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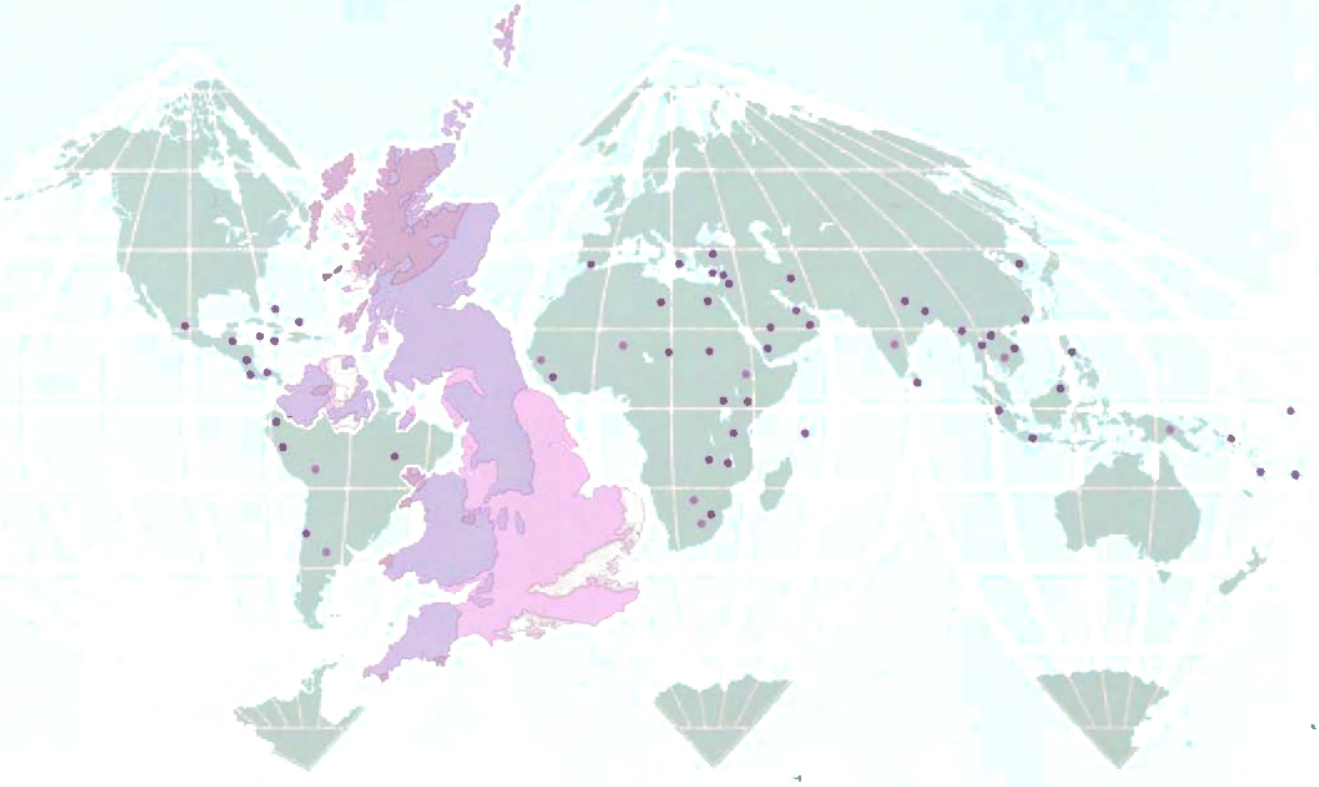
The Lower London Tertiary (Palaeocene) succession of Herne Bay, Kent



PREFACE

This paper describes one of the most important sections in the Lower Tertiary strata of south-east England. The author, working in conjunction with other members of the Tertiary Research Group, has over a period of several years made a detailed study of the stratigraphy and fish fauna of the area and the results, which include a full faunal list, are presented here. The Institute is pleased to publish this work in appreciation of the valued work of Mr Ward and his colleagues, particularly since these studies form a valuable adjunct to the Memoir: The geology of the country around Faversham (sheet 273), which is shortly to be published; even so, the views expressed do not necessarily represent those of the Institute.

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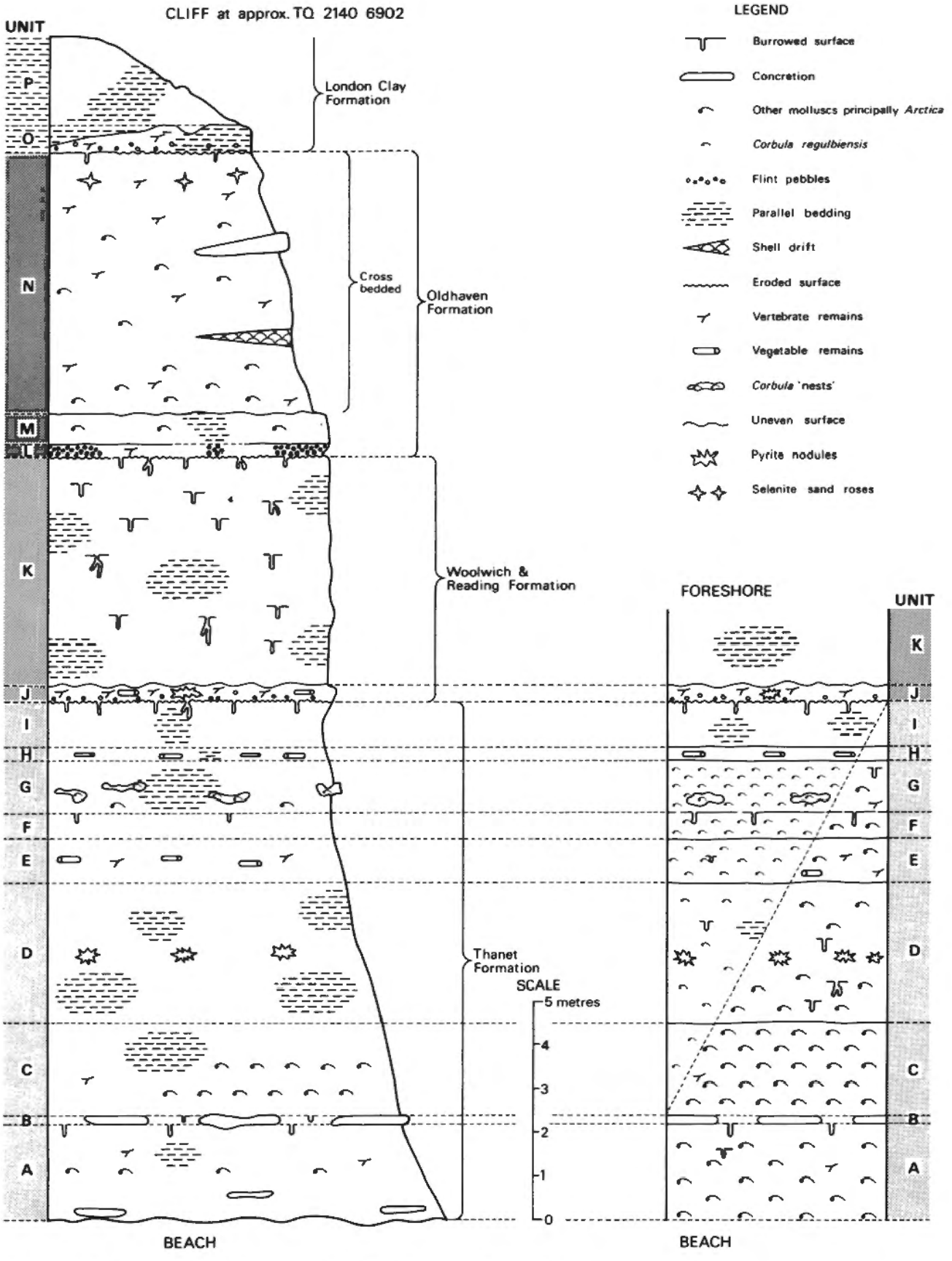

Figure 1 Generalised vertical section of the Herne Bay cliffs and foreshore

The Lower London Tertiary (Palaeocene) succession of Herne Bay, Kent

D. J. Ward

SUMMARY

An account is given of the cliff and foreshore exposures of the Thanet, Woolwich and Reading, and Oldhaven formations and of the London Clay Basement Bed. The new stratigraphical terms '*Eutylus cuneatus* Bed', 'Reculver Tabular Band', '*Panopea remensis* Bed', '*Astarte tenera* Bed' and '*Tornatellaea parisiensis* Bed' are proposed within the Thanet Formation. The vernacular terms '*Arctica morrisi* Bed' and '*Corbula regulbiensis* Bed' are similarly formalised and localised. The lithostratigraphical term 'Beltinge Fish Bed' is proposed to replace the incorrectly applied usage of 'Woolwich Bottom Bed' at the base of the Woolwich and Reading Formation. The position of the junction of the Thanet with the Woolwich and Reading formations is reviewed in the light of new faunal and sedimentological information. The status of the term 'London Clay Basement Bed' is discussed with regard to recent stratigraphical advances. A comprehensive faunal list is given which, where possible, refers the individual records with their frequencies to the appropriate lithological units.

On rend compte des affleurements auz falaises et à la basse plage des formations de Thanet, de Woolwich and Reading, et d' Oldhaven et du London Clay Basement Bed. Dans la Thanet Formation on propose les nouveaux termes stratigraphiques *Eutylus cuneatus* Bed, Reculver Tabular Band, *Panopea remensis* Bed, *Astarte tenera* Bed et *Tornatellaea pariensis* Bed. Les termes vernaculaires *Arctica morrisi* et *Corbula regulbiensis* Bed sont formalisés et localisés de façon semblable. Le terme lithostratigraphique Beltinge Fish Bed est proposé au lieu de l'emploi inexact de Woolwich Bottom Bed à le base de la Woolwich and Reading Formation. On se sert de nouveaux reseignements fauniques et sédimentologiques pour examiner la position de la jonction entre la formation de Thanet et celle de Woolwich and Reading. On discute le terme London Clay Basement Bed en égard aux progrès stratigraphiques récents. On donne une liste faunique d'ensemble qui, si possible, rapportent les enregistrements individuels avec leurs fréquences aux unités lithologiques propres.

Man berichtet über die Küsten- und Strandaufschlüsse von den Thanet, Woolwich und Reading, und Oldhaven Formationen und von der London Basement Schicht. Die neuen stratigraphischen Ausdrücke '*Eutylus cuneatus* Bed', 'Reculver Tabular Band', '*Panopea remensis* Bed', '*Astarte tenera* Bed' und '*Tornatellaea pariensis* Bed' werden in der Thanet Formation vorgeschlagen Die einheimischen Ausdrücke '*Arctica morrisi* Bed' und '*Corbula regulbiensis* Bed' sind äuhnlicherweise feste Form gegeben und lokalisiert. Der lithostratigraphische Ausdruck 'Beltinge Fish Bed' wird vorgeschlagen, um den falsch benutzten Brauch von 'Woolwich Bottom Bed' für die Basis von der Woolwich und Reading Formation zu ersetzen, Man bespricht die Stelle vom Treffpunkt der Thanetformation mit den Woolwich und Reading Formationen im Licht der neuen faunalen und sedimentologischen Information. Auch bespricht man den Stand des Ausdrucks 'London Clay Basement Bed' mit Rücksicht auf neuen stratigraphischen Fortschritten. Eine umfassende faunale Liste wird gegeben, die, wo möglich, die einzelnen Berichte mit ihrer Häufigkeit zu den passenden lithologischen Einheiter zuschreibt.

Bibliographical reference
WARD, D. J. 1978. The Lower London Tertiary (Palaeocene) succession at Herne Bay, Kent. *Rep. Inst. Geol. Sci.*, No. 78/10.

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INTRODUCTION

BACKGROUND

The cliffs and foreshore between Herne Bay and Reculver display what is probably the best and most accessible section of Lower Tertiary strata in the south-east of England. The dip of the strata averages 3° to the west, giving a continuous exposure from the upper Thanet Beds to the London Clay.

The first account of the succession is given in Prestwich's classic works of the 1850's (Prestwich, 1850, p. 265; 1852, p. 239; 1854, p. 111). He proposed the terms 'Thanet Sands' and 'Woolwich Beds' and the term 'London Clay Basement Bed' for the beds between the latter and the London Clay. Whitaker (1866, p. 412) amended this by restricting the definition of the London Clay Basement Bed and by separating the Oldhaven Beds. The Geological Survey Memoir of 1872 contains a more accurate written and diagrammatic section (Whitaker, 1872, p. 170), in which one can identify, without difficulty, all those units above the Thanet Beds described below. Both Prestwich's and Whitaker's papers include faunal lists and Prestwich (1852) gave a diagrammatic cliff section. Gardner (1883) in a rambling paper added to the description of the section, particularly within the Thanet Beds. Gardner's sections are less easy to interpret than Whitaker's (1872, fig. 45) and it is difficult to localise the exposures he describes.

After this pioneer era authors turned their attentions to more specific features of the geology. The authors of the principal papers relevant to the Herne Bay section, and their dates and topics, are as follows:

Chandler, M. E. J. (1961, 1964) Lower Tertiary flora
Cooper, J. (1977) London Clay palaeontology
Cooper, J. E. (1934) Thanet and Oldhaven Mollusca
Curry, D. (1965) General Palaeogene stratigraphy
Gurr, P. R. (1963) Herne Bay Woolwich Beds fish fauna
Haynes, J. (1956, 1958) Thanet Beds foraminifera
Hester, S. W. (1965) Woolwich Beds stratigraphy
Hutchinson, J. N. (1968) Coastal landslides of Kent
Pitcher, S. (1958) Geologists' Association Guide
So, C. L. (1967) Herne Bay coastal erosion
Stinton, F. (1965) Lower Tertiary teleost otoliths
Ward, D. J. (1973) Palaeogene chimaeroid fishes
Weir, A. H. and Catt, J. A. (1969) Palaeogene sedimentology, Kent
Wood, A. and Haynes, J. (1957) Thanet Beds foraminifera
Wrigley, A (1949a) Thanet Beds review; (1938, 1949b, 1953) Eocene Mollusca

PURPOSE AND SCOPE OF THE REPORT

The recent extension of the sea-wall and renewal of the groynes up to Bishopstone Glen has apparently accelerated erosion in the undefended cliff towards the east. The result has been some spectacular cliff falls and fine cliff exposures. The foreshore has been scoured and stripped of its protecting layer of shingle and mud, exposing the Thanet Beds, which are readily eroded. From observations made over the last five years it appears that the angle of the wave-cut platform cut into Thanet Beds is increasing. If this is so, the fine exposures, now common in winter months, will become increasingly less frequent as the beach establishes a new equilibrium. This has been the fate of many fine Tertiary sections (Barton, Bognor, Bracklesham), once the cliffs have been defended. It was therefore considered particularly urgent to gather as much information as possible from this section. This paper is intended to lay the framework for any such work and particularly to assist in the recognition of the various units on the foreshore.

DESCRIPTION OF THE SECTION (Figure 1)

GENERAL STRATIGRAPHY

The stratigraphical nomenclature used here follows as closely as possible the recommendations in the ISSC Guide (Hedberg, 1972) and the stratigraphical table of Cooper (1976, tables A–D).

	Thickness m
London Clay Formation: Harwick, Herne Bay and Sheppey Members	
Unit P London Clay	36.90
Unit O London Clay Basement Bed *sensu stricto*	0–0.60
Oldhaven Formation: Oldhaven Sands Member	
Unit N Glauconitic cross-bedded sands	~6.00
Unit M Glauconitic silty sand	0.75
Oldhaven Formation: Blackheath Pebbles Member	
Unit L Basal Pebble Bed	0–0.30
Woolwich and Reading Formation: Woolwich and Reading Bottom Bed Member	
Unit K Woolwich Marine Beds	~5.20
Unit J Beltinge Fish Bed	0.40
Thanet Formation: Reculver Silts Member	
* Unit I Unfossiliferous sandy silts	1.25
* Unit H Sandy silt with plant debris	0.25
* Unit G *Corbula regulbiensis* Bed	1.20
Unit F *Tornatellaea parisiensis* Bed	0.60
Unit E *Astarte tenera* Bed	1.00
Unit D *Panopea remensis* Bed	3.20
Unit C *Arctica morrisi* Bed	2.10
Unit B Reculver Tabular Band	0.20
Unit A *Eutylus cuneatus* Bed	7.75

* Regarded by some authors as part of the Woolwich Beds

THANET FORMATION

The Herne Bay section exposes the uppermost 17.5 m of the Thanet Formation. The cliff section is generally decalcified, with the exception of parts of the *Arctica morrisi* and *Eutylus cuneatus* beds. The other units can be distinguished, with difficulty, by means of leached molluscan casts. The foreshore outcrops are best examined in the winter months when scouring has removed most of the beach sand. A spring tide is essential. The succession comprises olive-grey sandy silts often speckled with large glauconitic grains. Most units yield a rich but fragile molluscan assemblage and a sparse fish fauna.

Two fossiliferous horizons are well known: the *Arctica morrisi* Bed and the *Corbula regulbiensis* Bed, though neither has yet been well localised and described. In old collections specimens from the Thanet Beds of Herne Bay, if labelled at all, bear the horizon-names 'Morrisi Bed' or 'Corbula Bed', the former encompassing all the non-silicified and the latter the silicified fossils. In fact silicified molluscs can be found in all the fossiliferous horizons within the Thanet Beds, but are relatively uncommon outside the *Corbula regulbiensis* and *Tornatellaea parisiensis* beds. Several new formal biostratigraphical units are described below and are given bed names analagous to the *Arctica morrisi* and *Corbula regulbiensis* beds, *i.e.* the name-species is a mollusc typical of, or virtually restricted to, that bed. The stratotype locality in each case is Herne Bay foreshore at the grid reference stated.

There is not universal agreement regarding the precise junction of the Woolwich and Thanet beds. Traditionally it is taken as the base of the *Corbula regulbiensis* Bed, although some authors place it 2.6 m higher up at the base of a clay unit. The stratigraphical units proposed here do not presuppose either position. The problem is discussed and the author's views are expressed below.

The thickness of the total section is accurate but the thickness of the individual beds described from the foreshore exposures are approximations.

Unit A

Eutylus cuneatus Bed [TR 217 691]. This bed is composed of stiff silty grey clay. Individuals of the mollusc *Eutylus cuneatus* are found frequently, in life position, throughout, but more commonly in the lower parts of the exposure. The most abundant mollusc is *Arctica morrisi*, which occurs as scattered individuals

and in thin compressed shell drifts. Other bivalve species are uncommon and fish remains are rare. Impersistent stone bands occur within the uppermost two metres of this unit.

Unit B
Reculver Tabular Band [TR 213 690]. This consists of light-grey silty sand which, where calcite-cemented, forms a persistent series of large tabular nodules that weather into prominent courses and litter the foreshore below the coastguard station [TR 211 690]. Where uncemented, this bed weathers faster than the adjacent units, forming a notch in the cliff. It is not to be confused with the 'tabular band' (base of the *Corbula regulbiensis* Bed) mentioned in the Geologists' Association Guide (Pitcher, 1958, p. 28). The term 'Oldhaven Reef' (Gamble, 1968, p. 592) is rejected owing to the possible confusion with similar cemented lenticles within the Oldhaven Formation. The base of the cemented blocks is cut by prominent burrows which penetrate into the silt below. This unit contains no indigenous molluscs. Specimens on the surfaces of the cemented blocks are from above or below the lithological change that distinguishes this unit.

Unit C
Arctica morrisi Bed [TR 207 688]. This bed is composed of grey silty clay with abundant individuals and closely packed drifts of *Arctica morrisi*. Many specimens have both valves intact and are in life position. Apart from *A. morrisi*, *Nucula spp.*, *Corbula regulbiensis* and occasional oysters, other bivalves are scarce. Gastropods are infrequent. Near the top of this unit there is a horizon where molluscs are preserved filled with pyrite. Fish remains are infrequent, except where concentrated within the shell drifts. Fossil driftwood is often bored by teredinids but is generally unabraded and is sometimes silicified.

Unit D
Panopea remensis Bed [TR 2040 6885]. This unit, which is composed of grey-green silty clay, contrasts with Unit C in having a diverse molluscan fauna which occurs as scattered individuals rather than in drifts. *Corbula regulbiensis* and *Arctica morrisi* are the predominant bivalves. Oysters, often attached to wood, together with *Garum edvardsi* and *Thracia* aff. *oblata* are at their most common close to the base of this unit. *Panopea remensis* is found in abundance at the top, where *Cyrtodaria rutupiensis* and gastropods are at their most common. An unmistakable horizon of irregularly shaped spiky pyrite concretions occurs at about the middle of this unit, often enclosing calcareous fossils or wood.

Unit E
Astarte tenera Bed [TR 2051 6881]. The lithology is a grey silty clay with a speckling of large glauconite grains. *Corbula regulbiensis* is the most abundant mollusc, and is concentrated with other bivalves in loose drifts. Spectacularly large, often articulated, specimens of *Arctica scutellaria* are common here, although the unit is most readily recognised by the presence of *Astarte tenera*, which is particularly well preserved here, again usually as articulated specimens. Other bivalves are usually somewhat rolled. Gastropods are not as abundant as in the unit below, although many of the bivalves, particularly *Arctica*, *Astarte* and *Nucula*, show gastropod borings. Vertebrate remains are at their most frequent here, but are still rare. It was from this horizon that Ward (1972, p. 320) first described the chimaeroid fish *Callorhynchus newtoni*; it is also the probable source of the fauna listed in Cooper (1934, p. 7). It is from this unit, and from Unit D, that many specimens labelled 'Morrisi Bed' in old collections were collected. Rolled wood is abundant; seeds and pine cones are more common here than in any other unit.

Unit F
Tornatellaea parisiensis Bed [TR 2048 6880]. This consists of glauconitic silty sand. *Corbula regulbiensis* is abundant and evenly distributed throughout. Other molluscs are scarce except when occasionally concentrated within large tabular masses of silicified matrix. These yield an abundant, diverse and exceptionally well preserved silicified fauna, particularly rich in small forms. The bryozoan *Membranipora eocena* is present, both loose in the sediment and as an incrustation on bivalves. Other fossils occur, notably otoliths, barnacles and vertebrate remains. Rolled wood is less common than in the *Astarte tenera* Bed.

Unit G
Corbula regulbiensis Bed [TR 2046 6875]. This also consists of glauconitic silty sand and is very similar to the underlying unit in both matrix and in the abundance of *Corbula*. Large, richly glauconitic clusters or 'nests' of *Corbula regulbiensis*, usually silicified, are characteristic. The *Corbula* are often rolled, but usually articulated. Other molluscs, which are relatively uncommon and poorly preserved outside these nests, include *Cucullaea decussata*, *Arctica morrisi*, *Aporrhais dispar* and *Siphonalia mariae*. At the base is a horizon, known informally as the '*scutellaria* horizon', which yields fossils preserved in, or as casts within, a brown glauconitic phosphatic matrix. Large internal moulds of *Arctica scutellaria* are the commonest fossils. Two specimens of the crustacean *Hoploparia gammaroides* have been found, one actually within an *A. scutellaria* cast. Similarly phosphatised burrows, possibly of *Hoploparia*, can be found *in situ*: the matrix is usually crowded with *Corbula* casts.

Unit H
This unit, which also consists of glauconitic sandy silt, is known informally as the 'Woody Nodule' bed and is characterised by large pyrite concretions which often enclose large twigs or small unabraded branches of wood. No calcareous fossils have been recorded.

Unit I
Glauconitic sandy silt. No macrofossils have been seen in the glauconitic sandy silts that compose this unit, which is regarded by some authors as the uppermost unit within the Thanet Formation. In this unit, as in all those below, trace fossils occur; these are principally short, unlined vertical burrows.

WOOLWICH AND READING FORMATION
The Woolwich facies of east Kent has been considerably reduced in thickness by erosion prior to the deposition of the succeeding Oldhaven Formation. The two units described below fall within the 'Bottom Bed' of Whitaker (1861). The Beltinge Fish Bed (*see below*) is proposed as a new formal lithostratigraphic term with the Herne Bay foreshore as its stratotype locality

[TR 2035 6876]. It replaces the 'Woolwich Bottom Bed' *sensu* Gurr (1963, p. 419), which is judged to be an incorrect usage of that term. The term 'Woolwich Marine Beds' was coined by Gamble (1970, p. 397) and replaces the preoccupied term 'Bishopstone Beds' (White, 1931, p. 3).

The Beltinge Fish Bed may be difficult to recognise in the leached and chemically altered cliff section, but is quite distinct in the foreshore section. It may, however, be distinguished within Unit 'b' of Prestwich (1854, p. 111) and within the section given by Gardner (1883, p. 3).

Unit J
Beltinge Fish Bed (= Woolwich Bottom Bed *sensu* Gurr 1963, p. 419). This is a dark olive-grey silty clay, with frequent rounded black flint peebles and large green-coated sand grains. Some of the pebbles weigh 4 kg. Solution-pitted, unrolled, green-coated flints occur which resemble, but are smaller than, those from the Bullhead Bed (basal Thanet Formation). Stringers of fine gravel and quartz grit are often incorporated in pyrite concretions. Pyritised burrow linings and lignite are common. There are no calcareous fossils. Pyritic internal casts of molluscs are occasionally found and are probably derived. There is an abundant vertebrate fauna consisting of sharks' teeth and vertebrae, chimaeroid plates, teleost teeth and bones, crocodile and turtle bones and scutes. These are concentrated in the pebble stringers and are often found attached to pyrite nodules. Wood and seeds are frequent; one cone has been found.

Unit K
Woolwich Marine Bed. This comprises dark grey-green (weathering to yellow-grey), intensely burrowed silty sands. Fragments of abraded wood are common; vertebrate remains are rare.

OLDHAVEN FORMATION
The Oldhaven Formation is completely, though often inaccessibly, exposed in the cliffs, but only partially exposed on the foreshore. The foreshore exposures can be examined only at extreme low water. The junction of the Woolwich and Oldhaven Formation is usually obscured by the shingle spit, known locally as the 'Rand', Some authors (Stinton, 1965, p. 176) regard the Rand as marking the outcrop of the Basal Pebble Bed (Unit L). Ward (1972, p. 120) suggests that the bed is too loosely packed to form such a feature. In February 1977, when the foreshore was particularly scoured, an exposure of Unit K was seen to the west of the main pebble bank of the Rand. The outcrop of Unit L (Oldhaven Formation: Basal Pebble Bed) was located by shallow excavations and traced between [TR 1955 6900] and [TR 2003 6877]. The Rand therefore predominantly overlies Unit K. Fossils derived from all the formations exposed along this section are concentrated on the Rand and are often difficult to attribute to a particular unit.

Unit L
Basal Pebble Bed. This unit, which is sometimes absent, is composed of rounded black and brown flint pebbles, usually set in a soft matrix of sand or silty sand, but locally set in a limonitic ironstone. Rolled sharks' teeth and fragments of turtle are common.

Unit M
Where Unit L is absent, this unit, which is composed of glauconitic silty sand, rests directly on the eroded top of the Woolwich and Reading Formation. No cross-bedding is apparent. Shell lenticles are less common than in the unit above; those within the cliff section are particularly well preserved. This unit is the equivalent of the Silt Bed at Shelford Sand Pit (Ward, 1972, p. 117).

Unit N
This unit consists of glauconitic cross-bedded sands. Lenticular drifts of disarticulated bivalves are common throughout. *Arctica morrisi* is the most abundant mollusc and usually lies with its convex surface uppermost. Fish and turtle remains, and occasionally wood and seeds, are concentrated within the drifts. Large tabular blocks of calcareous sandstone from this unit litter the beach and foreshore and often enclose well preserved molluscs, sometimes ophiuroids. The upper half of this unit is decalcified in the cliff, yielding selenite sand 'roses' and soft manganiferous concretions.

LONDON CLAY FORMATION
The Herne Bay cliffs formerly displayed extensive exposures of London Clay, not unlike those along the north coast of Sheppey. Cliff stabilisation, completed in about 1970, has considerably reduced the available section. The London Clay itself is placed outside the scope of this paper, as it is the subject of a separate work by Cooper (1977). The Basement Bed is well exposed in the cliff and foreshore, where it forms a low pholad-bored outcrop.

Unit O
London Clay Basement Bed. This unit, which is sometimes absent, consists of glauconitic silty clay with occasional ovoid black flint pebbles, silt streaks and patches of pyritised wood. Casts of molluscs occasionally occur, mainly *Arctica* and '*Natica*'. Vertebrate remains are common.

Unit P
London Clay. This is typically a stiff blue-grey clay, weathering to brown. Pyrite nodules, pyritised fossils and cementstones are common in the upper parts of the section.

STRUCTURE
The appended map (Figure 2) shows the outcrop of the whole sequence on the foreshore. Where gravel or sand obscured the section, the outcrops were proved by augering. The Reculver Tabular Band and the Oldhaven Pebble Bed form good marker horizons for tracing the beds within the cliff. The Reculver Tabular Band (Unit B) is first visible in the low cliff about 90 m to the west of the promenade at Reculvers [TR 2225 6918]. It rises in the cliff over the next 250 m and then dips to the west, disappearing into the beach shingle at about [TR 213 690]. Three minor faults are visible in the region of the coastguard station, and these have influenced the outcrop of the Reculver Tabular Band (Unit B) on the foreshore. They are marked on the map as Faults A, B, and C, and their respective throws are given. Fault A causes Unit B to be exposed on the foreshore where it forms a reef to the seaward. The exposure is terminated by Fault B, which brings the *Arctica morrisi* bed onto the foreshore. Fault C exposes Unit B where it forms an arcuate outcrop area at the base of the shingle beach.

The cliffs to the west of Bishopstone Glen, formerly known as Oldhaven Gap [TR 2071 6875], are defended by a sea-wall and are becoming overgrown and degraded. Exposures of the Oldhaven Formation are poor, but it can be seen in the region of the slip-road [TR 205 686].

STRATIGRAPHICAL DISCUSSION

THE JUNCTION BETWEEN THE THANET FORMATION AND THE WOOLWICH AND READING FORMATION

In western Kent the base of the Woolwich and Reading Formation is marked by a pebble bed which rests on the eroded surface of the Thanet Formation. East of Newington [TQ 86 65] the basal pebble bed is absent, and authors have had difficulty in drawing and justifying a junction. This is particularly true at Herne Bay.

Prestwich (1854, p. 112) arbitrarily placed the junction of the Thanet and Woolwich Beds at the base of his Unit 'a' (the *Corbula regulbiensis* Bed). He explained his decision thus: 'This want of clear divisional surfaces, and the occurrence of several of the same species of shells in the two series, might be considered an objection to their being thus separated. The fossils, however, taken as a group, are different from those of the Thanet Sands, whilst the sands are more siliceous and contain a larger proportion of green sand and some disseminated flint-pebbles — two mineral characters deriving some importance from their breadth and constancy. He suggested that the indistinctness of the junction could be due to the reworking of Thanet matrix in Woolwich times. Whitaker (1866, p. 410) stated of the formations '. . . it is almost impossible to divide the two' and (1872, p. 101) '. . . where the marked pebble bed is sometimes absent, there is a passage between the two formations.' His section (1872, figure 45) corresponds closely with that of Prestwich. Gardner (1883, p. 204), after more detailed fieldwork, disputed Prestwich's conclusions as follows: 'If the Survey list is accurate there is thus no marked palaeontological break in the marine series. There is equally no perceptible difference at Reculvers in the quantity of green grains in the two sets of beds.' Wrigley (1949, p. 43) added, 'Unquestionably the *Corbula* Bed fauna continues that of the Thanet Sands without any major change.' Both Wrigley and Gardner were of the opinion that the Thanet and Woolwich Beds were part of a single sedimentary cycle.

Gurr (1963, p. 419) redefined this junction, placing it at the base of a unit containing 'Black flint pebbles and coarse quartz grains in a matrix of dark grey clay, with sharks' teeth, turtle scutes and plant remains, in part cemented by pyrite', about 2 m higher in the succession. From this horizon Gurr recorded twenty-five species of fish. For most of these species this horizon marked their earliest occurrence in the English Palaeogene. Hester (1965, p. 126), however, argued for the traditional junction, citing examples of similar Bottom Bed faunas. One example is Swanscombe, where Stamp and Priest (1920, p. 190) recorded blocks of fossiliferous matrix within the basal pebble bed. They opined that, 'There can be little doubt that one has here an example of contemporaneous erosion — a bed of shelly "tuffeau" broken up soon after formation and mixed with flint pebbles'. They continued, 'The bed of coarse, glauconitic sand, which at Herne Bay takes the place of the pebble bed at the base of the Woolwich Beds, marks the first appearance of *Cyprina scutellaria, Pectunculus (Axinaea) terebratularis* and *Protocardium plumstediense. Corbula regulbiensis*, rare below, also becomes abundant. The small fauna recorded above from Swanscombe is unmistakably identical with this Herne Bay fauna.' This further point is, however, quite untrue. *Arctica scutellaria, Glycymeris terebratularis* and *Nemocardium plumstedianum* are also common in Unit E (*Astarte tenera* Bed), an observation confirmed by Gardner (1883, p. 204). It was on this mistaken premise that they correlated the Woolwich Bottom Bed with the Belgian zone of *Cyprina (Arctica) scutellaria.* For Stamp and Priest to presume that the admittedly derived (Thanet Beds) fauna within the Basal Pebble Bed belonged to the Woolwich Beds is curious, as the derived nature of this fauna would appear to be irrefutable evidence for the contrary conclusion. Similar blocks of Thanet Beds material can still be seen within the Basal Pebble Bed in the Swanscombe pit [TQ 59 73] and are similar in matrix and fauna to Units E and G described above. Unfossiliferous blocks of Thanet Beds and rolled lumps of soft chalk also occur, suggesting a nearby source. Other records of molluscs within the Basal Pebble Bed remain unexplained and are inconsistent with the normal fauna of oysters and sharks' teeth only. If they are re-exposed their precise stratigraphy should be investigated more thoroughly.

In placing the Thanet/Woolwich boundary where he did, Prestwich apparently satisfied two important criteria in establishing a geological boundary. These are the demonstration of a faunal dissimilarity and of a lithological distinction. Authors now universally agree that on faunal grounds this separation is invalid. Gardner argues that the presence of glauconite (green sand), which Prestwich considered significant, is likewise not diagnostic of a lithological distinction.

Table 1. Grain size analysis, Units A to K

Unit	Sieve aperture size in microns				
	500	250	125	63	<63
K	—	0.16	12.53	47.10	40.21
J	2.26*	6.49	6.17	13.55	77.53
I	2.95*	2.40	79.35	10.06	5.21
H	0.42	3.35	86.20	8.20	1.83
G	2.42†	9.18†	81.53	5.40	1.47
F	1.81†	2.96†	88.41	4.96	1.86
E	0.87†	1.61	88.04	7.66	1.82
D	—	0.20	81.40	16.49	1.90
C	—	0.13	41.43	54.80	3.64
B	—	2.02	70.61	25.06	2.31
A	0.11	1.43	2.49	82.52	13.45

*Green-coated quartz grains
†Glauconitic grains

This table displays the percentage by weight of each sample retained in each of a set of standard sieves. The samples were acid-treated to remove all calcareous fossils. The individual results displayed are the averages of several samples taken from within the mapped outcrop. No problems were encountered with silicification although limonite- and selenite-cemented aggregations were found in some samples of Unit A. These samples were discarded. Large botryoidal glauconite grains were present in the coarse fraction of Units E and F. Green-coated quartz grains were present in Units I and J.

From Table 1 it is evident that there is no pronounced lithological change associated with the *Corbula* Bed (Unit G). There is, however, a dramatic increase in the proportion of silt to clay (<63 microns) on reaching Unit J. This lithological distinction, combined with flint pebbles, green-coated flints and shark's teeth, which are all familiar features of the Woolwich basal pebble bed, can only indicate a major sedimentary discontinuity. There is no lithological or palaeontological evidence for placing the boundary in any other position. The bed that Gurr (1963) referred to as the Woolwich Bottom Bed, termed here the Beltinge Fish Bed, is undoubtedly the lateral equivalent of the Woolwich and Reading Basal Pebble Bed.

The long confusion is difficult to explain. Adherence to tradition combined with a lack of understanding of the Thanet Formation exposure is the probable cause. Unit J is sometimes difficult to distinguish in the leached, weathered cliff, but is quite unmistakable on the foreshore.

THE LONDON CLAY BASEMENT BED

Prestwich (1850), when defining the London Clay Basement Bed, included a series of shelly sands and gravels underlying the London Clay to the east of the London basin. Whitaker (1866, p. 412) separated these beds, naming them the Blackheath Beds (mainly pebbles) to the west and Oldhaven Beds (mainly sands) to the east. J. Cooper (1976a) gave them both the stratigraphic rank of 'Member' and included them in the Oldhaven Formation. He suggests (Cooper, 1976a, p. 13) that the 'London Basement Bed' seen in some temporary exposures and at Harefield, West London, and Bean, Kent, should be similarly separated and included in the Oldhaven Formation. He proposed (1976b, p. 31) the lithostratigraphic term 'Harefield Member', previously used only informally, for these glauconitic sandy clays overlying the Woolwich and Reading Formation and beneath the London Clay. The stratotype locality is Harefield [TQ 048 911]. A description of the section is given by Cooper and James (1975, p. 168) and Cooper (1976b, p. 31). Temporary exposures of Harefield Member were seen at Bignell's Corner [TQ 227 007], North London (Ward, 1976, p. 37), and at Fulmer [TQ 022 860] (Stinton, 1975, p. 4). The close lateral relationships between the Harefield Member and the Oldhaven Sands Member can be inferred from the proximity of the Bean exposure [TQ 590 717] to the well documented sections at Swanscombe. The section at Bean is described by Durkin and Baldwin (1968, p. 213), those at Swanscombe by Stamp and Priest (1920, p. 187) and Brown and Priest (1924, p. 142).

A London Clay Basement Bed of the type seen at Herne Bay appears to be a constant feature of the base of the London Clay Formation in Kent, irrespective of the presence or absence of the Harefield or Oldhaven Sands members. A typical section of London Clay Basement Bed *sensu stricto* is recorded by Ward (1972, p. 117) in a description of the section at Shelford Quarry, Kent [TR 160 600]. Prestwich (1850, p. 265) records 'Traces of *Ditrupa plana*' in the lower part of the London Clay at Herne Bay. This record cannot be confirmed by the author, but does suggest a possible correlation between the London Clay Basement Bed *s.s.*, the 'London Clay Basement Bed' containing *Ditrupa* in the Reading area (Prestwich, 1850, p. 266) and the *Ditrupa* Bed at Whitecliff Bay, Isle of Wight (Prestwich, 1850, p. 256).

COMPARISON WITH OTHER SECTIONS

THANET FORMATION

There can be little hope of long-distance correlation with any set of biostratigraphical units when they are based on fossils that are as facies-dependent as are the particular bivalves found in this formation. Two local sections have been equated to the *Corbula* Bed, those at Richborough and at Canterbury Barracks. The Richborough cutting is described in Prestwich (1852, p. 251) and corresponds quite well with that at Herne Bay. Prestwich's Bed 2, described as 'Very sandy light brownish-grey clay, full of small, rough, twiglike fragments or pieces of iron sandstone, with cores of yellow sand, and having the appearance of vegetable origin, — contains a very few and very small black flint pebbles . . . . 2½ (ft)' clearly represents Unit H described above. Prestwich's Bed 3, 'Very light and loose ash-green sand, rather fine, — in some places coarser, with one thin seam of shells (*Corbula, Glycimeris,* and *Cyprina*). The lower part contains an occasionally ochreous layer. A few small round flint-pebbles are dispersed throughout . . . . 8 (ft)' probably represents Units E, F and G.

The Thanet Formation thins rapidly to the south. The section at Canterbury Barracks (Whitaker, 1872, p. 90) is approximately on the 50 ft (15.24 m) isopachyte (Hester, 1965, p. 130, figure 7). The presence of silicified *Corbula regulbiensis* suggests the upper part of the Reculver Silts Member. Without investigation greater precision is impossible. There are numerous small exposures in roadsides, streams and railway cuttings recorded in east Kent by Whitaker (1872), but few have sufficient detail to attempt any sort of a correlation.

There would appear to be no equivalent within the Herne Bay section of the silicified facies formerly exposed between Faversham and Bekesbourne (south-east of Canterbury, *see* Whitaker, 1872, p. 87). A rich fauna, curiously lacking *Corbula*, was collected from the last remaining section at Nickle (Nackholt) Farm [TR 0947 5610]. The section and fauna have been described (Ward, James and Cooper, *in press*). The section of Thanet Formation exposed at Pegwell Bay does not overlap that at Herne Bay (Haynes, 1956, p. 84). The uppermost part of the Pegwell section resembles Unit A (*Eutylus* Bed) in being a stiff silty clay with discontinuous concretions, but has a more diverse fauna and thin partings of sand and coarse shell debris.

WOOLWICH AND READING FORMATION

Although sharks' teeth are a well known feature of the Woolwich Bottom Bed Member their absence from other sections in the quantities and diversity encountered at Herne Bay is unexplained. The Bottom Bed Member described above does not differ from other sections in Kent except in thickness. The nearest comparable section is at Shelford Quarry, north-west of Canterbury [TR 160 600] described by Ward (1972, p. 117). The exposure here is sandblasted and displays magnificent systems of *Ophiomorpha* burrows.

OLDHAVEN FORMATION

Decalcified sections of the Oldhaven Sands Member are fairly common in east Kent; however, those yielding a molluscan fauna are now few. Shelford Quarry again displays a fine section. The Oldhaven Sands are thinner here than on the coast, finer-grained in texture and terminate upwards with clay laminations. The indurated bed above the Basal Pebble Bed is present (Unit 5 of Ward, 1972, p. 117); and is the equivalent of Unit M at Herne Bay.

The fossiliferous section of Oldhaven Sands at Grove Ferry, the source of John Brown's 'Crag fauna' is now overgrown. See the accounts by Brown (1859, p. 133) and by Whitaker (1866, p. 416). The record of *Microgadus eocenicus* from Brown's excavation by Stinton (1965, p. 395) is typical of the Oldhaven Formation.

The railway cutting at High Halstow described by Whitaker (1889, p. 171) yielded a well preserved fauna. The vertebrates are listed by White (1931, p. 17) and the molluscs by Wrigley (*in* White, 1931. p. 111). Both lists contain most of the species typical of the Oldhaven Sands at Herne Bay. Their source was a lenticular shell drift, now completely excavated, typical of those in the cliff section at Herne Bay.

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APPENDIX

Biotic List

The following list is intended to be comprehensive, but only species collected by the author are assigned to individual beds. Other species are indicated by an asterisk and their occurrence is not tabulated. The foraminifera, which are taken from Haynes (1956, 1958), Wood & Haynes (1957) and Haynes and el-Naggar (1964), have not been assigned to lithological units and are listed separately after the rest of the fauna. Some collecting bias is present in favour of the larger molluscs and especially the fish, the author's particular interest.

A: abundant C: common F: frequent O: occasional R: rare.

	UNITS	A	C	D	E	F	G	J	L-N	O
PLANTAE										
Canticocculus sp. [seed]		-	-	-	R	-	-	-	-	-
Iodes multireticulata Reid & Chandler [seed]		-	-	-	C	-	R	R	-	-
**Osmunda dowkeri* (Carruthers) Chandler [wood]		-	-	-	-	-	-	-	-	-
Palmae [wood]		-	R	-	-	-	-	-	-	-
Pinus macrocephalus (Lindley & Hutton) [cone]		-	-	-	R	-	-	R	-	-
**Pinus prestwichi* Gardner [cone]		-	-	-	-	-	-	-	-	-
Vitis sp. [seed]		-	-	-	-	-	-	R	O	-
PORIFERA										
Clionid borings		-	-	O	O	O	O	-	C	-
Indet. siliceous spicules		-	-	-	O	C	A	-	-	-
BRYOZOA										
Membranipora eocena (Busk)		-	-	-	-	A	-	-	-	-
ANNELIDA										
Serpula sp.		-	-	-	-	O	O	-	-	-
DECAPODA										
Hoploparia gammaroides McCoy		-	-	-	-	-	R	-	-	-
Indet. crustacean claws		C	C	-	C	C	C	-	O	-
CIRRIPEDIA										
Euscalpellum sp.		-	-	-	-	F	-	-	-	-
BRACHIOPODA										
Lingula sp.		-	R	-	-	R	-	-	-	-
BIVALVIA										
Arctica morrisi (J. de C. Sowerby)		A	A	A	A	C	C	-	A	O
A. scutellaria Lamarck		-	O	O	C	F	A	-	O	-
Astarte (Ashtarotha) elevata G.B. Sowerby		-	-	-	-	-	-	-	O	-
A. (Ashtarotha) tenera Morris		-	-	-	C	-	-	-	-	-
Corbicula cuneiformis (Férussac)		-	-	-	-	-	-	-	O	-
**Corbula plateaui* Cossmann		-	-	-	-	-	-	-	-	-
C. regulbiensis Morris		O	F	C	C	A	A	-	O	-
C. sp. (morrisi Edwards MS.)		-	-	-	-	-	-	-	O	-
Cucullaea decussata Parkinson		-	O	F	C	F	F	-	-	-
Cyrtodaria rutupiensis (Morris)		-	O	F	F	O	O	-	-	-
Dosiniopsis bellovacensis (Deshayes)		-	-	-	-	-	-	-	C	-
D. orbicularis (Morris)		-	-	-	O	O	O	-	-	-
Eutylus cuneatus (Morris)		F	-	-	-	-	-	-	-	-
Garum edvardsi (Morris)		-	-	O	-	-	O	-	-	-
Glycymeris plumstediensis (J. Sowerby)		-	-	-	-	-	-	-	C	-
G. terebratularis (Lamarck)		-	-	C	C	C	C	-	-	-
Lucinoma sp.		-	-	-	-	-	R	-	-	-
Modiolus sp.		-	R	R	-	-	-	-	-	-
Nemocardium edwardsi (Deshayes)		-	-	-	O	-	O	-	-	-
N. (Arctopratulum) plumstedianum (J. Sowerby)		-	-	O	C	O	C	-	C	-
Nucula fragilis Deshayes		-	R	-	-	-	-	-	C	-
N. gracilenta Wood		-	-	-	-	-	-	-	C	-
N. proava Wood		-	-	-	-	-	-	-	C	-
N. sextans Wood		-	F	O	F	O	F	-	-	-
Nuculana substriata (Morris)		-	-	R	-	C	O	-	-	-
Ostrea bellovacina Lamarck		O	F	C	O	C	C	-	C	C
Panopea intermedia J. Sowerby		-	-	-	-	-	-	-	O	-
P. remensis Melleville		-	-	C	F	-	O	-	-	-
'Pecten' prestvichii Morris		-	R	-	-	R	-	-	-	-
Pholadomya konincki Nyst		R	-	-	-	-	-	-	-	-
Pterelectroma sp.		-	-	-	-	R	-	-	-	-

	UNITS	A	C	D	E	F	G	J	L-N	O
Tellina sp.		O	O	-	-	-	-	-	-	-
Teredinid		C	F	-	F	F	O	-	O	A
Thracia aff. *oblata* (J. de C. Sowerby)		-	-	C	C	-	C	-	-	-
SCAPHOPODA										
Antalis brevis (Deshayes)		-	-	-	C	C	F	-	-	-
Fustiaria nitens (J. Sowerby)		-	-	-	-	-	-	-	O	-
GASTROPODA										
Acirsa sp.		-	-	-	-	-	-	-	-	-
Aporrhais analogus (Deshayes)		-	-	-	-	-	R	-	-	-
A. dispar (Deshayes)		-	-	R	C	C	C	-	-	-
A. triangulata Gardner		-	-	-	-	-	-	-	C	-
'Bulla' sp.		-	-	-	-	-	-	-	O	-
Calyptraea suessoniensis (orbigny)		-	-	-	-	-	-	-	O	-
Desorinassa desori (Deshayes)		-	-	-	-	-	-	-	-	-
Epitonium bowerbanki (Morris)		-	R	-	-	-	-	-	-	-
Euspira bassae Wrigley		-	-	-	-	O	-	-	-	-
E. cantiana Wrigley		-	-	C	C	C	C	-	-	-
E. glaucinoides (J. Sowerby)		-	-	-	-	-	-	-	C	O
Ficus eocenica Wrigley		-	-	-	-	-	-	-	O	-
F. intermedia (Melleville)		-	-	-	-	O	O	-	-	-
Hemipleurotoma infraeocenica Cossman		-	-	-	-	-	-	-	C	-
Melanopsis buccinulum (Melleville)		-	-	-	-	O	-	-	-	-
'Natica' thanetensis Wrigley		-	-	F	-	F	F	-	-	-
Parvisipho sp.		-	-	-	-	-	-	-	O	-
Pyramidellidae		-	O	-	-	C	-	-	-	-
Sigatica abducta (Deshayes)		-	-	-	-	-	-	-	O	-
Siphonalia cooperi Wrigley		-	-	-	-	-	-	-	O	-
Siphonalia mariae (Melleville)		-	-	O	F	C	C	-	-	-
S. subnodosa (Morris)		-	-	-	-	-	-	-	O	-
Solariaxis sp. (*prestwichi* Edwards MS.)		-	O	-	-	R	-	-	-	-
Thanetinassa bicorona (Melleville)		-	-	-	-	-	-	-	-	-
Tornatellaea parisiensis (Deshayes)		-	-	-	-	A	-	-	-	-
Turritella sp.		-	-	-	-	R	-	-	-	-
ECHINODERMATA										
Astropecten sp.		-	-	-	-	-	O	-	-	-
Ophiura wetherelli Forbes		-	-	-	-	-	-	-	R	-
Ophiura sp.		-	-	-	-	-	O	-	-	-
PISCES Elasmobranchii										
Synechodus eocaenus (Leriche)		-	-	-	-	-	-	O	-	-
Heterodontus lerichei Casier		-	-	-	-	-	-	O	-	-
Notidanodon loozi (Vincent)		-	-	-	-	-	-	O	-	-
Squatina prima (Winkler)		-	-	-	R	-	-	F	F	O
Squalus orpiensis (Winkler)		-	-	-	R	R	-	O	-	-
S. minor (Leriche)		O	R	-	-	-	-	R	-	-
Palaeogaleus vincenti (Leriche)		F	O	-	R	R	-	C	-	-
'Lamna' inflata Leriche		-	-	-	O	-	-	O	-	-
Otodus obliquus Agassiz		-	-	-	R	-	-	F	O	O
Palaeohypotodus rutoti (Winkler)		R	R	-	-	-	-	C	C	F
Synodontaspis hopei (Agassiz)		-	-	-	-	-	-	F	O	O
S. teretidens (White)		C	C	-	C	O	O	A	A	F
Striatolamia striata (Winkler)		C	C	-	C	O	O	A	A	F
Isurus novus (Winkler)		-	-	-	-	-	-	R	-	-
Galeorhinus gomphorhiza Arambourg		-	-	-	-	-	-	R	-	-
'Hypolophus' sylvestris White		-	-	-	-	-	-	F	R	R
Myliobatis dixoni Agassiz		-	-	-	-	-	-	C	-	-
PISCES Chimaeroidea										
Amulodon eocenicus (Woodward & White)		-	-	-	-	-	-	-	R	-
Callorhinchus newtoni Ward		-	-	-	R	-	-	-	-	-
C. regulbiensis Gurr		-	-	-	-	-	-	O	-	-
Chimaera eophantasma Ward		-	-	-	-	-	-	R	-	-
Edaphodon bucklandi Agassiz		-	-	-	-	-	-	R	-	-
E. minor Ward		-	-	-	-	-	-	R	-	-
Elasmodus hunteri Egerton		-	-	-	R	-	-	O	-	-
Ischyodus dolloi Leriche		-	-	-	-	-	-	O	-	-

UNITS	A	C	D	E	F	G	J	L-N	O
PISCES Osteichthyes teeth and bones									
Acipenser toliapicus Woodward	-	-	-	R	-	-	R	C	-
Albula eppsi White & Frost	R	-	-	-	-	-	-	C	-
A. oweni (Owen)	-	-	-	-	O	-	O	-	-
Amia barroisi Leriche	-	-	-	-	-	-	-	F	-
Ardiodus marriotti White	R	R	-	O	R	-	F	C	-
Diaphyodus sauvagei (Leriche)	-	-	-	-	-	-	-	O	-
Egertonia isodonta Cocchi	-	-	-	-	O	-	C	R	-
Eutrichiurides orpiensis (Leriche)	-	-	-	-	C	-	-	C	-
Lepidosteus suessionensis Gervais	-	-	-	-	-	-	-	C	R
Ostracion sp.	-	-	-	-	-	-	R	-	-
Phyllodus toliapicus Agassiz	-	-	-	-	-	-	R	F	O
Pycnodus sp.	-	R	-	-	R	-	F	-	-
Scombridae	-	O	-	-	-	-	F	F	O
Xiphiorhynchus sp.	-	-	-	-	-	-	F	C	R
Indet. teeth, vertebrae and bones	O	O	F	F	F	O	C	A	C
PISCES Osteichthyes otoliths									
Albula eppsi White & Frost	-	-	-	-	-	-	-	C	-
Archegadus comptus Stinton	-	R	-	-	-	-	-	-	-
Archemacruroides ornatus Stinton	R	-	-	R	O	-	-	-	-
Argentina abbatiae Stinton	-	-	-	-	-	-	-	O	-
A. planulata Stinton	-	R	-	-	-	-	-	-	-
Cheimerius sp. nov.	A	-	-	-	-	-	-	-	-
Gadus thanetiensis Stinton	-	-	-	R	O	-	-	-	-
Lactarius curvidorsalis (Frost, *in* White)	-	-	-	-	-	-	-	C	-
Lepophidium subteres Stinton	-	-	-	-	-	-	-	R	-
Microgadus eocenicus (Frost, *in* White)	-	-	-	-	-	-	-	C	-
Ophidypterus retusus Stinton	R	O	-	R	O	-	-	-	-
Pagellus sp. nov.	-	-	-	-	R	-	-	-	-
Nemopteryx pinguis (Stinton)	-	-	-	-	-	-	-	O	-
N. trigonus (Stinton)	-	R	-	F	O	-	-	-	-
Polyperca serranoides Stinton	-	-	-	R	O	-	-	-	-
Primaevomesus tricrenulatus Stinton	R	-	-	-	-	-	-	-	-
Pristigenys sp.	-	-	-	R	-	-	-	-	-
Proraniceps leiopleurus Stinton	-	R	-	R	-	-	-	-	-
Raniceps sp. nov.	R	-	-	-	-	-	-	-	-
Trigla sp. nov.	-	-	-	-	R	-	-	-	-
REPTILIA									
Indet. chelonian	-	R	-	R	-	-	C	C	C
Indet crocodilian	-	-	-	-	-	-	O	R	-
'Trionyx'	-	-	-	-	-	-	C	C	-

FORAMINIFERA

Alabamina obtusa (Burrows & Holland)
Angulogerina cf. *wilcoxensis* Cushman & Ponton
Anomalinoides nobilis Brotzen
Astacolus danvillensis (Howe & Wallace) *venetti* Haynes
A. platypleura (Jones)
Asterigerina aberystwythi Haynes
Bulimina palaeocenica Brotzen
Ceratobulimina tuberculata Brotzen
Charltonia canterburyensis Haynes
Cibicides cantii Haynes
C. cf. *carinata* Terquem
C. cassivellauni Haynes
C. cassivellauni buximargo Haynes
C. aff. *yazooensis* Cushman
C. sp.
C. (*Cibicidina*) *cunobelini* Haynes
C. (*Cibicidina*) *mariae* Jones
C. (*Cibicidina*) *succedens* Brotzen
C. (*Cibicidoides*) *proprius* Brotzen
Cyclammina challinori Haynes
C. incisa (Stache)
Dentalina cf. *antenna* Cornuel
D. bifurcata d'Orbigny
D. cf. *consobrina* d'Orbigny
D. fallax Franke
D. glaessneri Ten Dam
D. lorneiana d'Orbigny
D. lorneiana aff. *cognata* Reuss
D. lorneiana semisulcata Haynes
D. megapolitana Reuss
D. ovoidea Marie
Discorbis aff. *midwayensis* Cushman
D. cf. *subaraneana* Cushman
D. sp.
Epistominella vitrea Parker
Eponides? aff. *toulmini* Brotzen
Glandulina aff. *dimorphina* (Bornemann)
G.? laevigata (d'Orbigny)
G.? ovula d'Orbigny
Globigerina pseudobulloides Plummer
G. triloculinoides Plummer
Globigerinella aspera (Ehrenberg)
Globorotalia velascoensis (Cushman) aff. *acuta* (Toulmin)
Globulina ampulla (Jones)
G. gibba d'Orbigny
G. gibba var. A. Haynes
G. gibba hollandi Haynes
Glomospirella woodi Haynes
Guembelina globulosa (Ehrenberg)
G. cf. *striata* (Ehrenberg)

Guttulina cf. *kishinouyi* Cushman & Ozawa
G. lactea (Walker & Jacob)
G. lactea elongata Haynes
G. cf. *laevigta* (d'Orbigny)
G. cf. *oregonensis* Bandy
G. problema d'Orbigny
G. trigonula (Reuss)
G. woodi Haynes
Gyroidina? gyroidinoides (Bandy)
G.? hanvillensis Howe & Wallace
Gyroidinoides voluptus Haynes
Haplophragmoides burrowsi Haynes
H. cf. *obliquicameratus* Monks
Hollandina pegwellensis Haynes
Hormosina sp.
Involutina cretacea (Reuss)
I. pyrotecnica Haynes
Lenticulina sp.
L. (O.) caudigera Wiesner *lemoni* Haynes
Marginulina costifera Ten Dam
M. cf. *densicostata* Thalman
M. cf. *dorsata* Cushman
Nonion applinae Howe & Wallace
N. laeve d'Orbigny
N. reculverensis Haynes
Nonionella aff. *austiniana* Cushman
N. cretacea Cushman
N. robusta Plummer *perdita* Haynes
N. sp.
Polymorphina anceps Philippi
P. eolithiformis Haynes
P. striata (Burrows & Holland)
P. sp. A. Haynes
P. sp. B. Haynes
Protelphidium hofkeri Haynes
P. sublaeve (Ten Dam)
Pseudoclavulina anglica Cushman
Pseudopolymorphina obtusa (d'Orbigny)
P. paleocenica Brotzen
P. sp. A. Haynes
P. sp. B. Haynes
P. sp. C. Haynes
Pullenia platti Haynes
P. quaternaria (Reuss)
P. quinqueloba (Reuss)
P. salisburyi Stewart & Stewart
Pulsiphonia prima (Plummer)
Pyrulina fusiformis (Roemer)
Rosalina koeneni Brotzen
R. mimiconcinna Haynes
R. cf. *ystadiensis* Brotzen
Sigmomorphina? bombasta Haynes
S. semitecta terquemiana Cushman & Ozawa
S.? sporadica Haynes
S. sp. A. Haynes
S. sp. B. Haynes
Siphonina aff. *wilcoxensis* Cushman
Textularia thanetana Lalicker
Trochammina pentagona Haynes
Trochamminoides sp.
Uvigerinella europaea (Cushman & Edwards)
U. oveyi Haynes
Vaginulina icenii Haynes
Verneuilina sp.
Virgulina dibollensis Cushman & Applin

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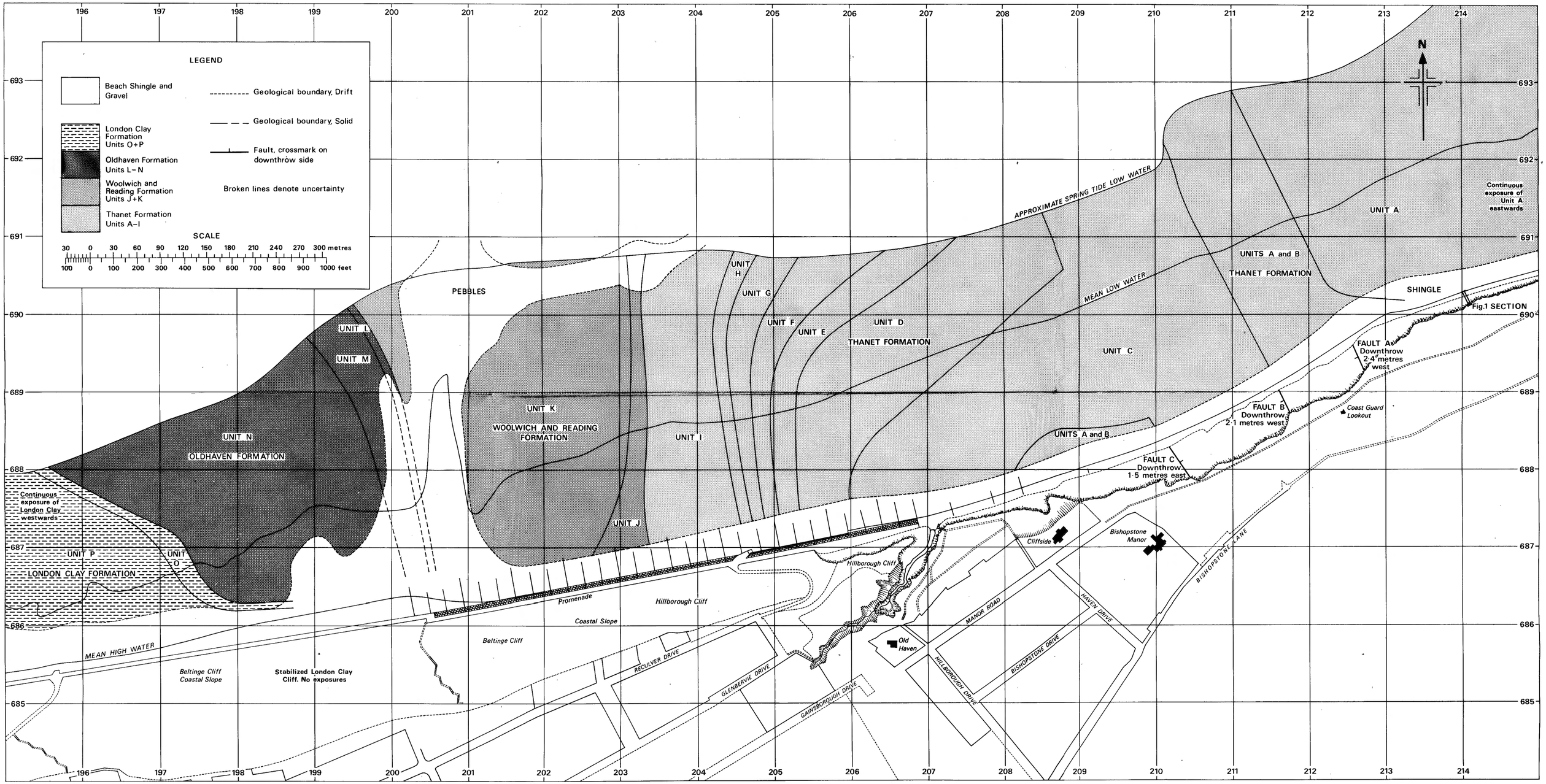

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Figure 2 Map of part of the foreshore between Herne Bay and Reculver, Spring 1976