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The marine nature conservation importance of British coastal chalk cliff habitats

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The Marine Nature Conservation Importance of British Coastal Chalk Cliff Habitats

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1. Introduction

Maritime chalk habitats have a long history of study; the flora of cliffs and maritime chalk grasslands have been described in detail and their nature conservation importance recognised (e.g. Smith, 1980). Marine chalk communities have not received the same degree of attention until recently, when the accelerated rate of loss of marine chalk and chalk cliff face in the southeast of England was recognised by the Nature Conservancy Council as a result of coastal planning applications. Subsequent studies demonstrated that marine chalk was a scarce habitat in Britain and Europe, with England holding a large proportion of this international resource. This report briefly reviews the chalk cliff resource and its marine nature conservation importance in Britain.

The littoral communities of the coast of Thanet, in east Kent, have been more heavily affected by coastal development than in any other area of the country. This is due to extensive urbanisation in the region, where houses have been built along most of the coastline. The soft, eroding nature of the Upper Chalk exposed in the cliffs has necessitated the construction of coastal protection works to protect these properties and very few sections of cliff now remain in a natural state. This area is also of considerable marine conservation significance for the pioneering work carried out here by Anand (1937 a,b,c) on the taxonomy and ecology of the algae of chalk cliffs. New coastal protection and development proposals in this district have recently been opposed successfully by NCC at resulting Public Inquiries. Thanet is used as a case study to examine the effects of coastal habitat loss on sites of marine nature conservation interest.

This report was originally written by S L Fowler in early 1990, but not circulated by NCC at this time. Much of the work it describes was funded by the NCC as part of its Commissioned Research Programme and the Marine Nature Conservation Review. It has been updated slightly for publication by English Nature in its Research Series.

2. Geology of chalk

Most chalk was laid down in the Upper Cretaceous Period, one hundred million years ago, when much of north-western Europe was inundated by the sea. The rock is primarily comprised of the remains of the external skeletons of haptophyte algae, foraminiferans and particles of bivalves, echinoderm plates and bryozoans. Intact fossils of some marine invertebrates are common in some strata. Because of the relatively large nature of most of its components, chalk can absorb and retain water well and is relatively easily eroded. The white chalks are very pure, containing up to 99% calcium carbonate, although some strata (the chalk marls) have a high clay content. Chalk is a pure limestone, whereas the rocks more commonly known as limestones have a lower calcium carbonate content and their impurities make them much harder. A characteristic of some chalks is the layers of flints found along bedding planes between the strata or in vertical joints, formed by accumulation of silica from the original material deposited. The Upper Chalk has most flint bands and the chalk is the most pure, whereas the Lower Chalk, which has no flints, has its silica content distributed throughout the rock. The Red Chalk, formed during the Lower Cretaceous and older than the white chalks, is the least pure of all these rocks.

Following deposition in the Cretaceous seas, where chalk of more than one kilometre in depth accumulated in places, the sea-bed was uplifted in the Tertiary Era exposing the chalk to erosion and volcanic activity (which covered and metamorphosed the chalk in some areas). Subsequent periods of deposition of sedimentary rocks covered the chalk, and the formation of the Alps during tectonic drift and collision caused the folding and tilting of strata in northern Europe. The result of these forces has been the creation of some harder chalks in areas where folding and thrusting has affected the rocks. At the Isle of Wight and in Dorset the chalks are vertically bedded, so that all the strata are exposed on the foreshore within a relatively short distance. The hardness of this chalk is demonstrated by the durability of the outcrops at the Needles. The horizontally bedded chalk at Flamborough Head which has been compressed, perhaps by the overlying strata and glaciation, is also hard. Elsewhere in southeast England, the chalks are almost horizontally bedded and relatively soft. The very gentle slope of the strata means that the range of Chalks are exposed at different places along the coast in Kent and Sussex.

3. The geographical distribution of chalk

Chalk strata are present in England, Northern Ireland, Belgium, northern France, Denmark, Germany, Poland and Russia; also in parts of the United States, Australia and the Middle East (Smith, 1980). Despite the extensive nature of these Cretaceous rocks, a few of these areas have no chalk exposed on land or the coast (for example the Ulster chalks were covered by basalt and metamorphosed to marble where the lava extruded). In most areas where chalk is present on the coast, these exposures are relatively small in comparison with the extensive areas of chalk inland.

Figure 1 shows the extent of chalk in northwest Europe and coastal chalk cliffs in Britain. Although chalk forms a significant length of the Kent and Sussex coasts in southeast England, with additional outcrops on the Isle of Wight, Dorset, Norfolk and North Humberside, less than 0.6% of the British coastline (or less than 2% of the English coast) is of chalk (Tables 1 and 2). Elsewhere in northern Europe, coastal chalk is exposed in northern France at Normandy and the Pas de Calais and on the Baltic coast of Denmark.

Coastal chalk is therefore an unusual marine habitat in the northeast Atlantic and Britain holds a large proportion of the European total. These exposures are concentrated in the southeast, where development pressures on the coast are severe.

Table 1. The length of coastal chalk in northwest Europe (km)

England (measured from 1:50,000 Ordnance Survey maps)		
Kent	38.0	(56% modified by coastal works)
Sussex	29.0	(33% modified by coastal works)
Isle of Wight	10.0	
Dorset	12.0	
Devon	3.0	
Norfolk	3.5	
North Humberside	17.5	
Sub-total	**113**	**km**
France (estimated by Tittley)		
Cap Blanc-Nez	3	
Normandy	82	
Sub-total	**85**	**km**
Baltic chalk: not calculated, but only short lengths present		

Table 2. The length of the British coast at the mean high water mark (km)
(measured from 1:50,000 Ordnance Survey maps)

England	5,912
Wales	1,622
Scotland	11,772
Total	**19,306 km**

Total length of chalk = 113 km, <0.6% of the British or <2% of the English coastline

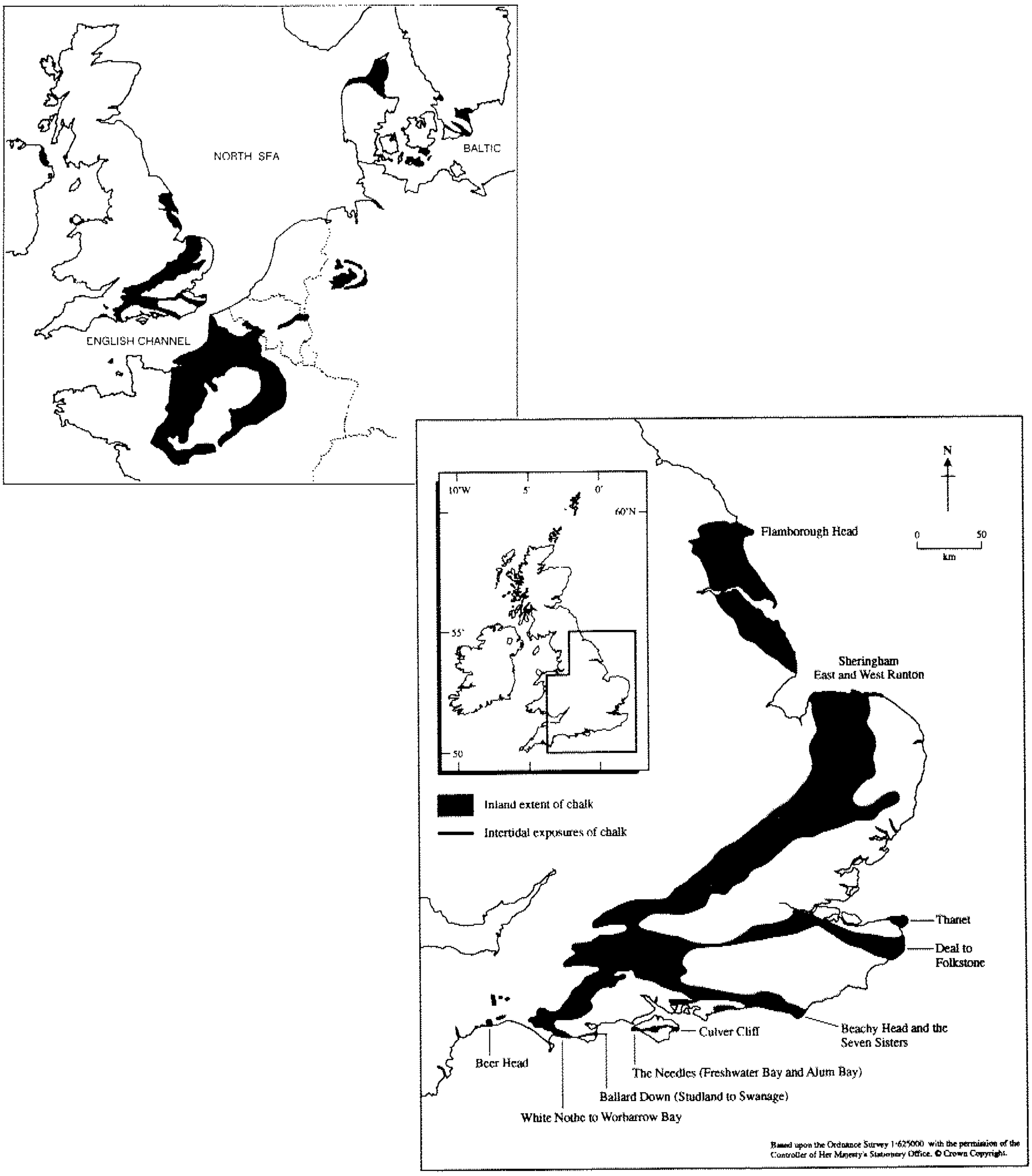

Figure 1. The distribution of chalk outcrops in northwest Europe and littoral chalk in Britain.

4. Coastal chalk habitats

The homogenous and soft, porous nature of chalk usually results in the formation of vertical cliffs, edged by a horizontal wave-cut platform when exposed to the sea. These physical characteristics of the rock also have a marked effect on the marine flora and fauna present.

Erosion operates in several ways, but the rate is generally irregular and difficult to estimate. Where the structure of the chalk is uniform, cliffing occurs by undercutting from wave action followed by cliff falls. Sub-aerial erosion from freshwater run-off at the cliff top also causes cliff falls and recession. If the chalk is of a more uneven structure, wave action can erode weaker sections more swiftly by attacking joints in the rock. Cliff recession then proceeds by caving, arching and stacking. Wave action hollows out caves and tunnels which may collapse to form chimneys, funnels or gullies. When a tunnel forms between two gullies, arching is followed by the formation of a stack as the tunnel roof collapses. On the Thanet coast and in parts of the Isle of Wight caves are present on the upper shore and above the high water mark; on Flamborough Head they extend from well above the high water mark to below low water.

Rates of cliff erosion have been calculated for chalk cliffs in south England by May (1971). An average annual retreat of 0.42 m was found for the cliffs between Seaford and Beachy Head between 1872 and 1962, with a maximum at Birling Gap of 0.99 m per annum between 1950 and 1962. Most losses occurred in winter, with a few large falls accounting for most of the change. This compares with an annual average of between 0.2 and 0.3 m retreat over an 80 year period in Dorset, South Foreland and Thanet, Kent.

Cliff recession produces a wave-cut platform on the foreshore at the cliff foot, although in many sites this is obscured by a shingle or sand beach or may lie below the low water mark. The outer edge of this platform, which usually has a low vertical face, also recedes landwards but at a slower rate than the cliffs. Vertical erosion gradually lowers the level of the platform and will undercut coast protection works (Wood, 1968). In Thanet this rate of lowering has been calculated at about 2 cm per annum (So, 1965). Boulders will also be present on the platform, derived from old cliff falls and old fault lines in the chalk may be visible as gullies. Below the low water mark, sublittoral chalk habitats are generally of boulders and bedrock outcrops. The subtidal bedrock outcrops may also have deep incised gullies and recede out to sea in a series of stepped platforms.

The soft nature of chalk results in the presence of a characteristic flora and fauna, but sometimes also the absence of the full range of species which may be found on adjacent hard rocky areas. Rock boring invertebrates such as small worms *Polydora* and piddocks (bivalve molluscs) are common on chalk. Some species which are intolerant of the friable and readily eroded nature of the substratum (such as large seaweeds) may be scarce, but replaced by other opportunistic species better able to withstand wave action without becoming detached. The high levels of turbidity from chalk particles in suspension in the water may also result in the absence of species requiring cleaner conditions. Despite the relatively low species diversity of some chalk shores in comparison with rocky shores elsewhere, particularly in southeast England, these habitats are considered to be of nature conservation importance because of their unusual features. Among the most important of these features are the specialised algal communities of chalk cliff habitats.

Littoral surveys of all chalk shores in Britain have recently been undertaken by the Natural History Museum (Tittley *et al.*, 1986, George *et al.*, 1988, 1989) and the subtidal surveyed by Dr Wood and the Marine Conservation Society. These will shortly be reviewed in one of the first volumes of the Marine Nature Conservation Review, which will cover chalk coasts.

5. Chalk cliff algal communities

The porous nature of chalk retains water and enables several species of algae and lichen to become established well above the high water mark, particularly in shaded locations such as on north-facing cliffs or boulders or in caves and tunnels. Some of these species bore into the surface layers of the rock. Although many individual species are quite widespread in the marine environment, the specialised communities they form on chalk are not found elsewhere (with a very few exceptions on some soft limestones and calcareous sandstones or coastal constructions of brick). These chalk cliff algal communities are therefore the most interesting and scarce of the marine communities on chalk shores.

The first detailed studies of the algal communities colonising these chalk cliff habitats were undertaken on the Thanet coast by Anand (1937 a,b,c) in the 1930s, when much of the area was still unprotected and had extensive cliffs, caves, arches, stacks and promontories. Anand (1937a) described seven species and two genera new to science and recorded two species new to the British Isles and several rare species, (Table 3). His studies of the ecology and community structure of these species uncovered several unusual communities. Many are only known from chalk cliffs and some are confined to unusual habitats; in caves and up to 16 m deep in tunnels which are formed within the cliffs by wave erosion (Anand 1937 b,c and Table 4).

Subsequent studies by Tittley (1971 and 1982) confirmed the presence of some of these species and communities in Thanet, but with a few differences. The closure of many of the caves and tunnels by coast protection works has resulted in some of the specialist communities characteristic of these habitats becoming very scarce and the progressive elimination of some of the species first described or known only from such locations (Price and Tittley, 1972; Tittley and Price, 1977). Thus *Kuetzingiella holmesii* and *Pleurocladia lacustris* have not been re-recorded since the 1930s (Tittley, 1986).

Table 3. Notable chalk cliff algal records from Thanet
(taken from Fowler and Tittley, in preparation)

Species and genera first recorded from Thanet by Anand		Rare and interesting species	
Chrysotila	Haptophyceae	*Prasinocladus lubricus*	Prasinophyceae
Chrysotila lamellosa		*Entocladia viridis*	Chlorophyceae
Chrysotila stipitata		*Pringsheimiella scutata*	Chlorophyceae
Chrysonema	Haptophyceae	*Pseudendoclonium submarinum* (= *Entocladia perforans*)	Chlorophyceae
Chrysonema litorale			
Apistonema carterae	Haptophyceae	*Trebouxia humicola*	Chlorophyceae
Entodesmis litoralis	Chrysophyceae	*Kuetzingiella holmesii**	Phaeophyceae
Entodesmis maritima		*Ectocarpus* sp. (= *Pilinia rimosa*)	Phaeophyceae
Thallochrysis litoralis	Chrysophyceae	*Petalonia filiformis*	Phaeophyceae
First records for Britain			
Pseudulvella applanata	Chlorophyceae	* not rediscovered in recent studies	
*Pleurocladia lacustris**	Phaeophyceae		

In response to the growing pressures of development upon the Thanet coast and other areas of coastal chalk, algal surveys of all the chalk cliffs in England have recently been completed under contract to the Nature Conservancy Council and the reports of this work should be referred to for a full account of chalk cliff algal communities and sites visited (Tittley, 1985b and 1988). Some components of the communities described by Anand were found at most sites visited, but with a discontinuous distribution. South-facing coasts (where exposure to sun and desiccation must be a limiting factor) generally had less well developed communities than north-facing cliffs and scouring caused by the presence of a fringing sand or shingle beach usually prevented the establishment of many communities. The hardness of the chalk was also an important factor in determining the range of species and communities which may become established. The softest substratum is the Upper Chalk on Thanet, which has the greatest diversity of species and range of habitat. Upper Chalk is not as soft where present on the Isle of Wight and in Dorset, having been exposed to folding and faulting. The Middle and Lower Chalks of the south coast are harder and lack some of the Thanet communities and species, as does the very hard chalk of Flamborough Head.

Studies of the artificial substrata which have replaced natural chalk habitats in many areas of the southeast have demonstrated that these do not support such a diverse and interesting flora (Tittley, 1982; Tittley and Shaw, 1980). Modern concrete and cement seawalls have a hard, uniform and impermeable surface which only support a very limited range of algae. The smooth surface of cement is particularly unsuitable for the settlement of many species. In contrast, older constructions of brick or limestone, which have a high calcareous content, may support some of the same species and communities found on natural chalk.

Table 4. Chalk-cliff communities of Thanet *sensu* Anand

	cliffs	caves	tunnels
Audouinella purpurea community		*	
Chalk-boring algae community	*	*	*
Calothrix community	*		
Chrococcus calcicola community		*	
Chrysophyceae-*Endoderma-Lyngbya* community	*	*	
***Chrysotila stipitata* community**		*	
Ectocarpus community			*
Enteromorpha intestinalis community	*		
Fucus community	*	*	
Gelidium-Polysiphonia community	*	*	
***Gloethece*-Chrysophyceae-*Ectocarpus* community**		*	
***Kuetzingiella holmesii* community**		*	
Lyngbya-Phormidium community		*	
Phormidium community		*	
Pilayella littoralis community	*		
Pilinia community			*
Polysiphonia-Ulva community			*
***Pseudulvella* community**			*
Ralfsia community	*		
Rhizoclonium-Vaucheria community	*	*	
Rivularia community	*		
Schizothrix community	*		

Important communities are emboldened

6. The marine nature conservation importance of chalk cliffs

The specialised marine plant and animal communities found on chalk shores and cliffs have been described above, as has the location of examples of coastal chalk in northern Europe and the restricted distribution of some of the littoral chalk habitats and communities of most scientific interest. The greatest proportion of European coastal chalk and many of the best examples of littoral habitats are located on the English coast. Britain therefore has an international responsibility for the conservation of these coastal features.

Following surveys of all the chalk cliff areas in England (Tittley, 1985b and 1988), the nature conservation importance of these sites for their chalk cliff communities has been assessed by Tittley (1988), in descending order of importance, as follows:

1 **Thanet**: Despite the major losses of chalk cliff habitats in this region, the remaining cliffs of Thanet still hold an excellent diversity of species and range of habitat. This area is also of considerable importance as the type locality for the species and genus first described from Thanet by Anand and as the classic locality for his pioneering studies of the ecology of these species and communities.

2 **North-facing Ballard Down, Dorset**: The most comparable site to the Thanet cliffs in Britain, with the similar (although not as soft) Upper Chalk, but with fewer species and poorer in range and extent of habitat.

3 **North-facing Flamborough Head, North Humberside**: The much harder chalk at this site and geomorphological variations result in considerable ecological differences from Thanet, but there is a good species diversity and range of habitats at this extensive site.

4 **Western Isle of Wight**: All types of Chalk are present along this section of coast, vertically bedded and harder than in Thanet and with ecological differences. There is a good range of habitat, but a poorer species list, despite the discovery of a possible new red alga.

5 **Eastern Isle of Wight**: There was a reduced range and extent of habitat here, with a still more limited species diversity, range and extent of habitat. Different communities with similarities to those at Thanet and Flamborough were present alongside each other, because of the different hardness of the vertically bedded chalk strata.

6 **Sussex and Kent**: The extensive chalk cliffs of Sussex and Kent (outside Thanet) face south and frequently have shingle beaches at their base. Where chalk cliff algal communities are present there is a limited species diversity and range of habitats.

7 **South-facing Ballard Down, Dorset**: The Lower Chalk along this section of coast is harder and less faulted than to the north. Some cliff algal communities are present in shaded areas, but the site is ecologically very different from the preceding sites.

8 **South-facing Flamborough Headland**: Cliff algal communities were very poorly developed along this coast.

9 **Beer Bay, Devon**: Chalk cliff communities found mainly on large chalk boulders in the spray zone. Some cave species were present in the limestone caves.

10 **White Nothe, Dorset**: Some chalk cliff algal communities present on large boulders in the spray zone.

11 **Lulworth Cove and Durdle Door, Dorset, and North Norfolk**: These cliffs lack algal communities.

The only comparable sites for chalk cliff algal communities known in northern Europe are on the north-facing Normandy coast. The Pas de Calais cliffs are scoured by sand, with little or no algae, and the Baltic chalk cliffs have none of these communities. Although the Normandy coast requires further study to enable a detailed comparison with the English sites, it would be possible to use the definitions of Hiscock and Mitchell, 1989 (see Annex 1) to assess the international and national importance of the algal communities at the British sites and the Nature Conservancy Council Guidelines for the selection of biological SSSIs (1989) to assess the importance of the sites themselves. This information will be presented in the Marine Nature Conservation Review of chalk coasts, currently in preparation.

Some chalk cliff communities and species are recorded at only a very few locations in the northeast Atlantic, in England and Normandy, and are therefore of international importance where they are present. Many of the more widely occurring chalk cliff communities and species will be of national importance, and a very few only of regional importance. The lack of detailed information on the Normandy chalk cliffs makes a precise assessment of ranking difficult. The Thanet sites are certainly of international importance. They are the best examples of chalk cliff habitats and algal communities in Britain and perhaps Europe, and additionally important as the type locality for the genera and species described by Anand (1937) and the site of the pioneering work on chalk cliff ecology. Thanet must therefore be considered the single most important chalk cliff site for marine algal communities in northern Europe. The north-facing sites at Ballard Down in Dorset and Flamborough Head, North Humberside must also be classed as of international importance, as should the extensive north-facing chalk cliffs of Normandy.

The absence of other good examples of chalk cliffs in the Northeast Atlantic may indicate that more of the British examples should be added to this list of internationally important chalk cliff sites. The Isle of Wight sites, with their vertically-bedded strata, provide an interesting comparison of the algal communities on the Lower, Middle and Upper Chalks, should therefore also be considered as of national, if not international importance.

The SSSI guidelines stress the importance of habitat rarity for site assessment. 'In general, the rarer the habitat, the larger the proportion of the total area which should be protected: this may in fact be 100%... Any habitat with a total area in Britain of less than 10,000 ha (the area of 10 km grid square) can be regarded as rare, and for these there should be a general presumption in favour of selecting all remaining areas.' Chalk cliff habitat, with a total linear extent of 113 km in Britain (about 82 km of this in a natural state) is certainly a rare habitat by this definition, and all other British chalk cliff sites with algal communities should therefore be considered to be of SSSI standard and hence of national nature conservation importance.

7. Development pressures on coastal chalk

Coastal defence works have been constructed since Roman times in low-lying areas to prevent flooding, but the main period of construction of coastal protection works began in the second half of the 19th Century when most coastal resorts built sea walls. As resorts expanded away from the fishing villages around which they had developed, building commenced on neighbouring cliff-tops and the requirement for coast protection works to halt erosion subsequently became apparent in the late 19th Century. Limited construction continued until the Second War. Post-war many protection works were found to require reconstruction and new works were continued (May, 1973). The Coast Protection Act 1949 placed the responsibility for carrying out protection works on local authorities, with powers delegated in some cases to the river authorities. Grants towards the costs of coast protection are available from the Ministry of Agriculture.

The growth of coastal towns in southeast England on soft, eroding coastlines has resulted in the extensive construction of coastal protection works to reduce cliff recession in the region. At the present time very few chalk or other eroding cliffs topped by housing or other developments in southern and eastern England are unprotected at sea level. Development pressures in the southeast for ports, roads and marinas have also had an impact. Major developments which have resulted in construction on chalk coasts include the Brighton Marina and the Channel Tunnel reclamation platform between Dover and Folkestone. These resulted in the loss of areas of chalk foreshore and shallow sublittoral habitat as well as cliff face. Planning Authorities generally no longer permit development in areas which are vulnerable to erosion or of high scenic or nature conservation value. The high costs of coast protection are now beginning to result in the abandonment of some residential properties on eroding cliffs and much low-grade agricultural land is not longer protected against coastal erosion. (Ironically, some of this low-grade, unproductive coastal farmland is of high nature conservation interest and becoming vulnerable to incursions by the sea which would be detrimental to this interest).

The marine habitat most greatly affected by coastal development has been the chalk cliffs, with their associated caves, tunnels and stacks. Coast protection works have concentrated on building seawalls and berms along the bottom of the cliffs. The line of the cliff is scarped to about 70-75° to prevent further falls and straightened out. Projections between gullies are torn down and the rubble used to fill a large concrete berm and apron at the base of the cliff which blocks any caves and tunnels.

The immediate result of these works is to remove the cliff face completely from the action of the sea. Gullies and caves are no longer formed or stacks replaced and a much reduced range of coastal habitats is present. In the long term, continued erosion at the seaward edge and surface of the wave-cut platform will cause it to narrow gradually and become lower (eventually undermining the seawall). Cliff falls will no longer supply boulders to the foreshore to renew those eroded by wave action. The value of the scarped cliff for wildlife is much reduced from that in its natural state. In addition to the loss of the specialist algal communities, seabird nesting sites and cliff vegetation will be removed and the improved access provided by the promenades associated with seawalls increases disturbance. Important geological exposures may also be lost. The construction of groynes to encourage beach formation and hence reduce erosion rates is less damaging, although shingle beaches at the base of cliffs will cause scour and prevent the establishment of cliff face algae. It has also been suggested that the scour of sand and shingle may accelerate cliff foot erosion (Wood, 1968). Artificial structures do not support the same algal communities as chalk, although limestone and brick may have a much reduced range of chalk species and communities.

8. Coastal protection and marine nature conservation on the Isle of Thanet: a case study

The built-up nature of much of the Thanet coast in southeast Kent, combined with the particularly soft nature of the Upper Chalk exposed on the cliffs and shore, has resulted in a large proportion of this coastline having been affected by coastal protection works. Chalk cliffs on the Thanet coast extend from the east of Minnis Bay, Birchington (Grid Reference TR 284 695), to the coast adjacent to Little Cliffsend, Pegwell Bay (Grid Reference TR 356 643), a linear extent of about 23 km (Figure 2). Much of this coast was originally of a deeply dissected nature with numerous gullies, caves, tunnels and stacks produced by wave action, particularly on the north coast from Birchington to Westgate. This was the area studied by Anand in the 1930s. Since the 1930s the majority of the Thanet cliffs have been subject to coastal protection schemes and very little natural chalk cliff with its unique algal flora remains in the area.

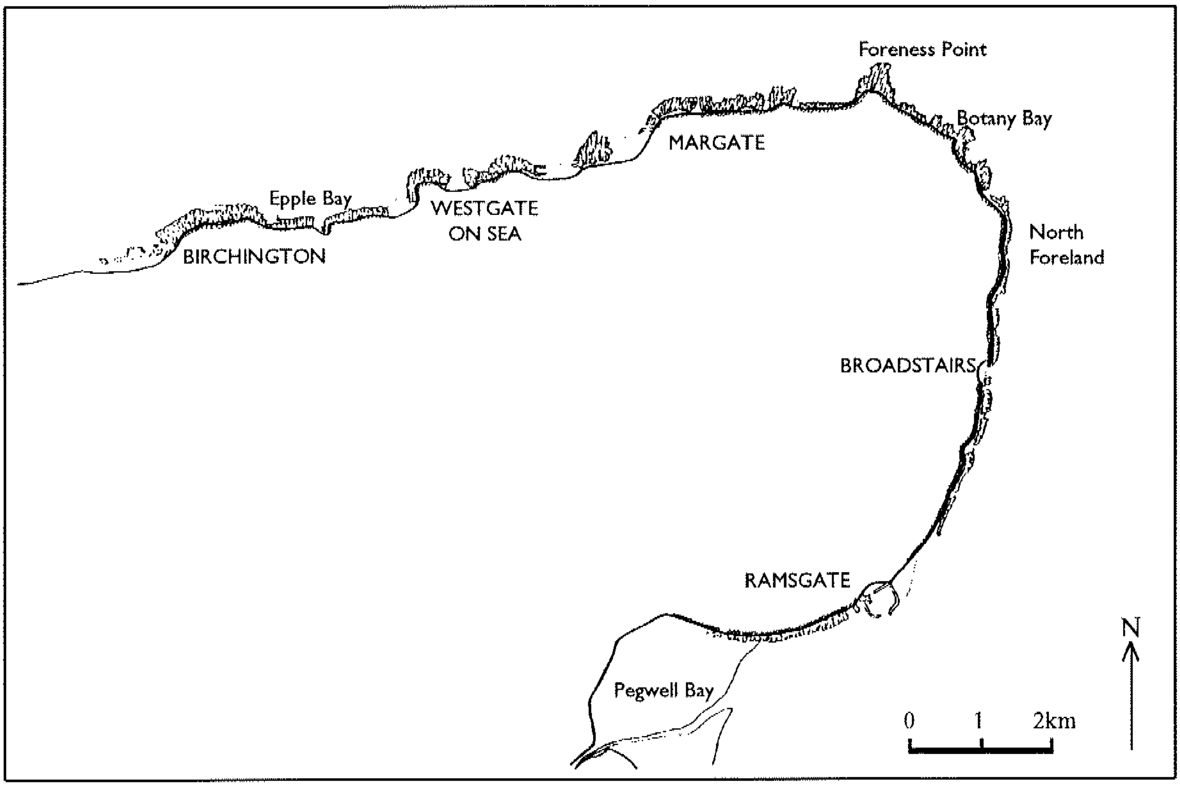

Figure 2. The Isle of Thanet, East Kent
(See Figure 1 for location)

Table 5 illustrates the rate of loss of natural chalk coastline in Thanet since beginning of this century, data derived from Thanet District Council records. These figures demonstrate that, following a small amount of coast defence work carried out in the late 1930s, there was a major programme of new coast defence construction along this section of coast in the 1960s and '70s. (Work carried out on the repair and renewal of old sections of seawall does not appear in these figures).

The progressive loss of the major part of Anand's original north coast study area and other Thanet cliffs from construction of seawalls and berms is shown in Figure 3. This Figure and Table 5 do not give a full indication of the scale of loss of cliff habitat, since the maps are small scale and the measurements of coastal length taken after construction works. A more accurate impression of the scale of actual habitat loss may be obtained from examination of

Table 5. Rate of coast protection in Thanet
(total coastal length 23 km)

Date	length of coast protected (km)	% coast protected
1900	4.5	19.5
1930	8.25	36.0
1940	10.0	43.5
1960	10.25	44.5
1965	14.25	62.0
1970	14.75	64.0
1980	14.75*	64.0
1982	16.0	70.0
1984	16.5	72.0
1986	17.1	74.0

* and 0.5 km of chalk platform reclaimed

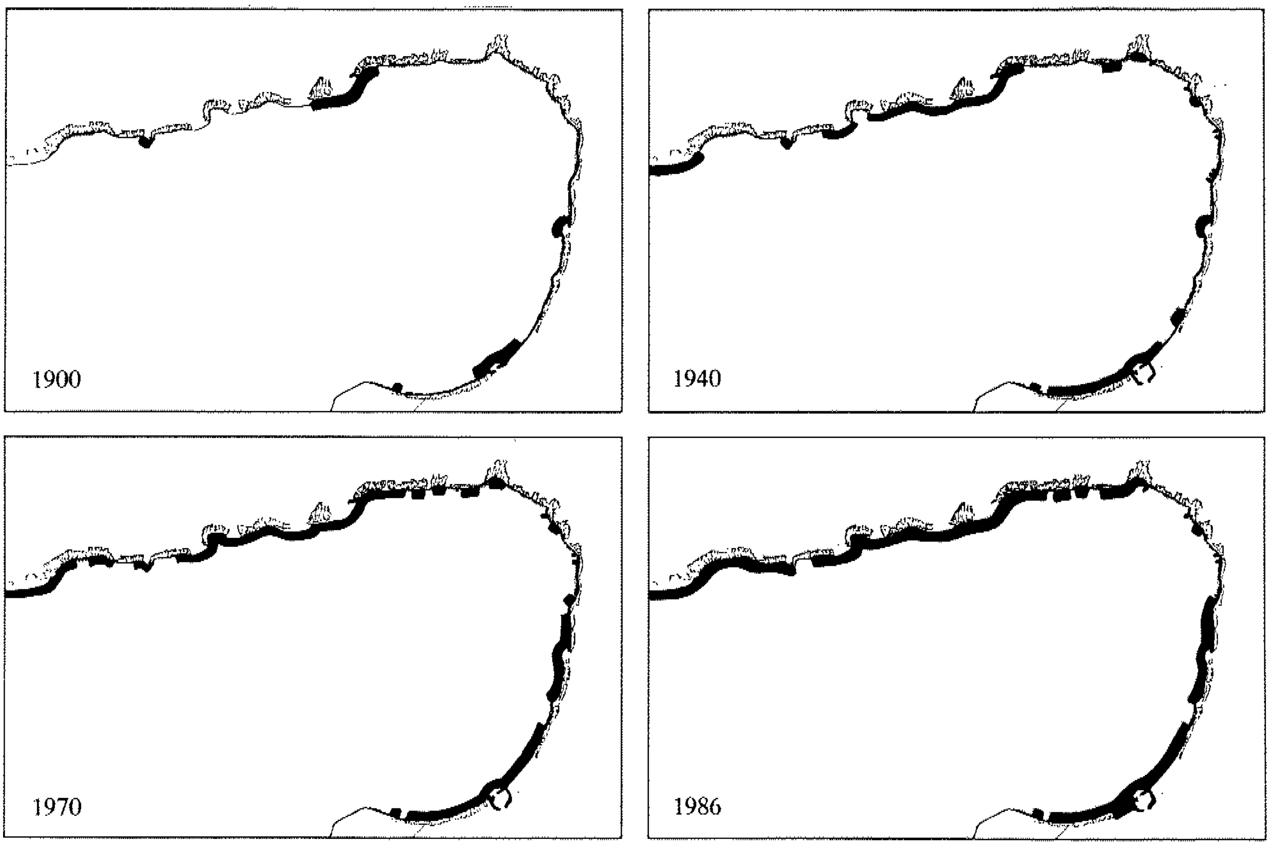

Figure 3. The extent of coastal protection works in Thanet from 1900 to 1986

work carried out by So (1963), who studied the form and origin of coastal features on Thanet and closely surveyed the cliffs between Epple Bay and Minnis Bay shortly before they were altered by coastal defence works (and after the scarping and protection of the cliffs at Westgate).

Figure 4 is taken from So (1963) and gives a detailed plan of a very complex area of cliff and sea caves at Birchington. Along this section of coast were numerous indentations, headlands, geo-like inlets, chimneys, caves and stacks, with a total cliff face length of about 53 m, not including two stacks and an additional 18 m in total depth of the 26 caves and tunnels present. This section of coast now consists of about 30 m of concrete berm and promenade below scarped cliffs. The proportional loss of natural chalk cliff habitat therefore greatly exceeds the figures given above in Table 5 and examples of some features, such as the caves and tunnels which Anand (1937b) describes as penetrating 16 to 40 m inland from the cliff face, are no longer found on the north coast of Thanet.

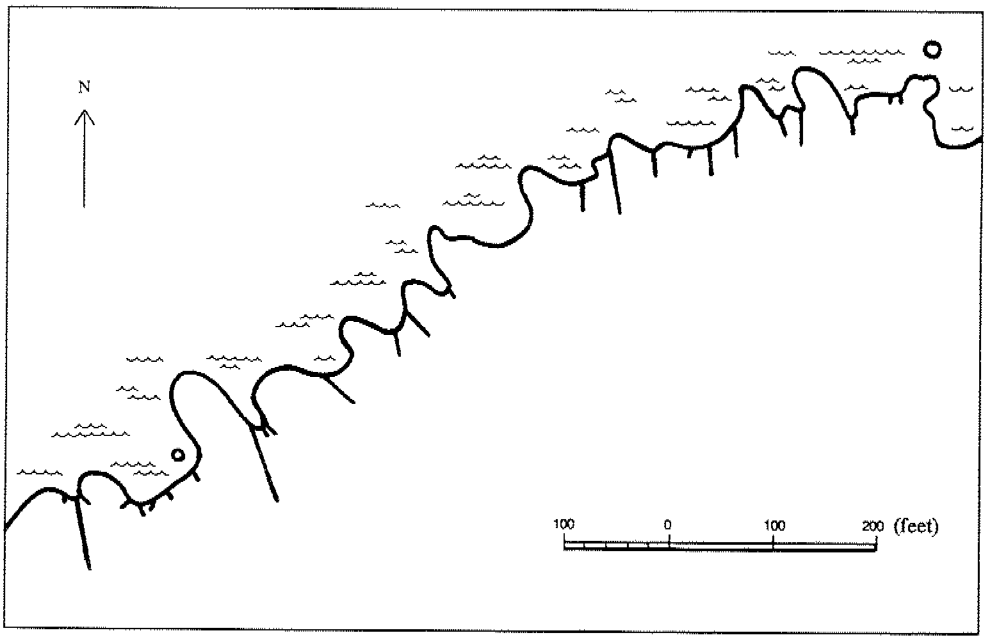

Figure 4. Plan of a section of natural chalk cliff in Thanet (from So, 1963)

Of the approximately 5 km length of coast remaining unprotected by coastal defences (seawalls, berms and promenades) in Thanet, only 600 m of Anand's original north-facing study area survives, at Epple Bay. Despite patchy protection works in the few caves and gullies on this section, the algal flora is still of national importance. There may still be new planning applications for coastal defence works for this section of coast in the future, since the cliffs are continuing to erode. Another 0.5 km of north-east and east-facing coast with high cliffs, large caves, stack and arch formations at Botany Bay is of interest for its algal communities; this has been a Site of Special Scientific Interest (SSSI) for its marine flora since 1979. The third area of unprotected chalk cliff which supports good examples of algal communities is at Pegwell Bay, where a length of 1 km remains. Part of this area was the subject of two Public Inquiries in 1986 and 1987, which resulted in the refusal of permission for coastal protection works and an access road to Ramsgate Harbour. A modified design for coastal protection works here has now been agreed with English Nature and a working party is looking at an alternative route for the harbour access road which avoids the most important sections of chalk cliff face.

Various proposals have been made for alternative means of slowing erosion on the Thanet coast. Rather than the usual scarping and construction of berms, it has been suggested that a sea wall may be built some distance to seaward of the cliff face and water allowed to move underneath it to continue to reach the cliff foot. This would reduce wave action and erosion but still enable the open cliff face to be retained. Such a method has been used to retain geological exposures for study. Unfortunately the reduction in splashing and wetting of the cliff face caused by this sort of construction would alter the environmental conditions needed for algal growth and still cause losses in cliff face algal communities. Examples of this effect can be seen at Pegwell Bay, where the sea has out-flanked old sections of sea wall and continued erosion behind it, but without the full range of algal communities becoming re-established.

The most rapid erosion takes place where caves and tunnels are formed at weak joints in the chalk. Blocking off these joints should reduce this erosion and avoid the necessity for berm construction along the whole cliff face. Unfortunately this type of coastal protection would still necessitate considerable lengths of cliff face on each side of the caves being obscured and the loss of caves and tunnels, which support some of the most unusual algal communities and rare species. Nevertheless, these alternative means of coastal protection should always be considered if it is absolutely essential that action is taken to reduce erosion. At Pegwell Bay, rather than the complete replacement and extension of the seawall which was proposed, an existing section of seawall has been refaced and extended slightly where it was being outflanked by the sea.

All three of the areas supporting important chalk cliff communities lie within SSSIs which are notified in part for their cliff algal flora. The northern part of Pegwell Bay, as far as Ramsgate Harbour, is part of the Sandwich Bay SSSI. The area from north Ramsgate to Herne Bay (covering all the rest of the Thanet chalk and including areas of cliff with coast protection works) is now designated as the Thanet Coast SSSI, and incorporates the former Botany Bay SSSI. Although the remaining unprotected coastline on Thanet does not support cliff algal communities, their exposures are of geological importance and the whole shore is of international importance for the numbers of Turnstones it supports. Both the Thanet Coast and the Sandwich Bay SSSIs are candidate Ramsar sites and Special Protection Areas because of their international ornithological importance.

9. Conclusions and recommendations

Many English chalk cliffs support specialised algal communities is of very high marine nature conservation interest which are very scarce elsewhere in Europe. Sites in Thanet, east Dorset, Flamborough Head and the Isle of Wight are of national, if not international importance. It is essential that these sites are recognised and conserved.

The construction of coastal protection works and other coastal developments has altered large sections of natural chalk coast, particularly in the south east of England. The Isle of Thanet has been used as a case study to demonstrate the progressive loss of this natural coastal habitat in one of the most heavily developed areas of the country.

Where natural chalk cliffs are replaced by artificial substrata through the construction of coastal protection works and other developments, they do not support such an interesting range of algae. Communities with some of the characteristics of chalk cliff algae can become established on artificial structures made from material with a high calcium carbonate content, but modern concrete and cement sea walls have a very limited range of species. There may be scope for habitat creation in chalk areas through incorporating chalk and limestone blocks into coastal structures.

Following significant losses of coastal chalk cliff habitats and associated algal communities, it is now essential to ensure that the remaining areas of coastal chalk are protected through SSSI designation and further developments and degradation of these sites resisted, particularly in those areas supporting rare algal communities. Most of these chalk cliff algal communities are now so restricted in their distribution that any form of coastal works which could alter the cliff face environment and may result in a further reduction in their range must be resisted. The use of cost benefit analyses to determine whether coast protection schemes are necessary will be of increasing importance in preventing the loss of further areas of coastal chalk in the south east, and particularly in Thanet. It must be stressed that even low impact alternative means of coastal protection are likely to be unacceptable in the most important chalk cliff sites.

Following this recent period of development of coastal chalk habitats, further detailed study is required to increase our knowledge of the taxonomy and ecology of the unusual species and communities of chalk cliff habitats, both in Britain and abroad, and the distribution of some of these species on other calcareous substrata.

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Annex 1

Criteria for assessing the nature conservation importance of habitats, communities and species (from Hiscock and Mitchell, 1989)

International

Communities which are outstandingly good examples of their type in the Northeast Atlantic.

Communities recorded at only a very few locations in the Northeast Atlantic.

Species which are recorded at only a few locations in the Northeast Atlantic.

Species recorded in higher abundance in the area under consideration than anywhere else in the Northeast Atlantic or where the area is one of only a very few locations where large quantities are recorded.

National

Communities which are outstandingly good examples of their type in Britain.

Communities recorded in only a very few similar physiographic situations in Britain.

(Both of these definitions refer to communities which are or are likely to be widely occurring in other similar physiographic situations in the Northeast Atlantic).

Species which are recorded at only a few locations in Britain, but are more widespread in other parts of the Northeast Atlantic.

Species recorded in higher abundance at locations under consideration than in any other location elsewhere in Britain or where the site is one of only a very few locations where large quantities are recorded in Britain.

Regional

Communities which are present in similar physiographic situations elsewhere in Britain but which are outstandingly good examples of their type in the location under consideration or are as good examples as similar communities present elsewhere in Britain. Communities recorded at only a few locations in the same biogeographic region.

Species which are unrecorded or recorded at only a few locations in similar physiographic situations in Britain but are widespread in other similar sites in other parts of Britain. Species recorded in higher abundance in the area under consideration than in any other part of Britain or where the site is one of only a very few locations where large quantities are recorded in Britain.