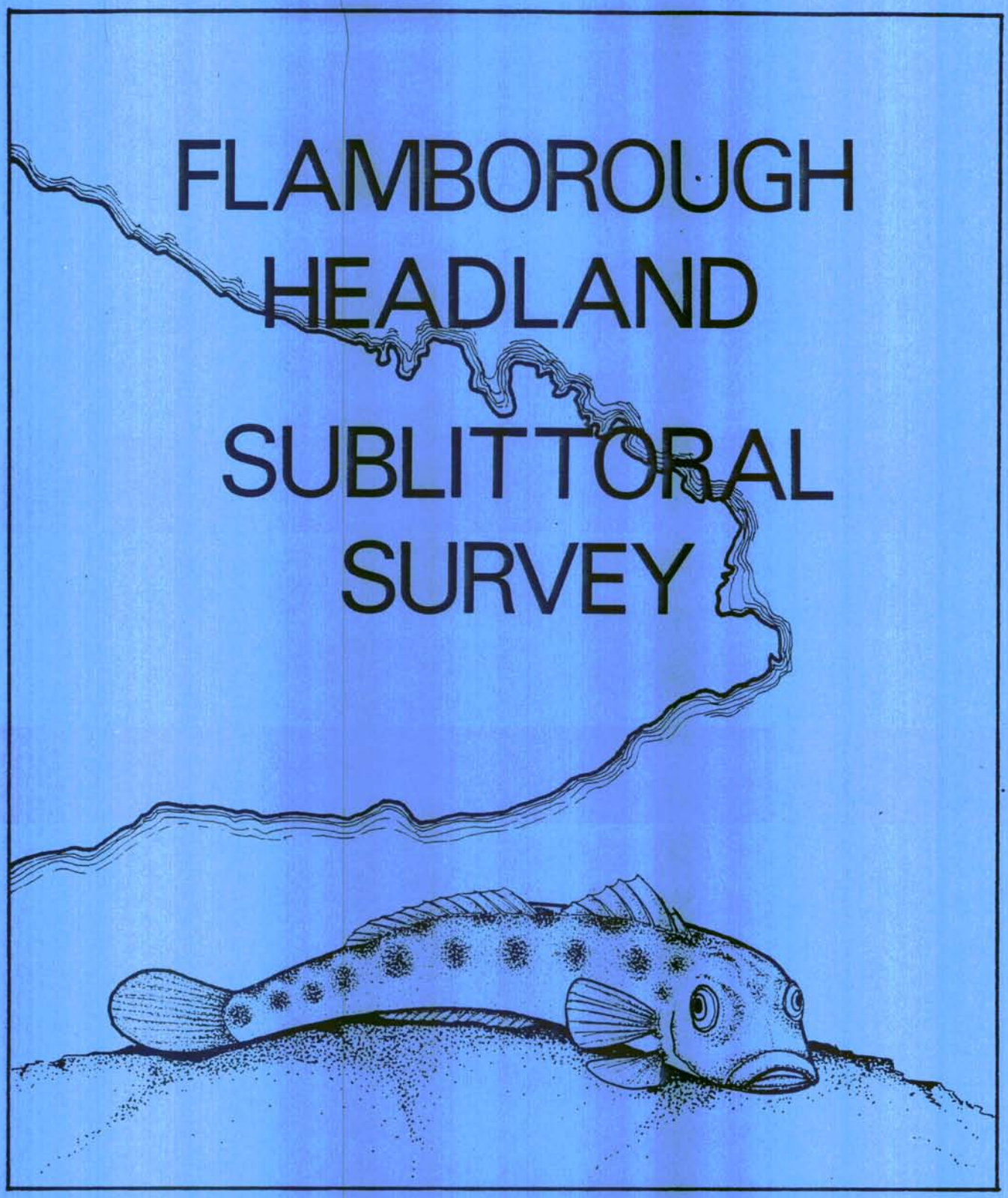
FLAMBOROUGH HEADLAND SUBLITTORAL SURVEY



ELIZABETH WOOD

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1988

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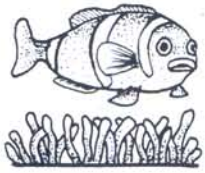
This work was commissioned by the NCC as part of its programme of research into nature conservation.

Flamborough Headland Heritage Coast

The Flamborough Headland Heritage Coast Project jointly funded the work with the NCC.

Marine Conservation Society members were involved in the survey and provided local support.



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Reference:
WOOD, E.M. 1988. Flamborough Headland sublittoral survey. A report for the Nature Conservancy Council and the Flamborough Headland Heritage Coast Project. 92 pp + appendices.

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6. CONSERVATION ISSUES

Synopsis

Flamborough Headland is a Heritage Coast and Site of Special Scientific Interest, noted not only for its dramatic scenery and geological formations, but also for the colonies of seabirds that breed on the cliffs. It is the most northerly outcropping of coastal chalk in the British Isles, and the chalk extends into the subtidal zone, an area which prior to this study had not been investigated in detail.

During August 1987, over a period of two weeks, 62 dives were made in the shallow sublittoral zone around the headland, from Speeton to Sewerby. Details of habitats and communities were collected at each site, and species checklists completed.

The seabed around the headland is predominantly rocky and includes a wide range of features. Close inshore along much of the north and east-facing parts of the headland the chalk platforms are dissected to form outcrops and gullies, with vertical faces often 4 metres in height, and sometimes up to 6 metres. These formations lead to terraced bedrock where the 'steps' become progressively lower further from the shore, until a flattish bedrock plain is reached.

Along the south-facing side of the headland there are no large outcrops, and the bedrock terraces are much lower. To the south-west the seabed becomes increasingly covered by small boulders, cobbles and pebbles. There are also patches of silty sand.

The algal-dominated (infralittoral) zone extended to a depth of about 6 m below chart datum on upward-facing surfaces. In the north and east kelp (Laminaria hyperborea) forests were present to a depth of about 3 to 4 metres below CD, with red algae contributing to the undergrowth, and extending into deeper water. Sessile animals occurred with the algae, but were particularly prominent on steep, vertical or underhanging faces of the outcrops. Wave action is considerable along the north and east-facing coastline, and some areas of shallow low-lying bedrock (especially gully bottoms) supported only a few scour-resistant species. On the south-facing side, L. hyperborea was largely replaced by L. saccharina, again with red algae present.

The deeper animal-dominated (circalittoral) zone supported a wide range of sessile organisms. Robust hydroids and bryozoans able to withstand strong tidal streams and sand scour were dominant, but also present were colonial tunicates, dead-man's-fingers (Alcyonium digitatum), and other sessile organisms.

In general the most prominent mobile animals were decapod crustaceans, starfishes and brittlestars. The population density of sea-urchins (Echinus esculentus) and fishes appeared to be relatively low. Several 'boring' species were widespread and abundant, including the bivalve molluscs Hiatella arctica and Zirphaea crispata, the small polychaete worm Polydora ciliata, and the sponge Cliona celata (non-massive form).

The shallow sublittoral around the headland is of considerable biological interest because of the range of habitats, communities and species present. Many of the species found at Flamborough occur off all coasts of the British Isles, while several have a northerly distribution. However, a significant number are southern species, some of which are apparently little known from the east coast or from other areas of sublittoral chalk. Apart from these attributes, the area also supports an important local fishery, and is a popular dive site.

A useful first step towards safeguarding the Flamborough Head marine environment and its wildlife is to stimulate interest amongst visitors and users. It is recommended that consideration is given to employing a specialist marine ranger or warden within the Heritage Coast project who would be responsible for promoting these aspects, including the production of relevant interpretive material. It is also suggested that a sublittoral study site is established, where the habitats and communities can be investigated in detail and changes monitored. The Marine Conservation Society is in an ideal position and has the specialist knowledge to coordinate a project such as this, which should not only provide useful information, but also act as an interesting focus for those who dive the area.

1 Introduction

The rocky headland at Flamborough, with its dramatic ckalk cliffs, juts about 8 km out into the North Sea and is flanked by broad expanses of sand to both north (Filey Bay) and South (Bridlington Bay). The main activities in the area are associated with recreation, nature conservation, fishing and farming; there is no heavy industry.

Flamborough Headland is designated a Heritage Coast (figure 1), and the coastal fringe is a Site of Special Scientific Interest (figure 40), yet prior to this survey very little was known about the biology and interest of the adjacent sublittoral zone.

The only publications consist of a series of papers on the fauna associated with kelp holdfasts off the north-east coast, including samples taken from North Landing (e.g. Moore, 1973).

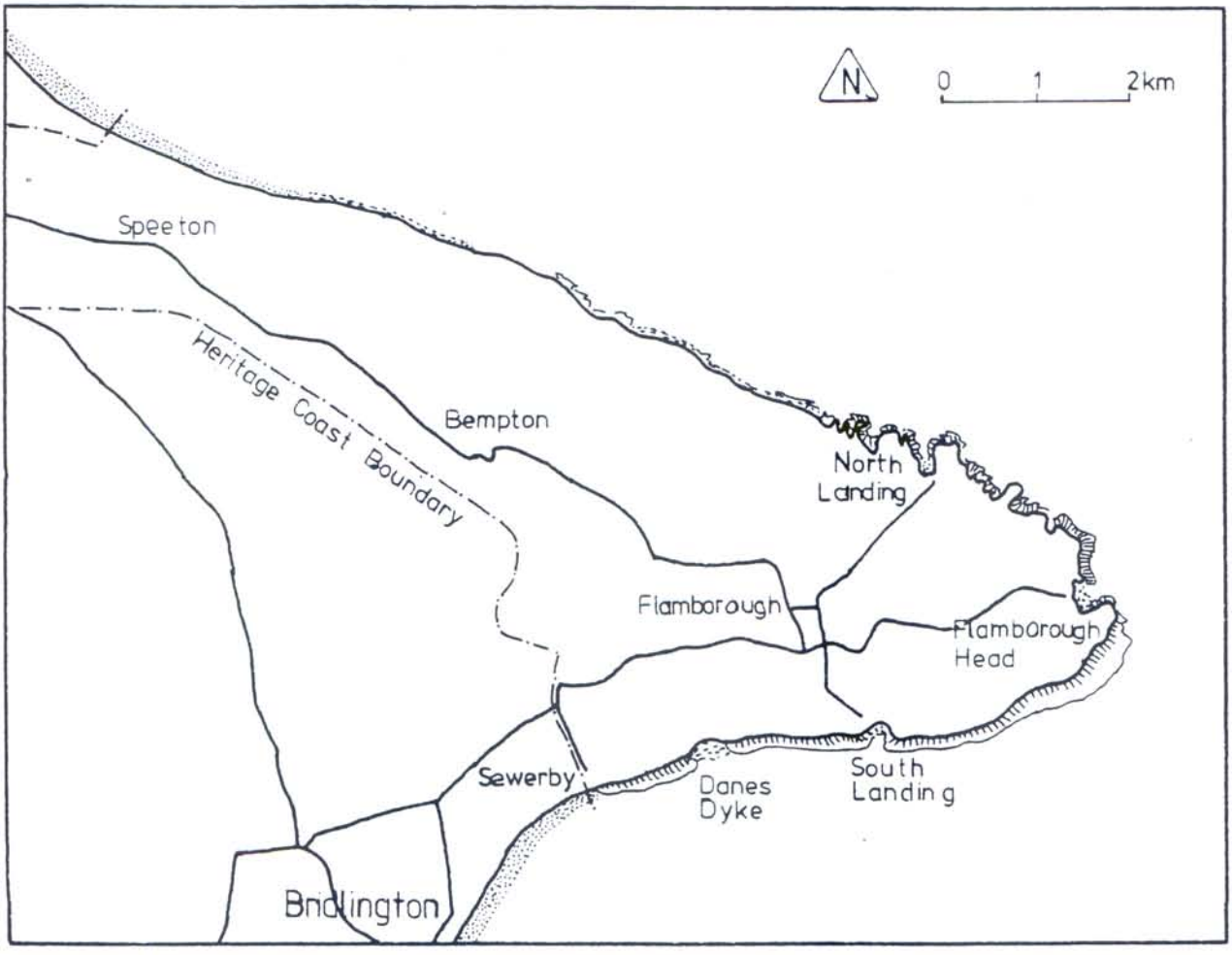


Figure 1. Map of the Flamborough Headland showing the study area.

The survey was commissioned by the Nature Conservancy Council (NCC) and the Flamborough Headland Heritage Coast Project, and the objectives of the study were:

a) to provide a detailed account of the habitats and communities in the shallow sublittoral around Flamborough Head, from Speeton to Sewerby.

b) to assess the biological interest and conservation importance of the site, both in relation to the North Sea coast, and in comparison with other areas of sublittoral chalk already surveyed.

The survey was carried out in two phases:
August 3rd-7th: main survey team.
August 10th-21st: main survey team + NCC survey team.

Dives were made at 62 sites around the 19.5 km stretch of coast, in a belt up to 1.25 km from the shore. Positions were located using a hand-bearing compass and/or shore marks and are shown in figure 41 at the back of this report. Location, depth and type of seabed at each site are shown in Appendix 1.

A 'Marine Nature Conservation Review sublittoral habitat record sheet' was completed for each dive (example in Appendix 2), and species lists (58 faunal, 38 algal) compiled. Written information was supplemented by photographs from a number of sites. A set of slides and copies of the raw data sheets are lodged with the NCC and the Flamborough Heritage Coast Project.

Many of the specimens were identified on site, but collections were made of interesting or 'difficult' species.

ACKNOWLEDGEMENTS

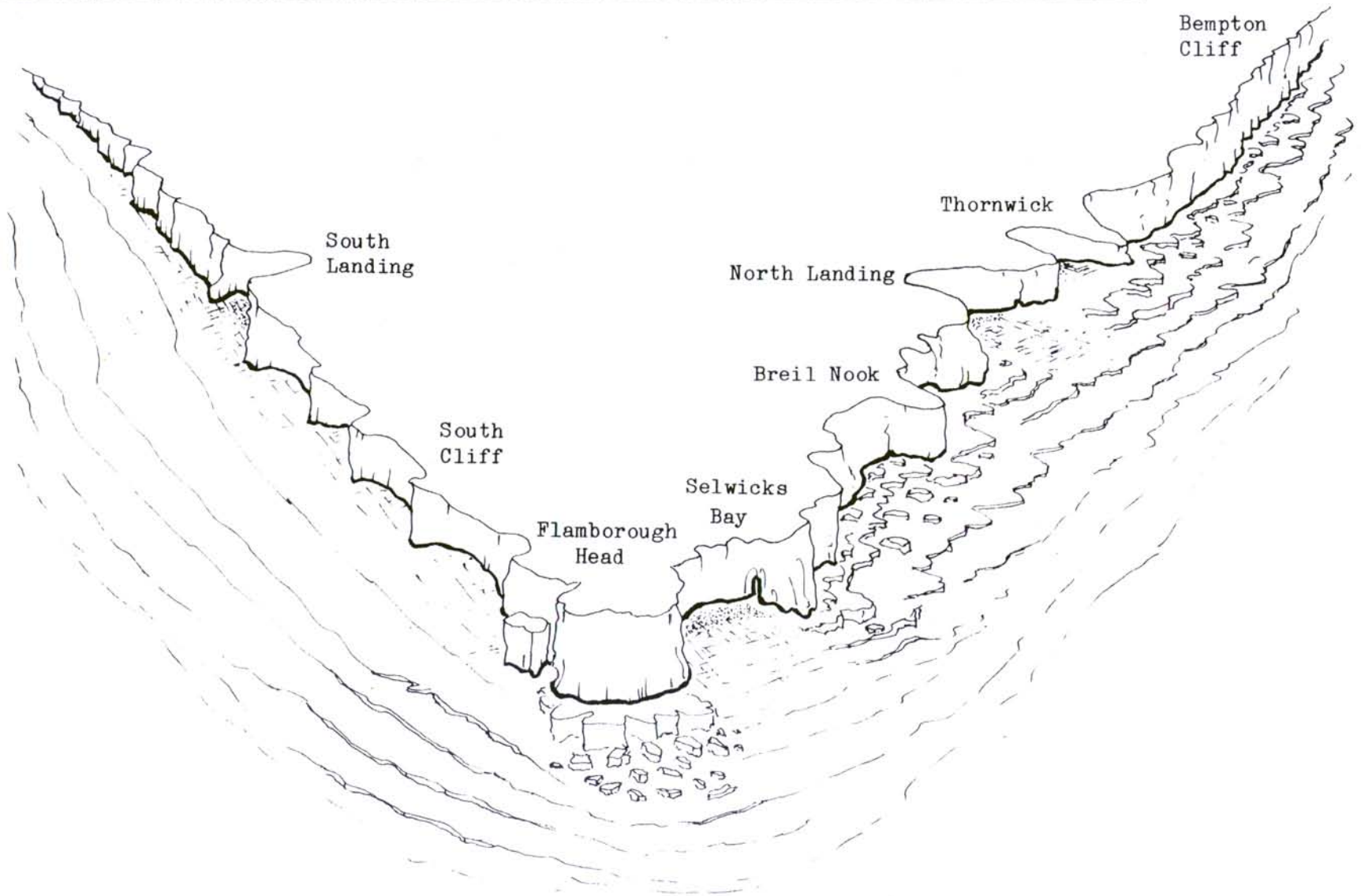
Sincere thanks go to Bob Foster-Smith, Dick Manuel, Christopher Wood, Teresa Bennett, Sarah Fowler and Robert Irving who undertook the survey. Thanks also to Bruce Smith, Trevor Toulson, Robin Seddon and Chris Garritty for acting as assistant divers and boatmen.

I am indebted to Graham Ackers, Roger Bamber, Bill Farnham, Peter Garwood, Sue Hiscock, Gordon Patterson, Bernard Picton and Martin Sheader for identifying a number of the species that were collected. During the preparation of this report I benefitted from useful discussions with David George, Sarah Fowler, Bernard Picton, Ian Tittley and David Connor. I would like to thank Jonathan Mullard, Richard Rafe and Sarah Fowler for reading part of the draft report, and providing relevant information. Christopher Wood also made useful comments, and made available unpublished survey data from other chalk areas.

Christopher Wood prepared all the maps, and Bob Foster-Smith a number of the drawings for this report, for which I am very grateful.

Finally, on behalf of the survey team I would like to thank Robin Broadley and Bob Briggs (Marine Conservation Society) for all their help, and Mr and Mrs Traves and staff of the Flaneburg Hotel for their hospitality and for kindly providing us with 'laboratory' space.

Figure 2. 'Bird's-eye-view' impression of the Flamborough headland to show the seabed features.



2. Physical Features

2.1. SEA-BED FEATURES

The seabed around the Headland is predominantly rocky, and includes features such as substantial outcroppings and boulders, terraced bedrock and plains of cobbles and pebbles (mostly flints). Sand and silt are mixed with the cobbles, especially further offshore, and there are patches of soft sediment elsewhere. The offshore limit of the rock was not reached, but sand plains were found to the west of both Buckton Cliffs and Sewerby Rocks. A 'bird's-eye-view' of the headland and seabed formations is shown in figure 2.

The chalk rock seabed around the headland steps downwards in a series of broad terraces. On the south-facing side these are extremely low, with faces less than 0.5 m high. To the east and north the terraces are much more substantial, but become progressively lower further out to sea. For example 500 m offshore (site 29), the faces are still 1 metre high; nearly one km out (site 28) the bedrock plain is virtually unbroken.

The platforms closest to the shore, especially those around the head itself, are dissected by deep surge gullies eroded by waves and mobile 'rock-mills'. The surge gullies run mostly, but not exclusively, at right angles to the cliff. There are also gullies in deeper water that run approximately parallel with the shore; the dimensions of the gullies are variable (see Chapter 3 for examples).

2.2. GEOLOGY

The Flamborough headland is formed of sedimentary rocks spanning a sequence from the Upper Jurrassic (140 million years ago) to the Upper Cretaceous (70 million years ago). These rocks are overlain to varying degrees by recent (Pleistocene) glacial deposits consisting mostly of boulder clay, gravel and sand. The chalk cliffs of the headland date from the Upper Cretaceous and are harder and more crystalline than the chalk exposures in southern England.

Although the geology of Flamborough Head is well known, the seabed has not been studied in any detail.

2.3. WAVE ACTION

The entire coastline around the headland is wave-exposed, but the greater fetch to the N/NE means that the most severe sea conditions are experienced along parts of the coast which face in those directions. Wave heights up to 20 m are theoretically possible for this area (Lee and Ramster, 1981).

In addition to the smaller fetch from the south, waves approaching from this direction would also tend to be dissipated because of the shallowness of the seabed, and the presence of an offshore sand bank (the Smithic).

2.4. TIDAL STREAMS

Tidal streams are noticeable throughout the area, except very close inshore, and reach at least 3 knots off the head (figure 3- this refers to a point 2 km from the shore and may not be the maximum encountered). 7 km off the head the flow subsides (maximum 2.5 knots), and off Bridlington it reaches only 0.9 knots.

The tidal flows are from north to south on the flood tide and south to north on the ebb. Slack water occurs approximately one hour after high and low water (figure 3).

2.5. TURBIDITY AND SEDIMENTATION

The waters around the headland are probably less turbid than areas immediately to the north and south, because of the absence locally of rivers and industrial discharges. In addition, large expanses of the seabed consist of relatively hard chalk that is not easily eroded (e.g. in contrast with the soft chalk at Dover). Moore (1972) obtained a level of 32.7 mg/l of suspended solids off North Landing during the time of his survey into kelp plants (July 1969), but year-round studies have not been carried out. Visibility (horizontal) during the survey ranged from about 0.5 to 6.0 metres.

The extent to which fine particulate material was deposited on the seabed varied. Close inshore off the north and north-east facing parts of the coastline water movement from waves and currents tended to keep sediment in suspension, and some of the surfaces were scoured clean. However, sessile organisms acted as sediment traps and were generally coated with a fine layer of silt, especially around their bases. Rock surfaces and sessile fauna in deeper water were less affected by wave turbulence and were significantly siltier.

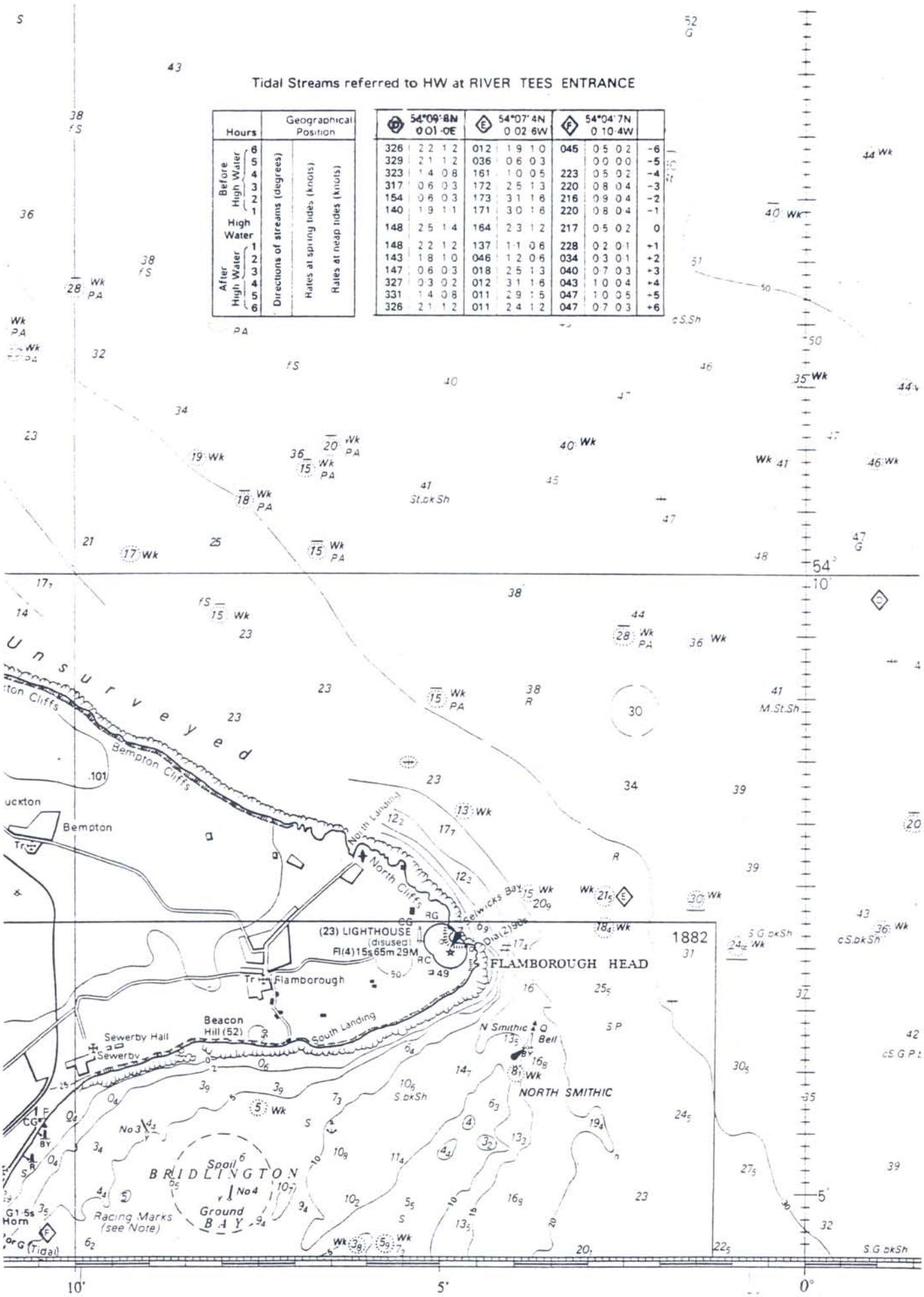


Figure 3. Part of Admiralty Chart showing tidal streams at 3 positions in the vicinity of Flamborough Headland.

2.6. TEMPERATURE AND SALINITY

Mean surface salinity is 34.25 parts per thousand, and mean surface water temperatures range from 5°C [winter] to 14°C [summer] (Lee and Ramster, 1981).

To the north of Flamborough the water becomes stratified during the summer months; to the south it remains well mixed throughout the year (see figure 36, page 75). No thermocline was discernable during the period of the survey.

3. Habitats and Communities

A broad description of the main seabed 'formations' around the headland has been given in the previous chapter. Several major zones and habitats, were identified, and each of these could be further sub-divided.

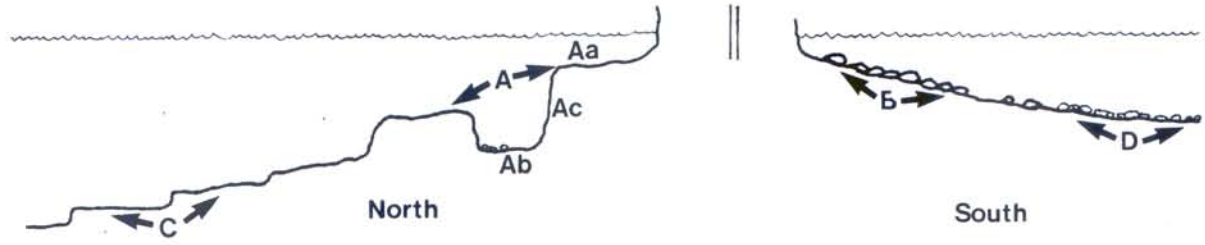


Figure 4. Diagram to show the major seabed and habitat types.

INFRALITTORAL Algae prominent: shore to approximately 6 m below CD

A. INSHORE ROCKY SEABED: MAJOR COMPONENTS ROCK OUTCROPS WITH SUBSTANTIAL VERTICAL FACES, LARGE STABLE BOULDERS AND BEDROCK.

Aa Upward-facing surfaces on tops of rocks
Ab Upward-facing surfaces of lower bedrock
Ac Steeply sloping/vertical/underhanging surfaces

B. INSHORE ROCKY SEABED: MAJOR COMPONENTS SMALL CHALK BOULDERS, PLUS COBBLES AND PEBBLES (Mostly of flint).

Ba Relatively stable boulders and cobble
Bb Mobile cobbles and pebbles
Bc Sediment pockets

CIRCALITTORAL Animal-dominated zone, 6 m and more below CD

C. ROCKY SEABED, MOSTLY IN THE FORM OF TERRACED BEDROCK

D. ROCKY SEABED, MOSTLY BOULDERS, COBBLES AND PEBBLES.

F. SEDIMENT PLAINS

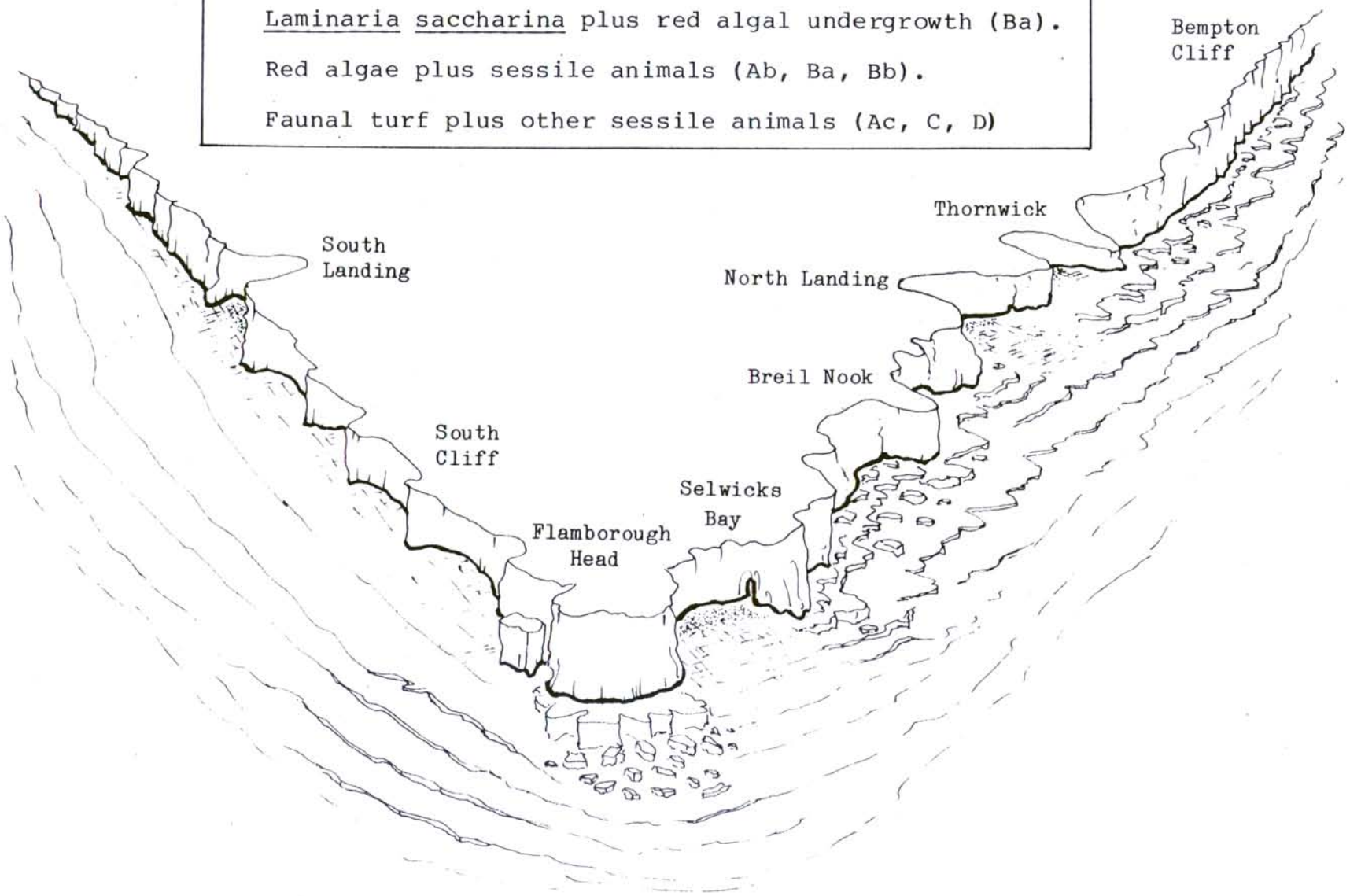
Figure 6. 'Bird's-eye-view' of the Flamborough Headland showing the seabed features and major habitats, dominated by:

Laminaria hyperborea forest, plus red algae (Aa).

Laminaria saccharina plus red algal undergrowth (Ba).

Red algae plus sessile animals (Ab, Ba, Bb).

Faunal turf plus other sessile animals (Ac, C, D)



A. INSHORE (INFRALITTORAL) ROCKY SEABED (Shore to approximately 6 m below CD): MAJOR COMPONENTS ROCK OUTCROPS WITH SUBSTANTIAL VERTICAL FACES, LARGE STABLE BOULDERS AND BEDROCK.

OTHER COMPONENTS: Small boulders, cobble, pebble and sand.

Along the north and east-facing parts of the headland the precipitous cliffs that are a feature of the coastline end at or just below the shore and the rocks continue seawards as outcrops and wide, terraced platforms. In Selwicks Bay and off Cattlemere the wave-cut platform extending from the cobble fringe at the cliff base is visible at low water, but elsewhere the platforms are mostly submerged.

Figure 7.
View westwards from Thornwick Nab along the north coast of the headland. The wave-cut platforms visible at the bottom of the photograph continue seawards, forming underwater terraces with vertical faces 3 to 4 metres high (photo: E. Wood).

The most dramatic subtidal formations are at the end of the headland, beneath the Fog Station. Here the platform closest to the shore is dissected by deep gullies, mostly running seawards in a north-easterly direction. Flat-topped outcrops up to 6 m high have been formed, their tops reaching the surface at low water. The gullies formed are correspondingly deep and relatively narrow, but gradually widen out further offshore. The base of the gullies usually consists of bedrock overlain with cobbles and small boulders.

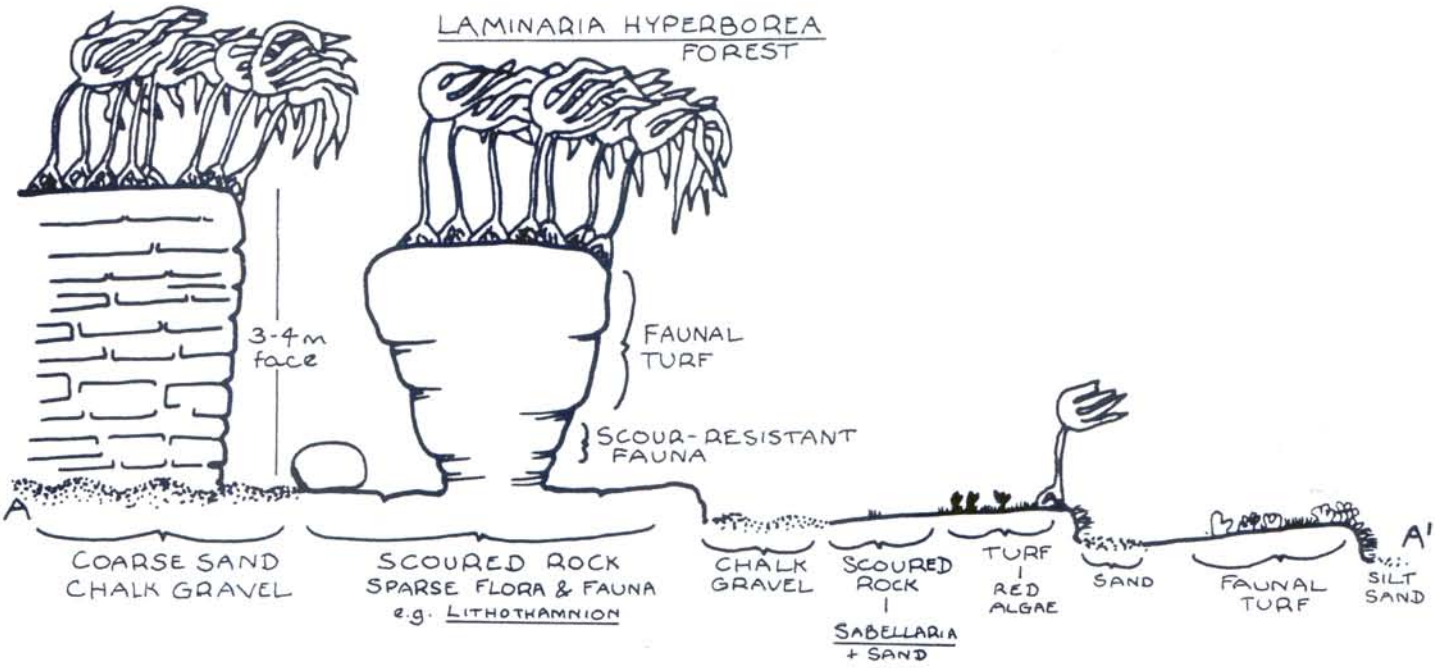
Figure 8. A large chalk stack off Flamborough Head, close to the area where the most dramatic underwater formations occur, consisitng of substantial outcrops with vertical faces up to 6 m high (photo E. Wood).

The nearshore subtidal platforms in other wave-exposed locations along the north-facing coast (e.g. off Petrel Hole, Thornwick Nab and North Cliff) are also dissected by gullies (figure 9). These run approximately at right angles to the shore, but are not so pronounced as off the head.

The platforms continue out to sea in the form of low terraces with faces up to several metres high. In places, large boulders overlie the bedrock.

On the south-facing part of the headland there are no substantial bedrock outcrops and relatively few large boulders (see habitat B).

Figure 9 (opposite). Approximate plan (bottom) and profile (top) at Cat Nab, site 12.


LAMINARIA HYPERBOREA FOREST
3-4m face
FAUNAL TURF
SCOUR-RESISTANT FAUNA
A
A'
COARSE SAND CHALK GRAVEL
SCOURED ROCK SPARSE FLORA & FAUNA e.g. LITHOTHAMNION
CHALK GRAVEL
SCOURED ROCK SABELLARIA + SAND
TURF RED ALGAE
SAND
FAUNAL TURF
SILT SAND

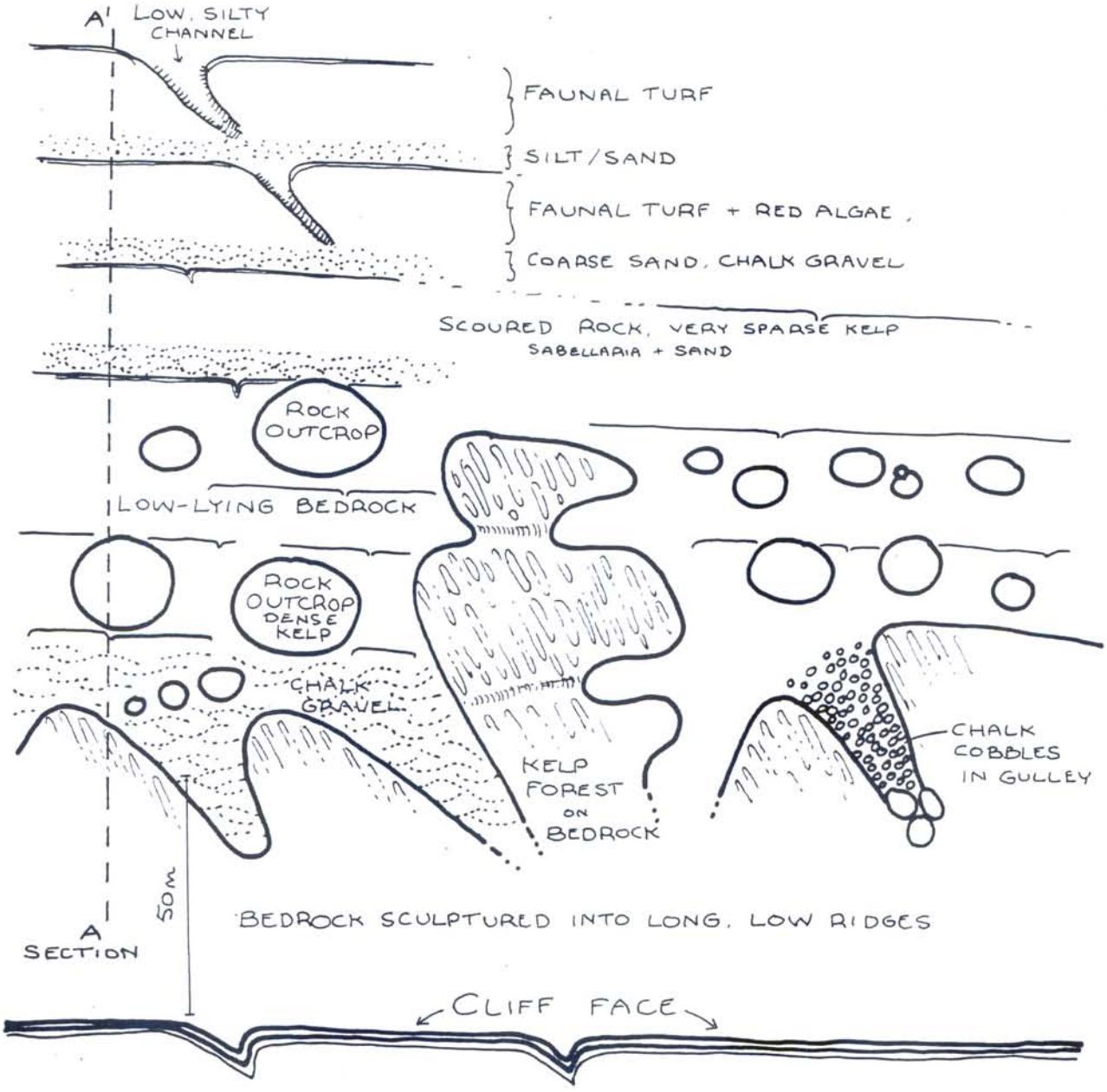
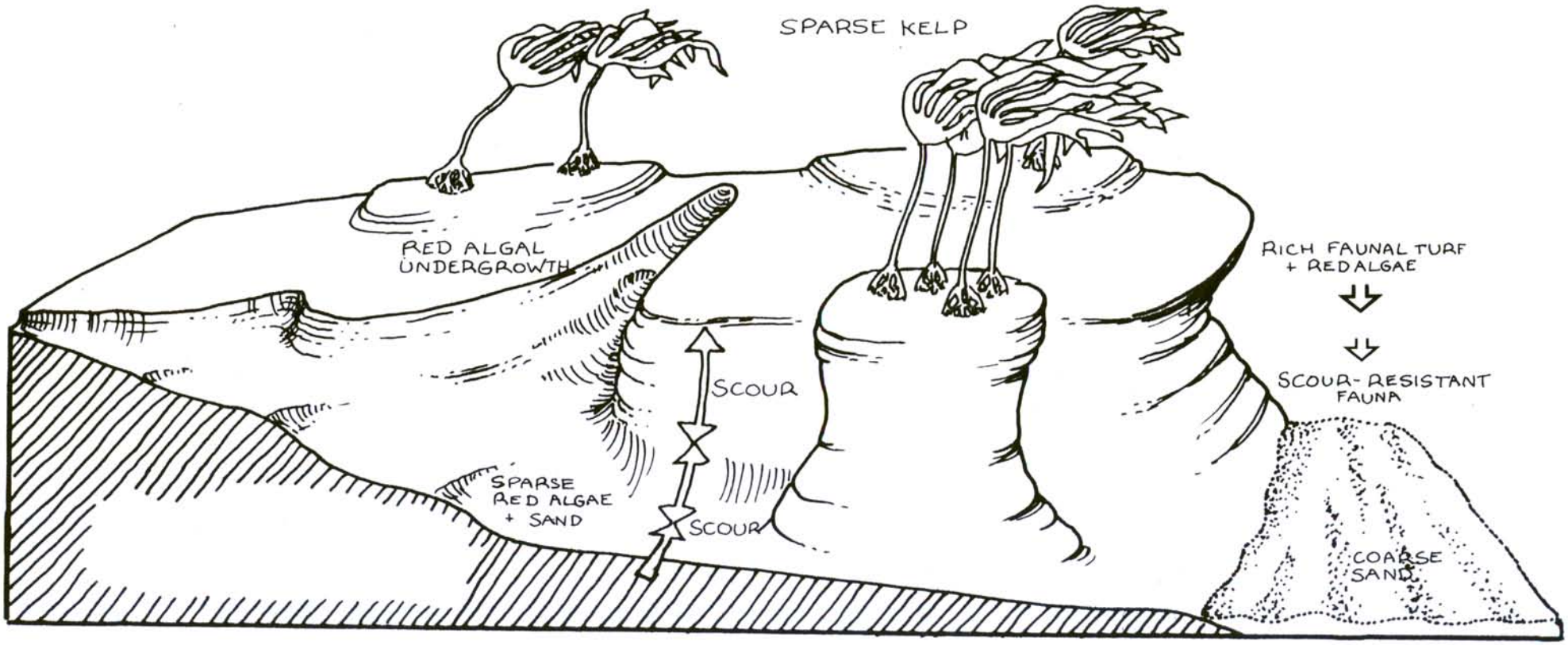

A
LOW, SILTY CHANNEL
A'
FAUNAL TURF
SILT/SAND
FAUNAL TURF + RED ALGAE
COARSE SAND, CHALK GRAVEL
SCOURED ROCK, VERY SPARSE KELP SABELLARIA + SAND
ROCK OUTCROP
LOW-LYING BEDROCK
ROCK OUTCROP DENSE KELP
CHALK GRAVEL
KELP FOREST ON BEDROCK
CHALK COBBLES IN GULLEY
50m
A SECTION
BEDROCK SCULPTURED INTO LONG, LOW RIDGES
CLIFF FACE

Figure 10. 3-dimensional sketch of inshore rocky habitat at Little Thornwick (site 15).



The major COMMUNITIES, all of which were wave-exposed, were associated with:

a) Upward-facing surfaces on tops of rock.
b) Upward-facing surfaces on lower bedrock.
c) Steeply sloping/vertical/underhanging surfaces.

Aa. UPWARD-FACING SURFACES ON TOPS OF ROCKS

The distinctive feature of these shallow upward-facing surfaces was the presence of kelp (Laminaria hyperborea, with L. digitata around low water mark). The most extensive L. hyperborea forests appeared to be to the south-east of the Head, off Cattlemere (sites 42 and 43), but dense stands were also present close inshore along much of the north and east-facing part of the headland (Fig 6). Along the south-facing side there were fewer stable rock surfaces in shallow water, and the L. hyperborea community was correspondingly poorly developed.

The habitat comprised several component parts; notably, the kelp plants (blade, stipe and holdfast), and the rock surfaces between plants. Brief descriptions of the communities are given below.

Site 7: Nettle Trip (4 m below CD).
A few L. hyperborea plants present on the top of a rock outcrop standing 2 m above the surrounding sandy plain. Sparse undergrowth of sessile animals and red algae.

Site 8: Bartlett Nab (1.7 m above CD to 2 m below CD).
This site, at the base of Bempton Cliff (figure 14), consisted of terraced bedrock outcrops and very large boulders. Laminaria digitata was present on elevated surfaces, and the rock between holdfasts was encrusted with red algae and colonised by patches of the horse-mussel Modiolus modiolus, numerous Patella and Nucella lapillus.

Site 12: Cat Nab (0 to 2.5 m below CD). Figure 9.
Dense L. hyperborea forest with 17 species of algae recorded in the kelp understorey. Small ridges and grooves in the surface of the platform provided suitable niches for the dahlia anemone and for the small worm Polydora ciliata.

Sites 13 and 14: North Cliff (0.5 to 1.5 m below CD).
Kelp forest, including Alaria esculenta; rock surface beneath covered by carpet of red algae, mostly Polysiphonia spp, and often covered in young Modiolus modiolus. Furcellaria lumbricalis occurred in areas where sand had accumulated. Labrus bergylta recorded.

Site 15: Little Thornwick (2.9 m below CD).
Well-spaced kelp plants (L. hyperborea); Polysiphonia and Modiolus as at sites 13/14; Plocamium cartilagineum also common.

Site 17: High Holme (4.5 m below CD).
Small (1 m or less tall) kelp plants were sparsely distributed on the tops of rock outcrops standing up to a metre high. The plants were heavily overgrown; the fronds with Obelia geniculata and Membranipora membranacea, the stipes with Electra pilosa, Halichondria panicea (figure 11) and red algae such as Membranoptera alata, Phycodrys rubens and Plocamium cartilagineum. The algal understorey here consisted mainly of Plocamium, with Delesseria, Hypoglossum and Phyllophora common. Sessile animals were also well represented. There were large patches of Myxilla incrustans and Halichondria panicea, many ascidians (e.g. Botryllus schlosseri, Polyclinum aurantium, Aplidium punctum and A. proliferum), and smaller turf species such as the bryozoans Crisia eburnea and Bicellariella ciliata.

Figure 11. Kelp stipes (site 17) heavily encrusted with Halichondria panicea. Brittlestars (Ophiothrix fragilis) are nestling amongst 'folds' in the sponge (photo E. Wood).

Site 19: East Scar, North Landing (3.0 m below CD).
Tops of ridges and outcrops with sparse kelp; the plants etiolated (stipes often 1.5 m long) with poorly-developed fronds. Stipes heavily encrusted with Halichondria panicea. Understorey of red algae dominated by Delesseria sanguinea and

Plocamium cartilagineum. By 5 m below CD this was giving way to an animal-dominated turf, mostly ascidians and hydroids.

Site 20: Carter Lane (3-4 m below CD).
Small kelp plants with epiphytes similar to those described for site 17 (above); although little Halichondria panicea. Understorey dominated by Delesseria and Plocamium, heavily overgrown by Electra pilosa.

Site 24: off Petrel Hole (2 m below CD).
Upward-facing surfaces of outcrops and boulders dominated by kelp, with mixed algal/animal undergrowth. Several plants from this site were examined (Table 1).

Site 25: off Petrel Hole (0.5-2.5 m below CD).
Well-spaced, etiolated kelp plants on the top of rock outcrops. The holdfasts were noticeably small, and were colonised mainly by Crisia spp. and Botryllus schlosseri. Rock surfaces between the holdfasts were also sparsely colonised; for example by Alcyonidium diaphanum, Alcyonium digitatum and Botrylloides leachii.

Site 26: Cradle Head (2-4 m below CD).
Moderately dense kelp forest. Rock surfaces between plants at least 50% covered by red algae (15 species recorded), with Plocamium cartilagineum prominent. Estimated 30% surfaces silty and uncolonised; 20% with faunal turf especially Polyclinum aurantium, Clavelina lepadiformis and other ascidians. Kelp stipes colonised especially by H. panicea (common), Electra pilosa and algae (e.g. Plocamium cartilagineum, Phycodrys rubens, Ptilota plumosa, Cryptopleura ramosa and encrusting coralline sp. [Lithothamnion]).

Site 37: off Fog Station (1 m above CD).
Laminaria digitata abundant on the tops of outcrops, with some L. hyperborea. Rock surfaces between holdfasts with almost 100% cover of crustose coralline algae.

Site 35, 38: off Fog Station (approx 0.3 m below CD).
Rock surfaces between kelp (mostly L. hyperborea) holdfasts dominated by a dense understorey of foliose algae (23 spp recorded), with Corallina officinalis, Phyllophora crispa,

Cryptopleura ramosa, Delesseria sanguinea and Hypoglossum hypoglossoides particularly prominent.

Sites 41, 42, 43: off Cattlemere (2 to 5 m below CD).
The densest and most extensive kelp (L. hyperborea) forest was found in this area at a depth of about 2.5 m below CD. The kelp plants were so densely packed on the upraised bedrock that the holdfasts virtually touched each other. There was a mixture of sizes; the largest plants being about 2-3 m tall.

The kelp fronds at this site were relatively 'clean', except for Obelia geniculata and occasional patches of Membranipora membranacea. The dominant encrusting species on the kelp stipes was Halichondria panicea, often occurring in extensive sheaths. Epiphytic algae were numerous and included Plocamium cartilagineum, Hypoglossum hypoglossoides, Phycodrys rubens and Ceramium sp. (see Table 1) Small crabs and starfish were often found amongst the stipe epiphytes. Electra pilosa was common at the base of the stipes and on the holdfast, together with various tunicates. Several holdfasts were collected, and a range of animals was found hidden within them (Table 1).

Figure 12. Laminaria hyperborea forest off Cattlemere. The kelp stipes and silty rock surfaces are colonised by red algae and animal turf (photo: E. Wood).

Rock surfaces between the holdfasts were densely covered by a mixture of red algae and sessile animals. Common algae included Plocamium cartilagineum and Delesseria sanguinea, but at least

	Epiphytes and associated organisms					
	Encrusting haptera		Within holdfast		Encrusting stipe	
	24	42	24	42	24	42
Ptilota plumosa	p	-	-	-	p	p
Cryptopleura ramosa	c	-	-	-	c	-
Phycodrys rubens	f	-	-	-	c	-
Plocamium cartilagineum	f	p	-	-	p	p
Rhodophyllis divaricata	-	p	-	-	-	p
Ceramium sp.	-	p	-	-	-	p
Pterothamnion plumula	-	-	-	-	-	p
Cryptopleura ramosa	-	-	-	-	-	p
Delesseria sanguinea	-	-	-	-	-	p
Hypoglossum hypoglossoides	-	p	-	-	-	p
Membranoptera alata	-	-	-	-	-	p
Phycodrys rubens	-	-	-	-	-	p
Brongniartella byssoides	-	-	-	-	-	p
Ectocarpacea	-	p	-	-	-	p
Dictyota dichotoma	f	-	-	-	-	-
Halichondria panicea	p	-	-	-	a	-
Dysidea fragilis	p	-	-	p	-	-
Dynamena pumilosa	-	-	-	-	-	p
Sabellaria spinulosa	-	-	f	c	-	-
Lanice conchilega	-	-	-	p	-	-
Balanus balanus	-	-	-	p	-	-
Pisidea longicornis	-	-	-	p	-	-
Janolus cristatus	-	-	-	p	-	-
Anomiidae (juvenile)	-	-	p	-	-	-
Smittina affinis	-	-	p	-	-	-
Electra pilosa	a	p	-	-	f	p
Scrupocellaria scruposa	-	-	p	-	-	-
Ophiothrix fragilis	-	-	c	f	-	-
Asterias rubens	-	-	f	p	p	-
Archidistoma aggregatum	-	p	-	-	-	-
Polyclinum aurantium	-	p	-	-	-	-
Aplidium punctum	-	p	-	-	-	-
Dendrodoa grossularia	-	-	p	-	-	-
Botryllus schlosseri	p	-	-	-	-	-
Fish eggs	-	-	p	-	-	-

Table 1. Examples of kelp-associated species (excluding meiofauna). Site 24: Petrel Hole; kelp on outcrops at 2.5-3.5 m below CD. Site 42: Cattlemere; kelp forest at 2.5-3.5 m bCD

Site 12: Cat Nab (3.0 to 5.2 m below CD).
Scoured bedrock, with some cobbles and coarse sand. In shallowest areas, dense Polydora ciliata 'turf' with Sabellaria spinulosa common; large patches of Taonia atomaria, with other red algae occasional. This assemblage gradually gave way to a community dominated by bryozoans, with few red algae.

Site 17: High Holme (5.5 m below CD).
Scoured bedrock, submerged by sand in places. Very little faunal turf; progressively less the lower the bedrock, where there was the greatest scour/submergence. Cliona celata occurred here (boring form only), and Urticina felina was common, especially in sandy pockets and at bases of rocks. Estimated 70% cover by crustose coralline algae with large patches of Taonia atamaria and other red algae occasional (e.g. Delesseria sanguinea, Plocamium cartilagineum, Hypoglossum hypoglossoides and Tilopteris mertensii)

Site 26: Cradle Head (2-4 m below CD).
Open, low-lying bedrock and boulders. A few foliose algae, but crustose coralline algae dominant on stable rocks; considerable bare surfaces on smaller boulders and cobbles. Asterias rubens present; faunal turf absent.

Site 35 and 38: Fog Station (0.8 m above CD to 4.5 m below CD).
The top end of a gully was investigated briefly during one dive, and found to consist of boulders with crustose coralline algae, Laminaria saccharina and Palmaria palmata. This led seawards into a system of wide gullies with a mixture of boulders, large cobbles and some areas of clean sand (figure 15). At 3-4 m depth below CD coralline algal crusts were still common, and there were tufts of Audouinella sp. and ectocarpoid algae. Small plants of Taonia atomaria and Dictyota dichotoma were also present. Animal life was restricted to species such as Cancer pagurus, Asterias rubens and Crossaster papposus present.

Site 42: Cattlemere (2.5-6.5 m below CD).
Low-lying bedrock, boulders and cobble in gullies. Noticeably silty; faunal turf sparser, except for Polyclinum aurantium, and Urticina felina in crevices. Crustose coralline algae present in areas subjected to scour, also Audouinella , ectocarpoid algae, Hypoglossum hypoglossoides and Taonia atomaria.

	Epiphytes and associated organisms					
	Encrusting haptera		Within holdfast		Encrusting stipe	
	24	42	24	42	24	42
Ptilota plumosa	p	-	-	-	p	p
Cryptopleura ramosa	c	-	-	-	c	-
Phycodrys rubens	f	-	-	-	c	-
Plocamium cartilagineum	f	p	-	-	p	p
Rhodophyllis divaricata	-	p	-	-	-	p
Ceramium sp.	-	p	-	-	-	p
Pterothamnion plumula	-	-	-	-	-	p
Cryptopleura ramosa	-	-	-	-	-	p
Delesseria sanguinea	-	-	-	-	-	p
Hypoglossum hypoglossoides	-	p	-	-	-	p
Membranoptera alata	-	-	-	-	-	p
Phycodrys rubens	-	-	-	-	-	p
Brongniartella byssoides	-	-	-	-	-	p
Ectocarpacea	-	p	-	-	-	p
Dictyota dichotoma	f	-	-	-	-	-
Halichondria panicea	p	-	-	-	a	-
Dysidea fragilis	p	-	-	p	-	-
Dynamena pumilosa	-	-	-	-	-	p
Sabellaria spinulosa	-	-	f	c	-	-
Lanice conchilega	-	-	-	p	-	-
Balanus balanus	-	-	-	p	-	-
Pisidea longicornis	-	-	-	p	-	-
Janolus cristatus	-	-	-	p	-	-
Anomiidae (juvenile)	-	-	p	-	-	-
Smittina affinis	-	-	p	-	-	-
Electra pilosa	a	p	-	-	f	p
Scrupocellaria scruposa	-	-	p	-	-	-
Ophiothrix fragilis	-	-	c	f	-	-
Asterias rubens	-	-	f	p	p	-
Archidistoma aggregatum	-	p	-	-	-	-
Polyclinum aurantium	-	p	-	-	-	-
Aplidium punctum	-	p	-	-	-	-
Dendrodoa grossularia	-	-	p	-	-	-
Botryllus schlosseri	p	-	-	-	-	-
Fish eggs	-	-	p	-	-	-

Table 1. Examples of kelp-associated species (excluding meiofauna). Site 24: Petrel Hole; kelp on outcrops at 2.5-3.5 m below CD. Site 42: Cattlemere; kelp forest at 2.5-3.5 m bCD

23 other species contributed to the understorey (table 2). Many of the larger plants were encrusted with Electra pilosa, but other bryozoans were not well represented. The dominant component of the animal turf here was Polyclinum aurantium, with Archidistoma aggregatum and lobe-like colonies of Botryllus schlosseri common. Lobsters, crabs (Carcinus maenas, Cancer pagurus, Hyas araneus) and starfish (Asterias rubens, Henricia sanguinolenta) were frequent, and Taurulus bubalis occasionally seen, but there were few other fish. There was a noticeable absence of Echinus esculentus.

Dilsea carnosa	f
Callophyllis laciniata	o
Corallinaceae- encrusting	r
Corallina officinalis	f
Plocamium cartilagineum	c
Phyllophora crispa	o
Phyllophora pseudoceranoides	f
Schottera nicaeensis	r
Calliblepharis ciliata	o
Rhodophyllis divaricata	o
Lomentaria arcadensis	o
Rhodymenia holmesii	r
Ceramium sp.	o
Griffithsia flosculosa	o
Cryptopleura ramosa	f
Delesseria sanguinea	c
Hypoglossum hypoglossoides	f
Phycodrys rubens	o
Brongniartella byssoides	o
Polysiphonia nigrescens	p
Polysiphonia urceolata	p
Rhodomela confervoides	r
Dictyota dichotoma	o
Desmarestia viridis	o
Sphacelaria plumosa	r

Table 2. Algal species recorded from the undergrowth between kelp plants at site 42 (r = rare; p = present; o = occasional; f = frequent; c = common).

Ab. UPWARD-FACING SURFACES ON LOWER BEDROCK

These areas included gully bottoms and other low-lying bedrock. A range of communities was found, depending on the type of substratum and the amount of scour and wave-disturbance. Examples are given below.

Site 8: Bartlett Nab (1.3 m below CD).
Lower substratum of large, smooth boulders separated by channels filled with very soft, fine silt plus small and large pebbles. Tops of boulders bare of animal turf, but with a layer of encrusting red algae. Urticina felina and Sabellaria spinulosa were found in depressions and crevices (figure 13 and 14).

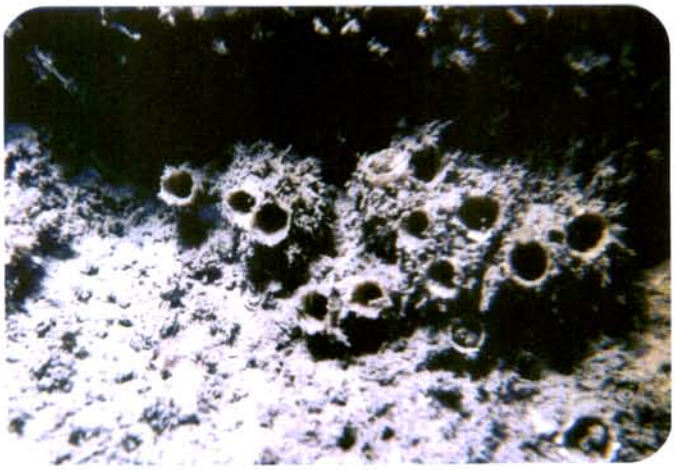


Figure 13.
A clump of tubes belonging to the worm Sabellaria spinulosa at the base of a boulder at site 8 (photo: E. Wood).

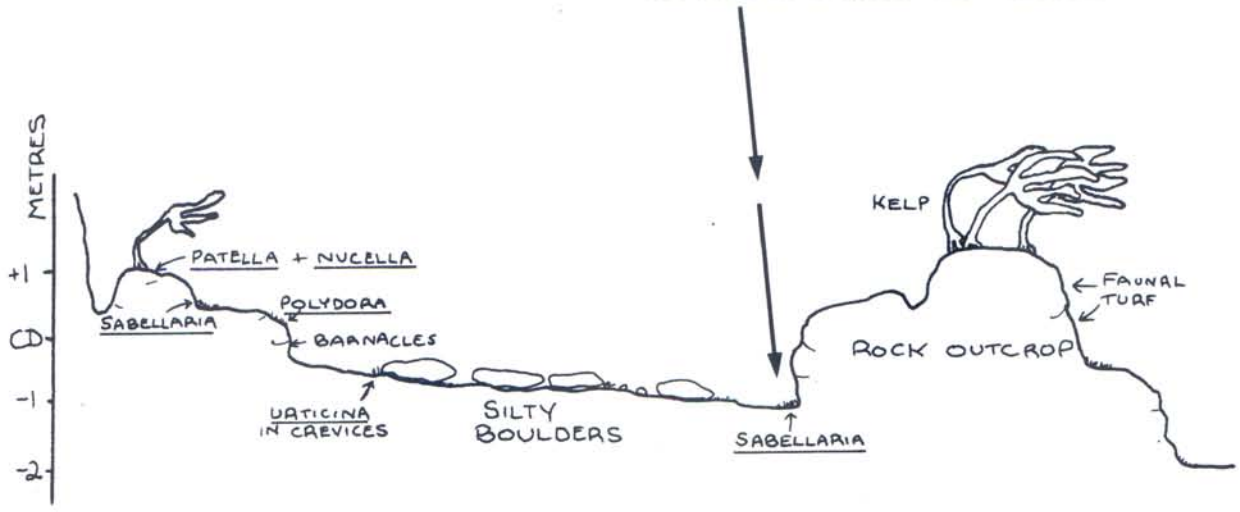


Figure 14. Profile at Bartlett Nab (site 8), showing a range of habitats.

Site 12: Cat Nab (3.0 to 5.2 m below CD).
Scoured bedrock, with some cobbles and coarse sand. In shallowest areas, dense Polydora ciliata 'turf' with Sabellaria spinulosa common; large patches of Taonia atomaria, with other red algae occasional. This assemblage gradually gave way to a community dominated by bryozoans, with few red algae.

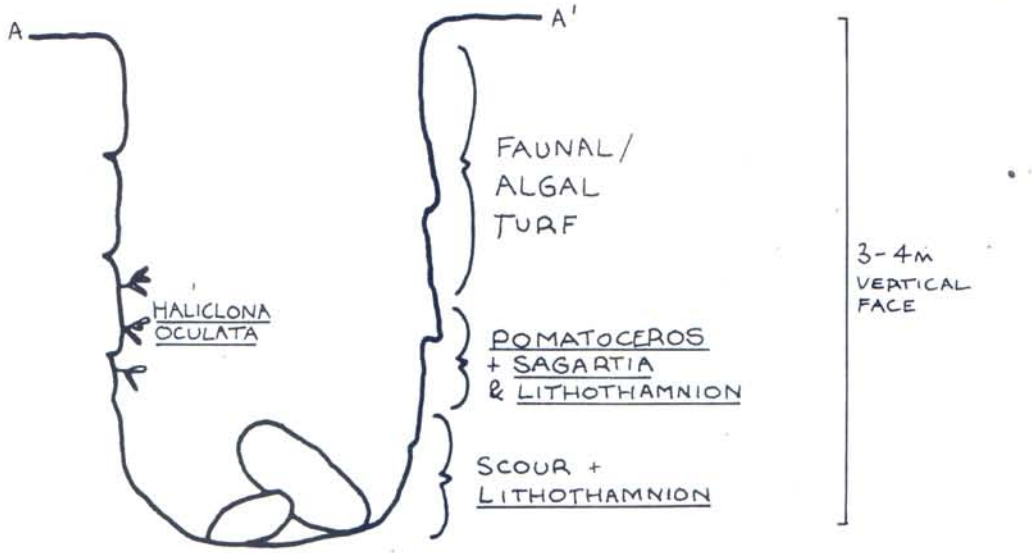
Site 17: High Holme (5.5 m below CD).
Scoured bedrock, submerged by sand in places. Very little faunal turf; progressively less the lower the bedrock, where there was the greatest scour/submergence. Cliona celata occurred here (boring form only), and Urticina felina was common, especially in sandy pockets and at bases of rocks. Estimated 70% cover by crustose coralline algae with large patches of Taonia atamaria and other red algae occasional (e.g. Delesseria sanguinea, Plocamium cartilagineum, Hypoglossum hypoglossoides and Tilopteris mertensii)

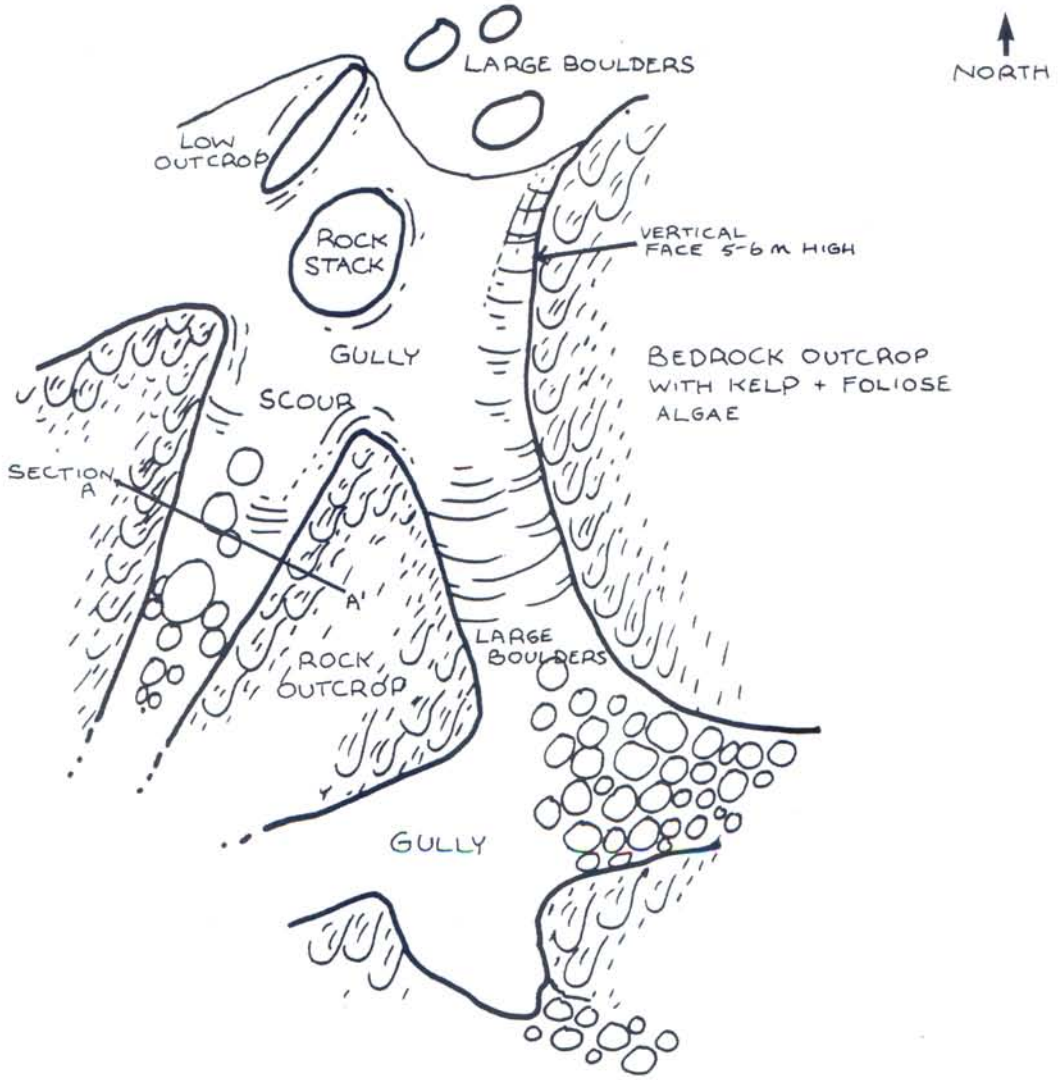
Site 26: Cradle Head (2-4 m below CD).
Open, low-lying bedrock and boulders. A few foliose algae, but crustose coralline algae dominant on stable rocks; considerable bare surfaces on smaller boulders and cobbles. Asterias rubens present; faunal turf absent.

Site 35 and 38: Fog Station (0.8 m above CD to 4.5 m below CD).
The top end of a gully was investigated briefly during one dive, and found to consist of boulders with crustose coralline algae, Laminaria saccharina and Palmaria palmata. This led seawards into a system of wide gullies with a mixture of boulders, large cobbles and some areas of clean sand (figure 15). At 3-4 m depth below CD coralline algal crusts were still common, and there were tufts of Audouinella sp. and ectocarpoid algae. Small plants of Taonia atomaria and Dictyota dichotoma were also present. Animal life was restricted to species such as Cancer pagurus, Asterias rubens and Crossaster papposus present.

Site 42: Cattlemere (2.5-6.5 m below CD).
Low-lying bedrock, boulders and cobble in gullies. Noticeably silty; faunal turf sparser, except for Polyclinum aurantium, and Urticina felina in crevices. Crustose coralline algae present in areas subjected to scour, also Audouinella , ectocarpoid algae, Hypoglossum hypoglossoides and Taonia atomaria.

Figure 15. Plan of a system of outcrops and gullies found at site 38 (bottom), and cross section through a gully (top).





Ac. STEEPLY SLOPING/VERTICAL/UNDERHANGING SURFACES

Where rock faces were either shallow and/or slightly upward-facing, illumination was sufficient for algae to grow (although often sparingly), and a range of species was seen. However, this habitat was characterised by a faunal turf comprising a range of species. There was generally a noticeable vertical zonation, reflecting increased scour at the base of the rocks.

Site 8: Bartlett Nab (1m above to 1 m below CD).
The vertical face of Bempton Cliff (figure 14) was covered at its base in encrusting red algae with Patella abundant and Semibalanus balanoides, Corallina officinalis and Chondrus crispus common. Vertical faces further out from the cliff supported a faunal turf including Clathrina coriacea, Halichondria panicea, Grantia compressa, Sabellaria spinulosa and Semibalanus balanoides. Scouring prevented this turf becoming established at the base of the vertical faces; here only Pomatoceros was present, with small papillae of Cliona celata above.

Site 17: High Holme (5.5 m below CD).
Up to 1 m high sides of outcrops densely covered with faunal turf (same range of species seen on upward-facing surfaces- see description in that section), together with patches of Plumularia setacea. A few algae present, notably Phyllophora crispa.

Site 19: East Scar, North Landing (5.5 m below CD).
Bedrock and boulder with faces up to 2 metres high and predominantly bryozoan/ascidian turf.

Site 24: Petrel Hole (2.5-3.5 m below CD).
Faces up to 2 m high were richly colonised by bryozoans (Crisea and Bugula spp.), together with tunicates such as Perophora listeri, Sidnyum turbinatum and Aplidium punctum. The small hydroid Plumularia setacea formed dense stands beneath overhangs, and sponges (e.g. Dysidea fragilis, Halichondria panicea and Haliclona oculata) were prominent. Effects of scouring at the rock base were very obvious. Apart from Lithothamnion there was little attached life, but crevices here provided an ideal habitat for Cancer pagurus, Homarus gammerus and the leopard-spotted goby, Thorogobius ephippiatus.

Site 25: Petrel Hole (0.5 - 2.5 m below CD).
Vertical faces of eroded chalk platform with rich animal turf dominated by ascidians and bryozoans. Cancer pagurus and Galathea strigosa in crevices.

Site 26 and 27: Cradle Head (2-4 m below CD).
Vertical and overhanging faces to 1.5 m in height, with many mobile (table 3) and sessile (table 4) animals.

Figure 16. Vertical rock face (site 27) with a large clump of the tunicate Clavelina lepadiformis to the left, and orange colonies of Aplidium punctum (centre-right). The red alga Rhodymenia holmseii is growing out from amongst the bryozoan (Crisia) turf. White colonies of dead-man's-fingers, Alcyonium digitatum are visible to the right (photo: S. Fowler).

Sites 35/36: Fog Station (2 m above CD to 4.8 m below)
Vertical and overhanging faces to 6 metres in height; richy colonised (see Table 3 and 4). The strata here are evidently bedded horizontally, and in places there have been differential rates of erosion leading to the formation of clefts which penetrate in as much as 2 metres. The interior of the clefts provided a suitable niche for various animals (see Table 3), and the silty ledges at the entrance were colonised by conspicuous animals such as Urticina felina, Haliclona oculata and Alcyonidium diaphanum.

	SITE		
	26	35	42/3
Clathrina coriacea	-	p	-
Leucosolenia botryoides	p	-	-
Scypha ciliata	-	p	p
Grantia compressa	-	p	p
Cliona celata	-	p	-
Halichondria panicea	-	c	-
Myxilla incrustans	-	-	f
Haliclona oculata	-	c	p
Dysidea fragilis	-	f	p
Tubularia indivisa	-	a	-
Tubularia larynx	-	a	-
Halecium halecinum	-	-	f
Plumularia setacea	-	c	-
Alcyonium digitatum	-	-	p
Urticina felina	p*	f*	-
Sagartia elegans	-	f	-
Sagartia troglodytes	-	-	p
Sabellaria spinulosa	f	-	-
Hiatella arctica	-	c	-
Crisiidae	-	c	a
Alcyonidium diaphanum	-	c	p
Cellopora pumicosa	-	p	-
Electra pilosa	-	a	-
Cellaria sinuosa	p	-	-
Bugula plumosa	p	f	p
Bugula turbinata	-	-	p
Clavelina lepadiformis	p	p	-
Polyclinum aurantium	f	f	p
Morchellium argus	c	f	-
Sidnyum turbinatum	p	-	-
Aplidium proliferum	-	-	f
Aplidium punctum	a	f	a
Botryllus schlosseri	f	-	p
Botrylloides leachii	f	c	p

Table 4. Examples of sessile fauna associated with very steep, vertical and/or underhanging surfaces, (* in crevices). p = present; f = frequent; c = common; a = abundant.

Site 26: Cradle Head; boulders/outcrops with faces to 1.5 m in height (2-4 m below CD).
Site 35: Fog Station; outcrops with faces to 6 m in height (2m above chart datum to 4.8 m below CD).
Site 42: Cattlemere , faces to 1 m in height (3-6 m below CD).

Figure 17.
Three sponge species are visible on this vertical face (site 36): the branching Haliclona oculata, yellow patches of Myxilla incrustans, and small white colonies of Clathrina coriacea. The starfish Henricia oculata is present, and many brittlestar arms (Ophiothrix fragilis) protrude from the undergrowth (photo: E. Wood).

Sites 41/42/43: Off Cattlemere (2.5 to 5 m below CD).
The faces were about one metre high and were colonised by a rich variety of species (Tables 3 and 4).

	SITE		
	26	35	42/3
Homarus gammarus	-	c*	-
Hyas coarctatus	-	p	-
Galathea strigosa	p*	c*	c*
Cancer pagurus	-	c*	c*
Inachus phalangium	-	p	f
Doto coronata	-	p	-
Acanthodoris pilosa	-	p	-
Cadlina laevis	-	p	-
Archidoris pseudoargus	-	c	p
Janolus cristatus	-	f	-
Coryphella lineata	-	f	-
Henricia oculata	p	-	-
Asterias rubens	-	p	-
Ophiothrix fragilis	c	c	a
Gadus morhua	-	p*	-
Pholis gunnellus	-	p	-
Thorogobius ephippiatus	p*	p*	-
Chirolophis ascanii	-	p*	-

Table 3. Mobile animals associated with steep, vertical and/or underhanging rock surfaces; * in crevices. (see Table 4 for site details).

B. INSHORE (INFRALITTORAL) ROCKY HABITAT (Shore to approximately 5 m below CD): MAJOR COMPONENTS SMALL BOULDERS, COBBLES AND PEBBLES.

OTHER COMPONENTS: Bedrock, large boulders (rare), gravel, sand.

The nearshore wave-cut bedrock platforms along the south-facing part of the headland are mostly covered by small boulders, cobbles and pebbles, so producing habitats quite distinct from those typical of the north-facing coast (described above in A).

Figure 17. View eastwards from South Landing. The flattish bedrock here shelves gently seawards and is largely covered by small boulders, cobbles and pebbles (photo: E. Wood).

The major COMMUNITIES were associated with:

a) Relatively stable boulders and cobbles, plus unscoured bedrock.
b) Mobile cobbles and pebbles.
c) Sediments.

Ba. RELATIVELY STABLE BOULDERS AND COBBLES

Site 51: off South Cliff (1.5 to 3.5 m below CD), fig 19. Chalk bedrock overlain with boulders and cobbles. Laminaria hyperborea was present on the tops of large boulders, and the understorey comprised algae such as Ceramium rubrum, Delesseria sanguinolenta and Plocamium cartilagineum. Electra pilosa encrusted many of the algae, and there were conspicuous patches

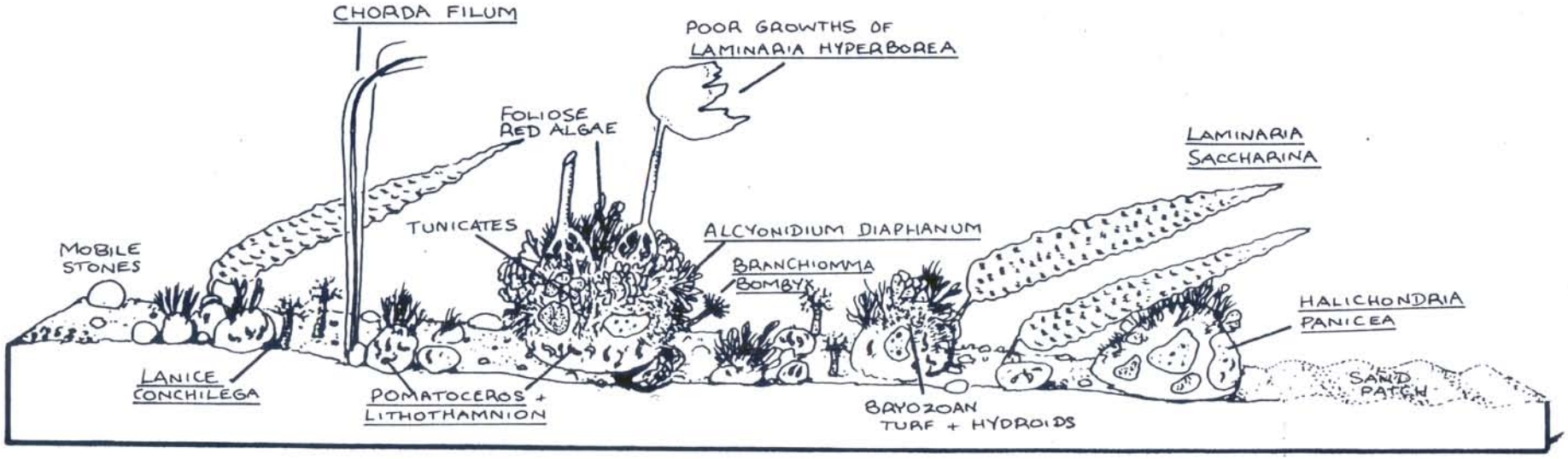


Figure 19. Communities at a depth of 2.5 m below CD off South Cliff (site 51).

of Alcyonidium diaphanum. A mixed faunal turf was present on the lower sides of the boulders with the hydroid Halecium halecinum, bryozoans Crisia eburnea and Bugula spp., and the ascidians Botryllus schlosseri, Morchellium argus and Aplidium proliferum prominent. Smaller boulders supported a sparser flora and fauna and L. hyperborea was replaced by L. saccharina. The shore crab Carcinus maenas, edible crab Cancer pagurus and the small spider crab Hyas araneus were common at this site. Asterias rubens also common.

Site 52: off South Cliff (from CD to 1.0 m above).
Cobbles and small boulders overlying sand. Rich kelp cover (especially Laminaria saccharina); sparse fauna including ascidians (especially Morchellium argus and encrusting didemnid). Crabs and starfish were common as site 51; Taurulus bubalis and the eel Anguilla anguilla were recorded.

Sites 53 and 54: off South Landing (5 m below CD)
Large and small cobbles with occasional boulders. The tops of stable rocks were often densely covered in algae, including Laminaria saccharina (frequent) and undergrowth species such as Brongniartella byssoides, Calliblepharis ciliata, Plocamium cartilagineum and Polysiphonia urceolata. However, the tops of some boulders were animal-dominated (figure 20). The sides supported a rich turf of tunicates and bryozoans together with Leucosolenia botryoides and the purse sponges Scypha ciliata and Grantia compressa. Smaller stones were less well colonised. Decapod crustaceans were common.

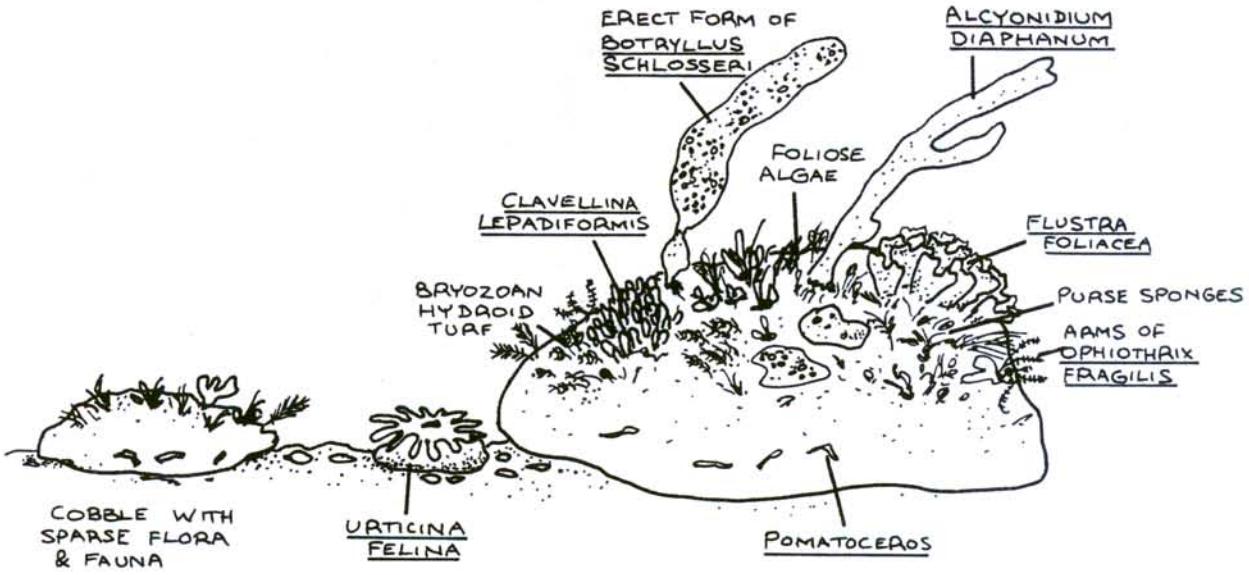


Figure 20. Faunal-dominated small boulder and cobble at site 54.

Site 58: off Beacon Hill (2 m below CD).
Silty cobbles and pebbles covered with L. saccharina and foliose red algae.

Sites 59/60: Danes Dyke (4.0 to 4.5 m below CD).
Seabed strewn with pebbles, cobbles and small boulders, some mobile (see Bb). The tops of stable rocks densely colonised by foliose and filamentous red and brown algae, especially Brongniartella byssoides, Plocamium cartilagineum, Delesseria sanguinea and ectocarpoids. L. saccharina also common. The upper surface of flatter rocks was often covered by Polydora ciliata in a silty mat. The sides of the rocks were covered by a mixed turf with bryozoans and ascidians prominent.

Sites 61/62: Sewerby Rocks (3.0 to 3.5 m below CD).
Mixed boulder, cobble, pebble, sediment seabed. Algal cover was similar to sites 59/60, except that one or two broken stems of L. hyperborea were found. Also, as at sites 59/60 there were few hydroids on the boulder sides; mostly bryozoans and tunicates. In places Halichondria panicea was common, harbouring Ophiothrix fragilis. Small crabs (e.g. Macropodia rostrata, Inachus phalangium, Hyas coarctus) were present amongst the turf, often heavily disguised.

Bb MOBILE COBBLES AND PEBBLES

Mobile cobbles and pebbles were present at most of the sites mentioned above, and in general were heavily colonised by Pomatoceros, with some small filamentous algae (e.g. ectocarpoids), crustose coralline algae, encrusting bryozoans and occasional hydroids. Decapod crustaceans were common, for example 7 species were recorded at Danes Dyke (site 59) and 8 species at Sewerby Rocks (Pandalus montagui, Pagurus bernhardus, Hyas araneus, Macropodia rostrata, Cancer pagurus, Liocarcinus holsatus, L. arcuatus, Carcinus maenas)

Bc. SEDIMENTS

Pockets and patches of coarse silty sediment occurred at most of the sites described under Ba and Bb. Visible animals associated with this habitat included the tube-dwelling worms Lanice conchilega and Sabella flabellata, the dahlia anemone Urticina felina, the starfish Asterias rubens, and fishes such as Callionymus lyra and Pleuronectes platessa.

DEEPER (CIRCALITTORAL) ROCKY SEABED (approximately 6 m or more below CD): MAJOR COMPONENT TERRACED BEDROCK

ΘTHER COMPONENTS: Rock outcrops, flattish bedrock plain, small boulders.

The dimensions of the terraces is variable, but the vertical faces range from a metre or more in height to about 20-30 cm further offshore. Also in deeper water, rock outcrops become progressively lower and have a more rounded profile, and the gullies open out to form areas of low-lying bedrock. All surfaces were noticeably silty.

A range of sites was invesigated, and the communities are described briefly below. A universal feature was the presence of many bryozoans and hydroids, but other groups were well represented.

Site 9: Scale Nab (9.5 to 11.5 m below CD).
Silty rock platforms. Flustra foliacea and Alcyonium digitatum prominent on raised areas; Polydora common on lower bedrock.

Site 11: Cat Nab (9.2 to 14.2 m below CD)
The topography at this site was unusual, consisting of rock outcrops running parallel with the shore, forming ridges, ledges and vertical faces (figure 21, bottom). All rock surfaces were silty, with a 0.5-1.0 cm layer on the ledges, and up to 3 cm of soft mud in some of the lower gullies. In places were silty mats of Polydora. Small bryozoans such as Bugula and Crisia were common on vertical, but more prominent were species such as Nemertesia antennina, Abietinaria antennina, Thuiaria thuja, Alcyonium digitatum and Flustra foliacea. Hiatella arctica and Zirfaea crispata were abundant, burrowing into the chalk, and both starfishes and sea-urchins were common.

Site 16: Thornwick Nab (8 to 10 m below CD).
Terraced bedrock with faces to 2 m in height. Communities are shown in figure 21 (top).

Site 18: High Holme (15.5 m below CD)
Terraced bedrock with vertical faces 20 to 150 cm in height and gullies 1 to 4 m wide. The tops of the rock platforms were dominated by Flustra foliacea, with species such as Haliclona oculata occasional. Vertical faces were colonised especially by Alcyonium digitatum, with Galathea squamifera in crevices. Starfishes were common, and sea-urchins occasional.

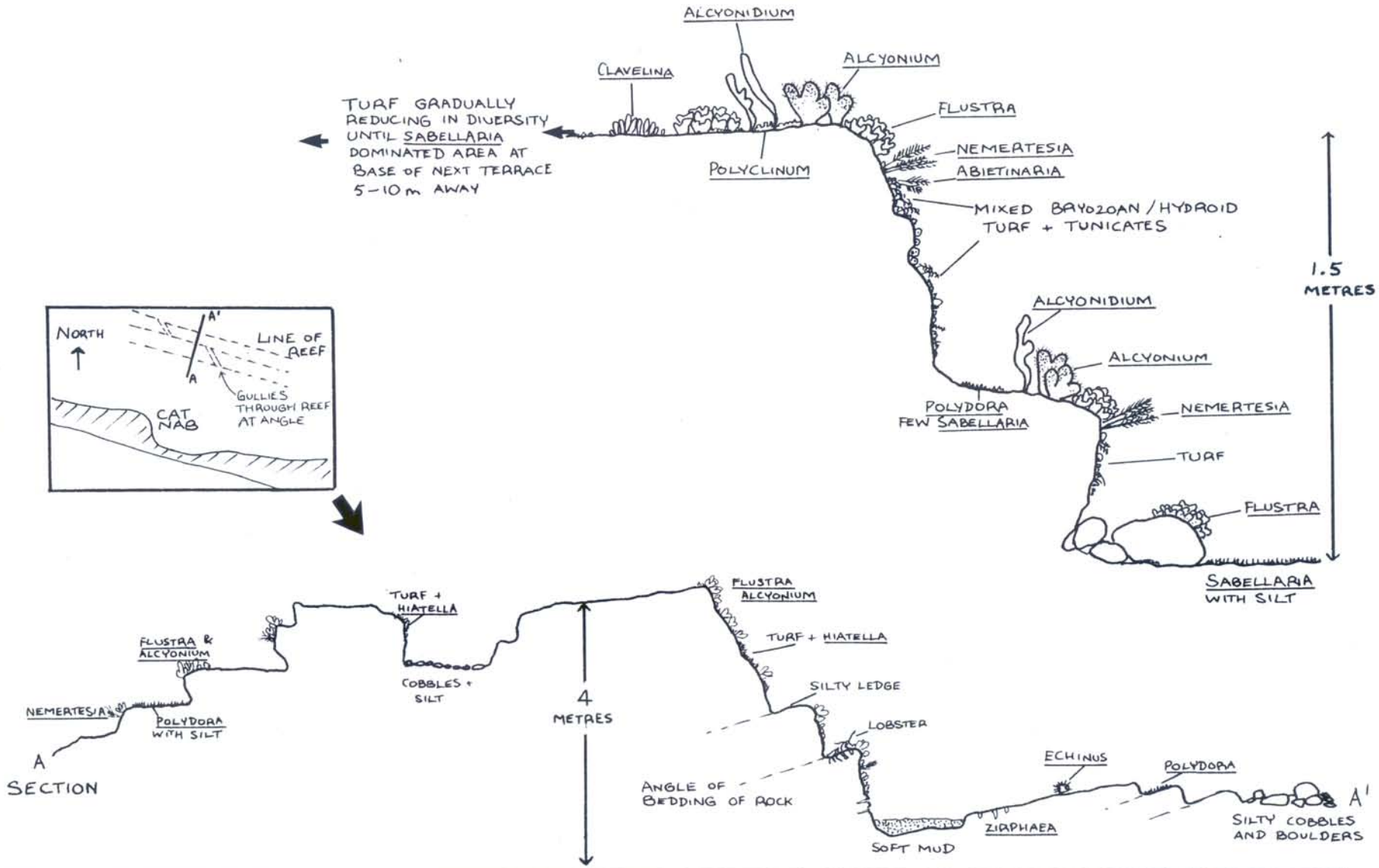


Figure 21. Communities associated with terraced bedrock off Thornwick Nab (top) and with the reef off Cat Nab (bottom).

Sites 21/22: Breil Nook (21 at 6m and 22 at 10 m below CD)
Bedrock platforms/terraces at both sites, with vertical faces to 1 m in height. Upper horizontal surfaces were often dominated by banks of Flustra foliacea with smaller bryozoans, but in places were Alcyonidium diaphanum, and small colonies of Alcyonium digitatum. Alcyonidium was also particularly common on lower bedrock surfaces at the shallower site, and many had Acanthodoris pilosa on them (figure 22).

Figure 22. Two nudibranchs (Acanthodoris pilosa) on a colony of the finger-like Alcyonidium diaphanum. They feed on this fleshy bryozoan, and also deposit their egg ribbons on it (left). To the right is the small gastropod Lacuna crassior, which also occurred very widely on A. diaphanum (photo: R. Manuel).

Polyclinum aurantium had a patchy distribution, but other tunicates were mostly confined to vertical surfaces, together with hydroids such as Nemertesia antennina, Abietinaria abietina and Tubularia indivisa. Starfishes were common at both sites, especially the sunstar Crossaster papposus. No fishes were seen at these sites, but decapod crustaceans were common, including the lobster and edible crab, and smaller species such as Hyas araneus and Inachus spp. The species recorded from this site are listed in tables 5 and 6.

Site 23: Breil Nook (15 m below CD).
Chalk bedrock with faces 4 to 50 cm high, also boulders. Communities (figure 23) broadly similar to the shallower sites, although fewer tunicates. Hiatella arctica was abundant, not only burrowing into the chalk, but also nestling at the base of large hydroids such as Nemertesia antennina.

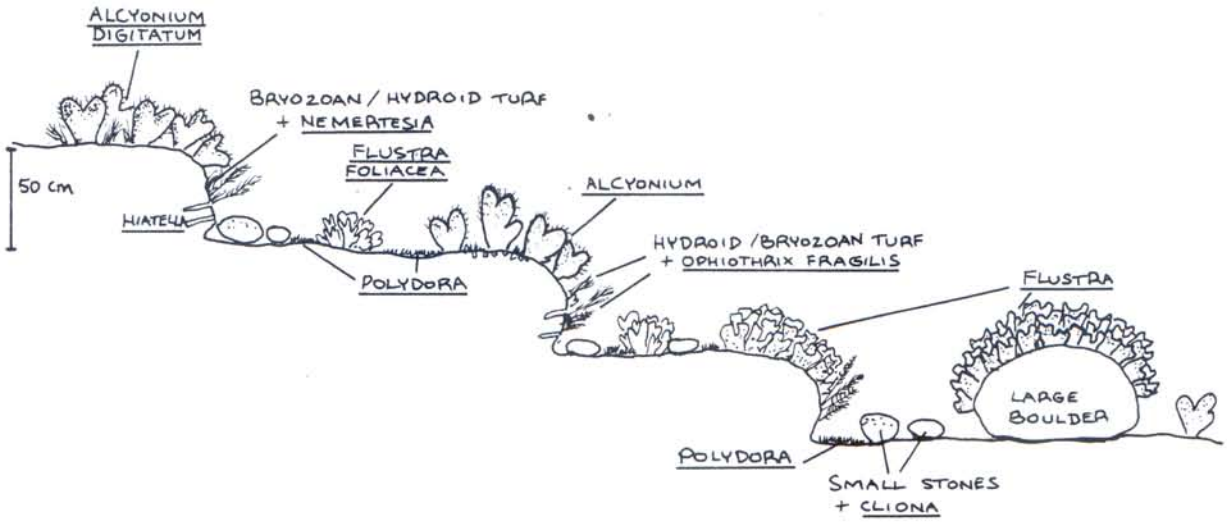


Figure 23. Details of the communities on terraced bedrock at Breil Nook, 15 metres below chart datum.

Site 27: Cradle Head (7 to 8 m below CD).
Terraced bedrock with vertical faces about 30 to 80 cm in height. Communities very similar to site 23.

Site 28: off Cradle Head (21.5 m below CD).
Uneven bedrock plain, covered with easily-disturbed, flocculent silt. A sparse bryozoan turf was present, with patchily distributed clumps of Flustra foliacea. There were few hydroids or tunicates, but Alcyonium digitatum was frequent. Crossaster papposus was the commonest starfish, and brittlestars were present, but only one Echinus esculentus was recorded.

Sites 29/30: Selwicks Bay (17 to 20 m below CD).
Irregular bedrock terraces with vertical faces no more than 50 cm high. Sessile fauna very similar to that shown in figure 23, although in places, tubes of Sabellaria spinulosa appeared to replace Polydora on lower bedrock surfaces. Again decapods were common, but fish rarely seen.

Site 34: off Fog Station (7.5 to 11.5 m below CD). Bedrock terraces with vertical faces 20 to 80 cm in height. Dense hydroid/bryozoan turf dominant, with Alcyonium digitatum, Alcyonidium diaphanum, colonial ascidians and the sponge Polymastia boletiformis common (figures 28 and 29).

Figure 28. Steeply inclined rock face at site 34 (depth 8 m below CD. Sparse growths of the alga Schottera nicaeensis amongst bryozoan (predominantly Crisia) turf. Also present are the tunicates Aplidium punctum (left) and Morchellium argus (right) (photo: T. Bennett).

Figure 29. Vertical face at site 34 with several colonies of Alcyonium digitatum, and in the centre the orange sponge Polymastia boletiformis. Beneath this is a nudibranch sea-slug (Janolus cristatus), which is feeding on the bryozoan turf (photo: R. Irving).

Sites 39 and 40: off High Stacks (14 to 17m below CD)
Wide (approximately 5 m) terraces, with vertical faces up to 50 cm high. The latter densely colonised, but upward-facing surfaces less so due to current scour. Lists of species recorded are in tables 5 and 6.

Site 44 and 45: Old Fall (9 m below CD)
Flattish, uneven bedrock with some upraised, flat-topped areas; vertical faces not exceeding 30 cm. Some small boulders; occasional large ones. Tunicates formed dominant cover at this site:- see figure 30 and lists in tables 5 and 6.

Figure 30. Recently broken rock. In the centre is a hole and siphons probably belonging to Zirphaea crispata; close by is a red siphon of Hiatella arctica. Small yellow papillae of the sponge Cliona celata are to the left, and on the right is a brittlestar Ophiothrix fragilis (photo: R. Manuel).

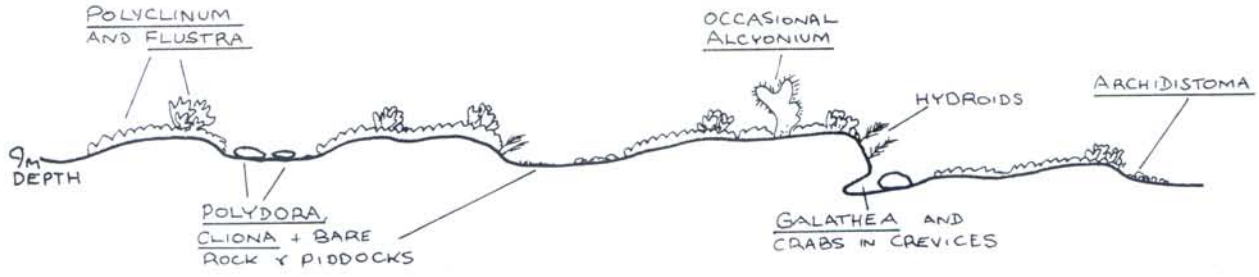


Figure 31. Communities associated with flattish bedrock off Old Fall (site 45).

	North side		South side	
	22	40	44	47
	9-11 m	16-17 m	9 m	10-15 m
Leucosolenia botryoides	c	a	c	f
Scypha ciliata	p	c	f	f
Polymastia boletiformis	p	-	-	-
Cliona celata (boring)	c	a	c	p
Halichondria panicea	-	p	-	f
Haliclona oculata	-	-	p	-
Tubularia indivisa	c	a	-	-
Eudendrium ramosum	-	p	-	-
Halecium halecinum	c	c	-	c
Nemertesia antennina	c	p	-	p
Abietinaria abietina	c	a	p	-
Hydrallmania falcata	p	p	c	-
Thuiaria thuja	-	p	-	-
Sertularella polyzonias	p	c	-	-
Rhizocaulus verticillatus	-	p	-	-
Alcyonium digitatum	a	p	f	f
Urticina felina	c	c	-	f
Sagartia elegans	-	p	-	-
Sagartia troglodytes	-	p	-	-
Polydora ciliata	a	-	c	c
Pomatoceros triqueter	p	-	f	-
Balanus balanus	-	c	-	-
Balanus crenatus	-	p	-	-
Dyopedos porrectus	a	a	-	-
Crisea eburnea	a	-	-	p
Alcyonidium diaphanum	c	a	c	p
Alcyonidium parasiticum	p	-	-	-
Bowerbankia pustulosa	-	-	-	f
Cellopora pumicosa	-	f	p	-
Electra pilosa	c	-	-	-
Flustra foliacea	a	a	c	a
Cellaria sunuosa	p	-	-	-
Scrupocellaria scruposa	-	p	-	f
Bicellariella ciliata	p	c	-	c
Bugula flabellata	c	c	c	c
Bugula plumosa	c	c	c	c
Clavelina lepadiformis	p	c	p	c
Archidistoma aggregatum	-	p	c	a
Polyclinum aurantium	c	c	a	c
Morchellium argus	p	p	-	c
Sidnyum turbinatum	p	-	-	f
Aplidium proliferum	-	c	-	-
Diplosoma listerianum	p	c	-	-
Perophora listeri	-	p	-	-
Botryllus schlosseri	c	p	p	p
Botrylloides leachii	c	c	p	-

Table 5. Sessile fauna associated with circalittoral, terraced bedrock (see page opposite for site details).

	North side		South side	
	22	40	44	47
	9-11 m	16-17 m	9 m	10-15 m
Pandalus montagui	p	-	-	-
Homarus gammarus	p	p	p	-
Pagurus bernhardus	p	p	f	p
Galathea strigosa	-	-	p	-
Pisidia longicornis	-	p	-	-
Hyas araneus	p	-	p	-
Inachus phalangium	c	p	-	-
Cancer pagurus	c	c	p	c
Buccinum undatum	-	p	p	p
Acanthodoris pilosa	c	-	-	-
Archidoris pseudoargus	-	p	p	-
Janolus cristatus	p	p	c	-
Hiatella arctica	c	-	p	-
Zirfaea crispata	-	-	c	-
Crossaster papposus	c	c	f	p
Henricia oculata	c	c	p	-
Asterias rubens	a	a	a	c
Ophiothrix fragilis	c	a	p	p
Ophiopholis aculeata	-	p	-	-
Echinus esculentus	-	-	p	-
Agonus cataphractus	-	p	-	-
Pholis gunnellus	-	c	-	-

Table 6. Mobile fauna associated with circalittoral bedrock.

Site 22: off Breil Nook; bedrock with low terraces (9-11 m below CD).
Site 40: off High Stacks, Selwicks Bay; bedrock plain (16-17 m below CD).
Site 44: Old Fall; bedrock with very low terraces (9 m below CD).
Site 47: Old Fall; bedrock with very low ledges, with some boulders and cobbles (9.5-14.5 m below CD).

Sites 47 and 48: Old Fall (9.5 to 14.5 m below CD)
Flattish bedrock; in places very low terraces with vertical faces less than 20 cm in height. Also boulders (some to 1 m in height), cobbles and pebbles present. Unstable pebbles remained uncolonised but most of the rocks were large and stable enough to be well colonised. Several species were conspicuous and common, including Clavelina lepadiformis, Alcyonidium diaphanum and Flustra foliacea, all of which preferred the tops of rocks. The tunicates Polyclinum aurantium (figure 32) and Archidistoma aggregatum (figure 33) were also widespread and common. The hydroid Halecium halecinum was common, and there were many

smaller 'turf' species, mostly bryozoans. Mobile fauna consisted mainly of Cancer pagurus and Asterias rubens, with a few Pagurus bernhardus and Crossaster pappossus.

Figure 32. At the centre of the photograph is a sandy-coloured colony of the widely distributed tunicate Polyclinum aurantium. To the right (top) is part of a colony of the erect bryozoan Alcyonidium diaphanum. Several small Asterias rubens are present, and in the foreground, Alcyonium digitatum (photo: E. Wood).

Figure 33. Characteristic 'bobble-like' growths of the tunicate Archidistoma aggregatum. This species was particularly common on stable rocky substrata off the south-facing coast of the headland (photo: R. Manuel).

Sites 49 and 50: South Cliff (7 m below CD)
Bedrock in low terraces, with vertical faces not exceeding 50 cm in height. The main difference at this site was the abundance of Alcyonium digitatum on upper surfaces, presumably reflecting greater stability of the substratum. Vertical faces were less well colonised, possibly due to scour. On the low-lying bedrock there were often considerable areas covered with a thick silty mat (1 cm +) comprising densely packed tubes of the small worm Polydora caeca and the amphipod Jassa falcata. The dahlia anemone Urticina felina protruded in places, and there were a few red algae and hydroids (figure 34).

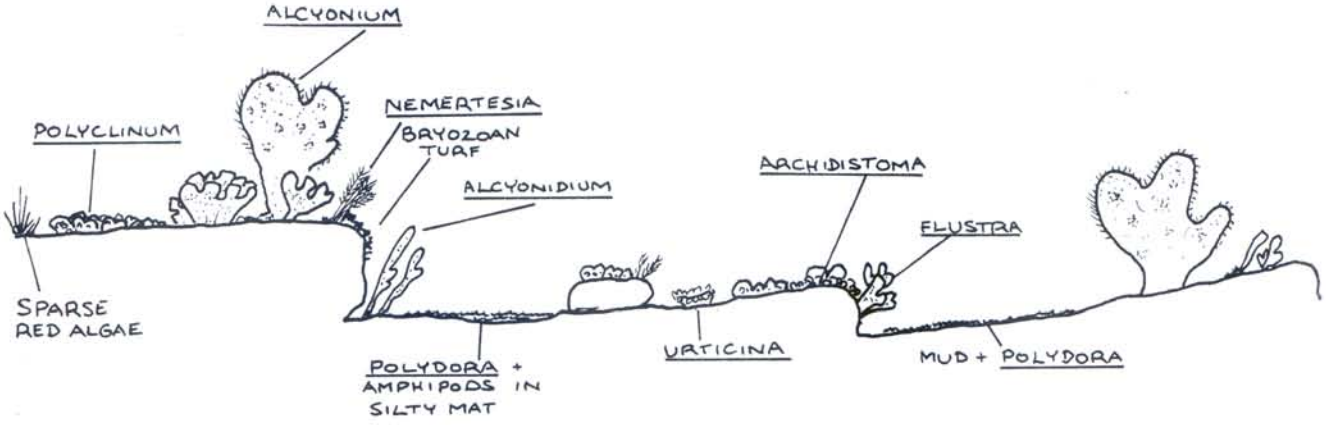


Figure 34. Details of typical communities at 7 m depth off South Cliff (sites 49 and 50).

D. OFFSHORE (CIRCALITTORAL) ROCKY SEABED (6.5 to 8 m below CD): MAJOR COMPONENTS BOULDERS (mostly small) AND COBBLES

These boulder/cobble plains are found along the south-facing part of the headland, west of South Cliff. They are an extension of the seabed type described in B, but the communities are dominated by animals. The offshore limit of the boulder/cobble plain was not reached, although at site 57 (8 m below CD and 1.25 km out from the shore) the boulders, cobbles and pebbles were overlain to some extent by coarse sand.

Sites 55 and 56: South Landing [east] (6.5-8 m below CD).
Algal cover patchy, with filamentous species such as Brongniartella byssoides and Griffithsia flosculosa present. Boulders and stable cobbles were densely colonised by Flustra foliacea (especially on the tops), with other bryozoans, e.g. Alcyonidium diaphanum, Crisia eburnea, Scrupocellaria scruposa, and Bugula spp. common. Halichondria panicea common in places, and a variety of tunicates, including Polyclinum aurantium, Archidistoma aggregatum and Botrylloides leachii. Halecium halecinum was the only common hydroid, but several other species were present. Alcyonium digitatum was widespread, and Metridium senile seen at the deeper site.

Siphons of the boring bivalve Zirphaea crispata were much in evidence on low-lying bedrock, and Venerupis saxatilis nestled in holes. Polydora ciliata and Cliona ciliata bored into rock surfaces that were uncolonised by turf species. Decapod crustaceans were common in this habitat, and included both shore crabs and edible crabs. Starfish were also widespread.

Small stones were colonised by Pomatoceros triqueter, with Ophiothrix fragilis hidden underneath.

Site 57: South Landing [west] (8 m below CD).
This site was overlain to a considerable extent by coarse sand, thus increasing scour and reducing the amount of available hard substratum. Algal cover was extremely sparse, and tunicates were noticeably uncommon in comparison with sites 55 and 56 (Polyclinum and Archidistoma absent). In other respects the faunal turf was similar. Fewer crabs were present, and the shore crab not recorded.

E. SEDIMENT PLAINS

Unbroken expanses of fine, rippled sand were found close inshore from Speeton to Buckton Cliffs. Around the rest of the headland the sediment plain was some distance offshore, and only pockets and patches of sand and silty gravel were found in the nearshore rocky zone.

An investigation of the fauna associated with the sediment areas was beyond the scope of this survey; only animals visible at the surface were noted.

Tubes of the polychaete worm Lanice conchilega were seen protruding from the sand, and surface casts indicated the presence of Arenicola. Terebellid worms were also seen. Empty shells of the razorshell Ensis siliqua and the heart-urchin Echinocardium cordatum were found on the surface, and judging by the number of siphons and 'depressions' seen, these animals were common.

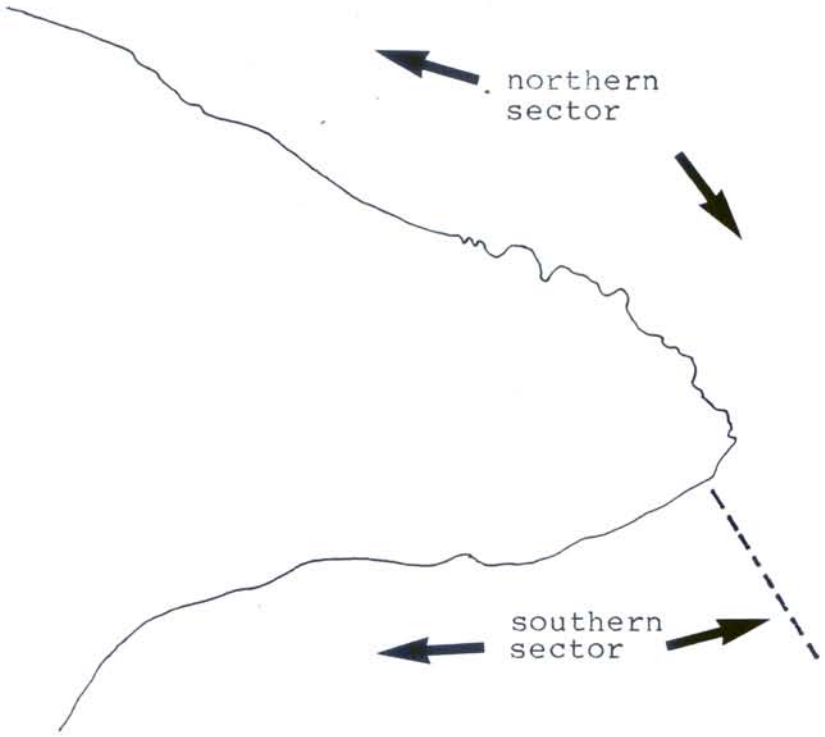
Hermitcrabs and Asterias rubens occurred on the sand, especially where there were rocks nearby. Swimming crabs were present, together with lesser weeverfish and flatfishes such as sole and plaice.

4. Flora and Fauna

This chapter provides lists of the species found during the survey. The lists and species are in taxonomic order and follow the coding system in the Marine Conservation Society Directory of the British Marine Fauna and Flora (Howson, 1987). The code number is in the left hand column.

An indication of the distribution and abundance of each species is also included (full details are in the raw data sheets). The total number of sites at which each species was recorded is shown in the table (right hand column), and this is broken down into the number of sites at which that species was either present (p), frequent (f), common (c) or abundant (a). The abundance scale used as a guide during the survey is shown in Appendix 3.

In the written section that follows each table, reference is made to the 'northern' and 'southern' sectors. This division was made on the basis of differences in seabed features and exposure to wave action (see Chapter 3) which have repercussions on the distribution of species.



ALGAE

		Number of sites at which:				Total number sites recorded
		p	f	c	a	
RHODOPHYCOTA (ZM):						
0	Rhodophycota indet. (encr)	4			1	5
97	Audouinella sp.	4	1			5
242	Palmaria palmata	4	3	1		8
256	Dilsea carnosa	7	1	1		9
323	Callophyllis laciniata	6				6
384	Corallinaceae indet. (encr)	3	2	3	3	11
404	Corallina officinalis	3	3	1		7
566	Ahnfeltia plicata	1				1
584	Phyllophora crispa	1	5	1		7
586	Phyllophora pseudoceranoides	7	1	1		9
588	Phyllophora traillii	1				1
595	Schottera nicaeensis	3	3			6
611	Chondrus crispus	3	1	1		5
631	Plocamium cartilagineum	3	8	15	4	30
643	Furcellaria lumbricalis	3				3
682	Calliblepharis ciliata	4	3	2		7
688	Cystoclonium purpureum	3				3
693	Rhodophyllis divaricata	1	1			2
701	Cruoria pellita	1				1
725	Rhodymenia delicatula	4	1			5
726	Rhodymenia holmseii	5	1			6
752	Lomentaria clavellosa .	1		1*		2
753	Lomentaria orcadensis	7	1			8
807	Ceramium sp.	3	1			4
823	Ceramium rubrum	2	1	4	1	8
846	Griffithsia flosculosa	6		2		8
888	Pterothamnion plumula	3				3
893	Ptilota plumosa	3	1	1		5
950	Cryptopleura ramosa	6	3	2		11
955	Delesseria sanguinea	9	11	13	3	36
985	Hypoglossum hypoglossoides	11	9	4		24
990	Membranoptera alata	9	1	1		11
995	Myriogramme bonnemaisonii	2				2
1012	Phycodrys rubens	4	5		1	10
1050	Brongniartella byssoides	10	2	5	4	21
1080	Laurencia pinnatifida		1			1
1097	Odonthalia dentata	1				1
1101	Polysiphonia sp.	2		1		3
1105	Polysiphonia elongata	3	2	1	1	7
1116	Polysiphonia nigra	1		2		3
1117	Polysiphonia nigrescens	2	1	1		4
1130	Polysiphonia urceolata	6	1	2		9
1137	Pterosiphonia parasitica	1				1
1144	Rhodomela sp.	1	1			2
1145	Rhodomela confervoides	7				7
1146	Rhodomela lycopodioides	2				2

CHROMOPHYCOTA (ZR):						
3	Ectocarpacea indet.	4	2	1		7
52	Giffordia sp.	3				3
406	Tilopteris mertensii	1				1
420	Sphacelaria plumosa	2				2
423	Sphacelaria radicans	1				1
439	Cladostephus spongiosus	2				2
457	Dictyota dichotoma	7	2	2		11
497	Desmarestia aculeata	1				1
500	Desmarestia viridis	7				7
506	Arthrocladia villosa	1	1*	1		3
625	Chorda filum	2				2
632	Laminaria digitata	1	1	1		3
633	Laminaria hyperborea	5	4	10	5	24
636	Laminaria saccharina	1	5	2	3	11
652	Alaria esculenta	1				1
CHLOROPHYCOTA (ZS):						
211	Enteromorpha sp.	1				1
215	Enteromorpha compressa	1		1		2
240	Ulva sp.	3	2			5
392	Bryopsis plumosa	2	2			4

Table 7. List of algae recorded during the Flamborough sublittoral survey. (* drift specimen).

The red algal species most frequently recorded were Delesseria sanguinea (36 sites), Plocamium cartilagineum (30 sites), Hypoglossum hypoglossoides (24 sites) and Brongniartella byssoides (21 sites). Each of these species occurred widely in both the northern and the southern sectors. Several species, however, were recorded only from the northern sector. These included Lomentaria orcadensis, Dilsea carnosa, Rhodymenia delicatula, Corallina officinalis, Myriogramme bonnemaisonii, Odonthalia dentata (site 37, above chart datum), Rhodymenia holmseii [fig 16] and Schottera nicaeenis [fig 27] (both often occurring towards the lower limit of algal growth- around 7 to 8 m below CD), and Ptilota plumosa and Phycodrys rubens (often epiphytic on kelp plants). Palmaria palmata and Membranoptera alata also tended to be associated with kelp plants, and all but one of the records of each was from the northern sector. Encrusting coralline algae (Lithothamnion) were also much more common to the north and east, especially at shallow wave-exposed and/or sand-scoured sites.

The most commonly recorded large brown alga was Laminaria hyperborea [fig 12] (24 sites), followed by L. saccharina (11 sites), but the distribution of each was different. L. hyperborea was only sparsely distributed in the southern sector, but thrived on stable bedrock and boulders to the north and east. In

contrast, L. saccharina, which tends to colonise small boulders and even large cobbles, was abundant on these substrata in the southern sector. Chorda filum was also restricted to the southern side. L. digitata was found in the shallow kelp forest, and Alaria esculenta was recorded from site 14, on the wave-exposed north coast.

Taonia atomaria (13 sites) occurred all around the headland, and thrived on low-lying, sand-scoured bedrock. Tilopteris mertensii was found in the same situation (site 17). Dictyota dichotoma (11 sites) was recorded only from the northern sector, often from amongst the kelp plants.

Ulva and Enteromorpha were found at various shallow sites around the headland, but the distinctive Bryopsis plumosa was recorded from only a few sites in the northern sector, amongst kelp undergrowth and on vertical faces in shallow water.

	Number of sites at which:				Total number sites recorded
PORIFERA (C):	p	f	c	a	
CALCAREA					
8 Clathrina coriacea	4	2	4		10
25 Leucosolenia botryoides	10	8	20	1	39
35 Scypha ciliata	18	9	9		36
58 Leuconia nivea	2				2
70 Grantia compressa	9	1	1		11
DEMOSPONGIAE					
221 Suberites domuncula	1				1
258 Polymastia boletiformis	6	1	2		9
302 Cliona celata	16	10	15	6	47
484 Halichondria panicea	12	4	12	4	32
523 Hymeniacidon perleve	2				2
596 Amphilectus fucorum	2				2
645 Myxilla incrustans	7	4	2		13
860 Haliclona oculata	14	4	5		23
890 Dysidea fragilis	8	4	3		15
909 Halisarca sp. *	1		2		3

Table 8. List of sponges recorded during the Flamborough sublittoral survey.(* inconspicuous, and may be more widely distributed).

In general, sponges were not a prominent feature of the benthic communities. Thirteen species were recorded, of which 9 were relatively common. One of the most conspicuous and widespread was the breadcrumb sponge Halichondria panicea, which was recorded from a variety of habitats around the headland (32 sites). However, the most extensive colonies were found encrusting the holdfasts and stipes of Laminaria hyperborea [fig 11].

Another widespread species was the boring sponge Cliona celata, which was recorded at 47 sites and was particularly common on upward-facing surfaces of low-lying bedrock. However, it was never particularly conspicuous, occurring only in the boring phase with the small inhalent papillae visible [fig 30]. Other small sponges such as Leucosolenia botryoides and the purse sponges Scypha ciliata and Grantia compressa were common components of the faunal turf, growing in particular amongst bryozoans on the sides of boulders and outcrops.

The white, lace-like Clathrina coriacea had a localised distribution, being found only on substantial vertical faces associated with the inshore surge gullies at the north and east-facing end of the headland [fig 17]. Myxilla incrustans [fig 17], sometimes forming relatively large colonies, was also recorded only from the northern sector, showing a preference for open bedrock areas. Haliclona oculata and Dysidea fragilis were also more common in the northern sector. The tall, branched colonies of H. oculata were particularly conspicuous, although never abundant, and were found both on the sides and tops of bedrock outcrops in current-swept situations [fig 17]. Polymastia boletiformis was found in similar situations, but only in the northern sector.

	Number of sites at which:				Total number sites recorded
	p	f	c	a	
COELENTERATA (D):					
SCYPHOZOA					
76 Cyanea capillata	1	1	4	1	8
77 Cyanea lamarkii	1				1
82 Aurelia aurita	3			1	4
HYDROZOA					
144 Tubularia indivisa	11	8	5	2	26
145 Tubularia larynx	3			1	4
238 Eudendrium ramosum *	1				1

335	Hydractinia echinata *	1				1
525	Halecium beanii	1				1
526	Halecium halecinum	6	5	12	2	25
585	Kirchenpaueria pinnata *	1	1	2		4
597	Nemertesia antennina	10	6	5	1	22
605	Plumularia setacae *	2	2	3	1	8
626	Abietinaria abietina	13	4	4	2	23
648	Dynamena pumila *		1			1
653	Hydrallmania falcata	10	1	1		12
660	Thuiaria thuja	2		1		3
669	Sertularella polyzonias *	6	1	1		8
675	Sertularia sp.	2		1		3
676	Sertularia argentea	2				2
677	Sertularia cupressina *	2				2
703	Clytia hemisphaerica *	2				2
730	Obelia dichotoma *	2				2
731	Obelia geniculata	1		2		3
732	Obelia longissima *	1		1		2
743	Rhizocaulus verticillatus *		1	1		2

ANTHOZOA

1024	Alcyonium digitatum	6	8	10	10	34
1151	Actinia equina			1		1
1168	Urticina felina	18	13	14	2	47
1225	Metridium senile	4				4
1231	Sagartia elegans	14	4	1		19
1232	Sagartia troglodytes	7		2		9
1247	Sagartiogeton laceratus	1				1

Table 9. List of coelenterates recorded during the Flamborough sublittoral survey. (* inconspicuous and may be more widely distributed).

Scyphozoan jellyfish were encountered in the water column off the north-facing coastline, with the large red-coloured lion's-mane jellyfish Cyanea capillata particularly common.

Amongst the hydroids, several species were relatively conspicuous and easily identified; others much smaller and less prominent. One of the most robust was Abietinaria abietina, which generally occurred in clumps on current-swept bedrock and stable boulders, each colony orientated in the same plane, at right angles to the current. The slightly smaller Halecium halicinum occurred in similar situations, together with clumps of Nemertesia antennina. Although both these hydroids were recorded from nearly 50% of all rocky sites, they were never abundant and did not dominate the communities. Another relatively large hydroid found in the area, although occurring only sporadically in deeper water off the north coast, was the distinctive bottlebrush hydroid Thuiaria thuja, again on current-swept bedrock.

Amongst the smaller hydroids, Tubularia indivisa was most widely recorded, although again was seldom abundant. The survey was carried out after the peak growing season for Tubularia, and in many cases only the stems remained. T. larynx was recorded only from around the end of the headland.

A range of small hydroids was found amongst the faunal turf (e.g. Sertularella polyzonias), or attached to other sessile organisms (e.g. Clytia hemisphaerica on Flustra foliacea; Obelia geniculata on the frond and stipe of Laminaria hyperborea). The small, feathery Plumularia setacea often occurred in extensive patches on overhanging surfaces of the large boulders and outcrops present along the north and east-facing parts of the coast.

Dead-man's-fingers, Alcyonium digitatum (34 sites) was most abundant in elevated situations on deeper bedrock off the north coast [fig 25]. Six species of anemone were found, of which one (Actinia equina) occurred only above chart datum and another (Sagartiogeton undatus) was recorded only once.

The plumose anemone, Metridium senile was equally sparsely distributed (4 sites), with only a few individuals seen. The dahlia anemone Urticina felina was recorded from 47 sites, and was frequent or common at many of them. It was found especially on low-lying bedrock and amongst stable cobbles and boulders, occupying crevices between rocks, or depressions at boulder bases. Sagartia elegans and S. troglodytes were widely distributed with no apparent habitat preference.

	Number of sites at which:				Total number sites recorded
	p	f	c	a	
NEMERTEA (G):					
79 Lineus ruber	1				1
ANNELIDA: POLYCHAETA (P):					
203 Eteone flava *	1				1
268 Eulalia indet (juv) *	1				1
1276 Polydora caeca			3	2	5
1278 Polydora ciliata	5	3	6	10	24
1484 Flabelligera affinis *	1				1
1576 Arenicola marina	2				2
2000 Terebellidae indet.	7				7
2031 Lanice conchilega	10	4	5		19

2162	Branchiomma bombyx	18	7	3	28
2255	Pseudopotamilla reniformis*	2			2

Table 10. List of nemerteans and polychaetes recorded during the Flamborough sublittoral survey. (* inconspicuous and may be more widely distributed).

A detailed study of the polychaete fauna was beyond the scope of this survey. Several species that appeared from amongst the faunal turf were identified, but other records were of conspicuous species easily identified in-situ.

Several tube-dwellers were particularly prominent. The flexible, grey tubes of Branchiomma bombyx were seen emerging from silty rock crevices and amongst turf at 28 sites. They were common on the boulder/cobble seabed in the southern sector, but were recorded from a range of other habitats. The keelworm Pomatoceros triqueter was common wherever there were small boulders and cobbles, and was the dominant animal on mobile stones. Similarly, Lanice conchilega was found wherever a suitable habitat was available, in the case of this species, pockets of coarse silty sand amongst rocks.

Sabellaria spinulosa occurred in areas of low-lying bedrock, sometimes forming small clumps at rock bases [fig 13]. It was recorded only from the northern sector. Two species of Polydora were recorded, both preferring low-lying silty bedrock, boulder or cobble areas. P. ciliata formed small burrows in the top few millimetres of the rock, from which the sediment-coated tubes extended. Polydora caeca lived in tightly-packed muddy tubes which formed soft mats in silty situations [fig 34]. Tube-dwelling amphipods (e.g. Jassa falcata) were often associated with these mats.

PYCNOGONIDA (Q)

4	Nymphon brevirostre
8	Nymphon hirtum
7	Achelia longipes
17	Achelia echinata
46	Callipallene brevirostris producta
62	Anoplodactylus pygmaeus
63	Anoplodactylus petiolatus

Table 11. List of pycnogonids recorded during the Flamborough sublittoral survey.

Pycnogonids were seen crawling on hydroids and bryozoans at several sites, and also emerged from collected material. A range of species was present and probably widely distributed.

		Number of sites at which:				Total number sites recorded
		p	f	c	a	
CRUSTACEA						
CIRRIPEDIA (R)						
64	Verruca stroemia	6				6
108	Semibalanus balanoides				1	1
109	Balanus balanus	3	1	2		6
110	Balanus crenatus	2		3		5
AMPHIPODA (S)						
166	Amphipoda indet. (tubes) *	1	1		1	3
955	Jassa falcata *		1			1
1022	Corophium bonnellii *	1				1
1052	Dyopedos porrectus	4	2	9	4	19
1062	Caprellidae indet *	5			1	6
ISOPODA (S)						
1589	Astacilla sp.*	1				1
DECAPODA (S)						
2322	Pandalus montagui	13	1	6		20
2360	Homarus gammarus	28	2	3	1	34
2444	Paguridae indet.	16	1	3		10
2465	Pagurus bernhardus	13	6	3		22
2470	Pagurus prideuxi	2				2
2489	Galathea squamifera	3	1	1		5
2490	Galathea strigosa	7	1	6		14
2502	Pisidia longicornis	8	3	1		12
2543	Ebalia tuberosa	1				1
2559	Hyas araneus	21	5	3		29
2560	Hyas coarctatus	5	1			6
2577	Inachus leptochirus	4				4
2578	Inachus phalangium	11	3	1		15
2646	Cancer pagurus	15	13	18	2	48
2667	Liocarcinus arcuatus		1			1
2669	Liocarcinus depurator	1				1
2670	Liocarcinus holsatus	1				1
2690	Carcinus maenas	7	6	4		17

Table 12. List of crustaceans recorded during the Flamborough sublittoral survey. (* inconspicuous and may be more widely distributed).

Four species of barnacle were recorded from a range of habitats, but were not a prominent component of the benthic fauna. Amphipods and isopods were present in the turf, amongst algae and beneath stones, but a detailed investigation of these small crustaceans was beyond the scope of this survey. However, one prominent species, the whip-forming amphipod Dyopedos porrectus [fig 26] was recorded from 19 sites and was often common. The whips were attached to a range of sessile species, including Tubularia.

Eighteen decapod crustaceans were identified during the survey, with the edible crab, Cancer pagurus, and the lobster, Homarus gammarus the most frequently recorded (48 sites and 34 sites respectively). In contrast, swimming crabs, Liocarcinus were recorded infrequently. The shore crab, Carcinus maenas was common, although mostly restricted to the southern sector where it was found as deep as 8 m below chart datum. Prawns, Pandalus montagui, were also prominent in this sector, where there were many stones under which they could take refuge. In contrast, squat lobsters, especially Galathea strigosa, were found mostly along the north and east-facing side of the headland, in crevices formed on the vertical faces of large boulders and outcrops.

Small spider crabs, in particular Hyas araneus and Inachus phalangium were common amongst the faunal turf. The long-clawed porcelain crab Pisidea longicornis was also found in the same habitat.

	Number of sites at which:				Total number sites recorded
	p	f	c	a	
MOLLUSCA (W):					
POLYPLACOPHORA					
79 Tonicella rubra	2	1	1		4
GASTROPODA					
124 Tectura virginea		2	3		5
139 Helcion pellucidum		1	1		2
193 Gibbula cineraria	4	3	1		8
242 Lacuna crassior	5				5
737 Trivia arctica	8				8
738 Trivia monacha	3	1			4
817 Nucella lapillus	1	2		1	4
844 Buccinum undatum	9	2			11
887 Hinia incrassata	1				1

1242	Tritonia hombergii	4				4
1267	Dendronotus frondosus	1				1
1274	Doto coronata	2				2
1297	Goniodoris nodosum	9				9
1319	Acanthodoris pilosa	6	4	7		17
1358	Limacia clavigera	4				4
1362	Polycera faeroensis	2				2
1363	Polycera quadrilineata	4	2			6
1382	Cadlina laevis	1				1
1403	Archidoris pseudoargus	17	3	2	1	23
1431	Janolus cristatus	16	9	6		31
1452	Coryphella lineata	5	1			6
1460	Flabellina pedata	3				3
1526	Facelina bostoniensis		1			1
PELECYPODA						
1650	Mytilus edulis				1	1
1675	Modiolus modiolus			2	4	6
1815	Anomia ephippium			4		4
1820	Pododesmus patelliformis		1			1
1822	Pododesmus squamula	2	1			3
2022	Ensis siliqua		1	1		2
2185	Venerupis senegalensis			1		1
2251	Hiatella arctica	2		4	7	13
2277	Zirphaea crispata	3	3	5		11

Table 13. List of molluscs recorded during the Flamborough sublittoral survey.

The blue-rayed limpet Helcion pellucidum was recorded from the fronds of Laminaria hyperborea, while the white tortoishell limpet Tectura virginea was generally found within the holdfasts.

The most frequently recorded of the shelled gastropods was the common whelk, Buccinum undatum (11 sites), which was seen mostly in deeper water. The topshell Gibbula cineraria and the cowries Trivia monacha and T. arctica occurred amongst the faunal turf but were nowhere common. The small snail Lacuna crassior [fig 22] was apparently feeding and/or living on the fleshy colonies of the bryozoan Alcyonidium diaphanum.

The relatively large nudibranch Acanthodoris pilosa, together with its egg ribbons, was also found on Alcyonidium [fig 22], and was recorded as common at 7 of the 17 sites where it occurred. The other important bryozoan predator was Janolus cristatus [fig 29], which was recorded from 31 sites and appeared to have a preference for Bugula spp. Many of the other nudibranchs recorded were bryozoan predators, but several were found on hydroids, for example, Flabellina pedata on a number of species, Doto coronata on Hydrallmania falcata and Dendronotus frondosus (small specimens) on Abietinaria abietina. Tritonia hombergi was found on Alcyonium digitatum, while the sponge-eating Archidoris

pseudoargus was widely distributed, particularly in the northern sector.

Attempts to remove piddocks from bedrock were unsuccessful, and species other than Hiatella arctica and Zirphaea crispata may have been present. The distinctive red siphons of H. artica were clearly visible amongst the faunal turf on the sides of boulders and outcrops [fig 30], but Z. crispata did not appear to have such distinct habitat preferences. In addition to boring into the chalk, Hiatella arctica was also found nestling at the base of clumps of Nemertesia.

Other bivalve molluscs included saddle oysters, found amongst kelp holdfasts and faunal turf, and Venerupis senegalensis, which occupied vacant piddock holes. Mussels were abundant at a few shallow sites but generally were not a prominent component of the benthic communities.

BRYOZOA

Bryozoans were conspicuous and widespread, occurring in a range of habitats and at many sites. Various small, 'tufty' species contributed to the faunal turf which formed a dense covering on many rock surfaces. Crisiidae (predominately Crisia eburnea when samples were collected for identification), together with Bugula spp., and others such as Bowerbankia pustulosa, Bicellariella ciliata and Scrupocellaria spp. were particularly prominent on the sides of boulders and outcrops, although were not confined to these surfaces.

Small, orange-coloured patches of the crustose bryozoan Cellopora pumicosa were also widespread amongst the turf, while Smittina affinis often encrusted kelp holdfasts. Electra pilosa was seen most frequently on shallow upward-facing surfaces, often encrusting algae. The erect, leafy form of E. pilosa was also found at several sites.

The largest bryozoans were the tall, fleshy Alcyonidium diaphanum [figs 22, 25] and the leafy Flustra foliacea [fig 25], both of which were very widespread (recorded from 45 and 38 sites respectively). Both appeared to reach a peak of abundance in deeper, current-swept areas, and F. foliacea was often dominant in these situations, its basal regions usually overgrown or encrusted by other species.

		Number of sites at which:				Total number sites recorded
		p	f	c	a	
BRYOZOA (Y):						
3	Crisiidae indet	1	2	6	5	14
10	Crisidia cornuta	4		1		5
28	Crisia eburnea	4	3	4	9	20
137	Alcyonidium diaphanum	14	11	17	3	45
139	Alcyonidium hirsutum	3				3
142	Alcyonidium parasiticum	3		2		5
251	Bowerbankia gracilis	1				1
254	Bowerbankia pustulosa		3		1	4
307	Umbonula littoralis	1				1
314	Escharoides coccinea	2				2
357	Smittina affinis	4	3			7
406	Escharella immersa			1		1
658	Eucratea loricata	3		1		4
664	Membranipora membranacea			6		6
678	Electra pilosa	8	3	9	10	30
694	Flustra foliacea	4	6	13	15	38
710	Securiflustra securifrons	1	2	1		4
812	Cellaria fistulosa	2				2
814	Cellaria sinuosa	7	1	2		10
836	Scrupocellaria sp.	2				2
838	Scrupocellaria reptans	1				1
841	Scrupocellaria scruposa	6	2	7	4	19
853	Bicellariella ciliata	6	6	9		21
870	Bugula avicularia	2				2
872	Bugula flabellata	14	8	18	3	43
875	Bugula plumosa	7	6	21	3	37
879	Bugula turbinata	6		5		11
PHORONIDA (ZA):						
3	Phoronis sp.		1			1

Table 14. List of bryozoans and phoronids recorded during the Flamborough sublittoral survey.

ECHINODERMATA (ZB):	Number of sites at which: p	f	c	a	Total number sites recorded
149 Crossaster papposus	23	8	8		39
166 Henricia oculata	23	10	6	1	40
190 Asterias rubens	4	12	25	13	54
235 Ophiothrix fragilis	6	9	30	5	50
278 Ophiopholis aculeata	3		5		8
313 Ophiura albida	1				1
355 Psammechinus miliaris	2				2
362 Echinus esculentus	9	1	2		12
407 Echinocardium cordatum	1		1		2

Table 15. List of echinoderms recorded during the Flamborough sublittoral survey.

Species diversity of echinoderms was low, but several of the species present were widespread and common. For example, Asterias rubens was recorded from 54 sites and was common at 25. Henricia oculata [fig 17] was also widespread, although fewer in number than Asterias. Henricia spp. are impossible to identify in-situ, and it is possible that H. sanguinolenta might also occur in the area. Crossaster papposus had a distinct preference for low-lying open areas, including both bedrock and boulder/cobble habitats.

The brittlestar Ophiothrix fragilis was recorded from 50 sites and was common at 30. It was found in all habitats, wherever there were suitable niches in which it could lodge. It was particularly prominent in less silty areas where there was strong water movement. For example on vertical faces of outcrops below the Fog Station, a mass of O. fragilis arms protruded from amongst the faunal turf. Ophiopholis aculeata was found in crevices at several sites.

The edible sea-urchin Echinus esculentus was recorded from only 12 sites (common at two, otherwise few individuals seen) and was found primarily in the northern sector. Psammechinus miliaris occurred amongst stones and faunal undergrowth, while the heart-urchin Echinocardium cordatum was found buried in sand on the plains to the west of Bempton Cliffs.

		Number of sites at which:				Total number sites recorded
		p	f	c	a	
TUNICATA (ZD):						
6	Clavelina lepadiformis	11	9	20	2	42
23	Archidistoma aggregatum	6	3	3	5	17
34	Polyclinum aurantium	14	7	12	2	40
46	Morchellium argus	5	2	9		16
52	Sidnyum turbinatum	14	9	10		33
63	Aplidium proliferum	7	7	2		16
64	Aplidium punctum		3	10	2	15
68	Didemnidae indet.	4	5	2		11
86	Didemnum maculosum	2	3			5
97	Diplosoma listerianum	5		1		6
117	Ciona intestinalis	1	1			2
129	Perophora listeri	11	3	4	2	20
143	Ascidiella scabra	5	2			7
149	Ascidia conchilega	1	2	1		4
194	Dendrodoa grossularia	2				2
209	Botryllus schlosseri	15	13	8	1	37
214	Botrylloides leachii	19	5	12		36

Table 16. List of tunicates recorded during the Flamborough sublittoral survey.

Tunicates were a prominent component of the benthic communities, occurring widely in a range of habitats. Species such as Clavelina lepadiformis [fig 16], Sidnyum turbinatum, Morchellium argus [fig 27], Botrylloides leachii, Botryllus schlosseri and Aplidium spp. were particularly common on the sides and/or tops of outcrops amongst the faunal turf. B. schlosseri often grew in an erect, leafy form, probably due to its habit of encrusting and then outgrowing 'stalked' organisms.

Most of the species had a ubiquitous distribution, except for Aplidium punctum [fig 27], which was seen at only one site in the southern sector, but was common at 10 out of the 15 sites at which it was recorded in the northern sector. In contrast, Archidistoma aggregatum [fig 33] was seen only to the south of Cradle Head, and reached the peak of its abundance off the south-facing coast. It sometimes formed extensive mats, especially on upward-facing surfaces of low-lying bedrock and boulders.

Polyclinum aurantium [fig 32] occurred in very similar situations, but was more widespread, and formed mats particularly off Cattlemere, to the south-west of the Head. Low-growing,

'creeping' colonies of Perophora listeri, consisting of numerous, small, transparent zooids, were widely distributed throughout the area, although were seldom abundant. Small, sheet-like colonies of Diplosoma listerianum and Didemnum maculosum were also widely distributed.

		Number of sites at which:				Total number sites recorded
		p	f	c	a	
OSTEICHTHYES (ZG):						
12	Anguilla anguilla	4	1			5
172	Gadus sp. (juv)	2				2
173	Gadus morhua	1				1
208	Pollachius pollachius	5	1			6
434	Myoxocephalus scorpius	11				11
438	Taurulus bubalis	4				4
448	Agonus cataphractus	2				2
473	Dicentrarchus labrax	1				1
605	Ctenolabrus rupestris	2				2
609	Labrus bergylta	6				6
619	Echiichthys vipera	2				2
653	Chirolophis ascanii	2				2
675	Zoarces viviparus	1				1
680	Pholis gunnellus	25		1		26
700	Callionymus lyra	8	1			9
728	Gobiusculus flavescens	1				1
742	Pomataschistus minutus		2			2
748	Thorogobius ephippiatus	6				6
877	Pleuronectidae indet. juv	1	2			3
903	Pleuronectes platessa	10	8			18
929	Solea solea	2				2

Table 17. List of fishes recorded during the Flamborough sublittoral survey.

The number of individual fish seen at any one site was invariably small. The most frequently recorded species was the butterfish, Pholis gunnellus (26 sites), which lived amongst rocks and faunal turf all around the headland. Other species seen in similar habitats included the scorpionfish Myoxycephalus scorpius and Taurulus bubalis, the eelpout (Zoarces viviparus), armed bullhead (Agonus cataphractus), and Yarrell's blenny (Chirolophis ascanii).

Leopard-spotted gobies (Thorogobius ephippiatus) were seen only around the eastern end of the northern sector where they occupied silty crevices in vertical faces. The ballan wrasse (Labrus bergylta), goldsinny, (Ctenolabrus rupestris), pollack and saithe were seen amongst kelp and rock outcrops in the same area, but were few in number.

Fish associated with flattish sandy areas and mixed ground included the weeverfish Echiichthys vipera, dragonet, Callionymus lyra, sole and plaice.

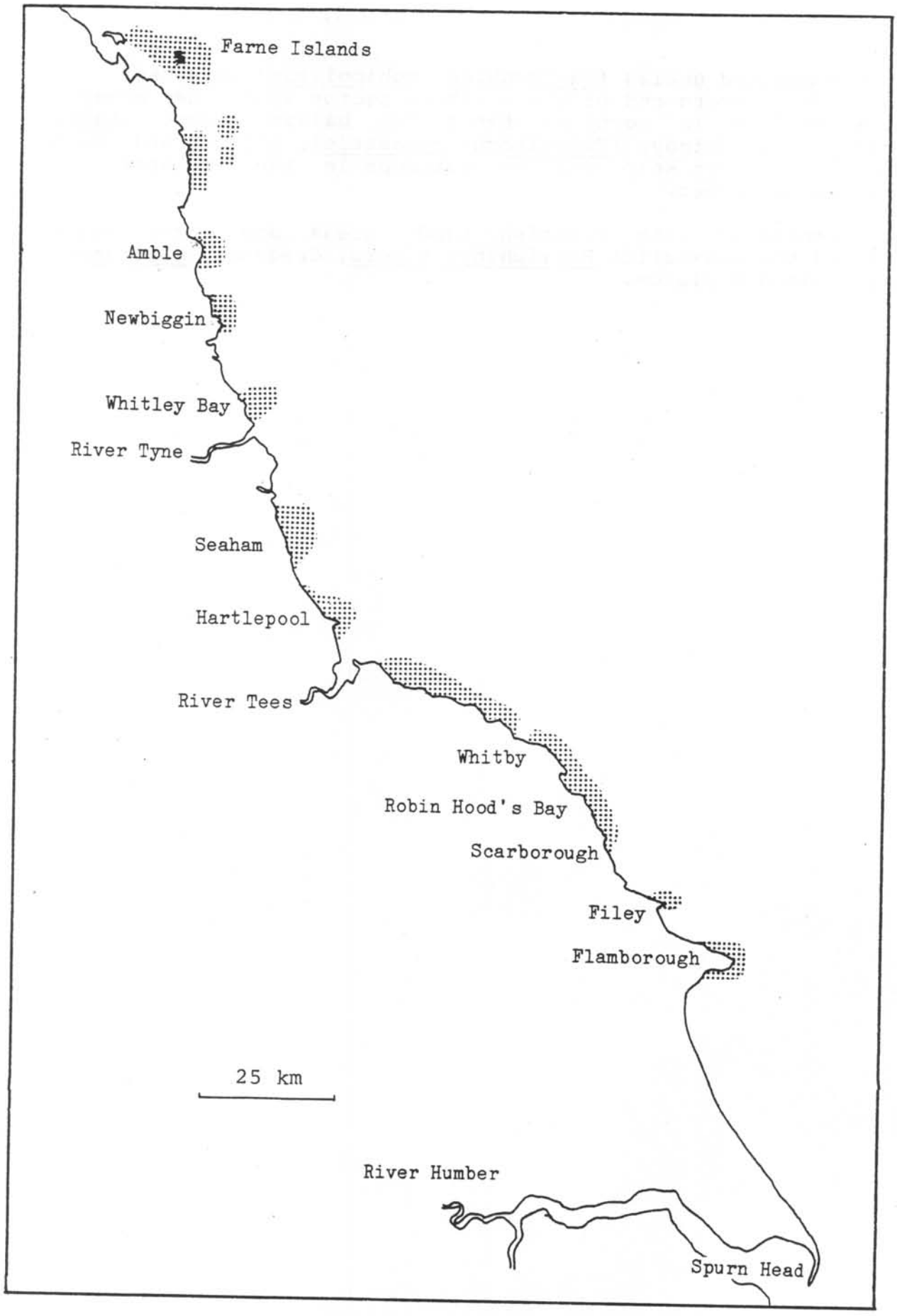


Figure 35. Map of the coast of north-east England, showing areas where rock is exposed subtidally (hatched).

5. Assessment of Biological Interest

Many factors contribute to the biological interest of an area, but of considerable importance are:

Diversity of species and their abundance
Range and types of habitats and communities
Presence of rare or unusual species
Presence of rare or unusual habitats and communities

The terms of reference for this study require that the biological interest of the shallow sublittoral zone around the Flamborough headland is assessed in relation to:

The North Sea coast
Other areas of sublittoral chalk

5.1. BIOLOGICAL INTEREST IN RELATION TO NORTH SEA COAST

5.1.1. General nature of seabed and associated communities

Regardless of the type of rock involved, the Flamborough Headland provides subtidal hard-bottom formations that are relatively uncommon along this part of the North Sea coast (fig 35). The communities associated with this substratum comprise a large range of species (around 270 recorded during this survey), the great majority of which are not found on adjacent sediment areas.

The rocky seabed stretches in an approximately 15 km arc around the headland, and is certainly the most southerly extent of 'dramatic' underwater scenery down the east coast. The rocky reefs off north Norfolk are low-lying with vertical faces no more than 1 m high (George and Platt, 1988).

It is also the most northerly outcropping of chalk on the North Sea coast.

5.1.2. Number of species present

Comparisons of species totals are misleading when surveys are carried out to different levels of detail and for varying lengths of time. However, the totals in table 18 result from fairly intensive diving surveys carried out over short periods during the summer months, and provide a reasonable basis for discussion. The groups consisting entirely or predominantly of small, often cryptic, animals (e.g. polychaetes, amphipods,

	ENGLISH CHANNEL				NORTH SEA			
	SEDIMENTARY CHALK						IGNEOUS & LIMESTONE	IGNEOUS
	IOW/ Dorset	Sussex	7 Sisters	Dover	north Norfolk	Flamboro	Farnes	St Abbs
Algae	33*	31*	39	43	15	65	74	67
Porifera	28	25	15	16	12	15	10	18
Hydrozoa	8	5	4	12	31	21	21	14
Anthozoa	15	8	12	10	7	7	6	9
Decapoda	24	8	26	16	13	18	22	18
Gastropoda	14	8	9	8	10	9	17	7
Opisthobranchia	5	8	8	13	5	14	11	18
Bivalvia	7	4	6	7	9	9	10	5
Bryozoa	11	9	5	13	34	26	25	30
Echinodermata	3	4	2	6	5	9	15	14
Tunicata	18	16	11	10	10	16	16	20
Pisces	24	20	24	20	6	20	16	27

Table 18. Numbers of species recorded from rocky habitats at a range of sites in the English Channel and the North Sea.

These totals result from diving surveys carried out over short periods during the summer months, but cannot be considered as definitive.
* Conspicuous species only - no collections made.

Sources of information:
Isle of Wight/Dorset & Sussex: Wood (1988); 7 Sisters: Wood & Jones (1986); Dover: Wood and Wood (1986); Cromer: George and Platt, (1988); Farnes: Connor (pers. comm.); St. Abbs: Earll, (1981, 1982).

isopods and pycnogonids) which cannot be identified in-situ have been omitted from the table.

The total species from the four North Sea sites are broadly similar in some respects, but there are several interesting differences. The paucity of algae occurring subtidally off north Norfolk is presumably due to the turbidity of the southern North Sea water, in comparison with that of the northern North Sea. In contrast, there is greater species diversity of hydroids and bryozoans, which are very important components of the subtidal communities (George and Platt, 1988).

The range of decapod crustaceans at Flamborough, the Farnes and St Abbs is greater, but the population density of certain decapods at north Norfolk is exceptionally high. A large number of gastropods were reported from the Farnes in comparison with the other areas. The diversity of echinoderms is also greater at both the Farnes and St Abbs, with Flamborough in an intermediate position. The diversity of both tunicates and fishes recorded is comparable for each of the three northern sites, and greater than at north Norfolk.

5.1.3. Types of communities and constituent species

The sublittoral communities off Flamborough have several features which make the site interesting from a biological point of view because of similarites and differences with adjacent North Sea sites. One obvious feature is the scarcity at Flamborough of the grazing sea-urchin Echinus esculentus, which in areas such as the Farnes and St Abbs has a considerable impact on benthic communities. Upper circalittoral rock faces in these areas, instead of supporting a faunal turf, are dominated by high densities of Echinus, with urchin-resistant species such as Lithothamnion, Alcyonium and Pomatoceros (Earll, 1981; Connor and Laffoley, 1987). At the Farnes the impact of Echinus is also evident in the kelp zone, where the algal undergrowth is very sparse due to grazing. At Flamborough, rich communities of algae and sessile animals are present.

A universal feature of slightly deeper, current-swept areas of seabed where Echinus is absent (north Norfolk), rare (Flamborough), or occasional (St. Abbs) is the presence of tall hydroids such as Abietinaria abietina and Nemertesia antennina (also Nemertesia ramosa at St. Abbs). The silt-tolerant bryozoan Flustra foliacea, which thrives in strong currents, was also prominent, especially off north Norfolk, where it was the most obvious sessile organism (George and Platt, 1988).

The Flamborough Headland is probably the southernmost point down the east coast where subtidal algal communities are well developed and where there are dense kelp (Laminaria hyperborea) forests. Off north Norfolk algae hardly penetrate subtidally,

and where they do, growth is sparse (George and Platt, 1988). However, light penetration is less at Flamborough than further north, and this affects the depth distribution of algae. Dense kelp forests extend to 4 m below chart datum at Flamborough (deepest recorded 6.5 m), while at St. Abbs and the Farnes the figures are 10-12 m and 18 m respectively (Earll, 1981; Connor and Laffoley, 1987).

The communities associated with shallow, wave-exposed rock faces (usually vertical or overhanging) which are found at St. Abbs and Flamborough are different in several respects. Neither of the two 'diagnostic' species at St. Abbs (the sponge Clathrina coriacea and the tunicate Dendrodoa grossularia) were prominent at Flamborough. Dendrodoa was rarely recorded, although other tunicates (especially Aplidium punctum, Polyclinum aurantium and Botrylloides leachii) were common.

Despite the presence of apparently suitable habitats, another species scarce at Flamborough was the plumose anemone Metridium senile. At St. Abbs and the Farnes this anemone was conspicuous on wave-exposed vertical faces in shallow water, and at St. Abbs it also occurred on current-swept bedrock at about 20 m depth (Earll, 1981; Connor and Laffoley, 1987). At north Norfolk it was patchily distributed although sometimes present in large numbers (George and Platt, 1988).

5.1.4. Species composition in relation to geographical position

Flamborough is in an interesting position from a marine biogeographical point of view. The entire east coast of Britain falls within the eastern province of the cold-temperate (Atlantic-Boreal) region, but during the summer months there is a marked difference in water characteristics between the northern and southern North Sea (Pingree and Griffiths, 1978). The boundary between the two water bodies (clearly visible on satellite photographs) is known as the 'Flamborough front' and extends roughly from Flamborough Head to the German Bight (fig 36). To the north the water becomes stratified during the summer; to the south there is turbulence and mixing within the water column throughout the year.

Western and southern parts of the British Isles lie within the Lusitanian province of the warm-temperate (Mediterranean-Atlantic) region and are endowed with many 'warm-water' species. The transitional zones between the warm-temperate and cold-temperate regions are considered to be around east Dorset in the south and the Orkneys in the north (fig 36), but many species are known to cross these 'boundaries'. In addition, northern parts of the British Isles are influenced by cold waters from the Arctic Province.

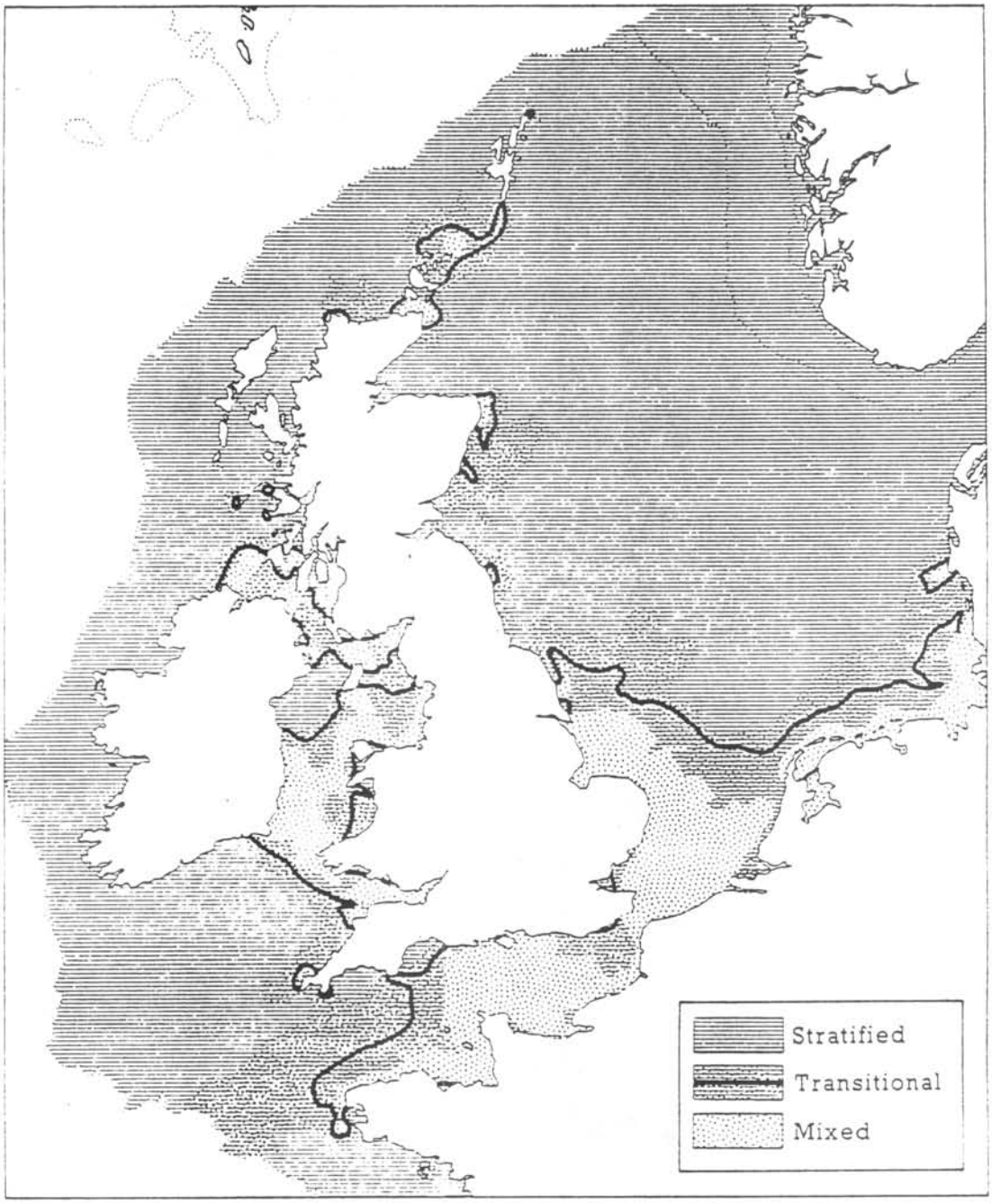


Figure 36. Tidal fronts on the shelf seas around the British Isles, from Pingree and Griffiths, 1978. The transitional zones between warm-temperate and cold-temperate waters are also shown

The sublittoral area off Flamborough is of interest because marine species with different affinities are present:

a) Ubiquitous species

Many of the species found at Flamborough are widely distributed around the British Isles, and although some had not been previously recorded, their presence is not surprising. The distribution of Dictyota dichotoma, taken from Norton (1985) provides an example (figure 37).

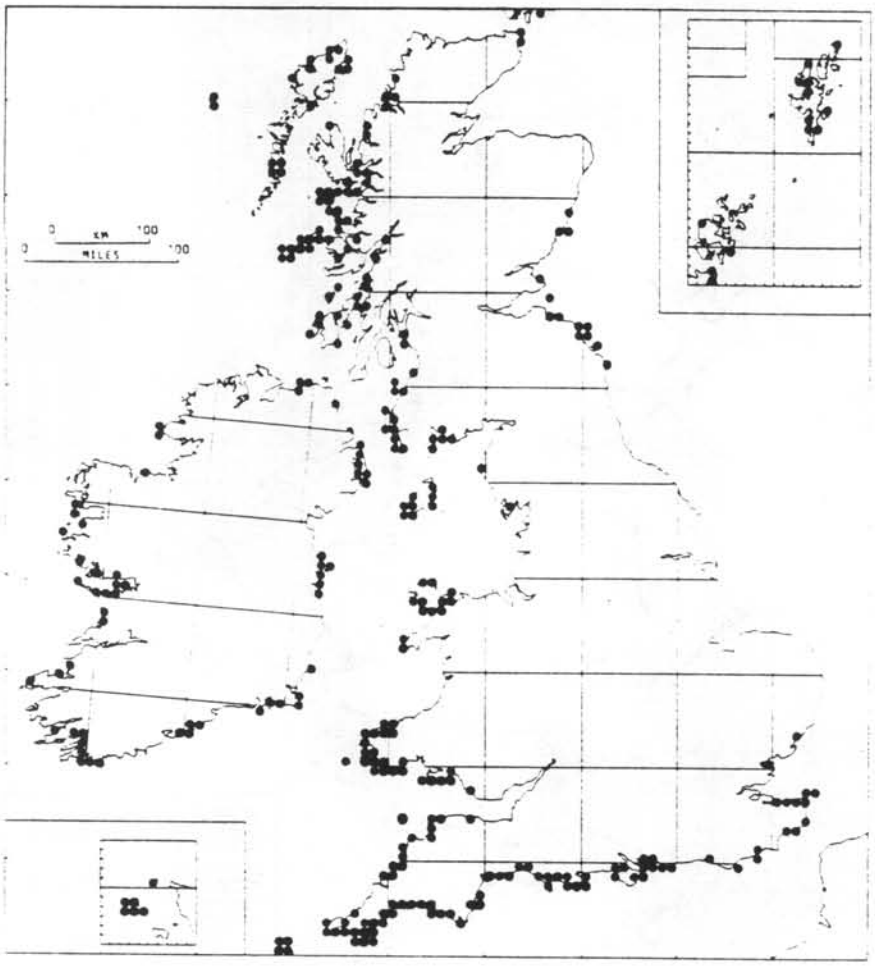


Figure 37. Distribution of the brown alga Dictyota dichotoma, taken from Norton (1985), with the following legend:

A widespread and common species thriving in tide pools and throughout the subtidal zone. Its apparent absence from much of the east coast of England requires verification. See van den Hoek (1982a).

b) southern species

Several 'southern' species of algae were recorded, in particular, Schottera nicaeensis, Taonia atomaria (fig 38), Rhodymenia holmseii, Calliblepharis ciliata and Sphacelaria plumula. T. atomaria, R. holmseii and S. nicaeensis were all relatively common at Flamborough, yet T. atomaria has only be recorded very sporadically from Norfolk and Kent (Tittley, pers. comm), and Flamborough is the most northerly recorded locality for R. holmseii. S. nicaeensis is similarly sparsely distributed on the east coast, and although recorded at St. Abbs (Earll, 1981), was apparently very rare.

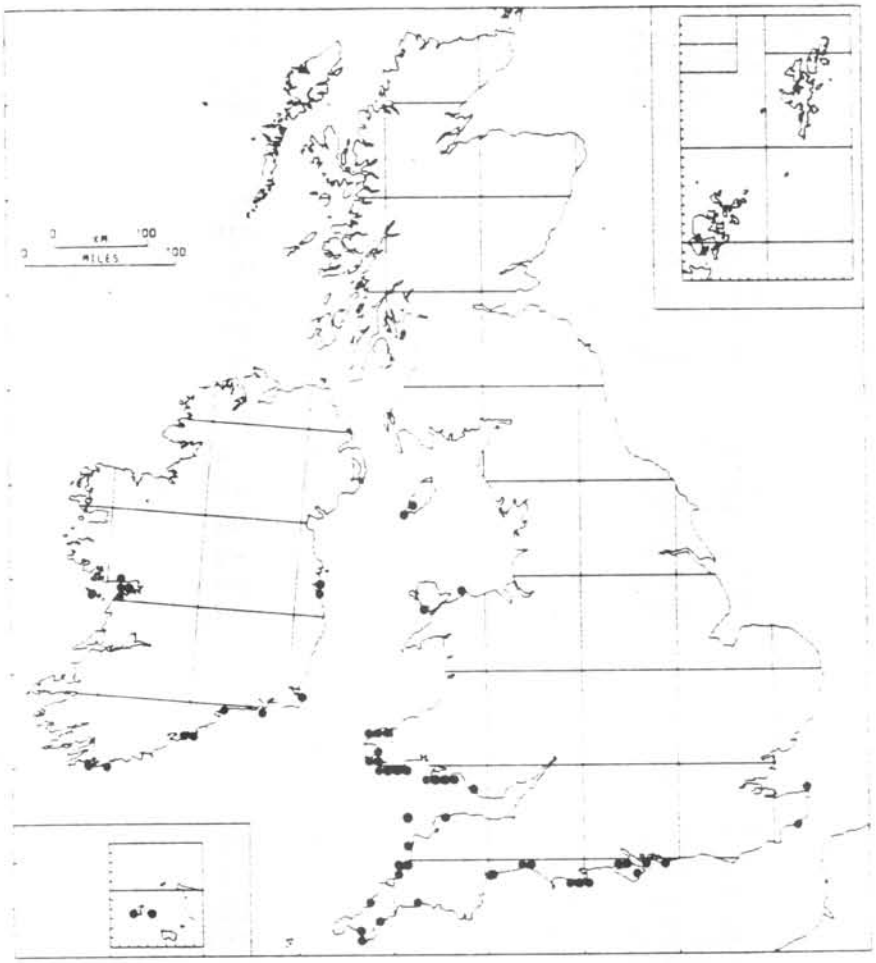


Figure 38. Distribution of the southern algal species Taonia atomaria, taken from Norton, 1985.

The sponge Polymastia boletiformis is also a south-western species, and although recorded at St. Abbs (Ackers et al, 1985), has not been found in the southern North sea (George and Platt, 1988), or east of Sussex (Wood and Wood, 1986).

Several of the tunicates found at Flamborough are, according to present literature, typical south-westerly species. Archidistoma aggregatum is known from S. Devon, Skomer and the east coast of Northern Ireland (Picton, pers. comm) but has not previously been recorded from the east coast. Aplidium punctum, A. proliferum and Perophora listeri are either rare or unrecorded off the east coast, yet at Flamborough were widespread and common.

The starfish Henricia oculata is also a southern species, although its distribution is a little uncertain due to the difficulty (impossibility underwater) of distinguishing it from the northern H. sanguinolenta. H. oculata alone was recorded from north Norfolk (George and Platt, 1988), but it is possible that both may occur at Flamborough. More specimens would have to be collected before this can be determined.

The discovery of the leopard-spotted goby Thorogobius ephippiatus is a new record for the Flamborough area. This Mediterranean fish is known from as far south as Redcar rocks (B. Foster-Smith, pers. comm), and as far east along the English Channel as Dover (where it is rare; Wood and Wood, 1986). It was not recorded from north Norfolk (George and Platt, 1988).

It is interesting to note that some warm-water species (e.g. the starfish Henricia oculata) have apparently reached Flamborough via the southern route (along the English Channel and through the southern North Sea). Others (e.g. the sponge Polymastia boletiformis) have evidently taken a westerly route around the British Isles and have reached Flamborough from the north.

c) Northern species

A few species characteristic of northern waters were found during the survey. Examples include the algae Odonthalia dentata and Ptilota plumosa, the nudibranch Cadlina laevis, the whip amphipod Dyopedos porrectus, and the bottlebrush hydroid Thuiaria thuja, which appears to reach its most southerly point of distribution at Flamborough.

Two of the fish recorded were northern species: the eelpout Zoarces viviparus (occurring from Scotland, down the North Sea coast to the eastern English Channel) and Yarrell's blenny, Chirolophis ascanii, (extending midway down east and west coast from the north).

5.2. BIOLOGICAL INTEREST IN RELATION TO OTHER AREAS OF SUBLITTORAL CHALK

5.2.1. Numbers of species present

Despite possible inaccuracies due to different intensities of surveying and sampling (see 5.1.2), some interesting trends emerge (table 18). The drop in algal species diversity at the eastern end of the English Channel and in the southern North Sea is to be expected, due partly to the increased turbidity of the water. More intensive sampling is required for the Dorset and Sussex areas of chalk before it can be confirmed that Flamborough supports the most diverse algal assemblage.

The number of sponge species is similar at Dorset and Sussex, and noticeably higher than all the other areas. Conversely, the diversity of hydroids and bryozoans at the North Sea chalk sites is high, possibly reflecting favourable current-swept, silty conditions. Flamborough (and north Norfolk) are species poor with regard to anthozoans, but the diversity of tunicate species is similar to that recorded for Sussex and Dorset, and higher than other areas of sublittoral chalk. Diversity of echinoderms is highest at Flamborough, and the range of fish species recorded is similar to all other sites except north Norfolk.

5.2.2. Habitats, communities and constituent species

A number of habitats and communities are associated with sublittoral chalk, but these are not necessarily developed to the same degree in each area. This is because of local differences in features such as seabed topography, rock type, light penetration, exposure to wave action and tidal streams, degree of scour and amount of silt present. Geographical position is also important (see 5.1.4)

The diversity of subtidal rocky habitats at Flamborough is as great if not greater than at other chalk sites, partly because of the wide range of seabed formations (table 19). The communities associated with these habitats are discussed (page 82) in relation to other chalk areas.

Sources of information for these comparisons are shown in the legend to table 19.

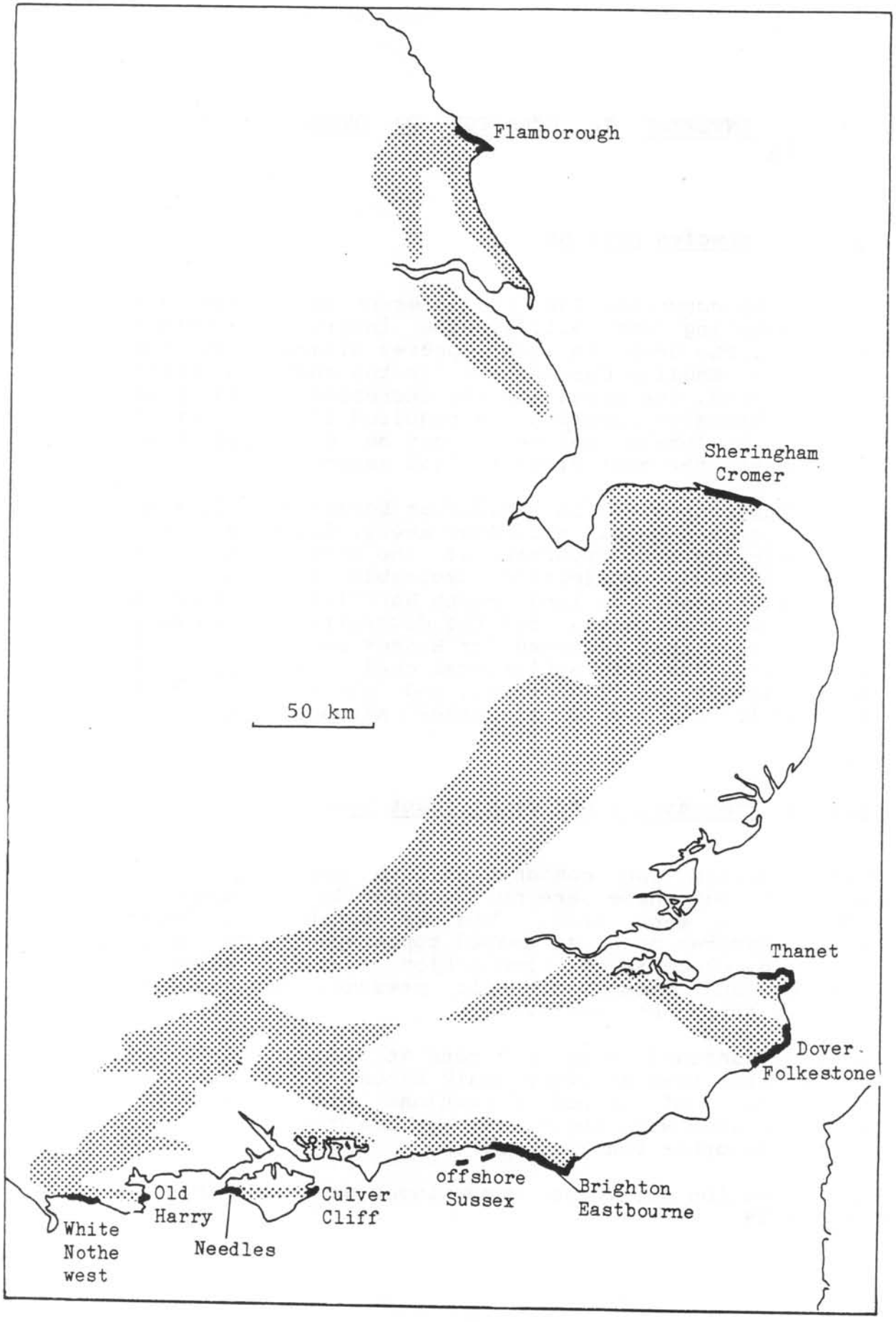


Figure 39. Extent of chalk in Britain (hatched), with coastal and offshore exposures shown in black.

** Major

* Secondary

	Isle of Wight/ Dorset	Sussex	Seven Sisters	Dover/ Folkestone	north Norfolk Sheringham/Cromer	Flamborough
Substantial chalk outcrops with gullies. Vertical faces to 6 m in height		*				*
Ridges and gullies. Vertical faces up to 2 m in height		**	**			**
Chalk reef platform with ridges and gullies up to 1 m in height		**	**	*	*	**
Terraced bedrock with faces 1 m or more in height	*					**
Flattish bedrock	**	*	*	**		**
Large boulders	*	*		**		*
Flattish bedrock overlain with boulders and cobbles	**		*	*	**	*
Boulders and cobbles, virtually no bedrock visible	**	*	**	*	**	*

Table 19. Seabed features at sublittoral chalk sites. Sources of information: Isle of Wight/Dorset and Sussex: Wood (1988); 7 Sisters: Wood and Jones (1986); Dover: Wood and Wood, 1986; Sheringham/Cromer [north Norfolk] (George and Platt, 1988).

a) Infaunal community.

The infaunal community is well developed in each of the main areas, although the relative hardness of the chalk at Flamborough (for example in comparison with outcroppings at Dover) presumably makes the substratum less easily penetrated by boring animals, and less prone to erosion. Although the density of piddocks and other boring bivalves at Flamborough was not investigated, the impression was that populations were not as high as at Dover. At least 5 species of boring bivalves are present at Dover; fewer species have been reported from the other areas.

The main difference in terms of species composition is that the piddock, Pholas dactylus, is apparently absent from Flamborough, and replaced by Zirphaea crispata. The other 'borers' such as Polydora ciliata and Cliona celata (non-massive form) are widespread and common throughout each area.

b) Kelp (Laminaria hyperborea) community.

Laminaria hyperborea forests are well developed on stable substrata at Flamborough, Dorset and Sussex; moderately well developed at Dover, but absent from the Seven Sisters (reason unknown), and from north Norfolk (presumably due mainly to the high turbidity of the water).

There is a rich undergrowth of foliose red algae and sessile animals in the kelp forest at Flamborough (except in very wave-exposed situation) as there is at the other kelp sites. Perhaps the most obvious difference in this community is the prevalence of colonial tunicates, and the relative lack of conspicuous sponges (except for Halichondria panicea on kelp stipes).

Flamborough is the only chalk site where the sea-urchin Echinus esculentus has been found, but unlike other localities around the British Isles it is seldom seen in the kelp forest. This is perhaps because the kelp is restricted to shallow turbulent water in which it is difficult for urchins to maintain a footing.

Another noticeable difference is the rarity of ballan wrasse and goldsinny, common amongst the kelp plants at Dorset and Sussex (and elsewhere around the British Isles), but seldom seen at Flamborough (or Dover).

c) Other algal communities

Each of the chalk areas, with the exception of north Norfolk, have well developed algal-dominated communities in shallow water. These occur on a variety of substrata, ranging from bedrock outcrops to cobbles. Many of the species present are common to all sites, and some (for example Laminaria saccharina) are found over wide areas of the seabed. There are several species which occur at Flamborough but have not been recorded from other chalk areas, including Odonthalia dentata and Ptilota plumosa (northern species). Conversely, species such as Halurus equisitifolius, which is conspicuous at chalk sites in the English Channel, was not recorded from Flamborough.

d) Communities associated with steeply inclined, vertical and overhanging surfaces.

These are very well represented along the north and east-facing sides of the Flamborough headland, and, except for the Sussex offshore reefs, are more extensive than in other chalk areas.

The communities on the steep faces at Flamborough are wave-exposed inshore, and current-exposed offshore and consist mostly of sponges, hydroids and tunicates amongst a dense turf of small, erect bryozoans. Typically, numerous brittlestars live amongst the turf, a feature not seen in other areas.

e) Communities associated with fissures and holes.

Large (arm-sized) fissures are present in the nearshore rock formations around the end of the Flamborough Headland, but are not developed to the same extent in other areas. However, many of the species typical of these fissures (e.g. crabs and squat-lobsters) occur widely at the other sublittoral chalk sites (especially north Norfolk [George and Platt, 1988]). An interesting feature of this community at Flamborough was the presence of the leopard-spotted goby, Thorogobius ephippiatus yet the absence of the tompot blenny, Parablennius gattorugine. Both these fish are relatively common from Sussex westwards, but rare off Dover and not recorded from north Norfolk.

f) Tide-exposed and sand-scoured circalittoral communities.

In each of the sublittoral chalk areas a certain amount of low-lying chalk bedrock is present in deeper water, but the most extensive exposures below the algal-dominated zone appear to be off the Flamborough Headland. Here a community

characterised by large hydroids (e.g. Nemertesia antennina, Abietinaria abietina) and Alcyonium digitatum was found. A very similar community was present off north Norfolk, where the substratum (as at Flamborough) also included areas of seabed where flint cobbles and pebbles predominated. Off Sussex and Dorset many of the rock surfaces in deeper water are still densely covered by red algae, but there are some sites where an animal-dominated community exists. Sponges such as Halichondria panicea appear to be more a more important component in these areas than at Flamborough.

5.2.3. Species composition in relation to geographical location

Many examples have already been given in the discussion above and in 5.1.4., but there are a few more worthy of mention. The sources of information are as in table 19.

Although a significant number of south-westerly species have reached Flamborough, others are noticeable for their absence. For example, the sponge Amphilectus fucorum, which is widespread and common at the English Channel chalk sites, and also at north Norfolk, is rare at Flamborough. Other species, such as the sponges Pachymatisma johnstonia and Hemimycale columella and the snakelocks anemone Anemonia viridis are found at Sussex chalk sites, but no further to the east. The spider crab Maja squinad has a similar distribution, and appears to be replaced to the east by the smaller Hyas species. Crepidula fornicata, an 'alien' now well established all along the English Channel, was found at north Norfolk, but not at Flamborough.

Most of the northern species that have reached Flamborough have already been mentioned (5.1.4.c).

6. Conservation Issues

6.1. INTRODUCTION

The aim of this short section is to review the conservation status and importance of Flamborough Head and adjoining seas, to outline the main uses and impacts within the marine environment, and to discuss prospects for conservation within the sublittoral zone.

6.2. CONSERVATION STATUS AND IMPORTANCE OF FLAMBOROUGH HEAD AND ADJOINING SEAS

The geology of the Flamborough Headland and its colonies of breeding seabirds were recognised many years ago as being of considerable importance, and the area was also seen to be of value for its terrestrial flora and fauna. These features led to the notification in 1952 of the 'Speeton and Flamborough Coast Site of Special Scientific Interest (SSSI)'. This was renotified in November 1986 under Section 28 of the Wildlife and Countryside Act, 1981, and renamed the 'Flamborough Head SSSI'. The SSSI stretches from Reighton to Sewerby (Fig 40), with its seaward boundary at mean low water. A large part of Bempton Cliff is managed as a nature reserve by the Royal Society for the Protection of Birds (RSPB).

In 1979 the Countryside Commission, in conjunction with the local authorities, designated the 'Flamborough Headland Heritage Coast', in recognition of the spectacular coastal scenery and rich variety of wildlife. The aim of the Heritage Coast Project is to conserve and enhance the scenic quality, and the wildlife and historical features, and to provide facilities for public informal recreation.

At present, the emphasis of the Heritage Coast Project is directed towards terrestrial countryside management. However, awareness and appreciation of the marine environment is achieved through displays, leaflets and books provided at the Information Centre at South Landing, and through activities such as shore walks.

The sublittoral zone does not have any protected status, but the biological importance of inshore areas is recognised (see Chapter 5), and in 1982 a proposal was made to establish a voluntary marine conservation area around the Headland. This idea was discussed in following years but not taken further, due mainly to concerns about possible restrictions on activities such as fishing and recreational diving.

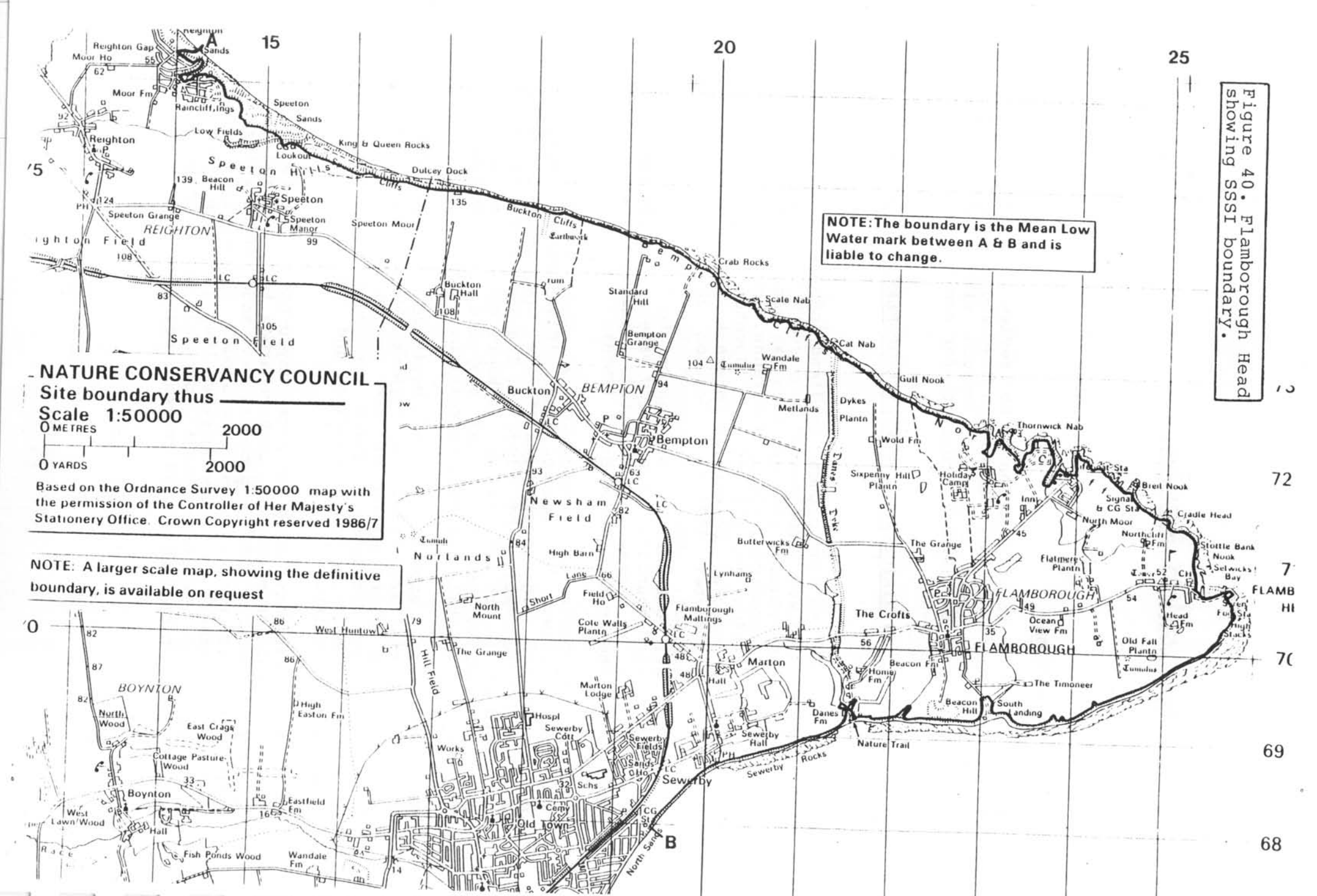


Figure 40. Flamborough Head showing SSSI boundary.

6.3. USES OF AND IMPACTS ON THE SUBLITTORAL ENVIRONMENT

Marine wildlife and habitats can be disturbed or degraded as a result of human activities and/or natural occurrences. Some parts of the coastline are subjected to greater pressures than others, and the 'problem' which is of particular significance in one area may be of negligible importance in another. The aim here is to discuss briefly the conservation issues relating to the sublittoral environment around the Flamborough Headland.

6.3.1. Commercial fisheries

Lobsters, edible crabs and other crustaceans thrive in nearshore rocky habitats around the headland, and have supported a fishery for many years. Queen Scallops, cod, sole and other species are fished from the soft seabed and mixed ground, and salmon are trapped in drift nets as they move along the coast to run up river.

The status of the populations of edible species in the area is unknown, but one aspect of concern is that seabirds may become entangled in the nets as they dive into the water to fish.

6.3.2. SCUBA diving

Flamborough Head has been a popular diving site for many years. A problem at busy times of year is that of congestion at the launching sites (principally South Landing), and there is also a danger that dive boats may disturb nesting seabirds.

Many divers take crustaceans and flatfishes from the seabed around the headland, but the impact of this selective fishery on populations is unknown. Possibly of greater concern is the removal of sea-urchins (*Echinus eculentus*) as 'souvenirs'. Although common in many parts of the British Isles, these conspicuous animals are evidently rare around Flamborough Head, and could be vulnerable to over-collection.

6.3.3. Boating

In addition to fishing and dive boats, other craft operate in the area, ranging from speedboats to larger vessels used for organised trips around the headland and/or to caves in the vicinity of North Landing. These boats may cause disturbance to seabirds, and several young cetaceans are known to have been damaged or killed by propellers (Mullard, pers. comm).

6.3.4. Sea Angling

The effects of sea angling on populations of marine fishes are unknown, but territorial species such as wrasse are probably the most vulnerable to over-exploitation. When caught, these fish are seldom returned to the sea. Problems may also arise from use of long lines from the cliff tops. When discarded or snagged these then become a hazard for seabirds.

6.3.4. Pollution

The only major industrial effluent in the immediate vicinity of the headland is discharged from a maltings into the sea off Sewerby. The effect of this effluent is unknown, but it is possible that the nutrient input could encourage greater algal growth in the area.

Sewage is also discharged into the waters around the headland. The largest outfall is at Dane's Dyke, where a stream flowing into the sea carries sewage after primary settlement. There is a plan to divert this effluent to the new outfall at Bridlington. Another small outfall reaches the sea at Thornwick Bay, again after primary treatment.

Dives made within 1 km of the Dane's Dyke outfall revealed visible signs of sewage effluent, but there was no evidence of pollution in terms of gross changes in benthic communities. Probably the impact of the effluent is very localised.

In general, the waters and seabed around the headland appear to be relatively clean. There is presumably some input of particulate matter from terrestrial run-off, and from dissolution of the chalk, but there are no rivers in the immediate vicinity and so no input of sediment or pollutants from this source. Strong tidal currents help to keep fine particulate matter in suspension.

However, there have been reports of increased sedimentation around the Headland (Briggs, 1987), and it has been suggested that this might be due to discharges of potash waste from the RTZ potash mine on the North Yorkshire coast, just north of Staithes. Sediment analysis is required before this can be verified.

6.4. CONCLUSIONS: NEEDS AND PROSPECTS

The marine wildlife and habitats found in the shallow sublittoral zone around the Flamborough Headland have been shown to be of significant biological and conservation importance, both regionally and nationally. This zone can be considered as an integral part of the Flamborough Headland and the Heritage Coast, with similar needs for positive management, and possibilities for study and appreciation. There are many links between sea and land, one of the most obvious being the nesting seabirds' use of inshore waters as a fishing ground.

A useful first step towards safeguarding the Flamborough Headland marine environment and its wildlife is to stimulate interest amongst visitors and users. This is done already to some extent through activities such as shore walks and talks, but there is considerable potential for expansion.

It is recommended that consideration is be given to employing a specialist marine ranger/warden within the Heritage Coast Project who would be responsible for developing and coordinating this programme. It would be particularly useful to produce publicity material explaining the biological interest and conservation importance of the sublittoral marine habitats and species around the Flamborough Headland.

It is also important that there is good communication between divers and fishermen, in order that the interests of both groups can be pursued with minimum conflict. The newly formed 'Marine Working Panel' should prove useful in this and other respects. It is recommended that consideration is given to producing a leaflet for divers, incorporating a code of conduct covering safety and conservation.

It is further recommended that a sublittoral study site is established, where the habitats and communities can be investigated in detail, and changes monitored. Much can be learnt from such a project. The biological data can be used to detect environmental change, and as a basis on which to assess requirements for management. The work can also provide a very interesting focus for those who dive the area. Such a scheme can lead to a greater awareness of, and interest in, the sublittoral environment, and this helps to achieve long-term conservation goals. The Marine Conservation Society is in an ideal position and has the specialist knowledge to coordinate a project such as this.

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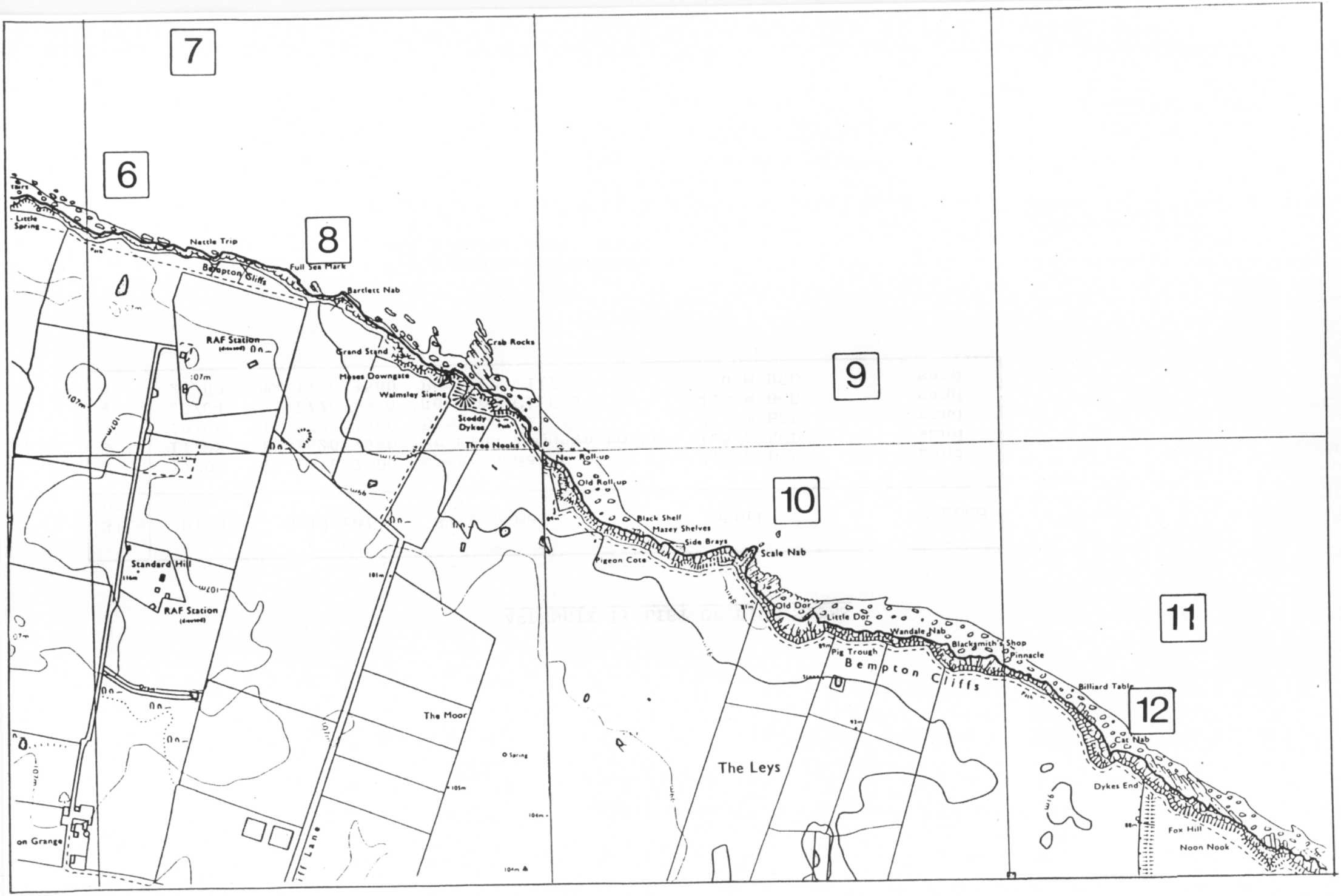
APPENDICES


1
2
3
4
5
King Rock
Double Rock
Crab Rocks
Brecon Hole
Dulcey Dock
Red Cliff Hole
Jackdaw Crag
Nanny Goat's House
Crowe Shoot
Rain Cliff
Jordan's Leap
Earthwork
Weather Castle
Mean Low Water
Mean High Water
Buckton Cliffs
Hailstone Shelves
Rotten Row (Path)
Blarner Shoot
Hartley Shoot
Bourdass Shoot
Matthew Allison's Nab
Grass Moor
Old Oven
Speeton Moor
Pit (disused)
117m
135m

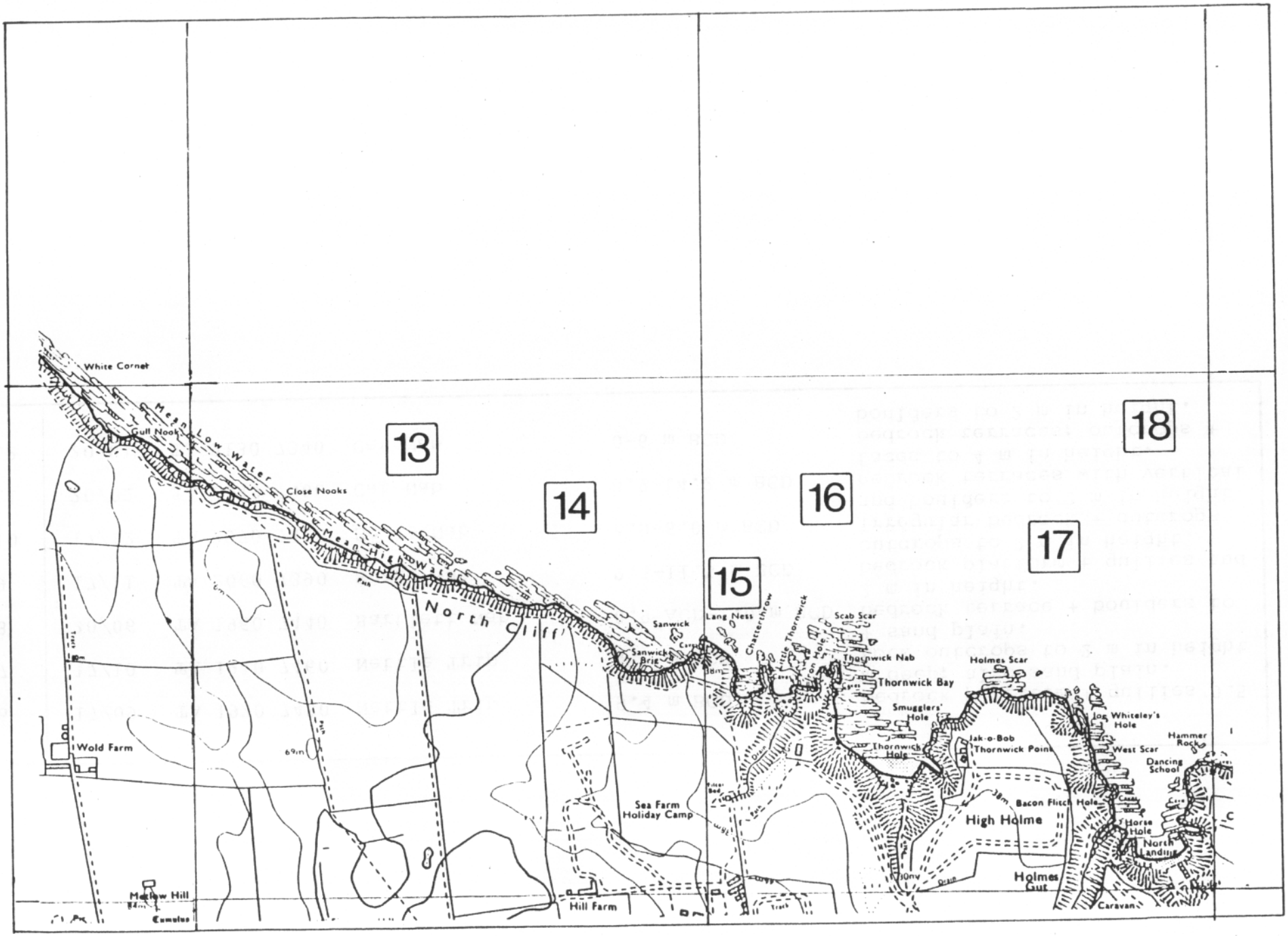
APPENDIX 1: LIST OF DIVE SITES

Site no.	Dive no.	Grid ref	Site name	Depth	Seabed
1	17/07	TA 1570 7600	Speeton Sands	4.3 m BCD	sand
2	17/08	TA 1620 7540	Nr King & Queen rocks	1.5 m ACD	sand
3	20/05	TA 1770 7560	Buckton Cliffs	7.5 m BCD	sand
4	20/04	TA 1770 7520	Buckton Cliffs	4.5 m BCD	sand
5	20/03	TA 1760 7500	Buckton Cliffs	0 m BCD	sand

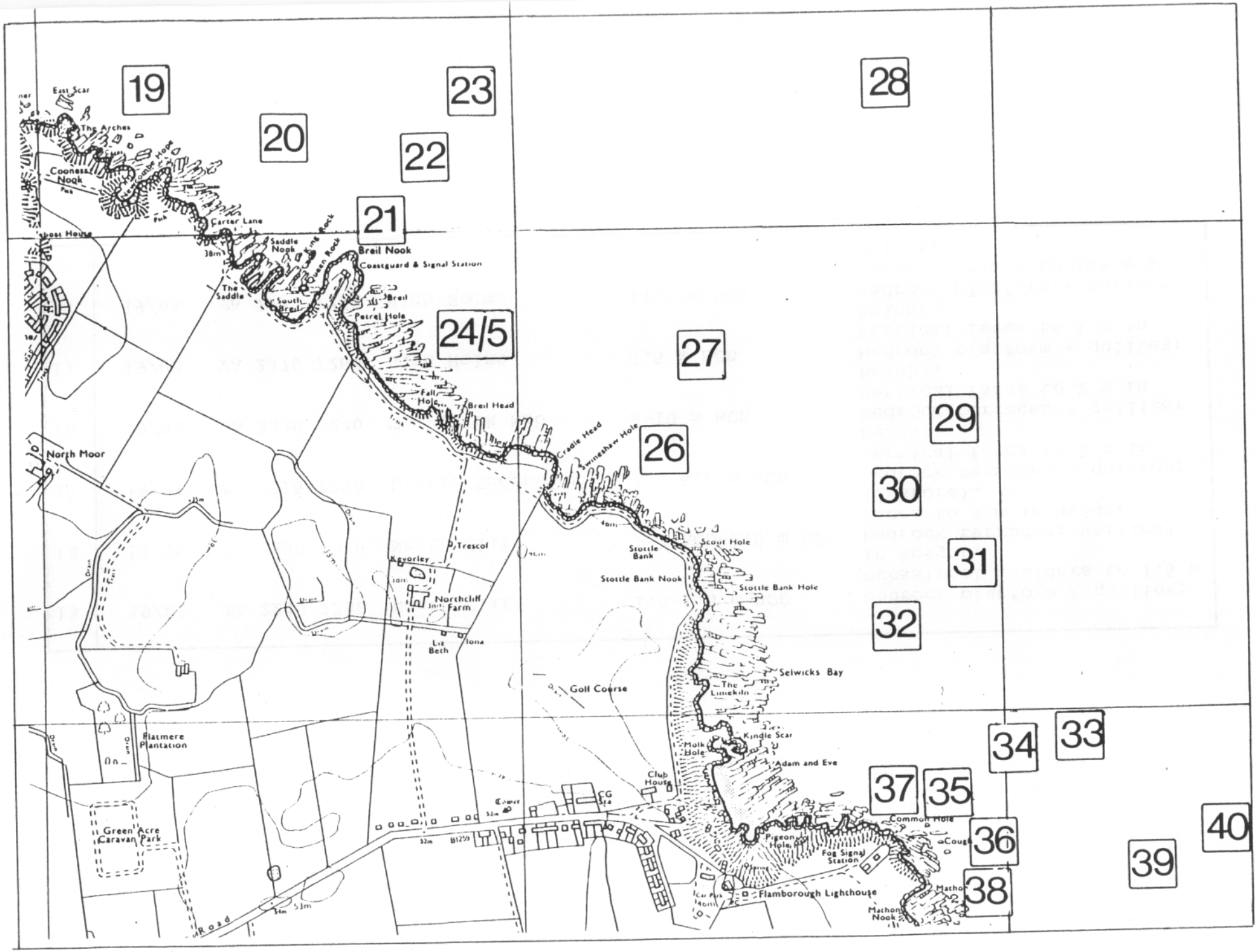
ACD = Above chart datum
BCD = Below chart datum


7
6
8
9
10
11
12
Little Spring
Nettle Trip
Bempton Cliffs
Full Sea Mark
Bartlett Nab
RAF Station
(disused)
Grand Stand
Crab Rocks
Moses Downgate
Walmsley Siping
Stoddy Dykes
Three Nooks
New Roll-up
Old Roll-up
Black Shelf
Mazey Shelves
Side Brays
Pigeon Cote
Scale Nab
Old Dor
Little Dor
Wandale Nab
Blacksmith's Shop
Pinnacle
Pig Trough
Bempton Cliffs
Billiard Table
Cat Nab
Dykes End
Fox Hill
Noon Nook
Standard Hill
RAF Station
(disused)
The Moor
The Leys
Spring
on Grange
ill Lane

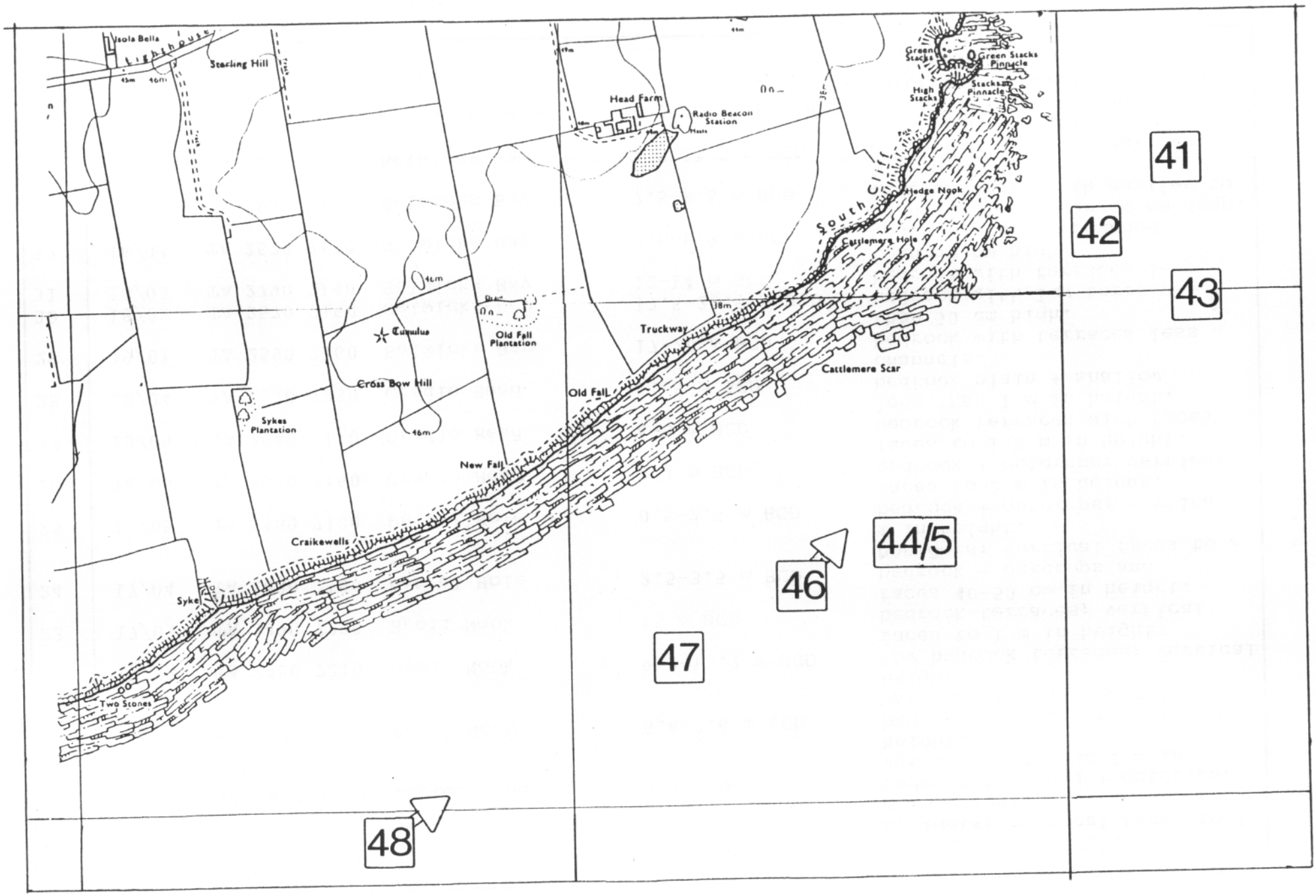
6	17/09	TA 1920 7480	Nettle Trip	9.4 m BCD	bedrock platform + gullies 0.5 m deep; also sand plain.
7	17/10	TA 1910 7460	Nettle Trip	4.5 m BCD	rock outcrops to 2 m in height + sand plain.
8	20/06	TA 1960 7440	Bartlett Nab	0.9 ACD-2.0 m BCD	bedrock terrace + boulders to 2 m in height.
9	17/11	TA 2060 7390	Scale Nab	9.5-11.5 m BCD	bedrock platform + gullies and outcrops to 2 m in height.
10	17/12	TA 2070 7420	Scale Nab	4.0-6.0 m BCD	irregular bedrock + outcrops and boulders to 2 m in height.
11	20/02	TA 2140 7360	Cat Nab	9.2-14.2 m BCD	bedrock terraces with vertical faces to 4 m in height.
12	20/01	TA 2130 7340	Cat Nab	0-6 m BCD	bedrock terraces; outcrops + boulders to 2 m in height.


13
14
15
16
17
18
White Cornet
Mean Low Water
Gull Nook
Close Nooks
Mean High Water
North Cliff
Sanwick
Sanwick Brig
Lang Ness
Chatterthrow
Little Thornwick Hole
Scab Scar
Thornwick Nab
Holmes Scar
Thornwick Bay
Smugglers' Hole
Jak-o-Bob
Thornwick Point
Thornwick Hole
Jog Whiteley's Hole
West Scar
Hammer Rock
Dancing School
Bacon Fletch Hole
High Holme
Horse Hole
North Landing
Holmes Gut
Caravan
Wold Farm
69m
Sea Farm
Holiday Camp
Hill Farm
Marlow Hill
84m
Cumulus

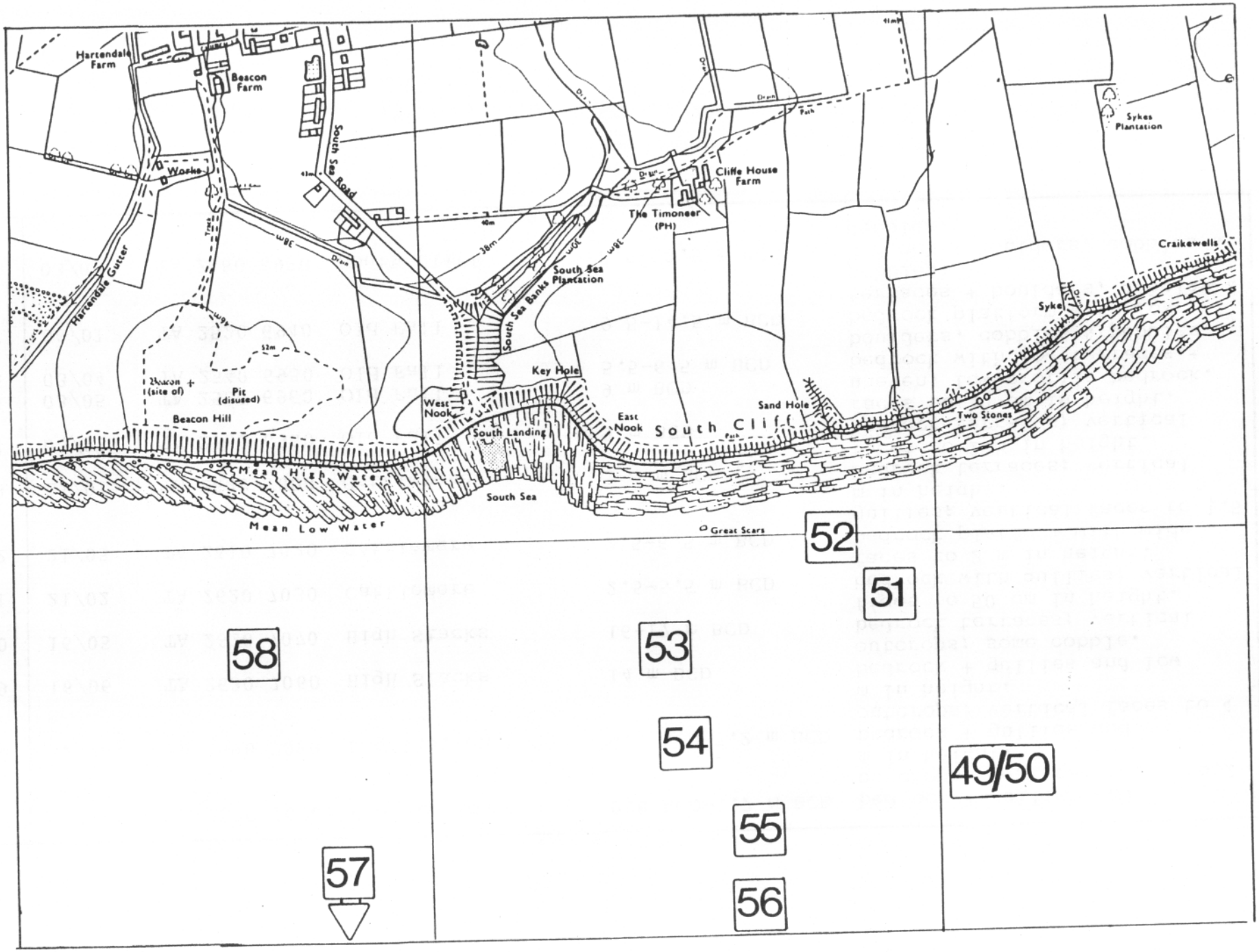
13	19/06	TA 2240 7280	North Cliff	1.0-6.5 m BCD	bedrock platform + gullies; occasional boulders to 1.5 m in height.
14	19/05	TA 2280 7270	North Cliff	1.3 ACD-2.0 m BCD	bedrock terraces; vertical faces to 3 m in height (inshore).
15	19/01	TA 2310 7250	Little Thornwick	2.0-5.0 m BCD	bedrock terraces + gullies; vertical faces to 2 m in height.
16	19/02	TA 2330 7270	Thornwick Nab	8-10 m BCD	bedrock terraces + gullies; vertical faces to 2 m in height.
17	19/03	TA 2370 7260	High Holme	5.5 m BCD	bedrock platform + gullies; vertical faces to 1 m in height.
18	19/04	TA 2390 7290	High Holme	15.5 m BCD	bedrock platform + gullies; vertical faces to 1.5 m in height.


19
20
21
22
23
24/5
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
East Scar
The Arches
Coonese Nook
Carter Lane
Ghost House
Saddle Nook
Queen Rock
Breil Nook
Coastguard & Signal Station
The Saddle
South Breil
Breil
Petrel Hole
Fall Hole
Breil Head
Cradle Head
Swinestaw Hole
North Moor
Keyorley
Trescol
Northcliff Farm
Liz
Beth
Iona
Stottle Bank
Scout Hole
Stottle Bank Nook
Stottle Bank Hole
Selwicks Bay
The Limekiln
Golf Course
Kindle Scar
Molk Hole
Adam and Eve
Club House
Flatmere Plantation
Green Acre Caravan Park
B1259
Common Hole
Pigeon Hole
Fog Signal Station
Flamborough Lighthouse
Mathon Nook

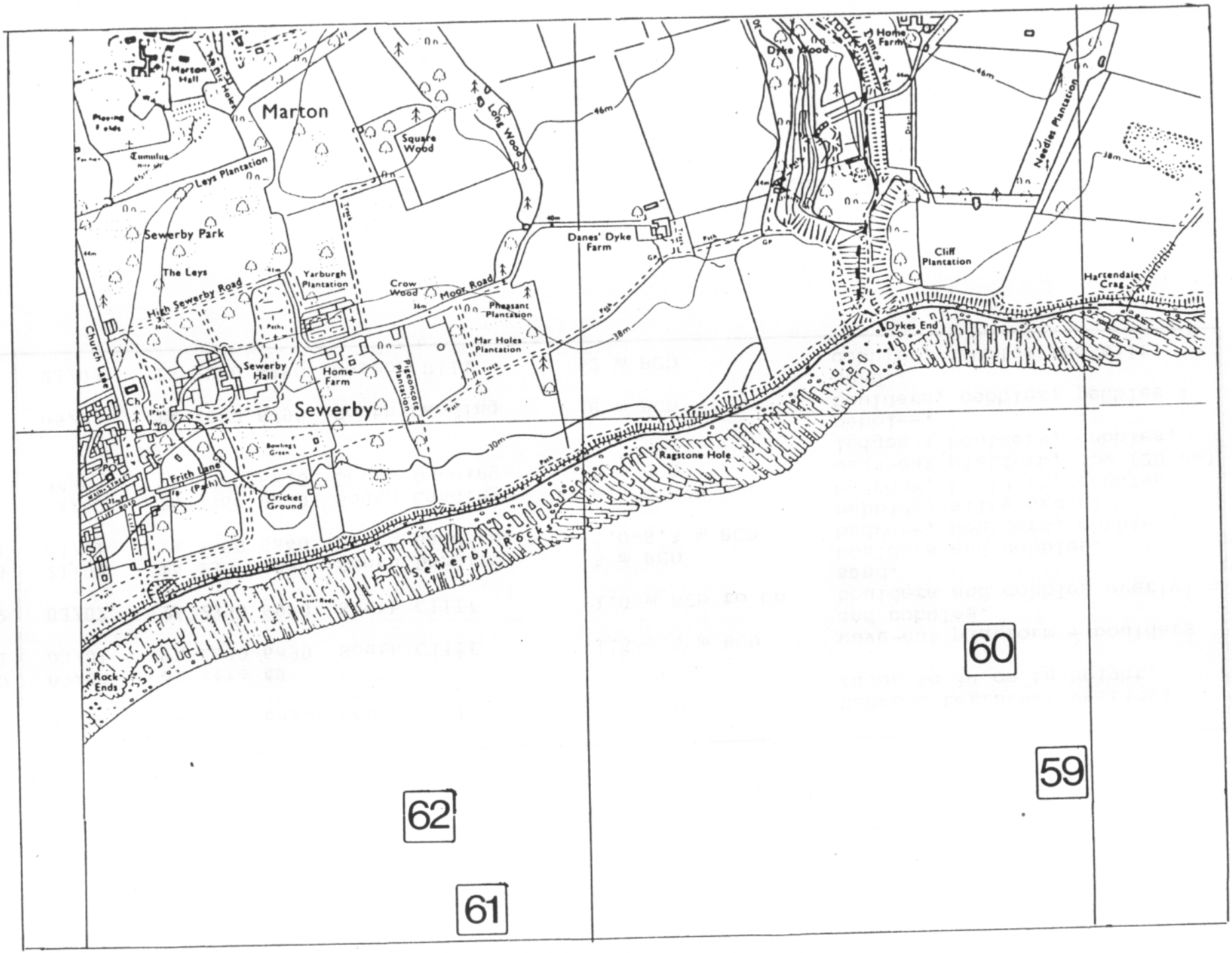
19	17/06	TA 2430 7230	North Landing	3.0-5.5 m BCD	bedrock with ridges + boulders; vertical faces to 1 m in height.
20	07/01	TA 2460 7270	Carter Lane	3-4 m BCD	bedrock terraces + outcrops; vertical faces to 1 m in height.
21	17/03	TA 2470 7200	Breil Nook	5.6-7.6 m BCD	bedrock outcrops + gullies; vertical faces to 2 m in height.
22	17/02	TA 2480 7210	Breil Nook	9.2-11.2 m BCD	low bedrock terraces; vertical faces to 1 m in height.
23	17/01	TA 2490 7230	Breil Nook	15 m BCD	bedrock terraces; vertical faces 40-50 cm in height.
24	17/04	TA 2480 7180	Petrel Hole	2.5-3.5 m BCD	bedrock + outcrops and boulders; vertical faces to 2 m in height.
25	17/05	TA 2480 7180	Petrel Hole	0.5-2.5 m BCD	bedrock + outcrops; vertical faces to 2 m in height.
26	18/06	TA 2530 7150	Cradle Head	2-4 m BCD	bedrock + outcrops; vertical faces to 1.5 m in height.
27	18/05	TA 2540 7170	Cradle Head	4-8 m BCD	bedrock terraces with faces less than 1 m in height.
28	18/04	TA 2570 7230	Cradle Head	21.5 m BCD	bedrock plain + shallow channels.
29	19/01	TA 2590 7160	Selwicks Bay	17-20 m BCD	bedrock with terraces less than 50 cm high.
30	18/02	TA 2570 7150	Selwicks Bay	17.5-20.5 m BCD	bedrock with low terraces.
31	16/03	TA 2790 7140	Selwicks Bay	12-14 m BCD	bedrock with terraces less than 50 cm high.
32	16/04	TA 2570 7130	Selwicks Bay	7.8-8.8 m BCD	bedrock plain + rounded channels less than 40 cm deep.
33	16/01	TA 2620 7100	Selwicks Bay	7.5-8.5 m BCD	bedrock plain with gullies to 1 m in depth.
34	16/02	TA 2600 7090	Selwicks Bay	7.5-11.5 m BCD	bedrock plain with gullies less than 1 m deep.
35	18/03	TA 2580 7070	Fog Station	2.2 ACD-4.8 m BCD	bedrock + gullies and outcrops; vertical faces to 6 m in height.
36	21/8	as site 35			


Isola Bella
Lighthouse
Starling Hill
Head Farm
Radio Beacon Station
Green Stacks
Green Stacks Pinnacle
High Stacks
Stacks Pinnacle
South Cliff
Sledge Nook
Cattlemere Hole
Tumulus
Old Fall Plantation
Truckway
Cattlemere Scar
Cross Bow Hill
Sykes Plantation
Old Fall
New Fall
Craikewells
Two Stones
41
42
43
44/5
46
47
48

37	21/06	TA 2570 7070	Fog Station	0.8 ACD-1.2 m BCD	bedrock + gullies and outcrops; vertical faces to 2 m in height.
38	21/07	TA 2590 7060	Fog Station	0.8 ACD-7.2 m BCD	bedrock + gullies and outcrops; vertical faces to 4 m in height.
39	16/06	TA 2630 7060	High Stacks	14 m BCD	bedrock + gullies and low outcrops; some cobble.
40	16/05	TA 2620 7070	High Stacks	16-17 m BCD	bedrock terraces; vertical faces to 50 cm in height.
41	21/02	TA 2620 7030	Cattlemere	2.5-5.5 m BCD	bedrock with gullies; vertical faces to 2 m in height.
42	21/05	TA 2610 7020	Cattlemere	2.5-6.5 m BCD	bedrock platform with wide gullies; vertical faces to 1.5 m in height.
43	21/01	TA 2620 7000	Cattlemere	2-8 m BCD	bedrock terraces; vertical faces to 2 m in height.
44	03/05	TA 2560 6960	Old Fall	9 m BCD	bedrock terraces; vertical faces to 30 cm in height.
45	03/05	TA 2560 6960	Old Fall	9 m BCD	uneven, low-profile bedrock.
46	03/04	TA 2540 6950	Old Fall	5.5-6.5 m BCD	bedrock with low terraces + boulders, cobbles & pebbles.
47	06/01	TA 2520 6940	Old Fall	9.5-14.5 m BCD	bedrock platform with low terraces + boulders, cobbles & pebbles.
48	03/03	TA 2480 6920	South Cliff	8.5-10.5 m BCD	bedrock + boulders, cobbles & pebbles.


Hartendale Farm
Beacon Farm
Works
South Sea Road
Cliffe House Farm
The Timoneer (PH)
Sykes Plantation
Craikewells
Hartendale Gutter
South Sea Banks Plantation
Syke
Beacon + (site of)
Pit (disused)
Beacon Hill
Key Hole
West Nook
East Nook
South Landing
South Cliff
Sand Hole
Two Stones
Mean High Water
South Sea
Mean Low Water
Great Scars
52
51
58
53
54
49/50
55
57
56

49	07/02	TA 2400 6850	South Cliff	7 m BCD	bedrock terraces; vertical faces to 30 cm in height.
50	07/03	as site 49			
51	03/01	TA 2390 6890	South Cliff	1.5-3.5 m BCD	wave-cut platform + boulders and cobbles.
52	03/02	TA 2390 6900	South Cliff	1.0 m ACD to CD	boulders and cobbles overlying sand.
53	21/04	TA 2350 6870	South Landing	5 m BCD	boulders and cobbles.
54	04/01	TA 2350 6840	South Landing	5.0-6.3 m BCD	bedrock, boulders, cobbles, pebbles, silty gravel.
55	04/02	TA 2360 6830	South Landing	6.5 m BCD	bedrock, boulders, cobbles.
56	04/03	TA 2360 6810	South Landing	8 m BCD	wave-cut platform; low (20 cm) ledges + boulders, cobbles, pebbles.
57	05/01	TA 2280 6790	South Landing	8 m BCD	boulders, cobbles, pebbles + sand.
58	21/03	TA 2260 6880	Beacon Hill	2 m BCD	cobbles, pebbles and silt.


Marton
Marton Hall
Tumulus
Leys Plantation
Sewerby Park
The Leys
High Sewerby Road
Yarburgh Plantation
Square Wood
Lobe Wood
Crow Wood
Moor Road
Danes' Dyke Farm
Pheasant Plantation
Mar Holes Plantation
Pigeoncote Plantation
Sewerby Hall
Home Farm
Sewerby
Church Lane
Frith Lane
Bowling Green
Cricket Ground
Rock Ends
Sewerby Rocks
Ragstone Hole
Dykes End
Dyke Wood
Home Farm
Needles Plantation
Cliff Plantation
Hartendale Crag
62
61
60
59

59	05/03	TA 2200 6850	Danes Dyke	4 m BCD	small boulders, cobbles + coarse to muddy sand.
60	05/02	TA 2190 6870	Danes Dyke	4.5 m BCD	boulders, cobbles + coarse to muddy sand.
61	06/03	TA 2070 6810	Sewerby Rocks	3.5 m BCD	boulders, cobbles + shelly, muddy gravel.
62	06/02	TA 2060 6830	Sewerby Rocks	3 m BCD	small boulders + cobbles on sand & gravel; also sand plain.

SITE NAME

SITE NO.

	STN./HABITAT 1	2	3	4	5	6	SITE 5
DEPTH ZONE (OPEN ROCK) (TICK)							
SUBLITTORAL FRINGE							
UPPER INFRALITTORAL	✓						
LOWER INFRALITTORAL							
UPPER CIRCALITTORAL							
LOWER CIRCALITTORAL							
NOT KNOWN							
DEPTH BAND (m) BELOW CHART DATUM (TICK)							
<0							
0-5	✓						
5-10							
10-20							
20-30							
>30							
SUBSTRATUM (SCORE 1=RARE, 2=SECONDARY, 3=PREDOM.)							
BEDROCK	3	3		2			
LG. BOULDERS (500 mm+)	2	2					
SM. BOULDERS (256-500 mm)				1			
LG. COBBLES (128-256 mm)				1			
LG. SLATES (128-256 mm)							
SM.ANG. COBBLES (64-128 mm)				1			
SM.RND. COBBLES (64-128 mm)				1			
SM. SLATES (64-128 mm)							
LG.ANG. PEBBLES (16-64 mm)				1			
LG.RND. PEBBLES (16-64 mm)				1			
MED.&SM. PEBBLES (4-16 mm)				1			
CLEAN GRAVEL (2-4 mm)				1			
MUDDY GRAVEL (2-4 mm)							
MAERL GRAVEL							
CLEAN SHELL GRAVEL							
MUDDY SHELL GRAVEL							
COARSE SAND (0.5-2 mm)							
CLEAN SAND							
MUDDY SAND							
SANDY MUD							
MUD							
CLAY							
WHOLE SHELLS							
TREE BRANCHES							
METAL							
CONCRETE							
WOOD							
ALGAE/SEAGRASS							
OTHER (note below)							
SEDIMENT FEATURES (SCORE 1-3)							
SEDIMENT PLAIN							
SEDIMENT POCKET							
SEDIMENT WAVES (>5 cm high)							
RIPPLES (<5 cm high)							
MOUNDS/CASTS							
BURROWS/HOLES							
SUBSURFACE COARSE LAYER							
SUBSURFACE CLAY/MUD							
SURFACE SILT/FLOC							
MOBILE							
WELL SORTED							
POORLY SORTED							
FIRM							
SOFT							

	STN./HABITAT 1	2	3	4	5	6	SITE 5
HARD-SUBSTRATUM FEATURES (SCORE 1-3)							
ROCK OUTCROP	3	3					
ROCK PLATFORM				3			
ROCK RIDGES							
ROCK WALL							
TERRACES							
OPEN GULLIES							
STEEP SIDED GULLIES							
LARGE CAVE (MAN)							
SMALL CAVE (HEAD)							
OVERHANGS							
VERTICAL SURFACES		3					
LEDGES (Small)		1					
POTHOLES							
ROCKMILLS							
BROKEN ROCK							
UNBROKEN ROCK							
LARGE FISSURES/CREV.(ARM)		1					
SMALL FISS./CREV.(FINGERS)	1	1		1			
PITTED/BORED							
BOULDERS ON BOULDERS/ROCK				1			
BOULDERS ON SEDIMENT							
BOULDER INTERSTICES				1			
COBBLE INTERSTICES	1			1			
PEBBLE INTERSTICES	1			1			
MOBILE COBBLES	1			1			
COBBLES/PEBBLES ON SEDIMENT							
SCOURED ROCK		1		2			
SANDY ROCKS							
THIN SILT ON ROCKS	1			1			
THICK/FLOC. SILT ON ROCKS							
WRECK							
MAN-MADE STRUCTURE							
OTHER (note below)							
SEDIMENT COVER (SCORE 1-3)							
SEAGRASS BED							
ALGAL MEADOW							
ALGAL TURF							
ALGAL MAT							
UNATTACHED ALGAE							
DIATOM FILM							
MUSSEL BED							
FAUNAL BED							
OTHER (note below)							
HARD-SUBSTRATUM COVER (SCORE 1-3)							
KELP CANOPY	2						
FOLIOSE ALGAE	2	1	1				
ALGAL TURF	1	1					
ALGAL CRUST				1			
FAUNAL BED							
FAUNAL TURF	1	3		1			
FAUNAL CRUST			1				
OTHER (note below)							

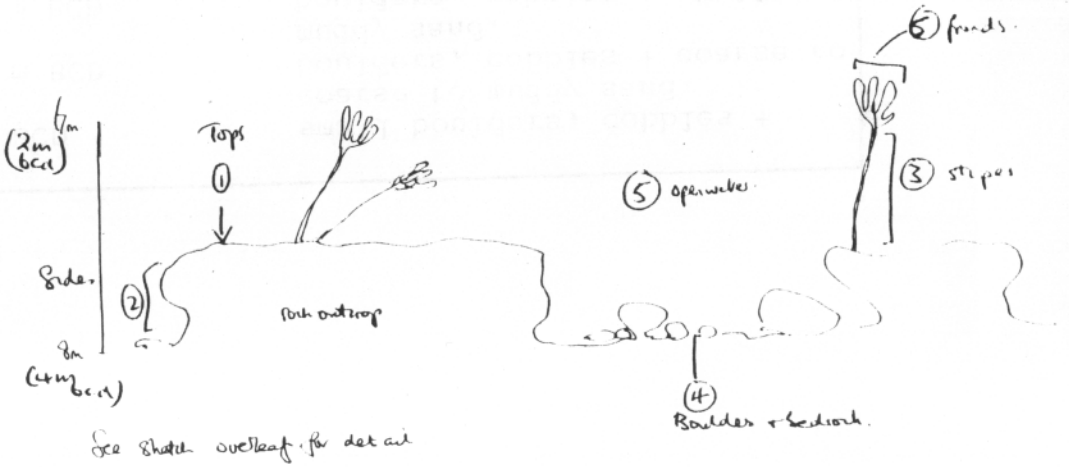
SITE NO.:

SITE LOCATION DETAILS (large- and small-scale maps, details for relocation of sites, transit marks etc.)

Appendix 2

Example of sublittoral habitat record sheets.

SKETCH/PROFILE OF SITE (showing different habitats and communities. Depth zones/limits clearly marked).



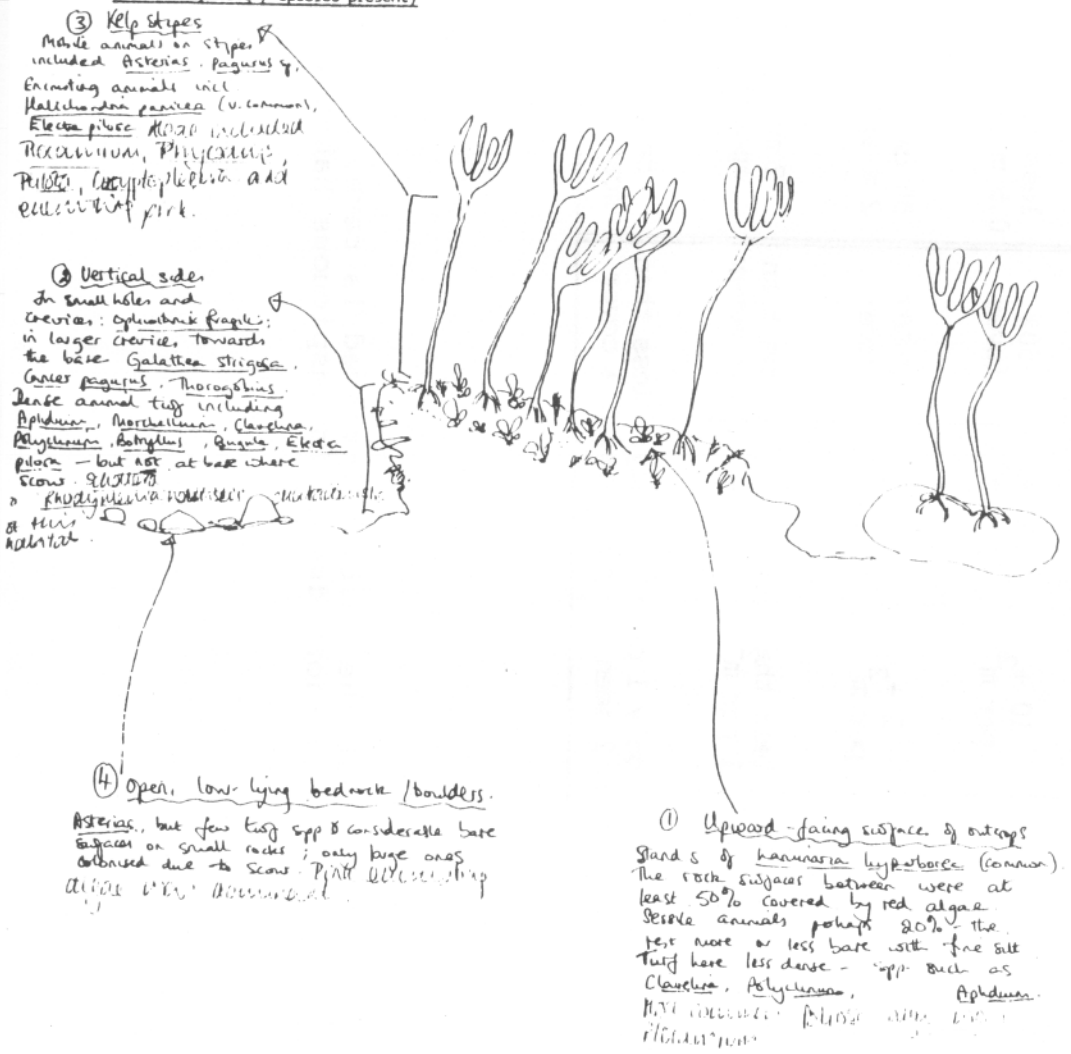
REPORT SECTION

WAS THIS SITE SELECTED FOR A PARTICULAR REASON (state):

GENERAL DESCRIPTION OF SITE

(to 1.5 high)
Inshore rocky area - bedrock outcrops + flat rock, low-lying areas (scoured) between. No apparent orientation - kelp dominated ; quite dense forest with undergrowth of reds + fauna turf.

DESCRIPTION OF EACH HABITAT SURVEYED (Include habitat number, description of substratum, depth band / zone and main communities / species present)



Compiled by the Field Studies Council's Oil Pollution Research Unit for the Nature Conservancy Council.
Version 2, April 1987.

SUBLITTORAL HABITAT RECORD

SITE NAME: CRADLE HEAD

SURVEY AREA: FLAMBOROUGH

RECORD NO.: 18/6 (26)

SITE NO.:

OS GRID REF.: TA 2530 7150 TO

	E - W	N - S		E - W	N - S
	TA	2530	7150 TO		

LAT.LONG.: TO

RECORDER: Elizabeth Wood
Teresa Bennett

DATE: 18 D 08 M 87 Y

TIME IN	1	5	0	9
TIME OUT	1	5	4	5
DURATION			3	6

BST/GMT

DEPTH CORRECTION APPLIED? NO (YES) +/- -4.0 m
DEPTH RANGE SURVEYED ..2-4... m BELOW SEA LEVEL/(CHART DATUM)
HORIZONTAL UNDERWATER VISIBILITY ....7m... m

SITUATION (TICK ONE)

OPEN SEA (>1 km offshore)	
OPEN COASTLINE-ROCK (>30° deep-water window)	✓
OPEN COASTLINE-SEDIMENT (>30° deep-water window)	
ENCLOSED COASTLINE-ROCK (<30° deep-water window)	
ENC. COASTLINE-SEDIMENT (<30° deep-water window)	

OVERALL SEABED INCLINATION (TICK)

OVERHANG	
VERTICAL (80-100°)	
V.STEEP (40-80°)	
STEEP (20-40°)	
GRADUAL (5-20°)	
HORIZONTAL (<5°)	✓

COASTAL TYPE (TICK)

HEADLAND	
LINEAR COAST	✓
LARGE BAY (>2 km)	
SMALL BAY (<2 km)	
SPIT/BAR	
BREAKWATER	
OFFSHORE SMALL ISLAND	
AMONGST ROCKS/ISLETS	
SOUND/NARROWS	
SHALLOW RAPIDS	
SEA LOCH	
ESTUARY/MARINE INLET	
ENTRANCE TO MARINE INLET	
POCKET BEACH	
LINEAR BEACH	
COASTAL LAGOON	
HARBOUR	
OTHER (note below)	

WAVE EXPOSURE (SURFACE) (TICK)

V.EXP. (prev. wind & swell)	
EXPOSED (prev. wind)	
SEMI-EXP. (strong wind freq.)	✓
SHELT. (strong wind rare)	
V.SHELT. (fetch <20 km)	
EXT.SHELT. (fetch <3 km)	

MAX. TIDAL STREAM STRENGTH (TICK)

VERY STRONG (6+ k)	
STRONG (3-6 k)	
MOD. STRONG (1-3 k)	✓
WEAK (<1 k)	
VERY WEAK (negligible)	

SALINITY REGIME (TICK)

NORMAL (around 34 °/oo)	✓
VARIABLE (30 °/oo+)	
LOW (<30 °/oo)	
NOT KNOWN	

WATER STRATIFICATION (TICK)

THERMOCLINE	
HALOCLINE	
NOT STRATIFIED	✓
NOT KNOWN	

ROCK TYPE (TICK)

IGNEOUS	
LIMESTONES	
CHALK	✓
CHERT/FLINT	
CLAY	
HARD SAND/MUDSTONES	
SOFT SAND/MUDSTONES	
HARD SLATE	
FRIABLE SLATE/SHALES	
NOT KNOWN	
OTHER (note below)	

SITE INFORMATION (TICK)

HABITAT DIVERSITY HIGH	
SPECIES AT OR NEAR LIMIT	
SPECIES RICHNESS (FOR AREA) (1=poor, 2=av., 3=gd.)	2
MNR,NNR,LNR,SSSI ETC. NEARBY	
PREVIOUS STUDY AREA	
EASE OF ACCESS (1=diff., 2=mod., 3=easy)	2
ACCESS RESTRICTED (LEGAL)	
EVIDENCE OF POLLUTION	
VERY CLEAN	
FRAGILE	
THREATENED (note below)	
OUTFALL NEARBY	
EVIDENCE OF PHYSICAL DAMAGE	
MAN-MADE LITTER/DEBRIS	
OTHER DISTURBANCE (note below)	

USAGE (TICK)

FIELD STUDY	
RESEARCH	
POPULAR DIVING SITE	
POTTING	
FIXED NETS	
AQUACULTURE	
MOORING	
PONTOONS	
DREDGING	
OTHER (note below)	

OTHER DATA/MATERIAL COLLECTED (TICK)

PHOTOGRAPHS: V-A	
C-U	
SPECIMENS COLLECTED	✓
SEDIMENT SAMPLES (INFAUNA)	
ALGAL CHECKLIST	✓
ANIMAL CHECKLIST	✓
PHYSICAL DATA (note below)	
OTHER (note below)	

Appendix 3.

Abundance scale used during the Flamborough Headland Sublittoral Survey.

	ANIMALS			ALGAE		
	Large, solitary & colonial spp. (e.g. large anemones & sponges, starfish, crabs, fish etc.)	Small, solitary spp. (e.g. small anemones, ascidians, sponges etc.)	Small colonial/crustose spp. (e.g. encrusting sponges, ascidians, bryozoans, hydroids).	Kelps	Foliaceous/filamentous spp.	Encrusting spp
Abundant	10 + per m^2	100 + per m^2	50% cover	less than 0.5 m apart	20% cover +	50% cover +
Common	1 + per m^2	10 + per m^2	10-50% cover	50 cm to 2 m apart	less than than 20% cover	20-50% cover
Frequent to occasional	less than 1 per m^2	1 + per m^2	less than 10% cover	2 m + apart	scattered	20% or less
Present*	only 1 or 2 seen	widely scattered	less than 1% cover	few, scattered	few	less than 1% cover

*May signify that the species involved is rare, but in some cases abundance unknown due to inconspicuous habits.

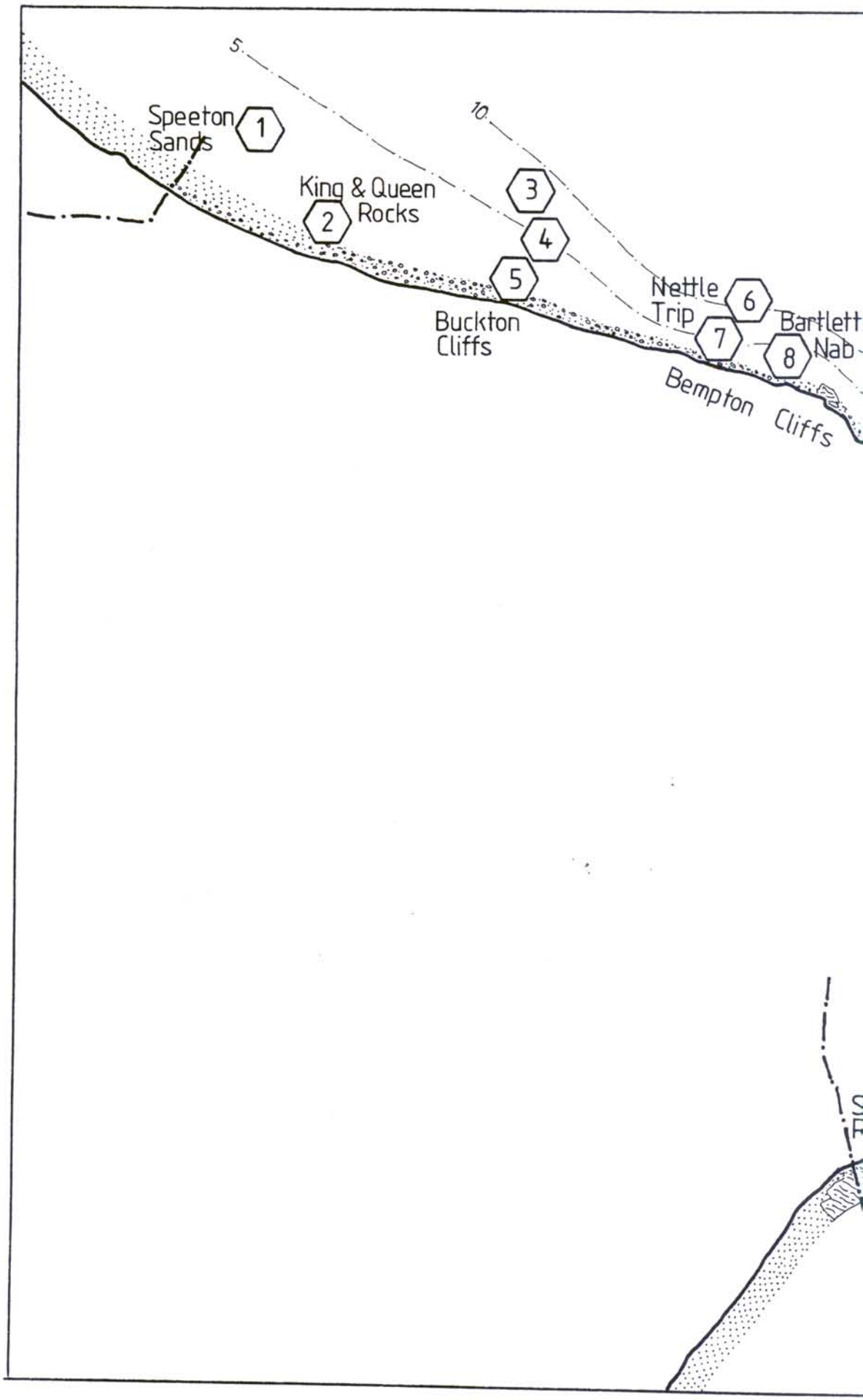

5
10
Speeton Sands
1
King & Queen Rocks
2
3
4
5
Buckton Cliffs
Nettle Trip
6
7
Bartlett Nab
8
Bempton Cliffs

FIGURE 41
Flamborough Headland
Location of dive sites