>	Moderately exposed to very sheltered
<i>Tidal stream range</i>	Strong to negligible
<i>Tidal range</i>	4.1 m (springs), 2.5 m (neaps)
<i>Salinity range</i>	Fully marine to low

Marine biology

Littoral

The mouth of the estuary is protected by Berwick Pier on the north shore and a wide sand spit at Sandstell Point on the south shore. On the pier and the adjacent bedrock, the mid eulittoral community is characterised by bladder wrack *Fucus vesiculosus* and barnacles (Fves) and the upper eulittoral zone on the pier is characterised by a sparse cover of spiral wrack *F. spiralis* (Fspi). The lower shore rocky outcrops associated with the pier appear more estuarine and silted than those on the steep pier wall and are dominated by barnacles *Semibalanus balanoides* with less abundant bladder wrack *F. vesiculosus* (FvesX). The more sheltered areas are characterised by knotted wrack *Ascophyllum nodosum* (Asc.VS). On the exposed, east-facing sandy shores of Sandstell Point, the clean mobile sand is characterised by the crustaceans *Eurydice pulchra* and *Bathyporeia* spp. (AEur). As a result of shelter on the west side of Sandstell Point the reduced mobility of the sand permits colonisation by the robust polychaetes *Paraonis fulgens* and *Scolecopsis squamata* and amphipods; few other polychaetes are present (AP.P).

The west-facing lower shores of Sandstell Point and Calot Shad, the top of Calot Shad, and the level cobble area beneath the bridges are exposed to rapid river flow across them. The characterising species in these areas are the ephemeral algal species *Porphyra purpurea* and *Enteromorpha* spp. (EntPor; EphX), which reflects the instability of the substrata and the exposure to scour. Stable, medium and fine sand is found on the more exposed eastern side of Calot Shad, although this is not as exposed as Sandstell Point. Consequently, this level sandflat is characterised by numerous polychaete species, especially *Eteone longa*, *Arenicola marina* and *Capitella capitata* (AP.P; MacAre). There are also brackish water-tolerant oligochaetes *Heterochaeta costatus* and *Tubificoides pseudogaster* present.

An ephemeral habitat is recorded at the lower shore of the river bend at Sandstell Point and also at English New Water Shiel, where the river flow continually erodes the banks. The muddy gravel is characterised by very few species, but typically enchytraeid oligochaetes are found. This biotope (OI) is probably present at most times along the estuary, but is likely to be transient depending on the river flow. Small patches of hard substrata that are less exposed to tidal streams and scour are characterised

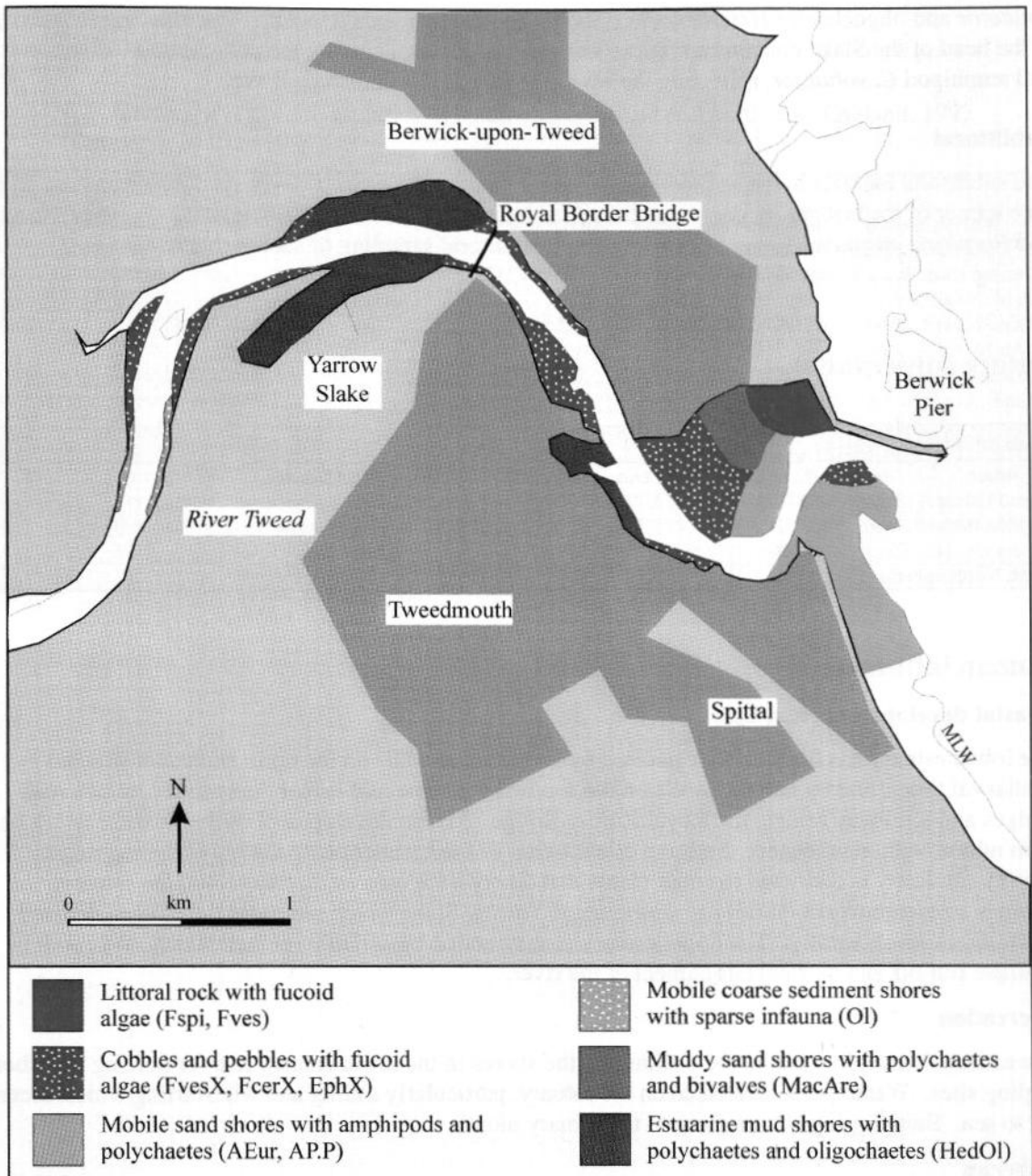


Figure 7.2 Indicative distribution of the main biotopes in the area (based on data from survey sites shown in Figure 7.1 and additional field observations).

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by furoid algal cover. Bladder wrack *Fucus vesiculosus* is predominant on a boulder pile, in sheltered areas on Calot Shad and on a silted rocky outcrop east of the harbour. Further upstream, *F. vesiculosus* is gradually replaced by the reduced salinity-tolerant wrack *F. ceranoides* and green algae *Enteromorpha* spp. *Fucus ceranoides* (FcerX) ranges from Calot Shad, where there are silted bedrock outcrops and boulders, to the highest recorded site upstream at English New Water Shiel where the substratum is of gravel and sand.

On the south shore upstream of the Royal Border bridge the old river route forms a muddy inlet known as Yarrow Slake. The sheltered muddy sand here, just east of the harbour and also at two sites upstream of the bridges, is characterised by the polychaete *Hediste diversicolor*, amphipod *Corophium*

volutator and oligochaetes *Heterochaeta costatus* and enchytraeids (HedOI). The especially fluid mud at the head of the Slake contains a reduced number of species including the polychaete *H. diversicolor* and amphipod *C. volutator*, reflecting the severe anoxia at this undisturbed site.

Sublittoral

The sublittoral habitats in the shallow parts of the estuary, such as the tide-swept cobbles and gravel in the vicinity of the bridges, appear to be colonised by the same characterising algae, *Enteromorpha* spp. and *Porphyra purpurea*, as the littoral habitats. Sublittoral sampling of such a shallow and fast flowing river was impractical.

Nature conservation

Conservation sites			
Site name	Designation	Centre grid ref.	Main features
Tweed Estuary	SSSI	NT 990 553	Ornithology
Northumberland Shore	SSSI, pSPA	NT 980 575 - NU 010 525	Ornithology
Northumberland Coast	AONB	NU 185 355	Landscape
North Northumberland	HC	NT 979 576 - NZ 297 933	Landscape

Human influences

Coastal developments and uses

The lower estuary has been partly canalised by fortification walls on the north shore, constructed in mediaeval times, and by harbour walls on the south shore. The mid-estuary is spanned by two road bridges and a railway bridge, the Royal Border Bridge. Recent development of the Tweed estuary has been minor, with maintenance dredging downstream of the harbour being the only ongoing major activity. Industry is restricted to small plants that do not back onto or discharge into the estuary. There is a sewage works outfall just upstream of Yarrow Slake which increases the oxygen demand and nutrient levels locally. The upper estuary is surrounded by agricultural land which may result in fertiliser run-off and nutrient enrichment of the river.

Recreation

The estuary is used by visitors for walking on the shores in the lower estuary and for boating to inshore angling sites. Watersports take place on the estuary, particularly sailing and windsurfing which occur out to sea. Bait-digging occurs close to the estuary mouth.

Fisheries

There is a long-established licensed trout and salmon fishery on the River Tweed and estuary; unlawful poaching of salmon also occurs.

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Survey sites

Surveys

314: MNCR littoral survey of the estuaries of south-east Scotland and north-east England, 1992
(Brazier & Murray 1994).

Littoral sites					
<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & Longitude</i>	<i>Biotopes present</i>	
314	1	Sandstell Point.	NU 006 523	55°45.8'N 01°59.4'W	EphX; AEur; AP.P
314	2	Berwick Pier.	NU 005 525	55°45.9'N 01°59.5'W	Fspi; FvesX; Fves; Asc.VS; EphX; MytX
314	3	Calot Shad.	NU 002 523	55°45.8'N 01°59.8'W	FvesX; Fves; FcerX; EphX; AP.P; MacAre
314	4	Tweed SW shores.	NT 998 522	55°45.7'N 02°00.1'W	Fves; FcerX; HedOl
314	5	Berwick Bridges.	NT 995 527	55°46.0'N 02°00.4'W	EntPor; FcerX; EphX
314	6	Berwick Town shore.	NT 995 531	55°46.2'N 02°00.4'W	FcerX
314	7	S shore at Lower Pool.	NT 992 532	55°46.3'N 02°00.7'W	FcerX
314	8	Yarrow Slake.	NT 985 530	55°46.2'N 02°01.4'W	HedOl
314	9	North shore Lower Pool.	NT 987 534	55°46.4'N 02°01.2'W	FcerX; HedOl
314	10	E of New Water Haugh.	NT 978 528	55°46.1'N 02°02.1'W	FcerX; HedMac.Pyg
314	11	NE English New Water Shiel.	NT 978 524	55°45.9'N 02°02.1'W	FcerX; Ol

Compiled by: Paul Brazier & Eleanor Murray

Tweed estuary to Bamburgh

Location

<i>Position (centre/limits)</i>	NU 100 430	NU 011 524 - NU 185 352
<i>County/District</i>	Northumberland	Berwick-upon-Tweed
<i>Conservation agency/area</i>	English Nature	Northumbria

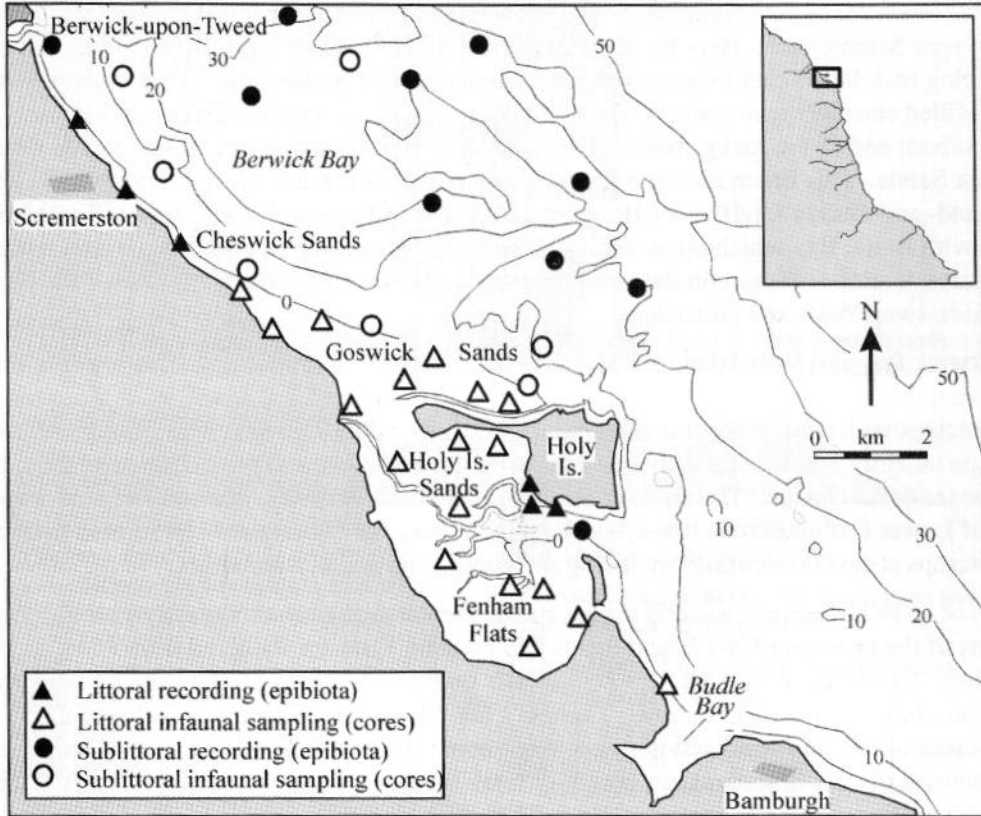


Figure 8.1 Location of area showing sites surveyed and main bathymetric features.

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Marine biological surveys

<i>Survey methods</i>		<i>No. of sites</i>	<i>Date of survey</i>	<i>Source</i>	
<i>Littoral</i>	Recording	6	September 1987 April 1988 July 1992	Connor (1989) Connor (1989) Holt (1994)	
	Infaunal cores and granulometry	18	September 1987 July 1992	Connor (1989) Holt (1994)	
	<i>Sublittoral</i>	Recording	10	September 1987 July 1992	Connor (1989) Holt (1994)
		Infaunal cores and granulometry	7	July 1992	Holt 1994

Introduction

This area includes the open coast from Spittal Point, south of the entrance to the River Tweed, to Bamburgh, west of Budle Bay. The sheltered coastline of Budle Bay and the north and east coastlines of Holy Island are considered in other summaries (9. Budle Bay and 10. Holy Island (N & E) and the Farne Islands, respectively). The coastline from the Tweed estuary to Bamburgh is very sparsely populated, with only a few farms and small villages amongst agricultural land. Access to the shore is limited to minor roads and footpaths and there is a causeway, which floods at high tide, from the mainland to Holy Island.

A broad sand beach runs south from the mouth of the River Tweed, interrupted by just over 3 km of rocky shore near Scremerston. Here the shore is backed by moderately high cliffs and has unusual steeply-dipping rock layers that form high ridges running parallel to the shore. These ridges form long, water-filled channels with deep, steep-sided rockpools and rockmills. Three sand-scoured skerrs mark the southern end of the rocky shores. The sandy beach continues south, widening into Cheswick and Goswick Sands. This beach is over 4 km long and broadens towards Holy Island; it includes the extensive sand- and muddy sandflats of Holy Island Sands and Fenham Flats. These sediment flats are continuous with Budle Bay which opens onto a more exposed sand beach near Bamburgh Castle. The sediment plains continue offshore in the northern parts of Berwick Bay; the south side of the Bay has a number of tide-swept reefs and pinnacles.

Parts of Berwick Bay and Holy Island are key sites for coastal geomorphology. This area has one of only four examples in England and Wales of a barrier-type beach and is the only example in the North Sea that coincides with conditions of coastal emergence rather than submergence. The raised beach of Flandrian age on Holy Island is the only one known on the east coast and provides important dateable evidence for sea-level change. The shore at Spittal, just south of Berwick-upon-Tweed, has important exposures of Lower Carboniferous rocks, and Whin Sill (very hard quartz dolerite formed from fluid magma) outcrops at several locations including on Holy Island and at Bamburgh.

This stretch of coast has a north-easterly aspect and is, for the most part, moderately exposed to wave action. Parts of the extensive Holy Island Sands and Fenham Flats are sheltered from wave action in the lee of Holy Island. Tidal streams flow southwards on the flood and generally slower northwards on the ebb, and follow the coastal outline. There is a net flow of water southwards due to the combined forces of tide and wind action. This long-shore drift carries small amounts of suspended sediment southwards. Tidal streams are generally weak but run faster over a series of reefs at the south-east side of Berwick Bay approximately 5-7 km offshore.

Surface water temperatures range from 6°C in winter to 13°C in summer, although local variations can occur depending upon weather conditions. Salinity is fully marine (approximately 35‰) on the open coast but is locally reduced on parts of Fenham Flats and Holy Island Sands where small creeks and streams run across the area.

Physical features

<i>Physiographic type</i>	Open coast
<i>Length of coast</i>	20 km
<i>Bathymetry</i>	30 m isobath within 7 km of shore; 50 m isobath within 10 km of shore
<i>Wave exposure range</i>	Exposed to sheltered
<i>Tidal stream range</i>	Strong to negligible
<i>Tidal range</i>	4.2 m (springs), 2.2 m (neaps)
<i>Salinity range</i>	Fully marine

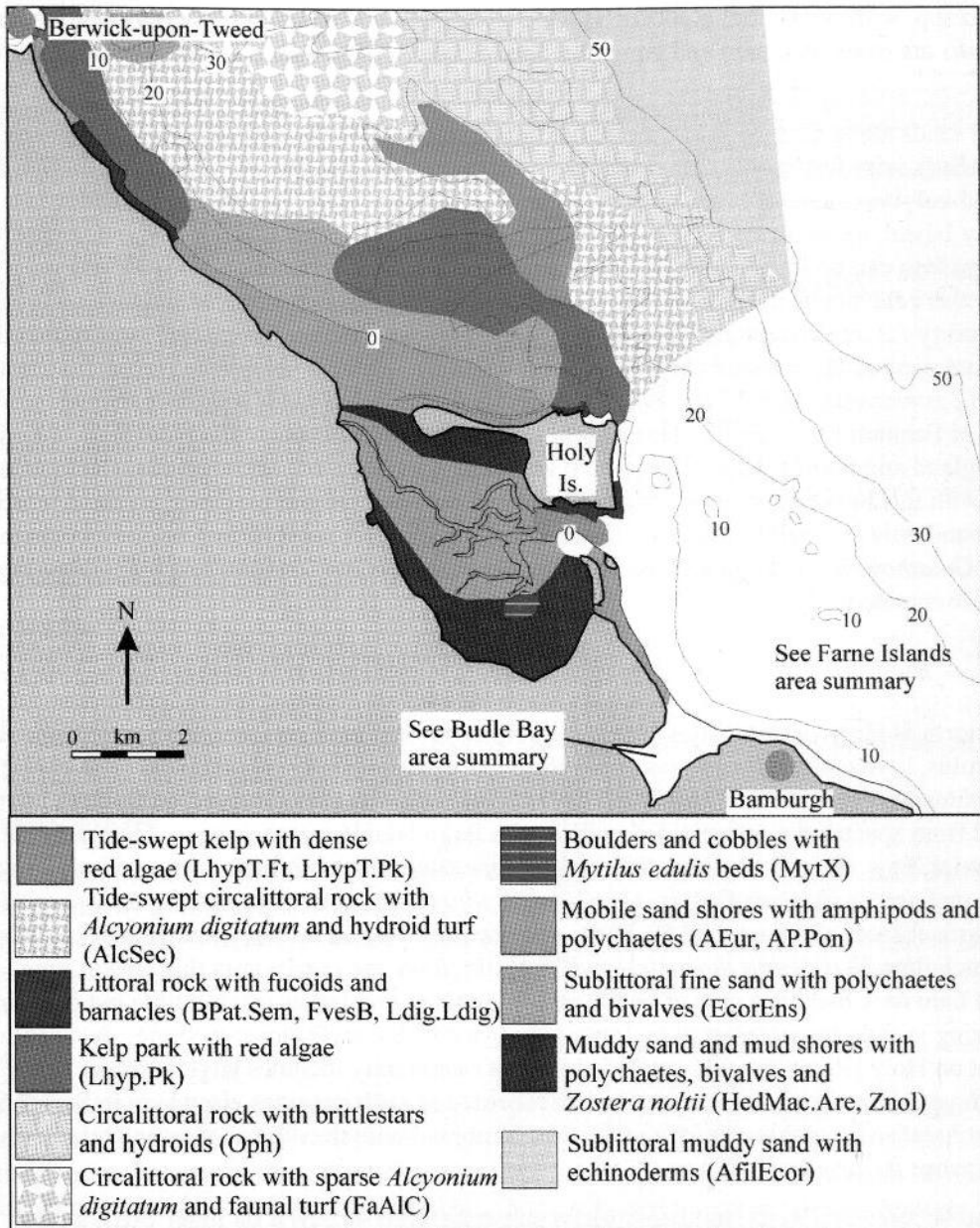


Figure 8.2 Indicative distribution of the main biotopes within the area (based on data from survey sites shown in Figure 8.1 and additional field observations).

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Marine biology

Littoral

The highly ridged rocky shores near Scremerston have both barnacle- and fucoid-dominated biotopes as well as long, deep rockpools (FK) running in line with the ridges. The animals and plants are distributed according to localised levels of wave exposure. Dense fucoids are found in the lee of the high ridges, whereas barnacles and limpets dominate their steep and exposed sides (FvesB).

The small bedrock outcrops on sand at Cheswick Black Rocks support biotopes typical of sand-scoured conditions. Opportunistic colonisers such as the algae *Porphyra purpurea* and *Enteromorpha* spp. are common, often on top of thick mats of sediment bound to the rock surface by the red algae

Audouinella spp. with occasional plants of *Mastocarpus stellatus*. Small, tightly-bunched mussels *Mytilus edulis* are often abundant and barnacles *Semibalanus balanoides* colonise patches of bare rock (MytFR).

The mobile sands along Cheswick and Goswick Sands support crustacean/polychaete-dominated biotopes (AEur), with few species other than the lugworm *Arenicola marina*, haustoriid amphipods and the sand-eel *Ammodytes tobianus*. With increasing stability in the more sheltered sediments behind Holy Island, more bivalves including the banded wedge shell *Donax vittatus* and striped venus *Chamelea gallina* can be found, often with the sand mason worm *Lanice conchilega* (AP.Pon). Mussel *Mytilus edulis* beds have colonised the sediment surface where scattered pebbles and shells provide stability for attachment and growth, particularly in the areas on the east side of Fenham Flats and south and west of Holy Island (MytX). The mussels also provide anchorage for furoid algae. Eelgrasses (*Zostera noltii* and *Z. angustifolia*) cover the beds of fine muddy sand on the west and south-west of Fenham Flats (Znol). This area holds the largest example of this biotope on the east coast of England and Scotland and is important as a feeding ground for wading birds. The fauna associated with this biotope includes a high diversity of polychaetes and molluscs, some of which are absent or found only in small numbers on the rest of the north-east coast of England. For example, the polychaete *Galathowenia oculata* and the sea slug *Akera bullata* are found in relatively large numbers in this area compared to the rest of Sector 5.

Sublittoral

A dense kelp forest, swept by strong tides, was surveyed on Park Dyke, a reef of terraced bedrock plains just north of Holy Island (Lhyp.TFt). The kelp stipes and rock surfaces are covered in a rich turf of hydroids, bryozoans, filamentous and foliose red algae and colonial ascidians such as star squirt *Botryllus schlosseri*. Lower infralittoral and circalittoral rock was also surveyed on Spittal Hurst, a reef formed from spectacular, steep-sided gullies with large boulders at their base, situated at the east side of Berwick Bay. Kelp park (Lhyp.TPk) with dense stipe flora and fauna fringes the shallowest parts of the reef and dead-man's fingers *Alcyonium digitatum* and the tubeworm *Pomatoceros triqueter* cover the vertical faces amongst the kelp parks and occur on rock in deeper water (FaAIC; AlcSec). Hydroids, including *Nemertesia antennina* and *Thuiaria thuja*, are common in this area. Large expanses of bare rock had been grazed by the urchin *Echinus esculentus* leaving little but coralline algae. Grazing is even more apparent on Inner Hurst, one of the reefs closer to shore. Just south of Castle Point on Holy Island, the tide-swept kelp forest community includes large numbers of the bryozoan *Alcyonidium diaphanum*, a species not recorded in such densities elsewhere in Sector 5. It is possible that localised variable salinity conditions, combined with the effects of strong tidal streams and scour, favour its development here.

Heavily sand-scoured and sand-smothered rocky substrata were surveyed on Inner Buss, a small reef of rocky outcrops on the sand plains just off Berwick-upon-Tweed. Recent rough seas had shifted sediment onto the reef just prior to the survey in 1992, as many kelp plants were found attached to rocks buried under several centimetres of clean sand. High densities of a few species of opportunistic colonisers and species tolerant to siltation and scour, including mussels *Mytilus edulis* and a brown alga, sea oak *Halidrys siliquosa* (XKScrR), are recorded at this site.

Most of the sublittoral sediments within Berwick Bay comprise fairly uniform, medium clean sand. The heart urchin *Echinocardium cordatum* and razor clams *Ensis siliqua* and *E. arcuatus* are present at high densities and the sand mason worm *Lanice conchilega* is found at most sites (EcorEns). In deeper water (over 25 m) offshore from Goswick Bay, the sediments are less well sorted. Muddy gravel and sand, some formed into large ripples, support a variety of fauna including ascidians, great scallops *Pecten maximus* and hydroids attached to the larger pebbles and small boulders. This biotope is found close to cobble and boulder plains that support species typically found on other rocky substrata in the area such as brittlestars, tubeworm *Pomatoceros triqueter* and the hydroids *Abietinaria abietina* and *Thuiaria thuja* (Oph).

Nature conservation

Conservation sites			
Site name	Designation	Centre grid ref.	Main features
Lindisfarne	NNR, SSSI, Ramsar, SPA	NU 100 430	Coastal habitats and flora, ornithology, invertebrates, marine habitats, geology
Northumberland Shore	SSSI, pSPA	NT 980 575 - NU 010 525	Ornithology
Bamburgh Coast and Hills	SSSI	NU 167 355	Geology, flora
Berwickshire & North Northumberland coast	cSAC	NT 980 575	Marine habitats, seals
North Northumberland Dunes	cSAC	NT 980 575	Dune vegetation
Holy Island and the Farnes	SMA	NU 255 385	Marine biology
Northumberland Coast	AONB	NU 185 355	Landscape
North Northumberland	HC	NT 979 576 - NZ 297 933	Landscape
Cocklawburn Dunes	WT	NU 033 481	Coastal habitats

Human influences

Sewage discharge

There are several minor sewage outfalls in the area: on Holy Island which discharges sewage after preliminary treatment; at Haggerston; two at Scremerston - a storm drain and an emergency overflow; one at Fenham and three in Bamburgh - two discharge crude sewage and one is an emergency storm overflow (National Rivers Authority data).

Commercial fishery

There are a number of fishing boats based in Berwick-upon-Tweed and on Holy Island which fish in this area, mainly by long-lining or beam-trawling. There is also a salmon-netting fishery which is based in Berwick-upon-Tweed and which fishes also along Cheswick Sands. The reefs in Berwick Bay are potted for crabs and lobsters. Oysters are cultivated at Old Law on the south-east point of Fenham Flats.

Wildfowling

A study by the University of Durham (Palmer & Evans 1991) has shown that the sediments in this area, particularly on Fenham Flats, have an unnaturally high lead content originating from large numbers of spent shot-gun pellets. Bait-digging in the area causes lead compounds to be released from the sediment as the surface layers are turned over. In turn the lead is taken up by eelgrasses *Zostera* spp. which is then eaten by wildfowl. However the lead content of the sediments is thought to be below critical levels (Palmer & Evans 1991).

Bait-digging

Bait-digging has been banned in Budle Bay and in the NNR is controlled by by-laws, apart from in the 125 ha immediately north and south of the causeway to Holy Island which is the permitted area for bait-digging. There have been a number of court cases regarding bait-digging and at present the situation is being contested by local angling groups. Bait-digging in the area disturbs waders and wildfowl and the sediment epifauna (mussel beds) and infauna, particularly in intensively and commercially dug areas (Townsend & O'Connor 1993).

Recreation

A large number of visitors use the causeway across to Holy Island each year to visit the priory and castle. This area is also popular with walkers and bird-watchers. Sea anglers take boat trips from Berwick out to Spittal Hirst in Berwick Bay. At the time of the survey over half a dozen boats were present at one time. Discarded and lost fishing tackle, along with refuse such as cans and bottles, were found on the sea bed in this area.

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Survey sites

Surveys

- 311: MNCR littoral survey of north-east England, 1992 (Holt 1994).
- 112: MNCR littoral and sublittoral survey of Berwick to Beadnell including the Farne Islands (Connor 1989).
- 310: MNCR sublittoral survey of north-east England, 1992 (Holt 1994).

Littoral sites

Survey Site	Site name	Grid reference	Latitude & longitude	Biotopes present
311 12	Huds Head to Redshin Cove, Berwick-upon-Tweed.	NU 015 505	55°44.8'N 01°58.5'W	Pra; Ver.B; Fspi; BPat.Sem; MytB; FvesB; Fves; Fser.Fser; Fser.Fser.Bo; SwSed; Ldig.Ldig
311 13	Cheswick Sands.	NU 051 462	55°42.6'N 01°55.1'W	AEur; AP.Pon
311 14	Cheswick Black Rocks.	NU 039 477	55°43.3'N 01°56.2'W	Ver.B; MytFR
311 15	NE of Goswick Sands.	NU 055 467	55°42.8'N 01°54.7'W	AEur; AP.Pon
311 16	NE of the Snook shore.	NU 115 439	55°41.3'N 01°49.0'W	AP.Pon

Littoral sites - continued

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>
112 1	Saltpan Rocks, Scremerston.	NU 025 494	55°44.2'N 01°57.6'W	YG; Ver.Por; PelB; Fspi; MytB; FvesB; Fser.R; Fser.Fser.Bo; G; Cor; FK; Ala.Ldig
112 2	E of Goswick, Goswick Sands.	NU 070 459	55°42.3'N 01°53.3'W	AP.Pon
112 3	Off Longbridge End, Goswick Sands.	NU 079 437	55°41.2'N 01°52.4'W	MacAre
112 4	N of Snook Point, Goswick Sands.	NU 093 444	55°41.5'N 01°51.1'W	AEur
112 5	N of The Snook, Goswick Sands.	NU 098 447	55°41.7'N 01°50.6'W	AP.P
112 6	W of Snipe Point, Goswick Sands.	NU 113 439	55°41.3'N 01°49.2'W	AEur
112 7	S of Causeway, Holy Island Sands.	NU 089 424	55°40.5'N 01°51.5'W	AP.Pon
112 8	SE of The Snook, Holy Island Sands.	NU 108 430	55°40.8'N 01°49.6'W	HedMac.Are
112 9	NW of Chare Ends, Holy Island Sands.	NU 117 428	55°40.7'N 01°48.8'W	HedOl
112 10	E of The Cages, Holy Island Sands.	NU 107 418	55°40.1'N 01°49.7'W	AP.Pon
112 11	N of Teahole Point, Fenham Flats.	NU 104 401	55°39.2'N 01°50.0'W	Znol; HedMac
112 12	NW of Cockly Knowes, Fenham Flats.	NU 118 388	55°38.5'N 01°48.7'W	Znol
112 13	SW of Guile Point, Fenham Flats.	NU 119 399	55°39.1'N 01°48.6'W	AP.P
112 14	By Stinking Goat, Fenham Flats.	NU 123 397	55°39.0'N 01°48.2'W	MytX
112 15	NE of Jack's Waste, Fenham Flats.	NU 127 395	55°38.9'N 01°47.8'W	Znol
112 19	NE of Ross, Ross Back Sands.	NU 149 377	55°37.9'N 01°45.8'W	AP.Pon
112 84	The Priory, Holy Island.	NU 127 416	55°40.0'N 01°47.8'W	YG; Ver.Ver; PelB; Fspi; AscX; FvesX; Fser.Fser; Fser.Fser.Bo; BLlit; Ldig.Ldig.Bo
112 85	Chapel Channel, Holy Island.	NU 123 417	55°40.1'N 01°48.2'W	MytX
112 86	Chapel Remains, Holy Island.	NU 123 417	55°40.1'N 01°48.2'W	YG; Ver.Ver; PelB; Fspi; BPat.Sem; Fves; Asc.Asc; FserX; MytX; Cor; FK

Sublittoral sites

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>
112 45	Burrow Hole, Holy Island.	NU 134 410	55°39.7'N 01°47.2'W	Lhyp.TFt; Lhyp.TPk
310 35	Northern Berwick Bay.	NU 047 534	55°46.4'N 01°55.5'W	AfilEcor
310 36	E of Berwick Harbour.	NU 022 520	55°45.6'N 01°57.8'W	EcorEns
310 37	Spittal Hurst, Berwick-upon-Tweed	NU 094 521	55°45.7'N 01°50.9'W	Lhyp.TPk; FaAIC
310 38	Jocks Linn, Berwick-upon-Tweed.	NU 032 490	55°44.0'N 01°56.8'W	EcorEns
310 39	Berwick Bay.	NU 053 504	55°44.8'N 01°54.8'W	AlcSec
310 40	Inner Buss, Berwick Bay.	NU 014 517	55°45.5'N 01°58.6'W	XKScrR; IGS
310 41	Inner Hirst, Berwick-upon-Tweed.	NU 088 504	55°44.8'N 01°51.5'W	FaAIC; Oph
310 42	North Beanstack, Berwick-upon-Tweed.	NU 088 474	55°43.2'N 01°51.5'W	FoR; Lhyp.Pk; AlcByH.Hia
310 43	E of Outer Tours, Berwick-upon-Tweed.	NU 116 489	55°44.0'N 01°48.8'W	AlcSec
310 44	Goswick Bay.	NU 069 522	55°45.7'N 01°53.3'W	CGS
310 45	Park Dyke, Berwick-upon-Tweed.	NU 115 466	55°42.8'N 01°48.9'W	Lhyp.TFt
310 46	Goswick Sands.	NU 086 454	55°42.1'N 01°51.7'W	NcirBat
310 47	Off Cheswick Sands.	NU 058 469	55°42.9'N 01°54.4'W	Lcon
310 49	NW of Snipe Point, Holy Island.	NU 118 441	55°41.4'N 01°48.7'W	EcorEns
310 51	1 mile N of Back Skerrs, Berwick-upon-Tweed.	NU 126 450	55°41.9'N 01°47.9'W	Lcon; FabMag
310 52	N of Castlehead Rocks, Berwick-upon-Tweed.	NU 131 459	55°42.4'N 01°47.4'W	Oph

Compiled by: Rohan Holt

Budle Bay

Location

<i>Position (centre)</i>	NU 150 360	
<i>County/District</i>	Northumberland	Berwick-upon-Tweed
<i>Conservation agency/area</i>	English Nature	Northumbria

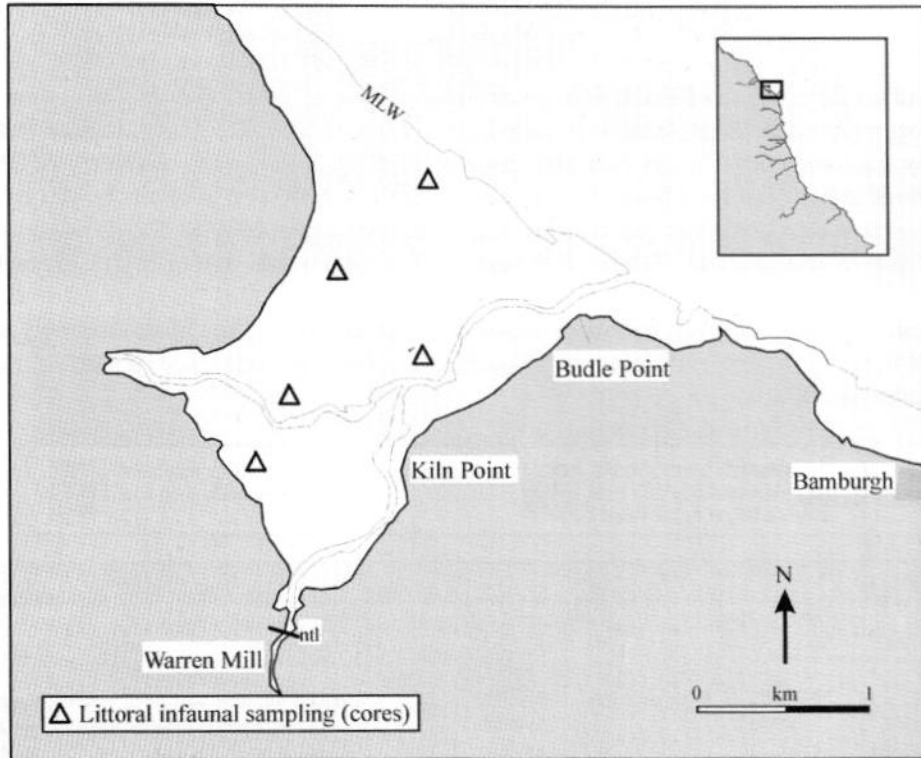


Figure 9.1 Location of area showing sites surveyed and main bathymetric features.

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Marine biological surveys

	<i>Survey methods</i>	<i>No. of sites</i>	<i>Date of survey</i>	<i>Source</i>
<i>Littoral</i>	Infaunal cores and granulometry	5	September 1987 July 1991	Connor (1989) Evans <i>et al.</i> (1994)

Introduction

The embayment of Budle Bay, north of Bamburgh Castle, is moderately exposed to the North Sea. The bay is afforded some shelter by Holy Island to the north but the south-east of the bay is more exposed to the predominantly north-easterly winds. The innermost parts of the bay are more sheltered. The bay consists of littoral sandflats, with a higher muddy component in the inner, westernmost area of the bay, and two small streams flow across Budle Bay from the south and from the west.

Physical features

<i>Physiographic type</i>	Embayment
<i>Length of coast</i>	3 km
<i>Area of inlet</i>	300 ha
<i>Length of tidal channel</i>	2.0 km
<i>Bathymetry</i>	Intertidal
<i>Wave exposure range</i>	Moderately exposed to sheltered
<i>Tidal stream range</i>	Weak to negligible
<i>Tidal range</i>	4.2 m (springs), 2.2 m (neaps)
<i>Salinity range</i>	Fully marine to variable

Marine biology**Littoral**

The exposed and uniform nature of Budle Bay gives a low habitat diversity, and thus only four biotopes have been recorded. The clean, well-sorted sand at low water and adjacent to Kiln Point is characterised by the robust polychaetes *Paraonis fulgens* and *Scolecopsis squamata* (AP.P; AP.Pon). The more sheltered area of flat muddy sand in the west of the bay, however, is characterised by the polychaetes *Scoloplos armiger*, *Pygospio elegans*, *Capitella capitata* and *Arenicola marina*, oligochaetes *Heterochaeta costatus*, *Tubificoides benedii*, *T. pseudogaster* and enchytraeids and the amphipod *Corophium volutator* (HedMac.Are; MacAre). Bivalves, including thin tellin *Angulus tenuis*, Baltic tellin *Macoma balthica* and *Abra tenuis*, are also recorded in the more sheltered areas. The presence of the polychaete *C. capitata* and oligochaetes reflects the influence of nutrient-rich sediment and reduced salinity.

Nature conservation**Conservation sites**

<i>Site name</i>	<i>Designation</i>	<i>Centre grid ref.</i>	<i>Main features</i>
Northumberland Shore	SSSI, pSPA	NT 980 575- NU 010 525	Ornithology
Lindisfarne	NNR, SSSI, Ramsar, SPA	NU 100 430	Coastal habitats and flora, ornithology, invertebrates, marine habitats, geology
Berwickshire and North Northumberland Coast	cSAC	NT 980 575	Marine habitats, seals
North Northumberland Dunes	cSAC	NT 980 575	Dune vegetation
Holy Island and the Farnes	SMA	NU 255 385	Marine biology
Northumberland Coast	AONB	NU 185 355	Landscape
North Northumberland	HC	NT 979 576 - NZ 297 933	Landscape

Human influences**Coastal developments and uses**

Development around the bay is limited to occasional cottages and farms to the south-west, with farmland landward of the bay. Bait-digging is prohibited in Budle Bay under Section 29 of the Wildlife and Countryside Act 1981. The water quality (in 1993) of the freshwater inputs was designated as grade 'A' by the National Rivers Authority.

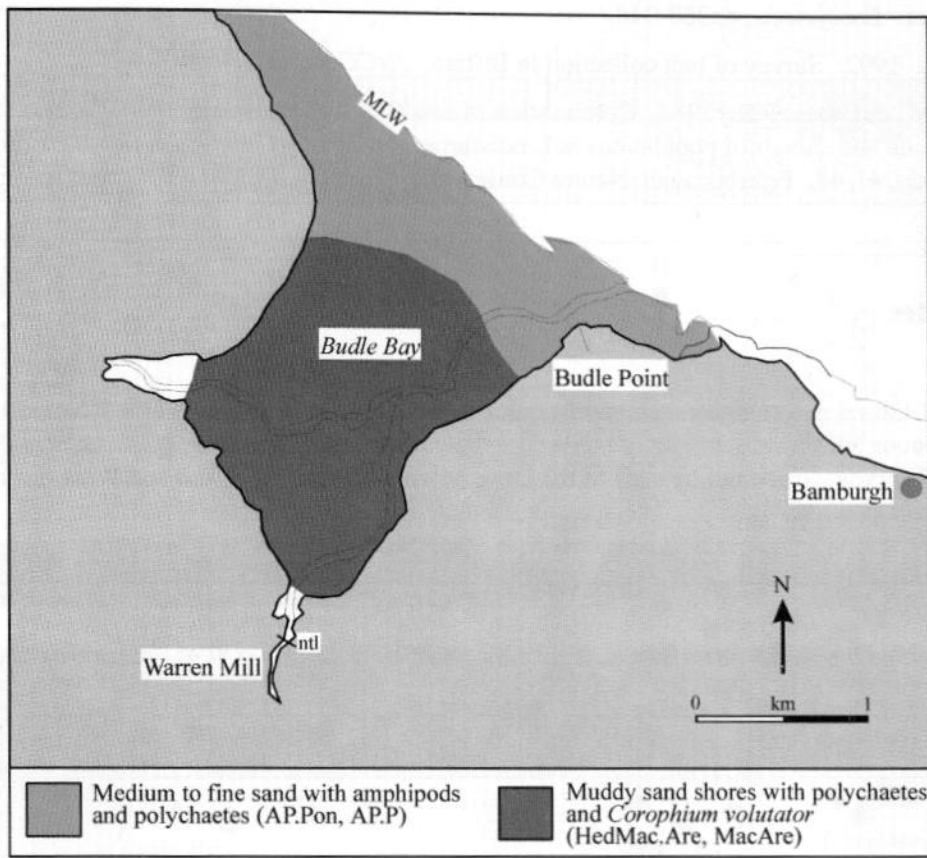


Figure 9.2 Indicative distribution of the main biotopes in the area (based on data from survey sites shown in Figure 9.1 and additional field observations and cited literature).
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Recreation

Recreational activities include power-boating, sailing and windsurfing in Budle Bay. The whole of Budle Bay is excluded from wildfowling, providing sanctuary for the numerous species of waders, wildfowl and migrants birds.

References and further reading

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Survey sites

Surveys

- 112: MNCR littoral and sublittoral survey Berwick to Beadnell including the Farne Islands, 1989 (Connor 1989).
- 317: Littoral survey carried out by staff of the Dove Marine Laboratory, Tyne and Wear during 1991 (Evans *et al.* 1994).

Littoral sites

Survey Site	Site name	Grid reference	Latitude & longitude	Biotopes present
112	20 N of Budle, Budle Bay.	NU 158 368	55°37.4'N 01°44.9'W	AP,Pon
112	21 W of Budle Point, Budle Bay.	NU 150 362	55°37.1'N 01°45.7'W	MacAre
112	22 SE of Links End, Budle Bay.	NU 149 357	55°36.8'N 01°45.8'W	HedMac.Are
112	23 E of Cockle Ridge, Budle Bay.	NU 145 353	55°36.6'N 01°46.1'W	MacAre
317	2 Mid Budle Bay.	NU 147 356	55°36.8'N 01°45.9'W	AP,P; MacAre; HedMac.Are

Compiled by: Paul Brazier

Location

<i>Position (centre/limits)</i>	NU 200 400	NU 215 357 - NU 252 398
<i>County/District</i>	Northumberland	Berwick-upon-Tweed
<i>Conservation agency/area</i>	English Nature	Northumbria

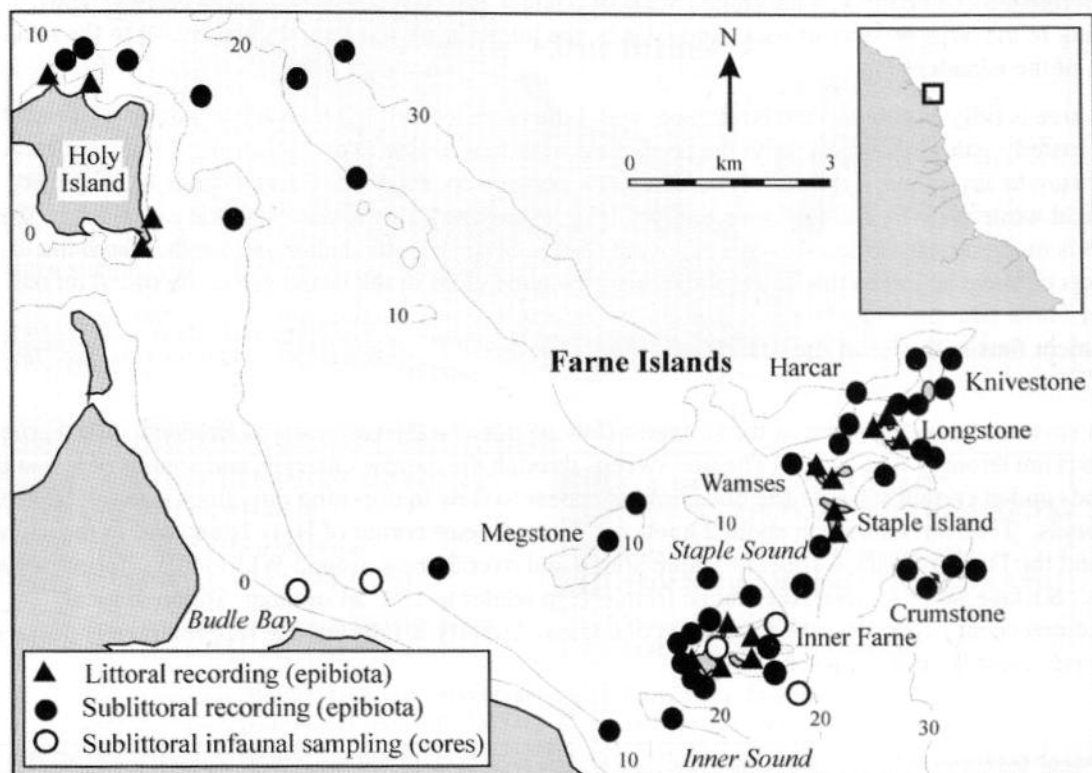


Figure 10.1 Location of area showing sites surveyed and main bathymetric features.
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Marine biological surveys

<i>Survey methods</i>	<i>No. of sites</i>	<i>Date of survey</i>	<i>Source</i>
<i>Littoral</i> Recording	16	September 1987 April 1988	Connor (1989)
<i>Sublittoral</i> Recording	44	September 1987 July 1992	Connor (1989) Holt 1994
Infaunal cores, suction samples and granulometry	5	September 1987	Connor (1989)

Introduction

This area includes the Farne Islands and the more exposed, rocky substrata on the north and east sides of Holy Island. The more sheltered sediment shores of the south and west of Holy Island are considered in area 8. Tweed estuary to Bamburgh.

The Farne Islands are a group of more than 20 small islands and rocky outcrops situated between 2 km and 6 km offshore. Around the Farne Islands, the rocky substrata extend from the shore into deep

water forming gullies, tunnels and submarine cliff faces. The islands are low-lying and topped with grass, and reach a maximum height of 19 m above mean high water of spring tides. The islands slope gently to the north-east and have steep cliffs on the southern and western sides.

The Farne Islands are formed from an igneous intrusion of quartz dolerite, with a small area of limestone on the Inner Farne island. The quartz dolerite gives the rock a smooth and even surface which is dissected at intervals by mostly vertical fissures and crevices. Some of the islands retain a capping of boulder clay and peaty soils. Peaty deposits on Inner Farne provide evidence for environmental changes during the Flandrian period, including changes in sea level. The shores are predominantly of bedrock, with limited areas of boulder and cobble between some of the islands. Owing to the large number of rocks and islands, the intertidal area is large in proportion to the total area of the islands.

The area is fully exposed to the North Sea, with little protection from wave action during north-east and easterly gales. However, with the prevailing wind from the west and south-west, the frequency of exposure to strong wave action is low. The most exposed shores on the Farne Islands are the near-vertical western cliffs, and the more gently sloping extensive bedrock shores on the east sides of the islands moderate the effects of wave exposure. Some of the islands shelter one another from the effects of wave action so that some of the most sheltered areas in the island group are found on the outer Farne Islands. Holy Island is slightly less exposed to wave action, and shelters the large sediment flats in the lee of the island (see area 8).

These parts of Holy Island and the Farnes are subject to a wide range of exposures to wave action and tidal streams, including some of the strongest flowing tides on the east coast of England. The Farne Islands are strongly tide-swept. The tide sweeps through the narrow channels and sounds between the islands and at certain states of the tide currents appear to flow in opposing directions through adjacent channels. Tidal streams reach about 2 knots off the north-east corner of Holy Island and in the sounds around the Farne Islands, 4 knots in Staple Sound and over 5 knots around Whirl Rocks during spring tides. Surface water temperatures range from 6°C in winter to 13°C in summer, although local variations occur depending upon weather conditions. Salinity is fully marine (approximately 35‰) on the open coast (Lee & Ramster 1981).

Physical features

<i>Physiographic type</i>	Offshore island group
<i>Length of coast</i>	24 km
<i>Bathymetry</i>	30 m and 50 m isobaths within 1 km of the outer Farne Islands (Knivestone)
<i>Wave exposure range</i>	Exposed and moderately exposed
<i>Tidal stream range</i>	Very strong to weak
<i>Tidal range</i>	4.2 m (springs), 2.2 m (neaps)
<i>Salinity range</i>	Fully marine

Marine biology

Littoral

In general rocky shores are steep, fringed with supralittoral lichens including *Caloplaca* spp. (YG). The more exposed shores tend to have fewer lichens and more of the green alga *Prasiola stipitata*, particularly on shores frequented by seabirds (Pra).

Barnacles dominate the lower littoral fringe on the more exposed shores and on those with a steep or vertical inclination, often with *Mytilus edulis* growing in small cracks and crevices (Ver.B). In the littoral fringe of the more sheltered shores, narrow bands of channelled wrack *Pelvetia canaliculata* are found with gastropods including common periwinkle *Littorina saxatilis*, typical of this upper shore

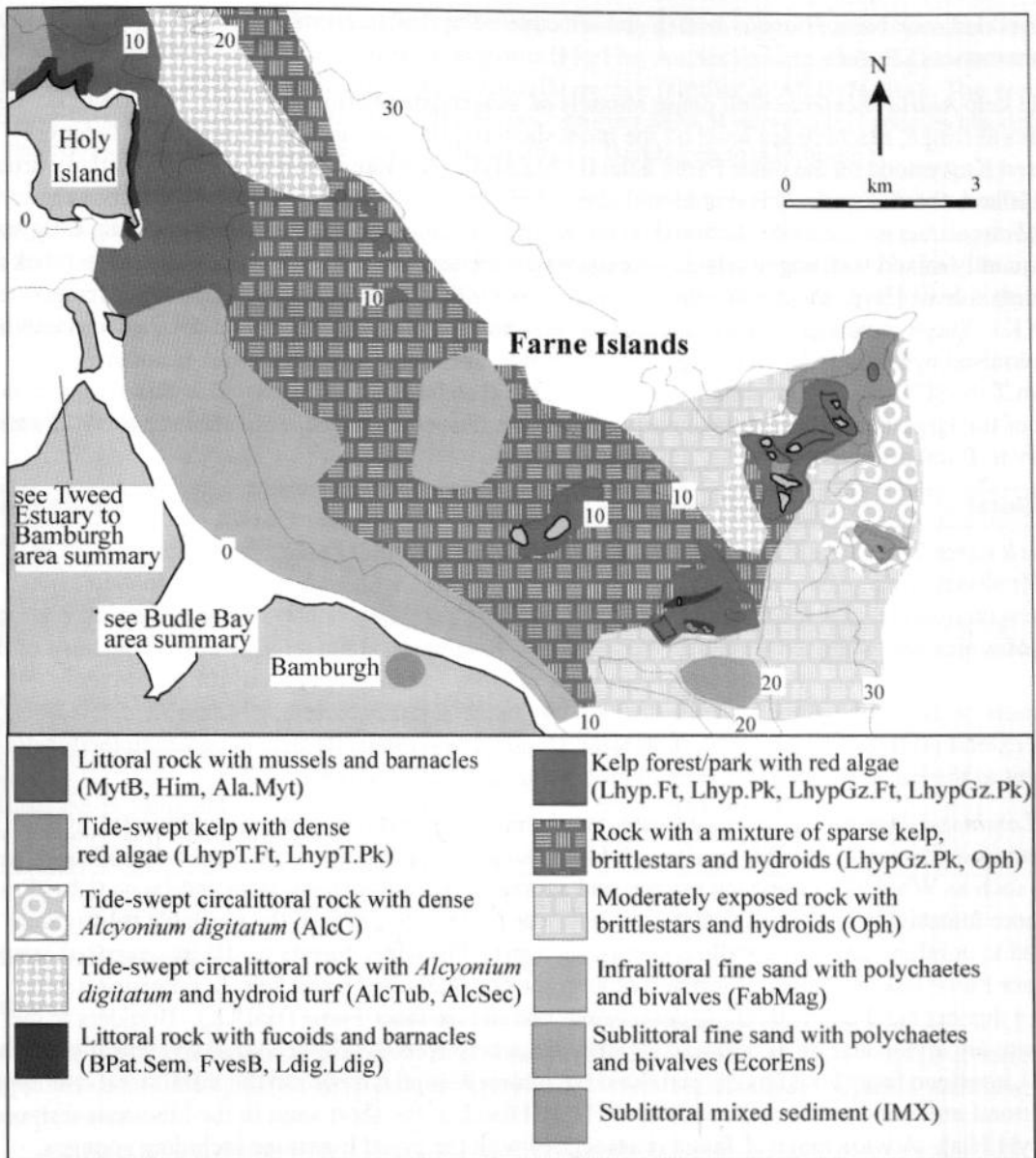


Figure 10.2 Indicative distribution of the main biotopes within the area (based on data from survey sites shown in Figure 10.1 and additional field observations).

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position (PelB). Spiral wrack *Fucus spiralis* and bladder wrack *F. vesiculosus* are found on the moderately exposed and more sheltered shores in the upper and mid eulittoral, and knotted wrack *Ascophyllum nodosum*, a fucoid characteristic of sheltered conditions, is found on the more extensive rocky shores on the Longstone, outer Farne Islands and on the boulder shores around Holy Island (Asc.Asc). In the lower eulittoral dense serrated wrack *F. serratus* (Fser.Fser.Bo) is widespread but occurs at slightly different heights on the shore depending on wave exposure, eventually giving way to barnacle and mussel-dominated mid and lower shores in the more exposed areas (MytB). The red alga *Mastocarpus stellatus* is common amongst the mussels and barnacles, and coralline encrusting algae become increasingly common further down the exposed shores. Thongweed *Himantalia elongata* forms a distinct band on a mussel *M. edulis*-dominated shore on the Inner Farne (Him). Rich, fauna-dominated biotopes occur on the short vertical and overhanging faces of limestone and sedimentary rocks in the lower eulittoral and sublittoral fringe around Holy Island. These are extensively bored by

the wrinkled rock borer *Hiatella arctica* and are covered by a rich assemblage of sponges, hydroids and anemones (SByAs).

Edible kelp *Alaria esculenta* with dense mussels *M. edulis* extends from the lower eulittoral into the sublittoral fringe, reaching sea level on the more sheltered sites and to a depth of 2 m on the more exposed Knivestone on the outer Farne Islands (Ala.Myt). At more sheltered sites, particularly around Holy Island, the *A. esculenta* is mixed with the kelp *Laminaria digitata*. A narrow band of kelp *L. digitata* occurs on the more sheltered, shallow, sloping shores on the Farne Islands (Ldig.Ldig) and is frequently mixed with sugar kelp *L. saccharina* on sheltered boulder shores. Sand-covered rock on the north side of Holy Island is dominated by sea oak *Halidrys siliquosa* in the sublittoral fringe (HalXK). Surge gullies in the sublittoral fringe are found at several sites around the Farne Islands and are colonised by mussels *M. edulis*, sponges, hydroids, anemones, bryozoans and ascidians (SCAn.Tub; SCAs.ByH). No extensive areas of littoral sediment were surveyed in this area, although some of the largest sandflats in north-east England are situated in the adjacent survey area (8. Tweed estuary to Bamburgh).

Sublittoral

Bedrock extends from the shore to depths of over 25 m on the outer Farne Islands, giving way to boulder slopes and to extensive plains of cobbles and boulders with coarse sediment in the sounds between the islands. There are a number of gullies which provide extensive areas of vertical bedrock, some of which are subject to wave surge conditions. A submerged tunnel is present at the head of the gully on the Knivestone. The north and east sides of Holy Island are rocky, in contrast to the remainder of the island which is formed from post-glacial deposits including blown sand. Bedrock plains extend north and east into the sublittoral, sloping more gradually than the areas immediately adjacent to the Farne Islands, reaching 20 m-25 m some 2 km offshore.

Kelp *Laminaria hyperborea* forest is found on upward-facing bedrock in the infralittoral (Lhyp.Ft). Most areas are heavily grazed by urchins *Echinus esculentus*, but a few sites in the most tide-exposed areas, such as Whirl Rocks, escape grazing and support a rich sub-canopy flora and fauna (LhypFa). The more intensively grazed sites have sparse foliose algae with much of the available substratum covered in coralline and non-coralline encrusting algae. The siltier forests on the less exposed areas of the inner Farne Islands support a mixture of kelp species, including sugar kelp *L. saccharina* which forms a distinct band below the *L. hyperborea* at one site on Inner Farne (HalXK). Boulders at the same site are dominated by *Saccorhiza polyschides*, a kelp species only recorded sporadically at other sites. Limestone faces bored by the wrinkled rock borer *Hiatella arctica* in the infralittoral and upper circalittoral are found to the north and east of Holy Island, at the short steps in the limestone terraces (AlcByH.Hia). A wide range of fauna is associated with the pitted limestone including sponges, anemones, brittlestars and ascidians.

Kelp *Laminaria hyperborea* park is found to 18 m depth around the outer Farne Islands and, like the kelp forests in the area, is heavily grazed by urchins *Echinus esculentus* (LhypGz.Pk). Tubeworms *Pomatoceros triqueter* and dead-man's fingers *Alcyonium digitatum* are abundant, particularly on vertical faces in the lower infralittoral and circalittoral (AlcC). Some of the less exposed lower infralittoral sites further inshore have abundant tubicolous amphipods.

In the lower circalittoral around the outer Farne Islands, strong tidal streams encourage a luxuriant growth of dead-man's fingers *A. digitatum* which carpets the rocky substrata (AlcC). Less tide-swept areas of bedrock and boulder are covered by vast numbers of tubeworms *P. triqueter* and encrusting coralline algae, while deeper bedrock, boulders and cobbles on coarse sediment in this area support dense beds of common brittlestar *Ophiothrix fragilis* (Oph). A turf of hydroids and bryozoans is widespread on the extensive plains of tide-swept boulders, cobbles and coarse sediment in the channels between the islands, and includes species such as bottlebrush hydroid *Thuiaria thuja*, *Abietinaria abietina*, *Nemertesia antennina*, sea fir *Sertularia argentea*, hornwrack *Flustra foliacea* and *Eucratea loricata* (Flu.SerHyd). This biotope is highly rated by Connor (1989) as one of the richest, in terms of diversity and abundance, in the Farne Islands area.

Lower circalittoral limestone ridges and bedrock plains off Holy Island support erect bryozoans such as hornwrack *F. foliacea* and *Securiflustra securifrons* (Flu.Flu; AlcSec) and in places is extensively bored by bivalves, possibly wrinkled rock borer *Hiatella arctica* (similar to AlcByH.Hia). The erect calcareous bryozoan *Smittina landsborovii* also occurs. During MNCR surveys this species has only been recorded in this and the adjacent area to the south (11. Bamburgh to Alnmouth) .

Sublittoral sediments in shallow water around the Farne Islands tend to be clean, mobile sand with few species other than the anemone *Cerianthus lloydii* and the sand mason worm *Lanice conchilega*. More stable sediments with lugworms *Arenicola marina* (FabMag) are found south of Holy Island. In deeper water, at 23 m off the south-east of Farne Island, an area of duned muddy shell gravel supports only a few mobile species and no recorded characteristic infauna or epifaunal species.

Nature conservation

Conservation sites			
Site name	Designation	Centre grid ref.	Main features
Northumberland Shore	SSSI, pSPA	NT 980 575 - NU 010 525	Ornithology
The Farne Islands	SSSI, NNR, SPA, NT	NU 230 370	Geology, seals, ornithology
Lindisfarne	SSSI, NNR, Ramsar, SPA	NU 100 430	Coastal habitats and flora, ornithology, invertebrates, marine habitats, geology
Bamburgh Coast and Hills	SSSI	NU 167 355	Geology, flora
Berwickshire and North Northumberland Coast	cSAC	NT 980 575	Marine habitats, seals
North Northumberland Dunes	cSAC	NT 980 575	Dune vegetation
Holy Island and the Farnes	SMA	NU 255 385	Marine biology
Northumberland Coast	AONB	NU 185 355	Landscape
North Northumberland	HC	NT 979 576 - NZ 297 933	Landscape

Human influences

Pollution

There are no major discharges of sewage or other wastes directly into the sea in this area, but there is a small outfall east of the castle on Holy Island. There are sewage outfalls on the adjacent mainland coast at Seahouses.

Commercial fishery

The area is heavily potted for lobsters and crabs by local fishing boats, particularly from North Sunderland harbour. Winkles are collected commercially on Holy Island. Intertidal reefs on the mainland are subjected to extensive bait (peeler crab) and shellfish collection.

Recreation

A major influence on the Farnes and Holy Island is the intensive recreational activities and associated disturbance. Large numbers of pleasure boat trips and dive boats from Seahouses and Beadnell visit the Farnes, particularly during summer holiday weekends. Anglers also make use of the area. The combined effects of all these visitors can periodically disturb the seals and birds from their 'normal' activities, although the net result is unknown.

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Survey sites

Surveys

- 112: MNCR littoral and sublittoral survey of Berwick to Beadnell including the Farne Islands (Connor 1989).
- 120: Farne Islands sublittoral survey 1982 (Edwards 1983).
- 310: MNCR sublittoral survey of north-east England, 1992 (Holt 1994).

Littoral sites

Survey Site	Site name	Grid reference	Latitude & longitude	Biotores present
112 16	Snipe Point, Holy Island.	NU 128 441	55°41.4'N 01°47.7'W	Pel; BPat.Sem; FvesB; Fser.Fser.Bo; MytFR; Cor; SByAs; Ldig.Ldig; HalXK
112 17	Broad Stones, Holy Island.	NU 140 421	55°40.3'N 01°46.6'W	BPat.Sem; Fves; Fser.R; SwSed; Ldig.Ldig.Bo
112 18	Castle Point, Holy Island.	NU 141 416	55°40.0'N 01°46.5'W	FvesB; Fser.Fser.Bo; Cor
112 28	W point of Farne Island, Farne Islands.	NU 215 360	55°37.0'N 01°39.5'W	Ver.B; Ver.Por; MytB; G; Ala.Myt
112 29	S point of Farne Island, Farne Islands.	NU 218 357	55°36.8'N 01°39.2'W	Pra; MytB; Cor; Ala.Myt; Ala.Ldig
112 30	Channel between East and West Wideopen, Farne Islands.	NU 224 359	55°36.9'N 01°38.6'W	Pra; PelB; AscX; FvesB; Fser.Fser.Bo; BLlit; Ldig.Ldig.Bo
112 31	S mid Knocks Reef, Farne Islands.	NU 223 364	55°37.2'N 01°38.7'W	SwSed
112 32	N mid Knocks Reef, Farne Islands.	NU 222 365	55°37.2'N 01°38.8'W	YG; Pra; PelB; Fspi; MytB; Him; Ala.Myt; Ldig.Ldig
112 33	Skeney Car, Staple Island, Farne Islands.	NU 237 374	55°37.7'N 01°37.4'W	Ver.Por; Pra; MytB; BPat.FvesI; FK; Ala.Myt
112 34	Channel between Staple Island and Brownsman Island, Farne Islands.	NU 238 377	55°37.9'N 01°37.3'W	Pra; Fspi; Fves; Fser; Ldig.Ldig; Lhyp.Ft
112 35	Channel between North and South Wamses, Farne Islands.	NU 234 384	55°38.3'N 01°37.6'W	Pra; Fspi; AscX; Fser.R; XKScrR
112 36	N North Wamses, Farne Islands.	NU 233 386	55°38.4'N 01°37.7'W	Pra; BPat.Sem; MytFves; FK; Ala.Myt; Ala.Ldig

Littoral sites - continued

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>
112 37	Sunderland Hole, Longstone, Farne Islands.	NU 246 389	55°38.5'N 01°36.5'W	YG; Ver.Ver; PelB; MytB; FvesB; Asc.Asc; Ala.Ldig
112 38	Brada, Longstone, Farne Islands.	NU 249 388	55°38.5'N 01°36.2'W	Pel; Fspi; Asc.Asc; Fser.R; Lhyp.Ft
112 39	NE Longstone, Farne Islands.	NU 249 389	55°38.5'N 01°36.2'W	PelB; MytB; FvesB; FK; Ala.Myt; SCAAn.Tub
112 83	E of Coves Haven, Holy Island.	NU 132 441	55°41.4'N 01°47.4'W	MytFR; Rho; Cor; SwSed; Ala.Ldig; Ldig.Ldig.Bo

Sublittoral sites

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & Longitude</i>	<i>Biotopes present</i>
112 40	NE Snipe Point, Holy Island.	NU 128 443	55°41.5'N 01°47.7'W	Lhyp.Ft; AlcByH.Hia
112 41	N of Snipe Point, Holy Island.	NU 128 448	55°41.7'N 01°47.7'W	Lhyp.Pk; IGS
112 42	NE of Castlehead Rocks, Holy Island.	NU 136 447	55°41.7'N 01°47.0'W	AlcByH.Hia; FaAIC
112 43	NE Goldstone, Holy Island.	NU 166 419	55°40.2'N 01°44.1'W	Lhyp.Ft; AlcByH; Flu.Flu
112 44	NE Plough Seat Reef, Holy Island.	NU 150 420	55°40.2'N 01°45.6'W	Lhyp.Ft; AlcByH
112 46	NW of Harkness Rocks, Bamburgh.	NU 168 367	55°37.4'N 01°43.9'W	FabMag
112 47	N of Harkness Rocks, Bamburgh.	NU 175 377	55°37.9'N 01°43.3'W	FabMag
112 48	NNE of Harkness Rocks, Bamburgh.	NU 178 388	55°38.5'N 01°43.0'W	FaAIC.Abi
112 49	NE of Greenhill Rocks, Inner Sound.	NU 206 344	55°36.1'N 01°40.3'W	FabMag
112 50	E of Islestone, Inner Sound.	NU 211 348	55°36.3'N 01°39.9'W	FaAIC.Abi
112 51	ESE of Farne Island, Inner Sound.	NU 232 353	55°36.6'N 01°37.9'W	IMX
112 53	SW Farne Island.	NU 216 358	55°36.9'N 01°39.4'W	Lhyp.TFt; LhypGz.Pk; EphR
112 54	Off Churn Rock, Farne Island.	NU 215 359	55°36.9'N 01°39.5'W	LhypGz.Ft; HalXK; XKScrR
112 55	NW Farne Island.	NU 215 360	55°37.0'N 01°39.5'W	Lhyp.TPk; Lhyp.Pk
112 56	Churn Gut, Farne Island.	NU 215 360	55°37.0'N 01°39.5'W	SCAn.Tub
112 57	St Cuthberts Gut, Farne Island.	NU 218 361	55°37.0'N 01°39.2'W	Lhyp.Ft; LhypGz.Ft; EphR; Oph
112 58	The Kettle, Farne Island.	NU 218 363	55°37.1'N 01°39.2'W	Ldig.Ldig; Lhyp.Ft; LsacX; XKScrR; HalXK
112 59	W of The Bridges, Farne Islands.	NU 220 362	55°37.1'N 01°39.0'W	LhypGz.Ft; Oph; Ven
112 60	N of The Bridges, Farne Sound, Farne Islands.	NU 218 369	55°37.5'N 01°39.2'W	Lhyp.Pk; EphR
112 61	N of Knocks Reef, Farne Islands.	NU 222 366	55°37.3'N 01°38.8'W	LhypR.Ft; EphR
112 62	N of East Wideopen, Farne Islands.	NU 227 364	55°37.2'N 01°38.3'W	FabMag
112 63	NW Little Scarcar, Farne Islands.	NU 227 363	55°37.1'N 01°38.3'W	XKScrR; HalXK; AlcC
112 64	SE of Scarcar, Farne Islands.	NU 230 359	55°36.9'N 01°38.0'W	LhypGz.Ft; LhypGz.Pk; Oph
112 65	N Megstone, Farne Islands.	NU 203 373	55°37.7'N 01°40.6'W	LhypGz.Ft; XKScrR
112 66	S Oxscar, Farne Islands.	NU 213 378	55°38.0'N 01°39.7'W	LhypR.Ft; LhypGz.Ft; Lhyp.Pk; EphR; XKScrR; FaAIC
112 67	S of Skeney Car, Staple Sound, Farne Islands.	NU 237 370	55°37.5'N 01°37.4'W	FaAIC; AlcC; Oph
112 68	Skeney Car Gut, Staple Sound, Farne Islands.	NU 238 373	55°37.7'N 01°37.3'W	LhypGz.Ft; AlcByH; FaAIC; AlcC
112 69	W of North Wamses, Farne Islands.	NU 232 384	55°38.3'N 01°37.8'W	LhypGz.Pk; EphR
112 70	N of Little Harcar, Farne Islands.	NU 240 388	55°38.5'N 01°37.1'W	LhypGz.Pk; HalXK; AlcByH; NcirBat
112 71	SW of Northern Hares, Farne Islands.	NU 242 390	55°38.6'N 01°36.9'W	LhypGz.Ft
112 72	N of Northern Hares, Farne Islands.	NU 243 395	55°38.9'N 01°36.8'W	FaAIC; Oph
112 73	E of Northern Hares, Farne Islands.	NU 248 393	55°38.7'N 01°36.3'W	LhypR.Ft; LhypFa; LhypGz.Pk; AlcTub; FaAIC

Sublittoral sites - continued

<i>Survey Site</i>	<i>Site name</i>	<i>Grid reference</i>	<i>Latitude & longitude</i>	<i>Biotopes present</i>
112 74	Between Knivestone and Northern Hares, Farne Islands.	NU 249 395	55°38.9'N 01°36.2'W	FaAIC.Abi
112 75	W of Whirl Rocks, Farne Islands.	NU 253 398	55°39.0'N 01°35.8'W	LhypFa; LhypGz.Ft; AlcByH
112 76	E Whirl Rocks, Farne Islands.	NU 255 398	55°39.0'N 01°35.6'W	Ala.Myt; AlcTub; Flu.Flu
112 77	E Knivestone, Farne Islands.	NU 253 396	55°38.9'N 01°35.8'W	SCAn.Tub; SCAs.ByH; FaAIC
112 78	E of Brada, Longstone, Farne Islands.	NU 251 386	55°38.4'N 01°36.0'W	LhypGz.Ft; AlcC; FaAIC; Oph
112 79	SE Bluecaps, Farne Islands.	NU 245 386	55°38.4'N 01°36.6'W	Lhyp.Ft; AlcC; FaAIC
112 80	NE (outer) of Crumstone, Farne Islands.	NU 259 374	55°37.7'N 01°35.3'W	FaAIC.Abi
112 81	NE (inner) of Crumstone, Farne Islands.	NU 258 373	55°37.7'N 01°35.4'W	AlcC; FaAIC; Oph
112 82	SW Callers, Farne Islands.	NU 249 372	55°37.6'N 01°36.2'W	LhypGz.Pk; SCAn; AlcC; Flu.SerHyd; Oph
120 1	South side of Knivestone, Farne Islands.	NU 252 396	55°38.9'N 01°35.9'W	Lhyp.TPk; FaAIC; Flu; Oph
120 2	Off Pinnacles, Staple Island, Farne Islands.	NU 238 374	55°37.7'N 01°37.3'W	LhypFa; FaAIC
120 3	Southwest side of Crumstone, Farne Islands.	NU 253 371	55°37.6'N 01°35.8'W	Lhyp.TFt; AlcTub; FaAIC
120 4	North east side of Longstone, Farne Islands.	NU 247 391	55°38.6'N 01°36.4'W	LhypFa; EphR
310 48	E of Emmanuel Head, Berwick-upon-Tweed.	NU 154 435	55°41.1'N 01°45.3'W	FaAIC
310 50	ENE Emmanuel Head, Berwick-upon-Tweed.	NU 160 440	55°41.4'N 01°44.6'W	AlcSec
310 53	SE of Emmanuel Head, Berwick-upon-Tweed.	NU 143 433	55°40.9'N 01°46.3'W	Lhyp.Ft

Compiled by:

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