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SWANSEA BAY (SKER) PROJECT

TOPIC REPORT : 3

GEOPHYSICAL INTERPRETATION AND SEDIMENT CHARACTERISTICS OF THE OFFSHORE AND FORESHORE AREAS

M. W. L. BLACKLEY

REPORT NO 60

1978

This project is supported financially by
the Department of the Environment

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SUMMARY

This report is the third in the Topic Report series concerning Swansea Bay.

Grab sampling, box-coring and vibrocoring techniques were used in conjunction with geophysical methods in order to provide a surface sediment distribution map of the area. The continuous seismic profiling (CSP) records also provided valuable information on the subsurface geology and the thickness of the Pleistocene and Holocene sediments including both the modern sandbanks and the large expanse of fine sediment situated in the middle of the research area. The sandbanks were shown to be between 8m and 12m thick while the mid-bay fine sediment was up to 80cm thick. This latter area of silt and clay was already in existence at least before 1859, but the dumping of large quantities of dredged spoil in recent years appears to have considerably added to its thickness.

Sandwave fields were detected in some areas, their orientation giving an indication of the direction of movement of the sediment. In the case of South Kenfig Patches, this was found to be southeasterly on the northern side and northwesterly on the southern side.

Examination of beach material showed that the finest material occurred at low water mark and that along the beaches the sand became marginally finer towards the centre of Aberafan Beach and in the areas around the River Kenfig and Sker Point further south.

1. INTRODUCTION

1.1 Preface

This is one of a series of Topic Reports concerning specific aspects of work undertaken by the Institute of Oceanographic Sciences in Swansea Bay. Topic Reports 1 and 2 included a general introduction to the area and outlined long and short-term topographic changes that had taken place both on and offshore.

The purpose of this report is to describe both the sea bed distribution and thicknesses of the superficial sediments using information gained by various sampling and geophysical techniques. A description of the beach samples taken on the various surveyed lines of section has also been included.

1.2 Description of offshore banks and associated areas

Although the offshore topography and bathymetry was dealt with briefly in Topic Report 1, Section 2.2, it will be touched upon again here. The most striking feature of the area is a group of sandbanks, the highly linear Scarweather Sands (9.6 km long, 1.6 km wide), the less linear Hugo Bank (5 km long, 1 km wide) and the South Kenfig Patches, which is a more diffuse sand body. All these features trend in an approximately east to west direction (Fig 1) as does the Shord Channel which separates Scarweather and Hugo Banks. Both Scarweather and Hugo Bank dry out at low water, the east end and central portions of Scarweather to +3m and +0.5m above Chart Datum respectively and Hugo Bank to +2.6m above Chart Datum. (Chart Datum is approximately the lowest level of astronomical tides). A study of the hydrographic charts shows that between 1859/60 and 1974 Scarweather Sands has increased in length westward and become less sinuous. Hugo Bank and Kenfig Patches were closely linked at the earlier date but became progressively more discrete thereafter so that by the 1974 survey a well-defined channel separated the two. Over the same period the main mass of South Kenfig Patches and Hugo Bank, especially, showed a tendency to have been displaced southwards although this was not necessarily apparent from the location of their crest lines.

The two remaining topographic high areas are the North Kenfig Patches and the Outer Green Grounds, parts of the latter being composed of massive Carboniferous Limestone. Both are thought to be associated with the remnants of glacial deposits and the effect of the resistance to erosion of these outliers can be seen by the irregularity of the -10m contour depicted on the hydrographic chart. Within this area delineated by the sandbanks in the south, the North Kenfig Patches in the east, the Outer Green Grounds to the north and the White Oyster Ledges to the west, the sea bed is remarkably smooth. The sea bed slopes towards the southwest with a gradient of barely 1 : 700 over a distance of 7km.

1.3 Field techniques

1.3.1. Grab sampling: A preliminary survey of the sea bed was undertaken using a Van Veen Grab. Later a Shipek Grab was used in conjunction with the box-coring programme. Both grabs worked well in cohesive and unconsolidated fine sediments but suffered from the same drawbacks. If coarse material was present to any degree there was a tendency for the jaws of the grab to remain slightly ajar resulting in the loss of some or all of the finer fraction of the sample. Also the sample was nearly always disturbed so that significant changes in sediment type occurring in the top few centimetres of the sea bed were either not apparent or else liable to misinterpretation.

Grab sampling data from the Hydrographic survey undertaken in 1974 by HMS Woodlark was also incorporated into the initial sediment distribution map. Whilst the samples collected by IOS were taken with the ship stationary, the

Woodlark's samples were collected with the ship underway.

1.3.2 Box-coring: With the results of the grab sampling programme completed, selected areas were then box-cored in order to obtain undisturbed samples. These samples could be as much as 40cm deep. The apparatus used was a Reineck Corer (Bouma and Marshall, 1964) which consisted of a gimbled frame through which a central column slid vertically. This column was weighted as necessary to ensure penetration of the sea bed. Into the lower end of the column was welded a rectangular frame into which sample boxes 45 x 28 x 18 cm deep were fitted. A closing mechanism pivoted at the boxholder and closed over the bottom of the sample box when the corer was triggered on the sea bed. Relatively undisturbed samples of silts, clays, sands and small gravels were collected in this way.

1.3.3 Vibrocoring: Cores were obtained in unconsolidated material by means of a vibrocorer. This was a slightly modified version of the pattern used by the Institute of Geological Sciences and is described by Kirby (1972). The vibrocore frame was lowered onto the sea bed and the core barrel forced into the sediment under the weight of the vibrating motor. In fine sediments cores up to 5m in length could be retrieved. Fine structures in the top few centimetres of the cores were liable to be lost due to the vibrations, and drag features could be induced at depth in the core as the plastic liner penetrated the sediment.

The sites of the grab, box-core and vibrocore samples are shown in Figure 1, the sites mentioned in the text being numbered.

The three sampling techniques already described were very time-consuming and produced spot samples only. They were used primarily to confirm the interpretations derived from the continuous geophysical recording data.

1.3.4 Sidescan Sonar: This enabled a wider knowledge of both the surface sediment distribution and the bedforms to be gained. An EG & G dual channel system was used. A sonar transducer, emitting an acoustic pulse, was towed behind the ship. This pulse was returned from the sea bed to the transducer and then to the ship where it was recorded on a facsimile recorder. As the ship continued on its predetermined course, fix marks were recorded onto the recorder paper and the Decca or HiFix coordinates logged. The intensity of the returning signal depended mainly on the angle of incidence of the transmitted energy and the lithological and topographical variations of the sea bed.

1.3.5 Continuous Seismic Profiling (CSP): A Huntec ED10 Boomer and Huntec ST2 high resolution streamer were towed behind the survey ship. The boomer transmitted pulses of energy of known frequency to the sea bed. Here part of the signal was reflected back from the sea bed while the remainder penetrated layers of different acoustic properties and was reflected back off these lower layers. These reflected signals were received back at the streamer where they were converted into electrical signals and recorded on an Alden 19" recorder. Fix marks were recorded on the chart as before. By adjusting the penetration and resolution of the instrument both surface morphology and sediment thickness above sub-surface structures could be determined. Some problems with ship's noise were encountered both with the CSP and the sidescan sonar surveys.

1.4 Laboratory Techniques

1.4.1 Grab samples: Most of these samples were described in the field using an IOS Grain Size Comparator Disc (Kirby, 1973). This consisted of a perspex disc divided into eight segments, each section containing a uniform specimen of material ranging from granule to clay size. The sample to be measured was placed over the clear perspex area of the disc and sized by visual comparison with the fractions in the segments.

1.4.2 Box-cores: As the initial box samples were so bulky sub-samples approximately 30 x 18 x 5 cm were taken at right angles to one another down the box. On returning to the laboratory those samples that were composed of all or nearly all non-cohesive sediments were allowed to dry a little and then the upper surface of the sample was coated with several layers of lacquer. When the coating had dried it was removed and the under surface of the peel showed the difference in permeability of the sediment due to the variation in grain size. The material remaining in the box could then be analysed further as necessary.

The clay samples were not amenable to this treatment and also the nature of the exposed surface made a visual description very difficult. The samples were therefore sliced longitudinally, sealed by polythene sheeting and subjected to X-rays. The intensity of the X-rays passing through the fine sediments was affected by the density or grain size of the material present. The resulting 18 x 30cm contact print revealed the detailed internal structure of the cores.

1.4.3 Vibrocores: For ease of handling the plastic core tubes were cut into 1m lengths and sealed on board the ship. On return to the laboratory they were dealt with in a similar manner to the box-cores.

1.5 Data Interpretation

1.5.1 Sidescan Sonar: The track of the ship taken from the Decca or HiFix positions was first plotted (Fig 2). Attempts were then made to correlate the variations of the sidescan records with samples collected physically from the sea bed. A map was gradually built up to show the different sediment boundaries, possible rock or boulder clay outcrops and distribution of bedform features.

1.5.2 Continuous seismic profiling: The ship's track was plotted as before (Fig 3). Where the thickness of the unconsolidated sediments was not excessive it allowed the boundaries and thickness of the sediments above the bedrock or boulder clay to be determined. All these calculations assumed the velocity of sound in water to be a constant 1500 ms^{-1}. Sound passing through unconsolidated sediment and older geological deposits would have velocities in excess of this figure. Thicknesses and depths below the sea bed are therefore somewhat underestimated. Information as to the position and direction of movement of the sandwaves and the distribution of various subsurface features was also deduced from the profiling records.

2. DISTRIBUTION OF SURFACE SEDIMENTS

At the beginning of the research programme, little had been published on the sediment distribution in Swansea Bay, the only information available being contained in the hydrographic charts of the area. C M G Vivian (1973) collected 48 grab samples mainly in the northern part of the bay. In 1975, N Johnson analysed some of the samples collected by HMS Woodlark during the previous year's survey work. This information, together with some additional data, was then brought together by M B Collins and G Ferentinos in the first sediment distribution map of the northern part of Swansea Bay. The report, entitled "Sediment transport through the area south of Eastern Gower as related to the sediment budget of Swansea Bay" (April, 1976) was the first Interim Report under a contract placed by the Institute of Oceanographic Sciences with the Department of Oceanography, University College of Swansea. S R Turner, 1976, also covered the area in her PhD thesis "Some aspects of sedimentary bodies in part of the Bristol Channel". A more recent sediment map can be found in the second of the series of Interim Reports (1977), the original map having been enlarged to cover an area extending in a westerly direction from Nash Point to off Oxwich Bay.

As most of the above data have only recently become available, a detailed surface sediment map (Fig 4) had to be produced independently, using information gained from box-core, vibrocore and grab samples, and augmented with sidescan sonar and continuous profiling records. Fig 5 shows a grain size distribution map of the sea bed sediments in phi(∅) units (Fig 6) where $\emptyset = -\log_2$ diameter in mm. Due to the inconsistency in sediment distribution overall and the different sampling techniques used it was felt that little was to be gained by an attempt at detailed statistical analyses of the seived sample data.

The following descriptions are based on information obtained from the various sampling and surveying techniques employed during the project. Some repetition is virtually impossible.

2.1 The Banks and other sand areas

2.1.1 Offshore: The banks themselves and most of the intervening area from just south of the North Kenfig Patches to Scarweather Sands are covered by pale brown fine sands. The sand spreads continue east and west from Scarweather with the shell content increasing in an easterly direction.

Because of periods of bad weather during the cruises no box-coring or vibrocoring samples could be taken in the Scarweather Sands area. S Turner found that, on the whole, the sands in this area were exceptionally well sorted with the mean grain size increasing slightly from 2.5∅ to 2.0∅ on moving from the southwest to the central part of the bank. (For relationship of phi-scale to other size classifications see Figure 6). Box-cores (BC) 39 and 40, taken close to the Shord Channel, showed over 30 cm of brown well-sorted fine sands with indistinct laminations, the surface having a mean grain size of 2.4∅. Further north on Hugo Bank similar grain size material was encountered. IOS surveys found over 2m of medium to fine sand with occasional shell fragments and granules to the west of Hugo Bank (Vibrocore (VC) 19). On Kenfig Patches itself the sand appeared to be somewhat coarser, BC13 having 30 cm of, again, well-sorted sand but with a mean grain size of 2.1∅. Immediately to the south, VC 17 contained a core of nearly 2m of laminated medium to fine sand. Here the mean grain size of surface material was 1.8∅ becoming slightly finer with depth. Northwest of the South Kenfig Patches, BC's 12 and 11 showed steeply dipping cross bedding inclined up to 35^{o} from the horizontal. There was also more variation in sediment type with depth. Towards the northwestern extremity of the main sand area the surface sand cover was only a little over 1cm thick, overlying some 30 cm of silty clay. Most samples taken between the banks and to the east of

Hugo Bank and Scarweather Sands indicated that the sea bed in these areas was composed of coarse shelly sands with a proportion of granule size or coarser material. However, sidescan records suggest that parts of the areas between the banks are nearly or completely devoid of sandy material. Unsuccessful grab sampling in some of these areas supported this observation.

The sand spread to the west of Scarweather narrowed and continued out of the immediate research area. G Ferentinos (Collins and Ferentinos, 1977) has traced this sand spread further to the west and suggested that it forms the northern boundary of a much larger westward moving sand stream in the Bristol Channel.

Another large surface expanse of sand was found north and south of the Outer Green Grounds area. To the north the sand thickened from 10cm in VC14, to 40cm in VC15 and over 60cm in VC16. VC14 may have reflected the nearness to the disused spoil ground just south of Swansea Docks with 30cm of grey clay/silts below the sand cover. The other two VCs showed a mixture of medium to fine sand with some shells and clay pellets with depth. On the southern side of the Outer Green Grounds a similar thinning of the sand cover was also found. This could be seen in BCs 6, 35 and 34 where the brown shelly sand decreased in thickness from 16cm to 10cm to 3cm. In each case the underlying surface was an irregular dark grey clay surface with pebbles.

2.1.2 The beach: Initially, in December 1974, the foreshore zone between Witford Point and just north of Porthcawl was closely sampled at positions corresponding to high water (HW), mid water (MW) and low water (LW) levels. These samples were brought back to the laboratory where the sand fraction was sieved at $\frac{1}{4}\phi$ intervals. Eleven sections were subsequently established (Fig 1) over the 12km stretch covering Aberafan Beach, Margam Beach and Kenfig Beach (Topic Report 2, Section 1.3.2) and sampled at HW, MW and LW on alternate months during the survey period. The initial analysis showed that the variation in size of the sand fraction of the beach material obtained was very small, so that only October and December 1975, and February, April and August 1976 samples were sieved. The mean and standard deviations can be seen in Table 1 and Figure 7. From Figure 7 it can be seen that finer sandy material was always at low water mark. The concentration of fine material on Aberafan Beach may be due to the close proximity of the River Neath. The MW samples were coarser than the HW samples on Aberafan and Margam Beaches but this situation was reversed for the last three sections, V, X and Z on the Kenfig Beach. This may be explained by the fact that samples collected at high water on the Aberafan and

Margam beaches tend to contain a higher proportion of fine wind-blown sand. This theory is supported when the sorting coefficients are compared, the material in the Aberafan and Margam HW samples being better sorted than any of the others.

Along the foreshore there was a tendency for the material to become finer towards the centre of Aberafan Beach, where the finest had a mean grain size of 2.9ϕ; towards the River Kenfig, and towards Sker Point.

2.2 Gravels

The sampling of the area immediately to the south of Scarweather Sands was difficult. Either no samples were obtained after repeated attempts or occasionally large cobbles, covered with epifaunal growth, were collected. Some of the cobbles obtained from the west of the bank had a light grey clay, possibly of Pleistocene or Flandrian age, adhering to them. According to S Turner (1976) this coarse type of sediment extended down to the Nash Sands with only a few small isolated patches of finer sediments.

The other areas devoid of recent sands and clays were the topographically high regions of the North Kenfig Patches and the Outer Green Grounds. Both areas are thought to be partly glacial in origin and in the former the grab samples contained angular/subangular pebbles and cobbles up to 10cm in length.

The size of the gravels and the covering of epifaunal growth on some of them indicates that they are unlikely to be moved under the present tidal and most wave conditions. Their distribution seems closely linked with the underlying till deposits and suggests that they may have originated from erosion of these deposits when the sea was at a lower level. The finer material would have been removed leaving a protective layer of gravel over the remaining glacial spreads.

2.3 Mud and clay

The initial grab sampling showed that a vast area of very fine silts, clays and sands exists in the central part of the Bay, stretching from the Port Talbot tidal harbour in the north to the area of sand and gravel north of the Scarweather Sands. The topographic highs of the Outer Green Grounds and the North Kenfig Patches results in a narrowing of the area covered by the fine deposits in this region.

Nearly all the box-core samples close inshore between the Port Talbot tidal harbour and the North Kenfig Patches were of at least 30 cm thickness and of a transitional type, between the fine to medium sands of the foreshore and the silts of the central Bay area. In VC12 similar sediments with bands of much coarser shelly sands reached a thickness of 1.73m, below which depth lay laminated silts and clays. The site of VC1 is of interest as 11cm of fine sand overlay grey clays of possible Flandrian age. Both offshore and towards the tidal harbour the sand content of the cores decreased and was replaced by clays and silts, sometimes laminated. Maximum thicknesses of cohesive sediments were obtained in VC3 and VC11 where thicknesses of 73cm and 79cm respectively of laminated silts and clays were noted. In each case the remainder of the core below was composed of at least 2.5m of medium to fine sand with occasional silts. BCs 1, 3, 4, and 22, taken in this area of cohesive sediments around the dredged channel, show that the top 3cm or so werecomposed of a very soft brown glutinous clay. BC3 was of particular interest as it showed a repeated sequence of sedimentation. Each unit was approximately 5cm thick beginning with a sandy silt and grading up into a clay. On the far side of the tidal harbour the silts and clays thin out again in a northward direction, being 25cm thick in VC4 but only 3cm in VC24.

In the narrow central region there is a greater proportion of fine sand, although the sediments are again mainly silts and clays. Within this region an area of 1 km^2 was sampled every 200m with the box-corer. It was intended to study both the degree of local variability of sediment in this apparently uniform area, and the internal structure of each core. The sequence of sedimentation varied so much from box-core to box-core that any correlation from one to another proved impossible. This reflected the considerable degree of variability in detail within the area as a whole. The central grid area was composed of laminated silts and clays with a very thin patchy surface covering of sand. On the northeastern and southwestern boundaries these silts and clays were covered with fine shelly sand up to 15cm thick. This sand cover thinned in a south-easterly direction and overlaid the irregular laminated silts and clays. At a depth of 10 to 12 cm some of the finer sands showed cross bedding whilst many of the clay zones contained infilled burrows.

Further south still, away from the grid, the silt and clay content increased. In VC7 the top 26cm was made up of soft greyish brown silts and clays underlain by coarse shelly sand. The thickness of silt and clay was at least 40cm in BC8 with the top couple of centimetres a glutinous brown clay very similar to those encountered around the tidal harbour.

Most of the vibrocores taken northwest of the sandbanks contained clay pellets and larger clay fragments up to 3.0cm in length. They varied in shape between rounded small pellets and angular fragments to large flat plates. Their occurrence was most noticeable in those parts of the core that contain high concentrations of broken shell fragments and other coarse material though they could occur sparingly in other types of sediments but were usually absent from cores containing deposits of more uniform sand. It is thought that these pellets originated from the erosional products of clays formerly exposed on the sea floor, the larger fragments being moved under storm conditions.

2.4 Remaining areas of mixed sediments

Immediately to the west and the southeast of the North Kenfig Patches, a spread of mixed sediment types occurs, being composed of silts, sands, pebbles and cobbles. The sidescan records indicate that there were some larger, more uniform areas of finer material running at right angles to the shore opposite the mouth of the River Kenfig. BC28 from this area contained over 20cm of fine brown clays and sands, with a surface mean grain size of 2.8ϕ.

3. SEA BED FEATURES

3.1 Sandbanks

The surface expression of these banks can be seen in the continuous seismic profiling (CSP) records. Four traverses of Scarweather were made (Fig 8). Traverses A and B crossed the wide western end of the bank and shows the bank to be roughly symmetrical in this area. Further east (Traverse C) the bank becomes narrower and asymmetrical with a steeply sloping south face. Further east again (Traverse D) the angle of this steep face lessens somewhat. The whole bank appears to be sitting on a flat surface possibly of Pleistocene or Flandrian sediment. Just to the south of Scarweather a large channel-type feature, approximately 600m wide, has been cut in the southern extremity of this platform. The ledge between the bank and this depression is about 700m wide in the central part but narrows to the east and is not detected at all in the extreme west. Although the ledge could not be identified in this area it may be hidden under the western edge of the sand. S Turner (1976) suggested that this step feature was erosional in origin and represented a cutting back of the Pleistocene deposits by the present day pattern of tidal currents. The changes in the outline of the Scarweather Sands between 1859 and 1974 lend support to this view.

The Shord Channel separates the Hugo Bank from the Scarweather Sands. Traverse E (Fig 9) shows the Bank is overlying layered sediments in the south and possibly Boulder Clay in the north. The north face of the bank is steeper than the south, the south face being a much gentler feature.

Further north is the more diffuse South Kenfig Patches. Traverse F (Fig 9) crosses the symmetrical eastern end. Unlike the other two banks a Boulder Clay outcrop on the northern side of the Patches was noted and may have had an influence on the siting of the Bank.

3.2 Sandwaves

From the side scan sonar it was noted that the flanks of the Scarweather Sands, most of Hugo Bank, and a large portion of the Shord Channel are covered with megaripples. Larger sandwaves appeared on the CSP records on the north and south limbs (Fig 10) (Traverse G) of the Kenfig Patches (heights 4.5 m and 2 m respectively); to the east and west of Hugo Bank (heights 1 m and 4.5 m respectively); east of Scarweather (height 2 m) and just southwest of Hutchwns Point (Fig 10) (Traverse H) up to a height of 8 m. If it is assumed that the steeper slope of asymmetrical sandwaves reflect the dominant current direction and therefore sediment movement, only those sandwaves on south Kenfig Patches and possibly those to the west of Hugo Bank showed a preferred orientation. Those on the north flank of South Kenfig Patches indicated southeasterly movement of sediment whilst those on the southern limb a northwesterly movement, thus suggesting a possible closed circulation within the bank itself. S Turner (1976) also noted the sandwaves southwest of Hutchwns Point and thought that they showed a southeasterly direction of transport.

G Ferentinos and M B Collins, (Second Interim Report to IOS Taunton) found sand waves south of the Scarweather Bank with heights of 5 - 7 m. Here the steep faces of the sandwaves were orientated towards the west.

4. THE SUBSURFACE GEOLOGY INCLUDING ESTIMATED THICKNESSES OF SEDIMENTS

The subsurface geology was investigated using the techniques already described. The evidence confirms a complex evolutionary history as a response to the detailed solid geology, glacial erosion and deposition, and sea level oscillations. The CSP records show the major geological boundaries above the bedrock and these have been interpreted after discussion (C R Price, personal communication). The list below summarises the succession of sediments as seen in the records.

Holocene	Most 'recent'	including sandbanks, dredged spoil, etc.
	Flandrian	peats, clay, silts, sand and gravel

Pleistocene	Outwash sediments	associated with buried channels and glacial deposits
	Glacial tills and (?)morainic deposits	
Pre-Pleistocene	Bedrock	

In all cases only the most recent deposits and possibly some of the Flandrian clays were penetrated by the box-corer and vibrocorer. Areas most likely to have glacial deposits at or near the surface had to be avoided so as not to damage the equipment.

4.1 Bedrock morphology

As indicated in Section 2.1.1 of Topic Report 1, bedrock onshore is situated at -8.5 m OD (Ordnance Datum, Newlyn, which is approximately mean sea level) in the east of Kenfig Burrows (Appendix 4); between -13 and -22m OD in the Margam area, and between -25 and -30 m OD in the Port Talbot district, with recent unconsolidated material above that level. Over most of the Bay bedrock was also mantled with a substantial thickness of glacial material and more recent sediments. This effectively masked the bedrock on the CSP records and resulted in it only being identified tentatively in a few places. The profiling and sidescan sonar records suggest that the 'high' area east of South Kenfig Patches may possibly be an isolated bedrock outcrop. A Triassic conglomerate is already exposed on the foreshore at low water adjacent to this area. Bedrock was also detected further south at about -20 m OD to the east of South Kenfig Patches and at a similar depth towards the east end of the Shord Channel. Bedrock also occurs at a similar depth towards the south of Nash Sands (S Turner 1976).

A thinning of the sediment cover in an area lying between and to the west of the Hugo Bank and Kenfig Patches revealed bedrock there to be at -27 m OD approx. This depth is again recorded just south of the Scarweather Sands. Further to the west of the research area in the northern part of Swansea Bay the bedrock has been eroded into a series of basins reaching depths of -80 m OD with intervening rock bars at -50 m to -60 m OD (R Al-Saadi and M Brooks 1973).

In sum, although only limited information is available regarding bedrock depth it suggests that over much of the area the surface slopes gently from the east to the southwest, ie with an orientation comparable to the present-day sea bed.

4.2 Pleistocene Deposits

Above the bedrock lie the glacial drift deposits. These deposits have been sampled by Evans (1973) and have been described as poorly sorted,pebbly and sandy reddish-brown and grey clays. In the few places where the base of the drift can be detected its thickness appears to be about 6 m. It is likely to be much thicker than this in other places and two boreholes drilled by IGS from MV Whitethorn to the west of the area indicate thicknesses ranging from 8 to 18 m. Figure 11 shows the surface or near-surface extent of these glacial deposits. In the North Kenfig Patches area the CSP records showed remnants of glacial drift exposed on the sea bed. The core of this topographically high area may possibly be bedrock and the drift just a mantle cover however.

To the southeast of the area towards Nash Sands these Pleistocene deposits are relatively thin, being of the order of up to 2 m thick (S Turner 1976).

4.3 Buried channels and associated deposits

Large areas of the irregular Pleistocene surface have been eroded into numerous buried channels ranging from shallow depressionsto channels 4 m to 5 m deep and 400 m wide. The areas in which the buried channels can be detected are also shown in Figure 11. The extent to which buried channels exist under the banks is not known. These channels were subsequently infilled in stages, but the date of such infill is in doubt. This can be seen just south of the North Kenfig Patches (Fig 12) where a succession of horizontal layers of infill 2 to 3 metres thick rest on the irregular Pleistocene surface.

4.4 Holocene deposits including sandbanks

With the rise in sea level associated with the Flandrian transgression a wide range of sediment was deposited over the undulating drift surface. Peat, clays and sandy clays can be seen exposed on the beaches between Port Talbot and Sker Point at the present time although no peat deposits were encountered in any of the box-core or vibrocore samples collected during the research programme.

S Culver (1976) has shown that the Flandrian and post-Flandrian pattern of sedimentation indicates an initial shallowing of water probably caused by an accumulation of sediment and then a migration landward of the inter-tidal environment. The sediments associated with this environment occur widely in the Bay today either on the surface or just below it. The absence of, or in some cases similar nature of,the most recent sediments to the underlying Flandrian deposits make it very difficult to distinguish between the two when using CSP methods. However, the sandbanks (see below) provide a notable exception to this observation. Assuming that most of the material above the Boulder Clay is of Holocene age these deposits would have a thickness of 2 m to 5 m in the west of the Shord Channel, thickening up to 6 m to 8 m in the central part of the Channel. Further north, the sediments are likely to be some 5 m to 10 m thick. In VC1 just south of the entrance to the Port Talbot tidal harbour over 4 m of silts and clays were encountered under 11 cm of fine sand. This is by far the greatest thickness of silts and clays obtained and comes from an area where S Culver (1976) identified Flandrian deposits at the surface. Thicknesses of nearly 4 m were also measured in the area offshore from the River Kenfig.

After the end of the Flandrian stage when the sea level began to stabilise a large area of Boulder Clay, buried channel infill deposits and Flandrian sediments were left to be eroded by both wave and tidal current action. According to S Culver (1976) the conditions then were very similar to those which prevail in the Bay today. Large quantities of sand were available and went towards the formation of various sandbanks in the area.

The CSP records depict only minor structures within the banks so, assuming that each bank rests on a flat surface, it is possible to determine the corresponding thickness. Maximum thicknesses of 8 m for Kenfig Patches and Hugo Bank and possibly 12 m for Scarweather are obtained (see isopachyte map, Figure 13). The only evidence for the composition of the banks is from vibrocore 17 on Kenfig Patches, where 2 m of fine to medium slightly laminated sand was found. There is no reason to believe that the other banks are very different nor that they vary with depth.

The other main area showing a thickness of recent sediments, stretches from the tidal harbour in the north, passes between the North Kenfig Patches and the Outer Green Grounds and terminates north of the Scarweather Sands. Even here most of the vibrocores penetrated medium to fine sand after initially passing through a fine sediment layer. The age relationship between this fine sediment layer and the underlying sand is not known at the moment. VC14 contained over 2.5 m of medium to fine laminated sands 1.2 m below the sea bed. It was noted that in many of the cores taken in an area to the southwest of the tidal harbour there is a distinctive junction between the overlying fine muds and the underlying sands. This resulted in a band of whole or fragmented shells with some sand and clay pellets usually about 10 - 15 cms thick but sometimes as much as 30 cm. The maximum thickness of this surface layer of fine sediment recorded in any of the vibrocores is almost 80 cm.

Commander George Alldridge collected bottom sediment samples during the Hydrographic Survey of 1859 for the area between Neath and Porthcawl. When the boundary of the area which he had called 'mud' was encircled it was found to agree very closely with the present day distribution. This indicated that for at least a century fine grained sediment has been present on the surface in this area.

Section 5.3 of Topic Report 1 showed that, between 1967 and 1969 alone approximately 11.2 x 10^6 tonnes of capital dredging material from Port Talbot tidal harbour was deposited at a spoil ground off Mumbles Head. Furthermore at the present time over $\frac{2}{3}$ of a million tonnes of fine spoil is being dredged annually from Port Talbot and Swansea together. These data would imply either that the thickness of silt and fine clay had increased since the 1859 survey although the absolute boundaries had not or that the net movement of fine particles was outside the Bay.

5. CONCLUSIONS

Although the bedrock was mantled with a substantial thickness of superficial material, the CSP records indicated a surface with a gentle slope to the south-west. Upon this surface glacial drift of varying thickness has been deposited. Some of the present day topographic features, such as the North Kenfig Patches and the Outer Green Grounds, largely owe their existence to the surface expression of these deposits.

Channels cut in the drift surface and bedrock appear to have been infilled, probably with outwash material. This is shown locally as successive layers, 2 to 3 metres thick. The rise in sea level associated with the Flandrian transgression followed and resulted in the deposition of a wide variety of sediments in a mantle up to 10 m thick.

Later, conditions similar to those which exist today were established and resulted in the formation of South Kenfig Patches, Hugo Bank and Scarweather Sands. All three are resting on a flat Pleistocene or Flandrian surface. The first two banks are approximately 8 m thick whilst Scarweather Sands is in the region of 12 m. Their present-day position seems to be a response to the hydrodynamics acting on the sediments in this area, although existence of a Boulder Clay outcrop to the north of the South Kenfig Patches may have some effect on this particular bank's position. The banks themselves are composed of, and in general surrounded by, fine to medium sands mostly between 2 to 2.5Ø. However, the channels between the banks are floored with a much coarser material, reminiscent of the cobble lag deposits found on parts of Kenfig Beach. Brown shelly sand was also found in the vicinity of the Outer Green Grounds overlying Boulder Clay and thickening away from the Grounds in a northerly and southerly direction.

A large central area of very fine sediment up to 80 cm thick occurs in a natural depression lying between the North Kenfig Patches and the Outer Green Grounds. In many of the vibrocores the junction between the fine silts and clay and the underlying sands was very distinctive being a layer of fragmented shells and sand and clay pellets up to 30 cm thick. The boundary of the mud mapped by Commander Alldridge in 1859 is very similar to the area occupied by the present day fine sediment, but its thickness is thought to be greater now due to the deposition of dredging spoil. It is hoped to determine the age and rate of deposition of this material by using a radioactive isotope of Pb^{210}. Over the remaining areas where the Pleistocene tills were at or near the surface the sediment is much coarser.

Sand waves were detected on the limbs of the South Kenfig Patches, east and west of Hugo Bank, east of Scarweather Sands and southwest of Hutchwns Point. Where the waves were asymmetrical, those on the north flank of South Kenfig Patches and those off Hutchwns Point indicated movement of material in a southeasterly direction whilst those on the southern limb of South Kenfig Patches indicated tramsport in a northwesterly direction.

The sands of Aberafan, Margam and Kenfig beaches were sampled at HW, MW and LW on a number of occasions along the lines of the topographical survey sections. Normal to the beach the finest material was always found at LW while alongshore the material tended to become finer towards the centre of Aberafan Beach, towards the River Kenfig and again towards Sker Point.

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TABLE 1 Mean grain size and standard deviation in Ø units for samples collected along the eleven survey sections on Aberafan, Margam and Kenfig beaches at HW, MW and LW. (n = 6) For location see Figure 1.

Section	HW		MW		LW	
	Mean Ø	Std Dev	Mean Ø	Std Dev	Mean Ø	Std Dev
C	2.12	0.44	2.09	0.70	2.53	0.89
E	2.26	0.29	2.16	0.47	2.89	0.52
G	2.08	0.32	1.97	0.44	2.52	0.70
L	2.05	0.38	1.76	0.73	2.38	0.62
N	2.03	0.46	1.98	0.58	2.04	0.61
P	2.19	0.40	2.07	0.45	2.22	0.58
R	2.25	0.42	2.25	0.53	2.31	0.70
T	2.00	0.39	1.85	0.72	2.20	0.67
V	1.61	0.74	1.74	0.86	2.26	0.84
X	2.02	0.58	2.05	0.76	2.32	0.58
Z	2.00	0.69	2.14	1.00	2.50	0.69

APPENDIX 1

Decca positions of grab sampling sites

Date Collected	Sample No	Position (Decca)	
		Red	Purple
16.5.75	1	40.55	71.10
	2	39.50	73.62
	3	39.53	71.58
	4	38.65	73.72
	5	39.00	72.00
	6	38.22	72.52
	7	38.45	72.30
	8	38.64	69.53
	9	37.49	72.78
	10	39.15	66.40
	11	37.90	69.70
	12	37.40	71.20
	13	37.10	73.00
	14	38.70	64.70
	15	38.35	66.92
	16	36.80	72.00
	17	37.70	66.69
	18	36.68	36.70
	19	36.21	71.59
	20	35.30	70.98
	21	35.19	72.00
	22	34.80	72.05
	23	34.62	71.07
	24	35.96	77.15
	25	35.20	65.80
	26	37.23	64.82
	27	37.20	61.45
	28	38.14	63.51
	29	38.70	62.68
	30	38.47	58.30
	31	40.10	56.00
	33	39.70	63.16
	34	41.60	65.75
	35	40.15	69.20
	36	42.81	68.61
	37	41.80	71.04
	38	40.65	74.03

		Red	Purple
14.2.76	1	41.24	56.00
(Collected in conjunction	2	41.15	53.45
with box-coring	3	39.35	55.28
programme)	4	35.72	64.29
	5	35.26	69.00
	6	34.69	71.00
	7	36.11	71.49
	8	36.71	65.83
	9	37.75	64.15
	10	38.45	62.64
Feb 1976			
(Collected by University	320	42.18	64.30
College Swansea for	321	41.10	64.12
IOS)	325	41.30	61.90
	326	41.60	62.80
	327	42.15	61.80
	328	42.10	58.20
	351	42.80	56.20
	353	42.92	60.00
	354	43.70	58.00
	386	44.00	56.20

APPENDIX 2

HiFix positions and length of box-cores recovered. Where the nature of the sediment resulted in most of the box-core sample being lost, the word 'Sample' has been written.

Date Collected	Box No	Position	(HiFix)	Length of core retrieved cm
6.4.76	1	74.00	86.00	40
7.4.76	2	72.00	107.50	40
	3	63.40	95.80	40
	4	60.25	90.00	40
8.4.76	5	118.00	110.50	20
	6	109.14	108.23	26
	7	97.95	115.42	30
	8	93.70	129.03	40
	9	83.09	136.91	30
	10	74.76	139.93	40
	11	74.94	157.67	23
	12	76.24	163.95	33
	13	72.10	170.71	30
	14	79.51	180.82	Sample
	15	75.82	184.45	"
	16	72.91	188.18	"
	17	79.80	173.86	22
	18	79.90	166.84	Sample
	19	86.63	158.11	23
10.4.76	20	82.13	65.65	38
	21	60.08	68.96	28
	22	43.57	80.57	20
	23	55.08	89.56	30
	24	61.12	100.73	30
	25	53.82	110.25	32
	26	55.90	133.48	
	26	56.28	132.59	16
	27	53.91	143.07	Sample
	28	57.41	164.12	20

Date Collected	Box No	Position (HiFix)		Length of core retrieved cms
5.6.76	1	84.12	112.83	30
	2	81.44	112.42	30
	3	79.53	111.96	Sample
8.6.76	4	60.24	130.08	12
	5	68.13	128.91	30
	6	75.74	127.91	16
	7	83.72	126.11	37
	8	80.81	116.19	30
	9	83.84	116.39	29
	10	86.56	116.08	Sample
	11	88.73	116.21	28
	12	58.49	181.33	20
	13	57.57	171.86	Sample
	14	56.45	158.52	26
	15	52.41	131.66	20
	16	51.25	122.50	30
	17	47.22	106.33	30
	18	45.45	96.01	30
	19	79.92	100.23	30
	20	82.50	99.78	30
	21	86.36	99.13	30
	22	90.00	99.44	30
	23	92.54	99.71	30
	24	64.02	104.26	20
	25	89.18	103.69	30
	26	85.78	104.21	22
	27	83.04	104.69	30
	28	80.18	104.31	30
	29	80.33	107.21	18
	30	139.32	69.67	Sample
	31	137.22	91.03	30
	32	91.01	107.91	30
	33	88.59	108.01	30
	34	86.01	107.83	30
	35	82.64	107.50	20
	36	80.44	107.71	18
	37	86.14	111.96	30

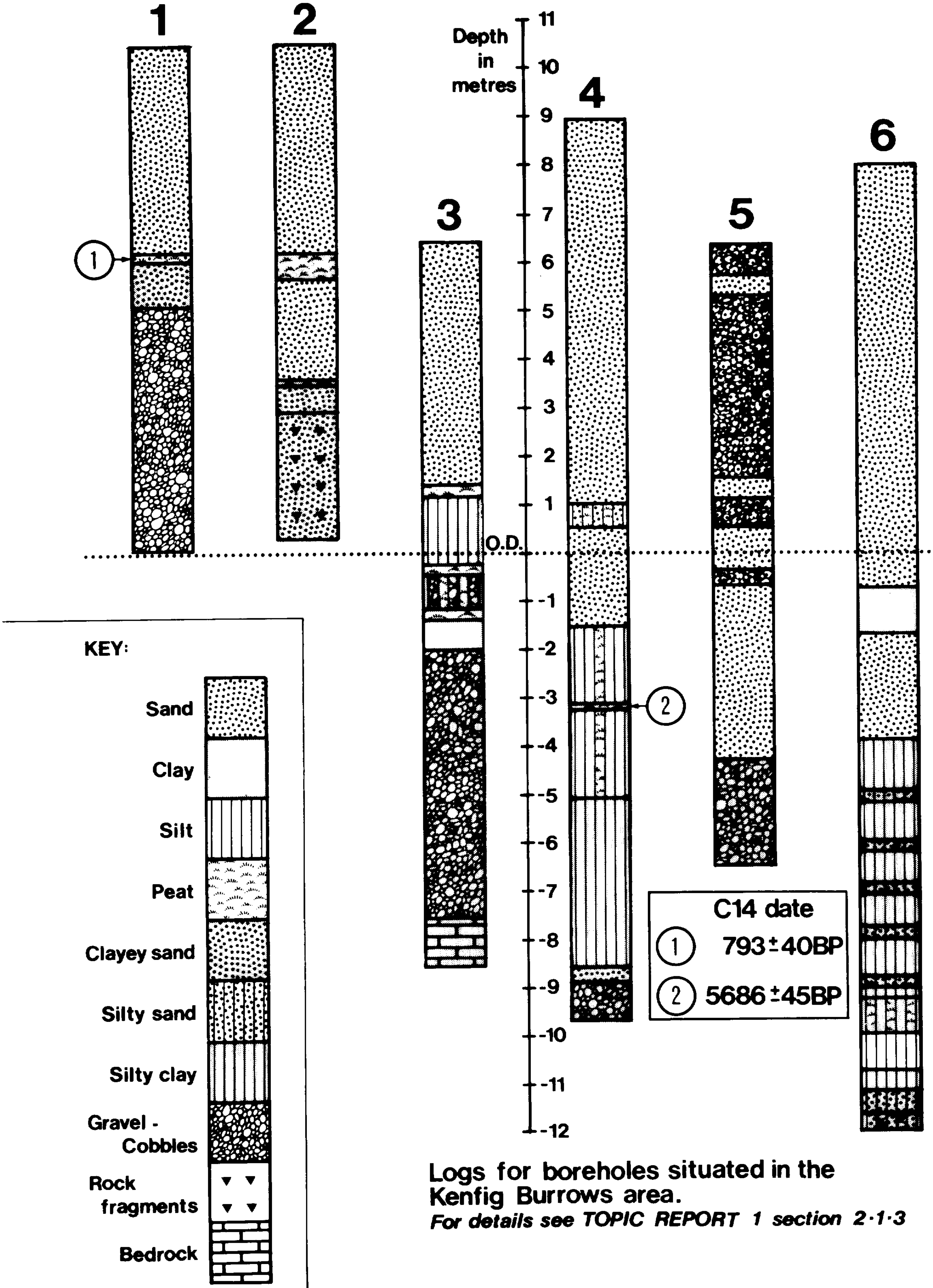
38	89.05	111.83	30
39	91.52	111.70	30
40	91.66	114.78	30

APPENDIX 3

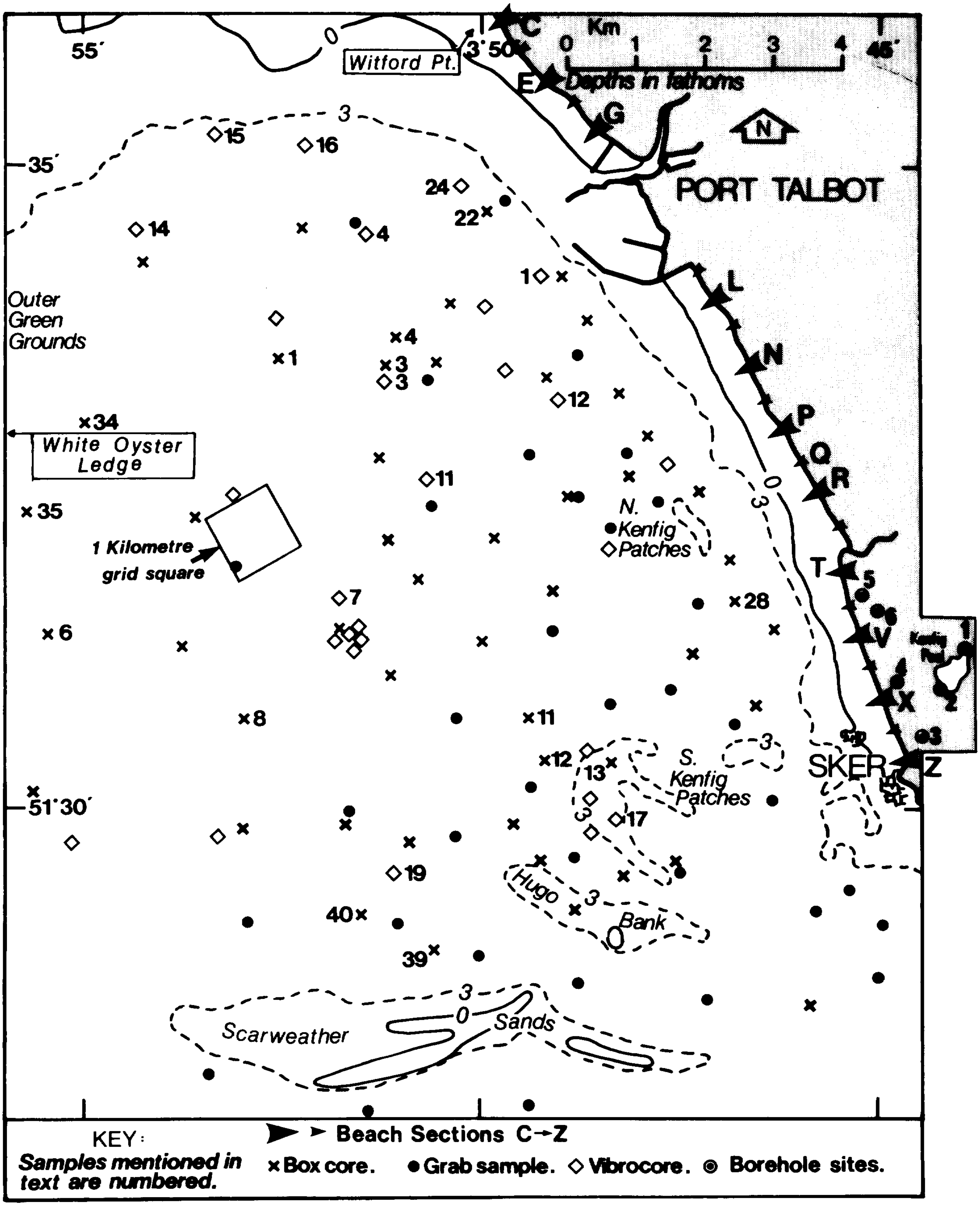
HiFix positions and length of vibrocores recovered. Cores marked * have had top metre removed and sent to Harwell for radioactive tracer analysis.

Date Collected	Core No	Position (HiFix)		Length of core retrieved (metres)
12.1.77	1	39.98	73.85	4.24
	2	40.00	72.13	0.99
	3	41.03	69.95	2.44
	4	41.60	71.58	3.46
	5	40.48	72.26	2.63
	6	42.07	68.69	2.04
16.1.77	7	40.66	66.07	1.40
	8	40.26	65.50	* 2.64
	9	40.35	65.73	* 2.96
17.1.77	10	40.30	69.40	0.72
18.1.77	11	40.40	69.40	3.35
19.1.77	12	39.50	72.78	3.69
	13	41.96	65.77	0.49
	14	43.72	67.24	3.93
	15	43.41	69.45	3.37
	16	42.48	71.26	2.89
23.3.77	17	37.55	68.18	1.91
	18	37.80	68.08	0.93
	19	39.14	63.20	2.04
	20	40.92	59.97	-
	21	42.23	56.77	1.31
	22	38.52	71.80	-
	23	38.40	73.97	3.70
	24	41.17	73.14	2.17
24.3.77	25	37.85	67.58	-
	26	38.04	68.28	0.49
	27	40.45	65.59	* 2.99
	28	40.39	65.71	1.25

30	63.06	165.71	No sample retrieved
30	63.41	166.14	Sample
31	67.79	142.00	"
32	77.37	120.90	"
33	90.85	103.72	23
34	99.64	82.75	30
35	43.75	61.39	25
36	44.50	59.05	Sample
37	42.25	57.25	"
38	34.97	69.23	"
39	38.42	62.59	30
40	39.19	61.76	25
41	39.68	63.00	20
42	40.57	60.42	Sample

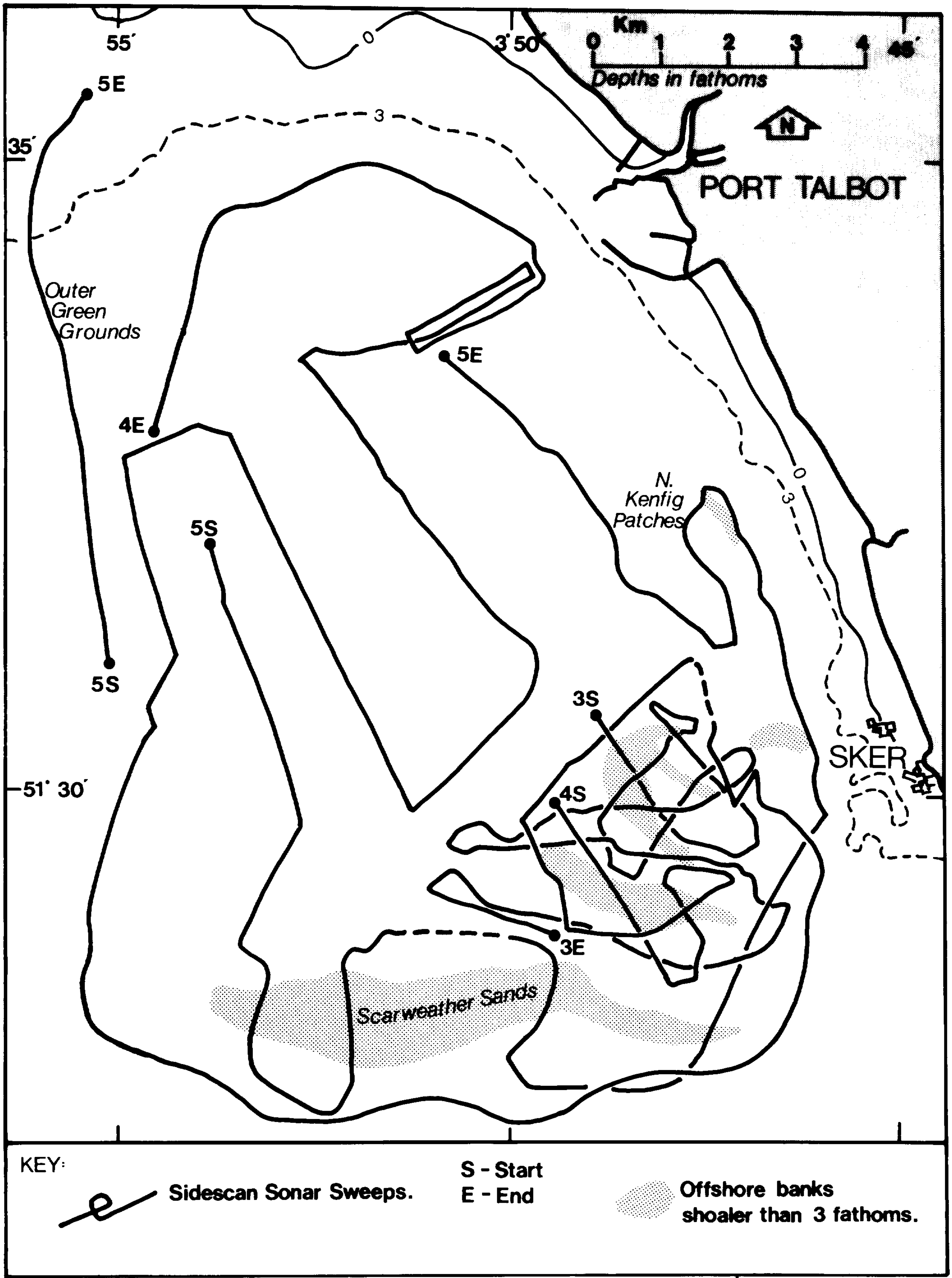


Logs for boreholes situated in the Kenfig Burrows area.
For details see TOPIC REPORT 1 section 2·1·3



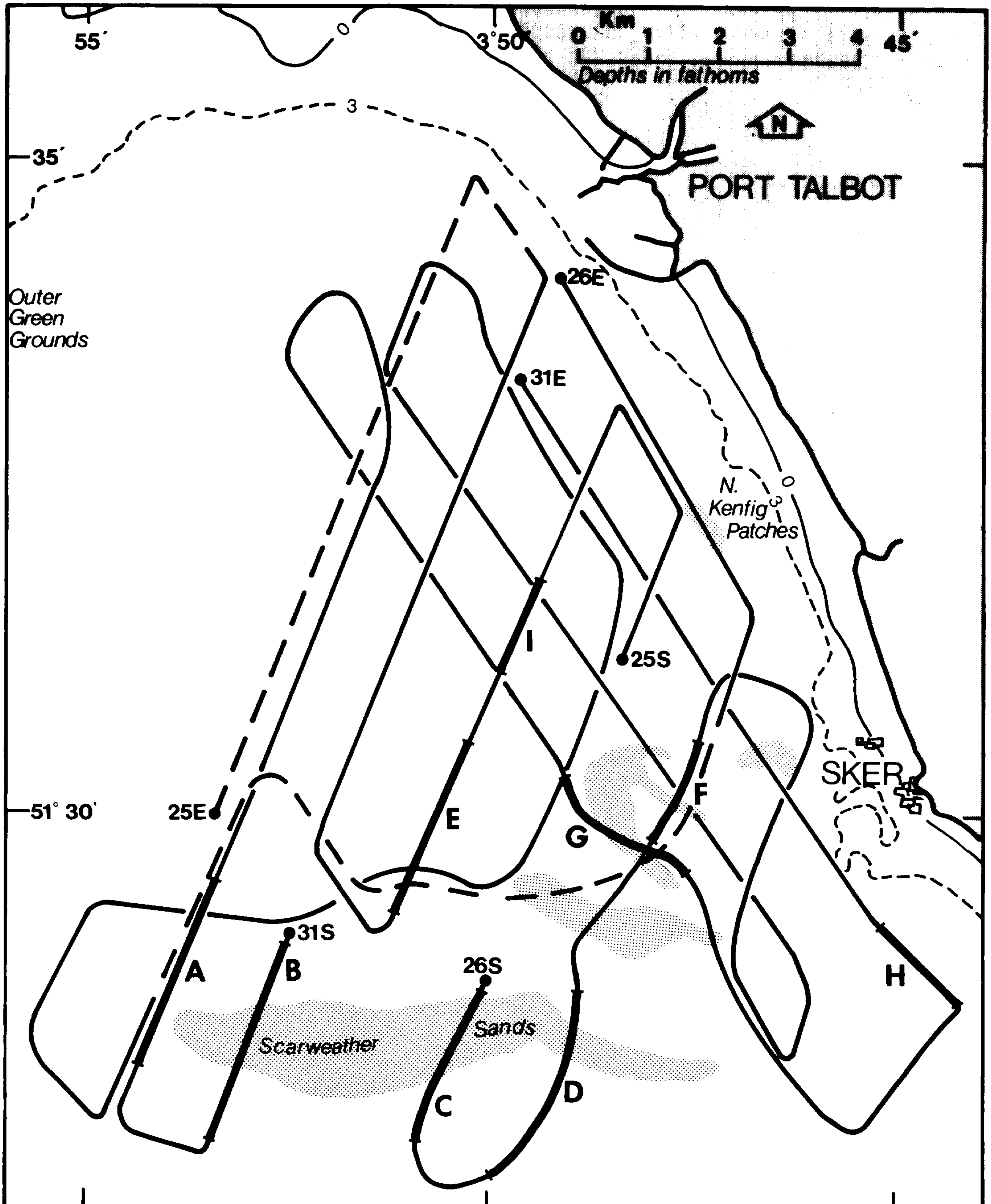
Site map showing location of Box core samples, Grab samples, Vibrocore samples and Borehole sites.

Fig.1



Sidescan Sonar survey, R.V. Edward Forbes cruise 6/76.

Fig. 2

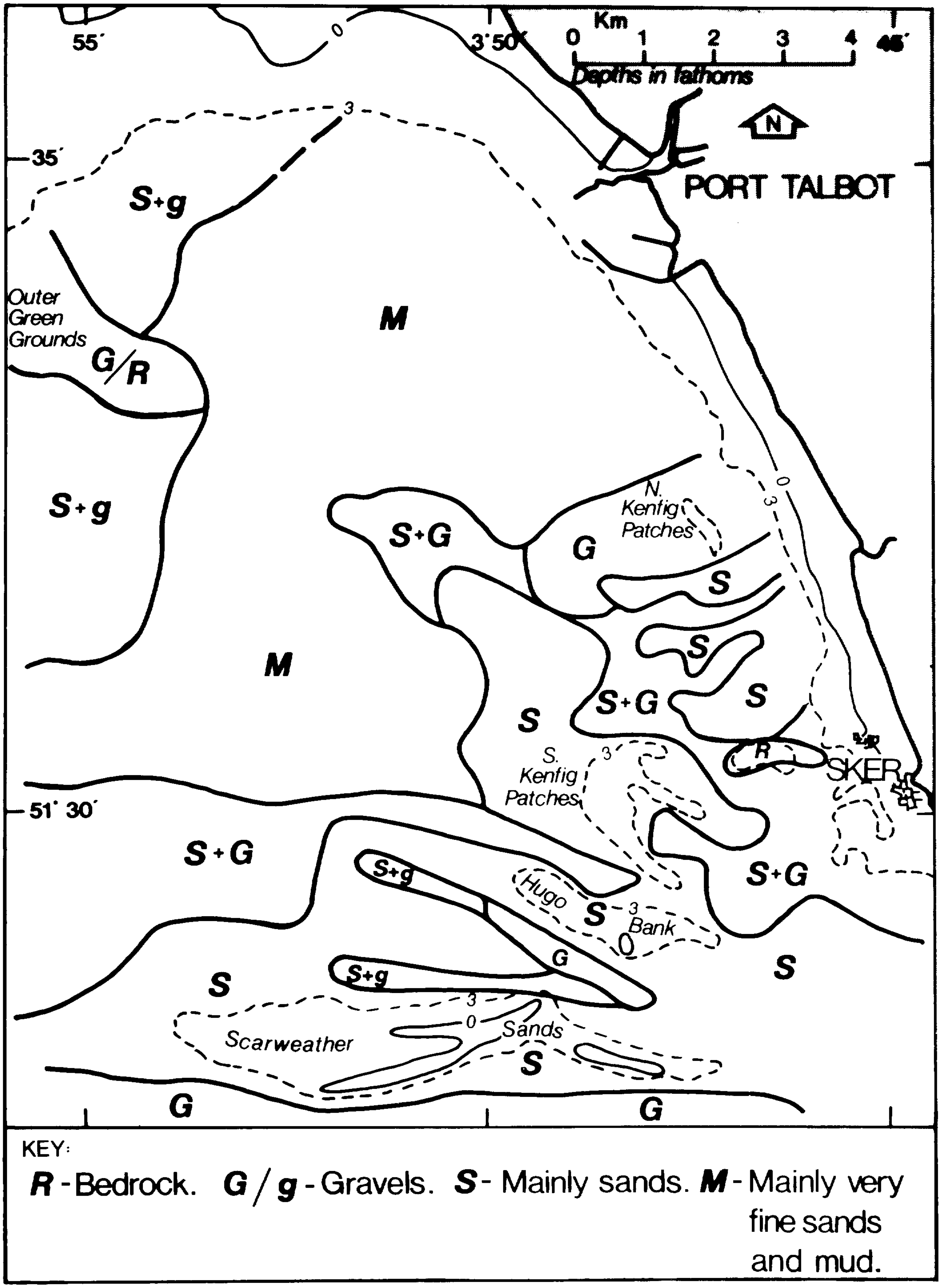


KEY:

——	Recording trace satisfactory.	S - Start	E - End
– – –	,, ,, poor.		Offshore banks shoaler than 3 fathoms.
A	Traverses A - I mentioned in text.		

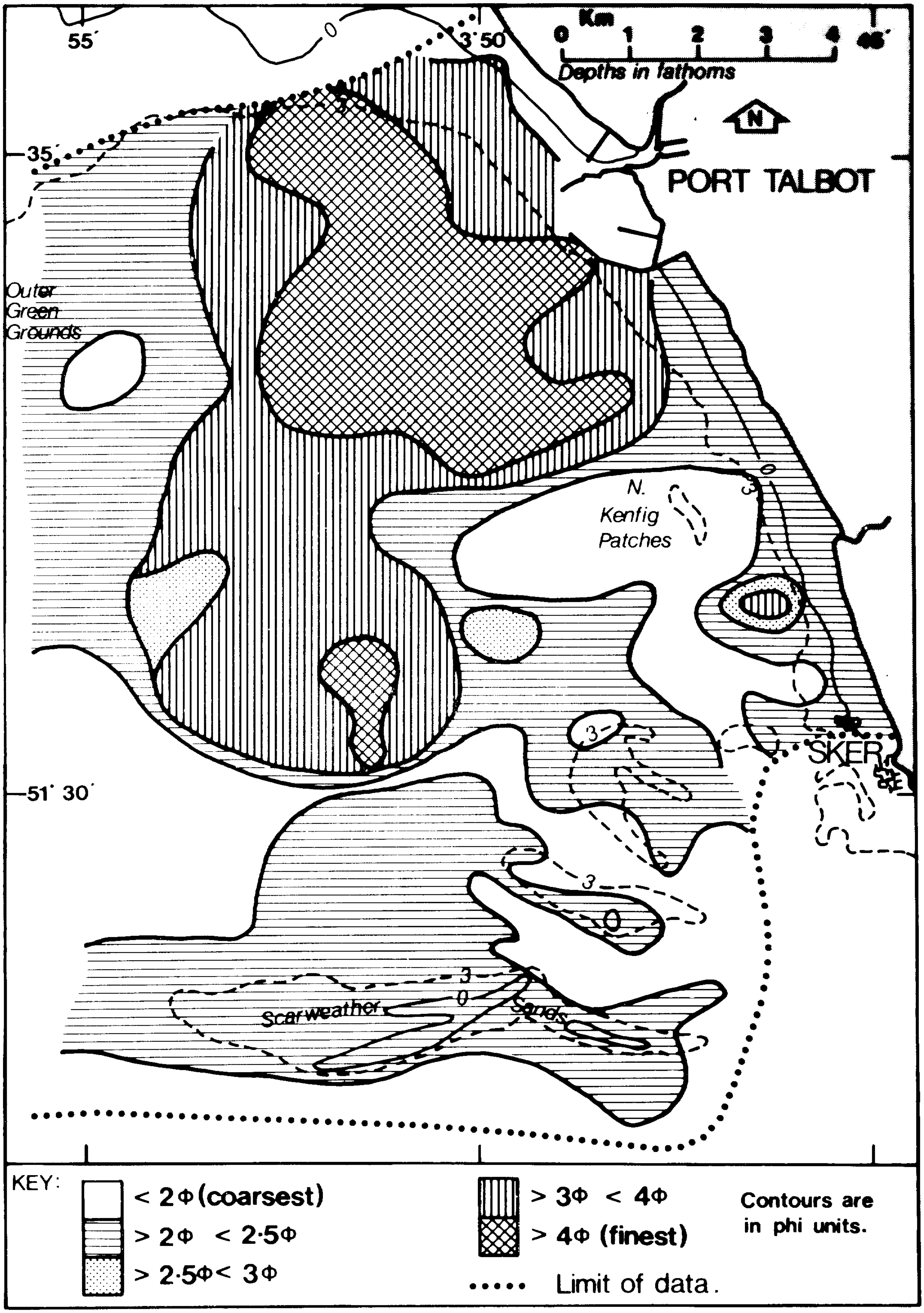
Continuous Seismic Profiling runs made on 25, 26 & 31 May 1975.

Fig. 3



Surface sediment distribution map of research area as determined from Box core, Grab and Vibrocore samples, also from Side scan sonar and Continuous seismic profiling records.

Fig. 4



Mean grain size distribution.

Fig. 5

Key
- **L** Large
- **S** Small
- **V** Very
- **C** Coarse
- **M** Medium
- **F** Fine

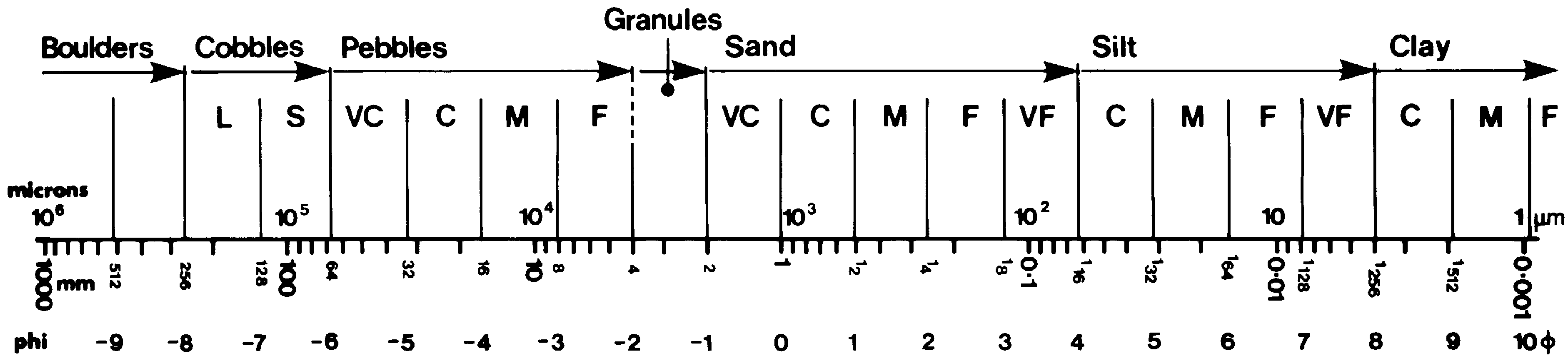
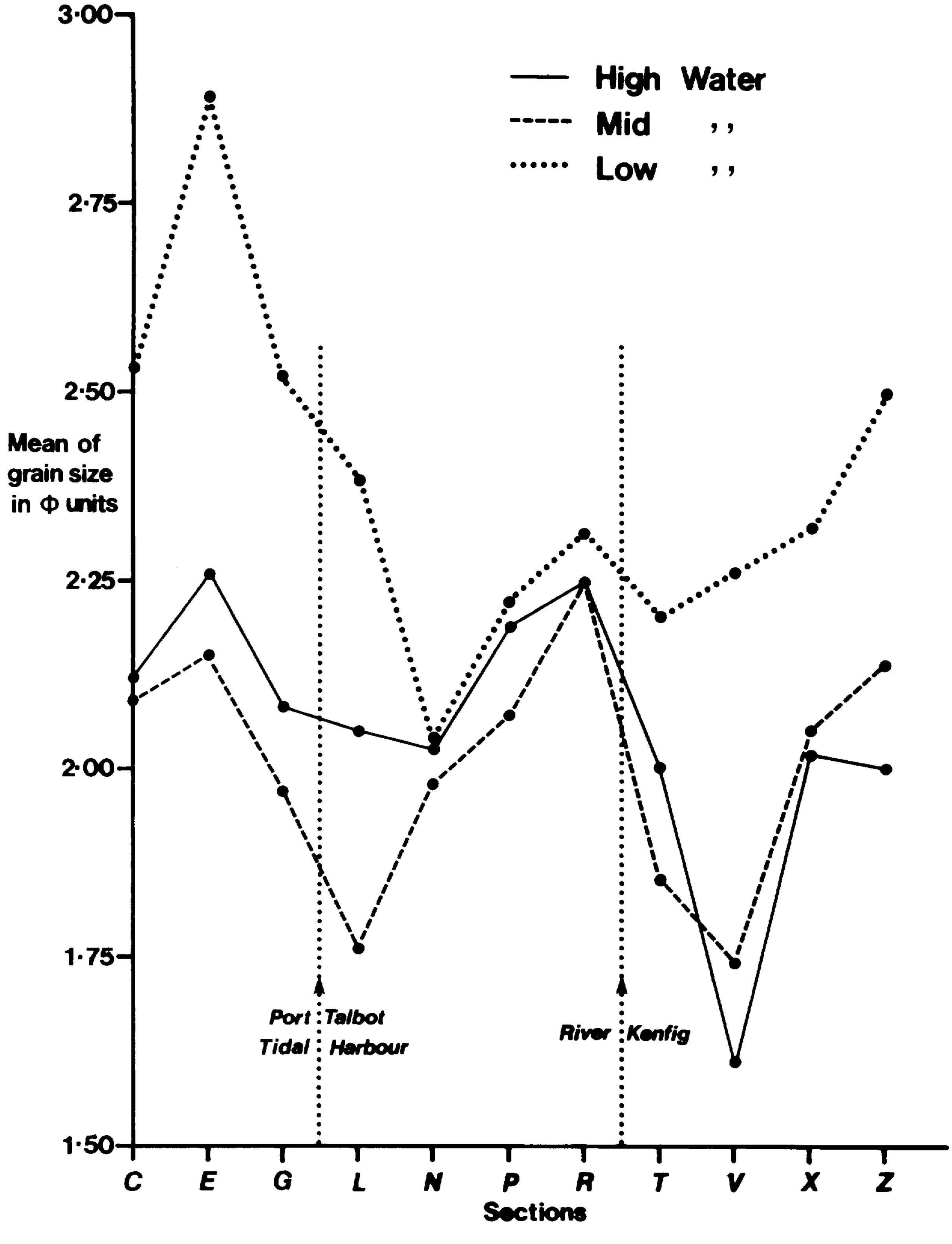


Fig. 6

Particle size grading terminology.

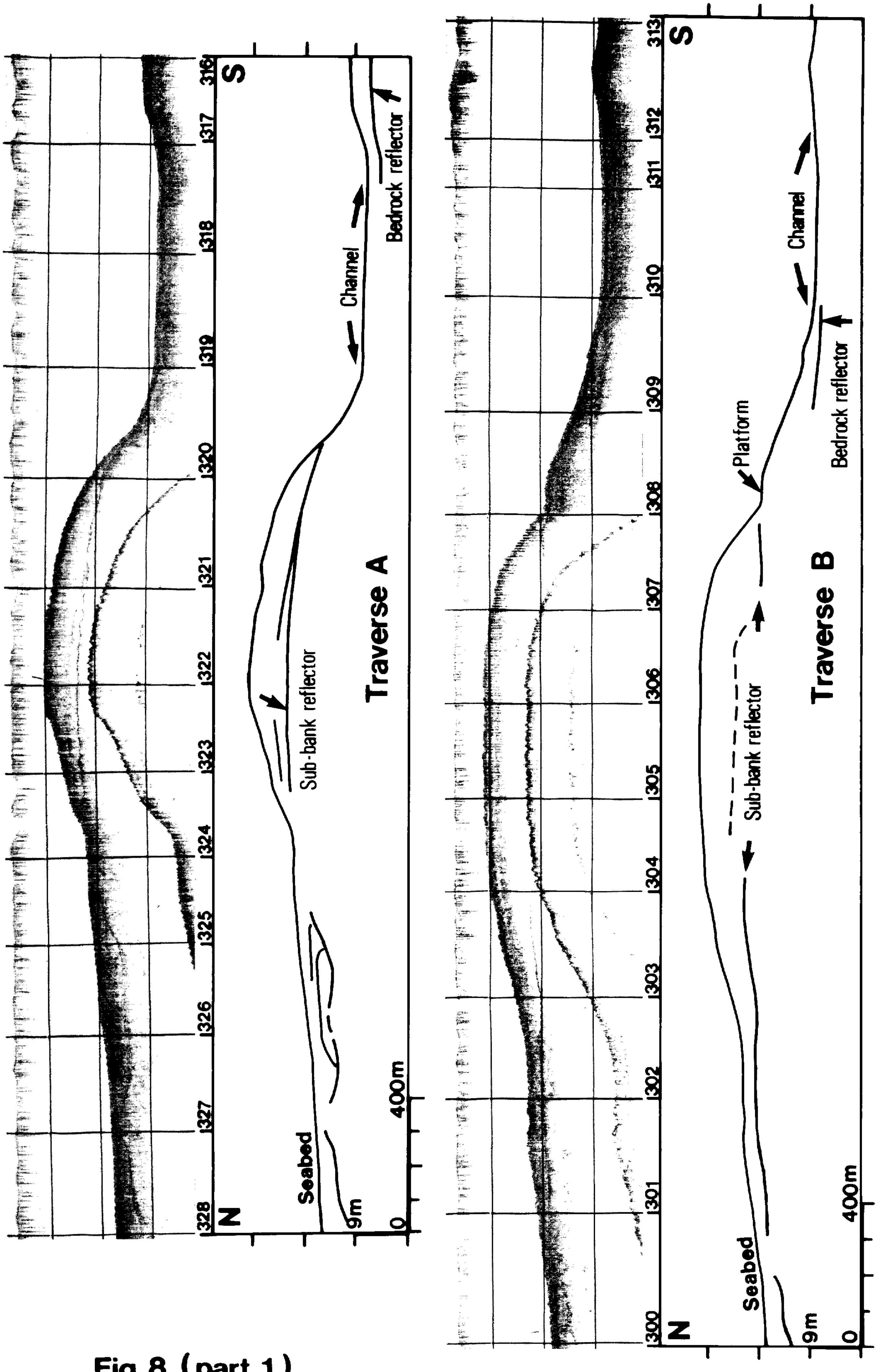


Plots of mean phi size of samples collected at HW, MW & LW against appropriate survey section along Aberafan, Margam and Kenfig beaches. (n=6)

Fig. 7

Figure 8 (Part 1)

Traverse A	Wide western end of Scarweather Sands, Symmetrical in shape: a broad channel has been cut in the sea bed to south of the bank.
Traverse B	Scarweather Sands, symmetrical in shape, sub-bank and possible bedrock reflecter shown. Small platform visible on southern side of bank.

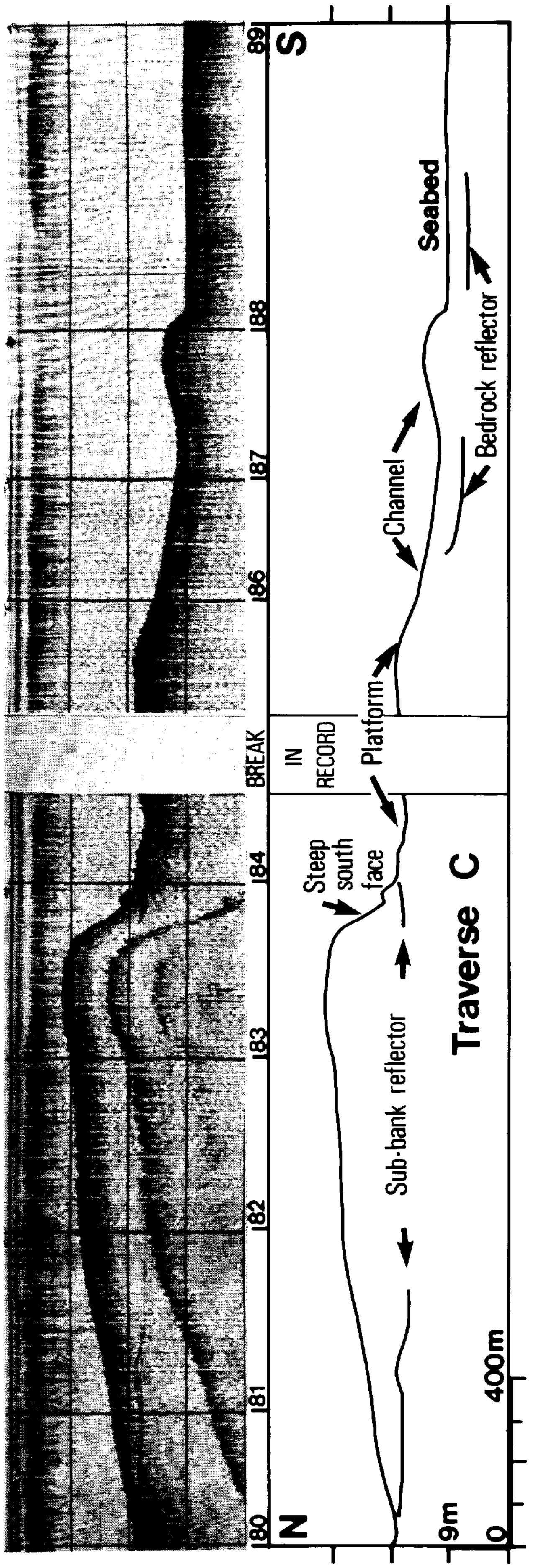


Traverse A
N
S
Channel
Bedrock reflector
Sub-bank reflector
Seabed
9m
400m
0
Traverse B
Platform

Fig. 8 (part 1)

Figure 8 (Part 2)

Traverse C	Scarweather Sands, asymmetrical in shape with steep south-facing slope. Ledge and channel to south of bank clearly visible.
Traverse D	Scarweather Sands, slope of south face less acute.


N
S
180
181
182
183
184
186
187
188
189
BREAK
IN
RECORD
Platform
Steep south face
Sub-bank reflector
Channel
Bedrock reflector
Seabed
Traverse C
9m
0
400m

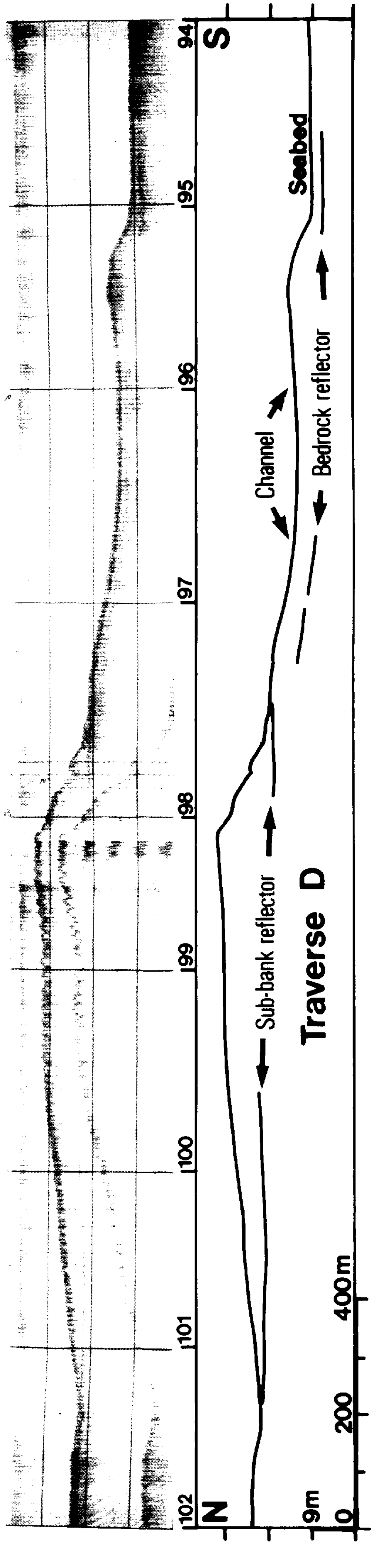
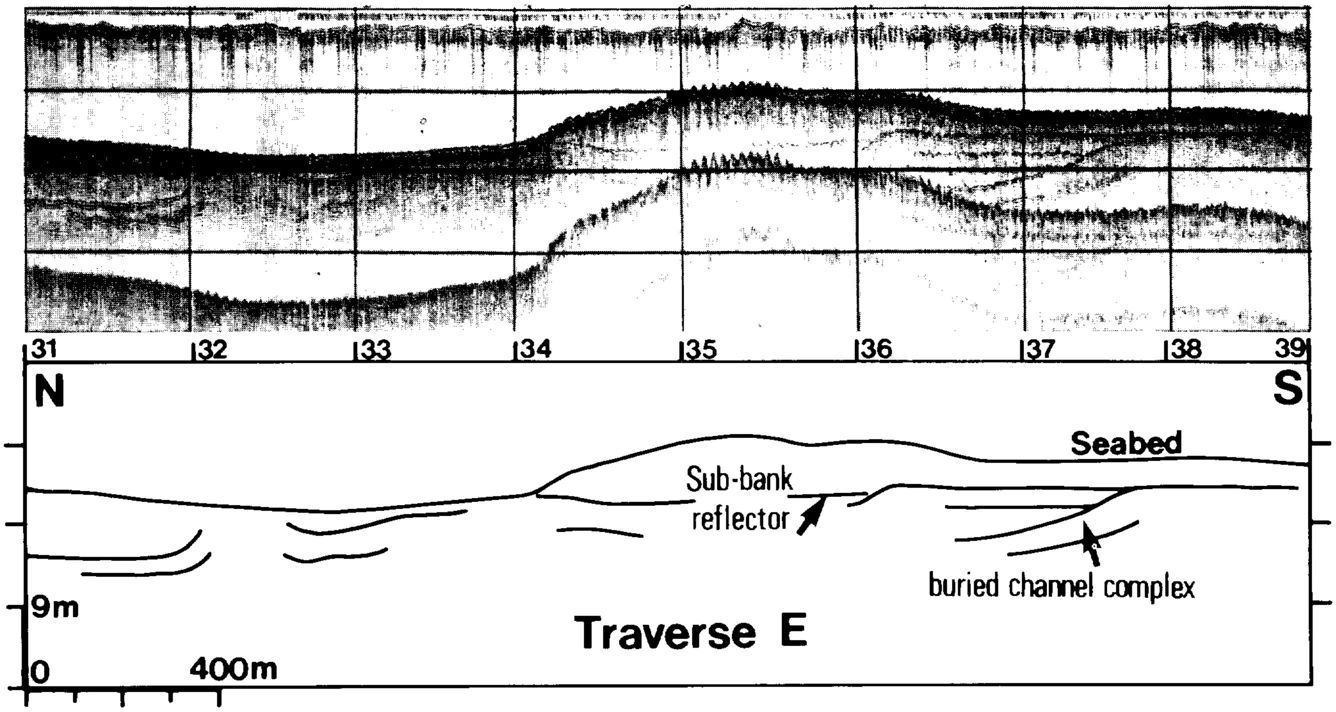
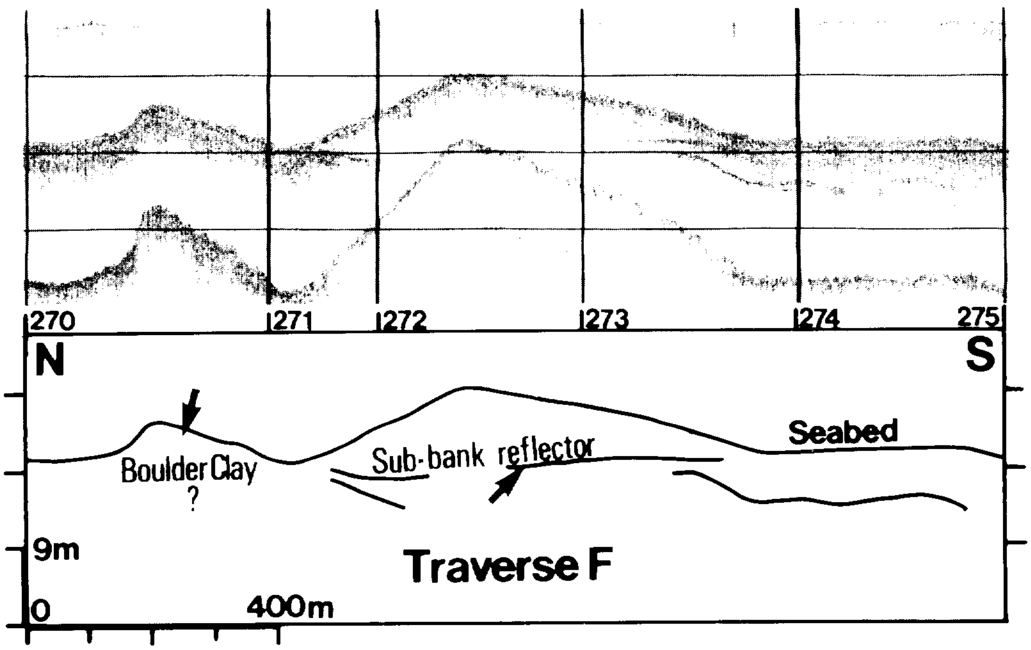

N
S
102
101
100
99
98
97
96
95
94
Sub-bank reflector
Channel
Bedrock reflector
Seabed
Traverse D
9m
0
200
400m

Fig. 8 (part 2)

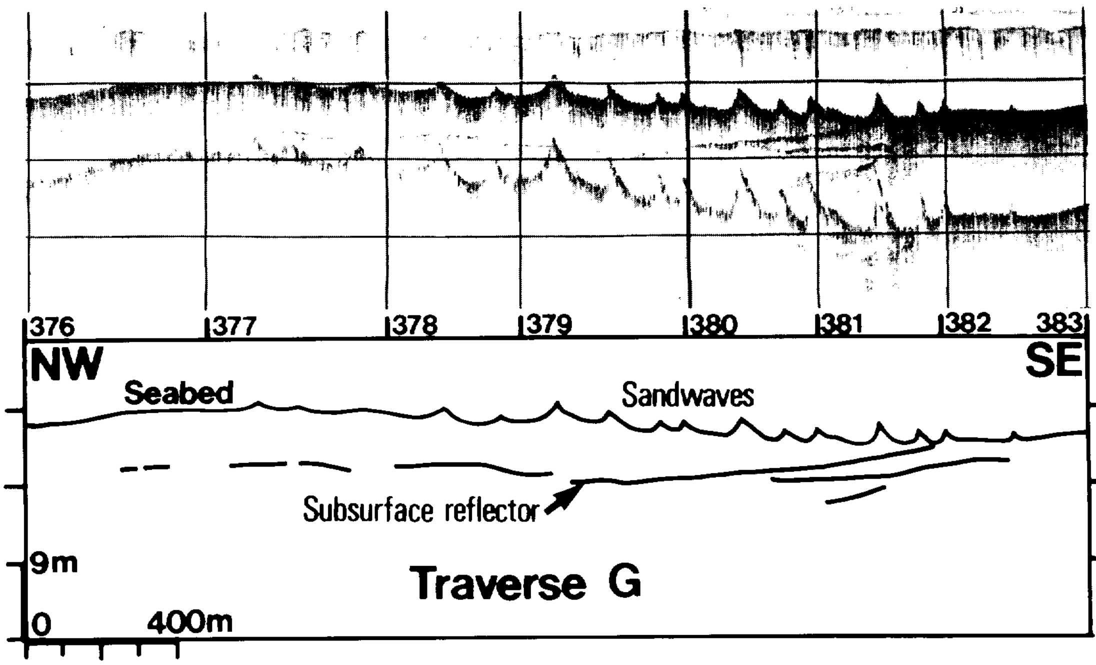


Hugo Bank showing subsurface reflectors and complex of buried channel deposits to south of bank.

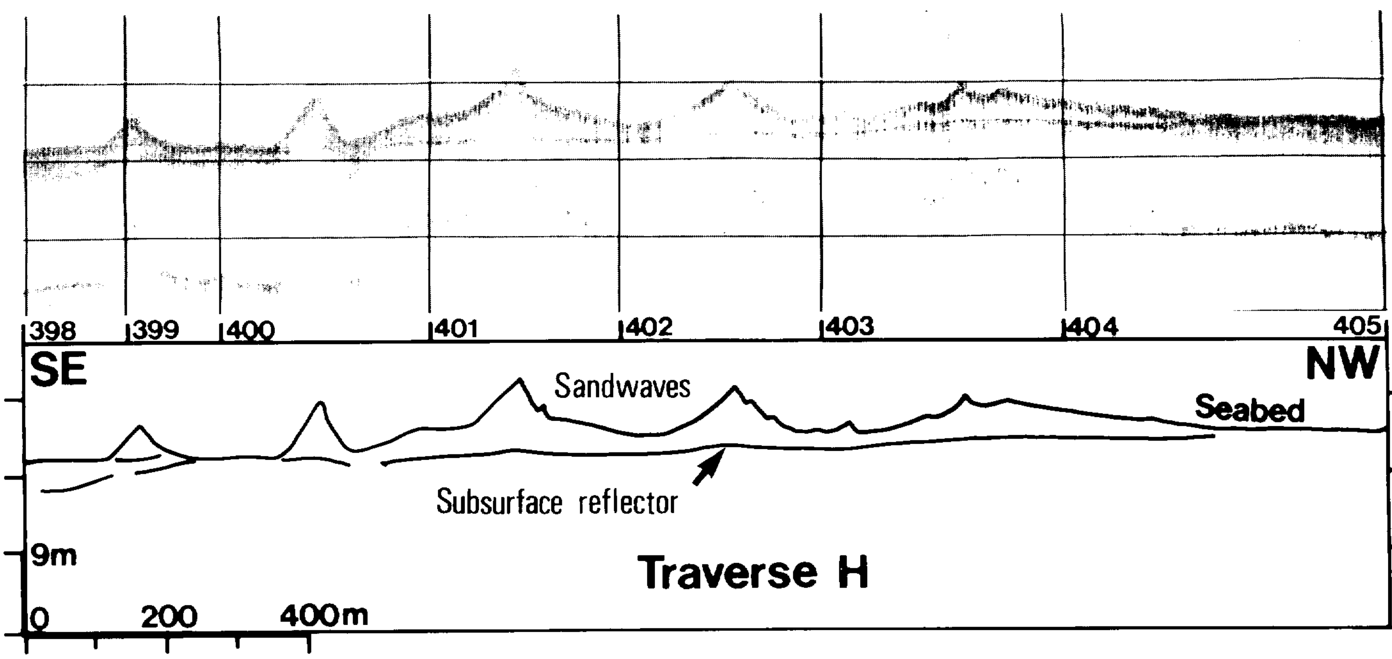


South Kenfig Patches showing subsurface reflectors and possible Boulder Clay outcrop to north of bank.

Fig. 9

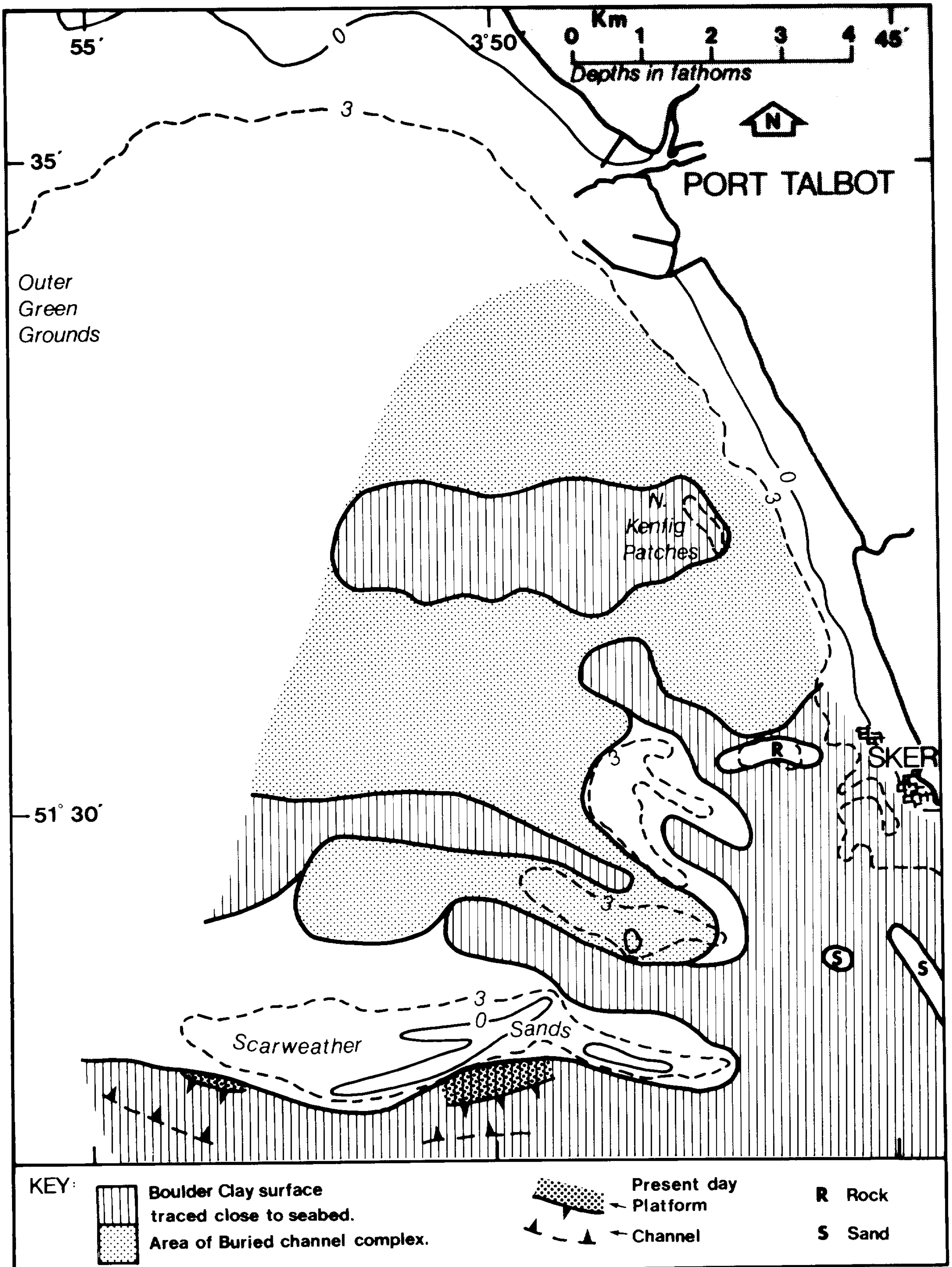


Sandwaves and subsurface reflector on south side of the South Kenfig Patches.



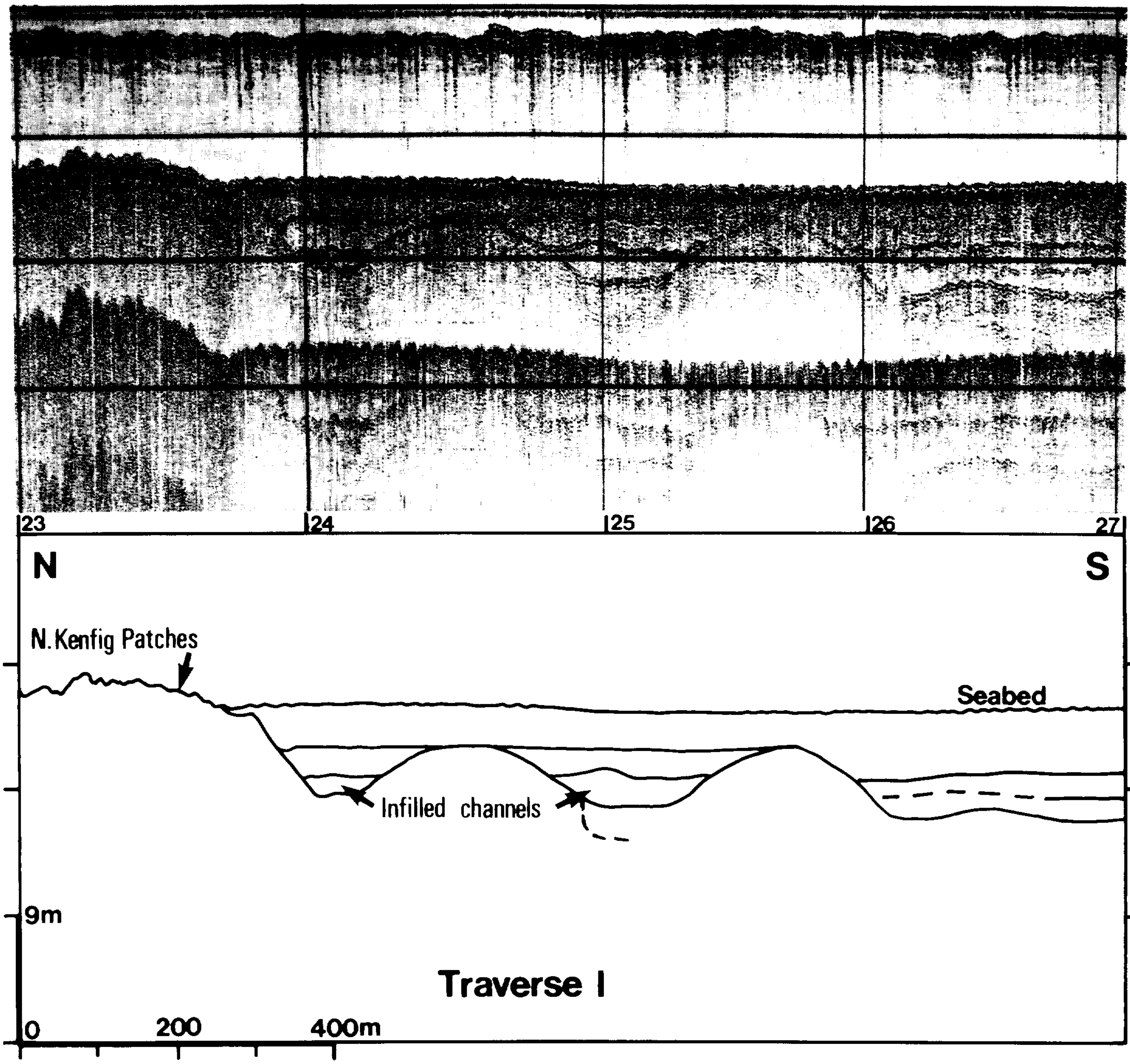
Sandwaves and subsurface reflector south-west of Hutchwns Point.

Fig. 10



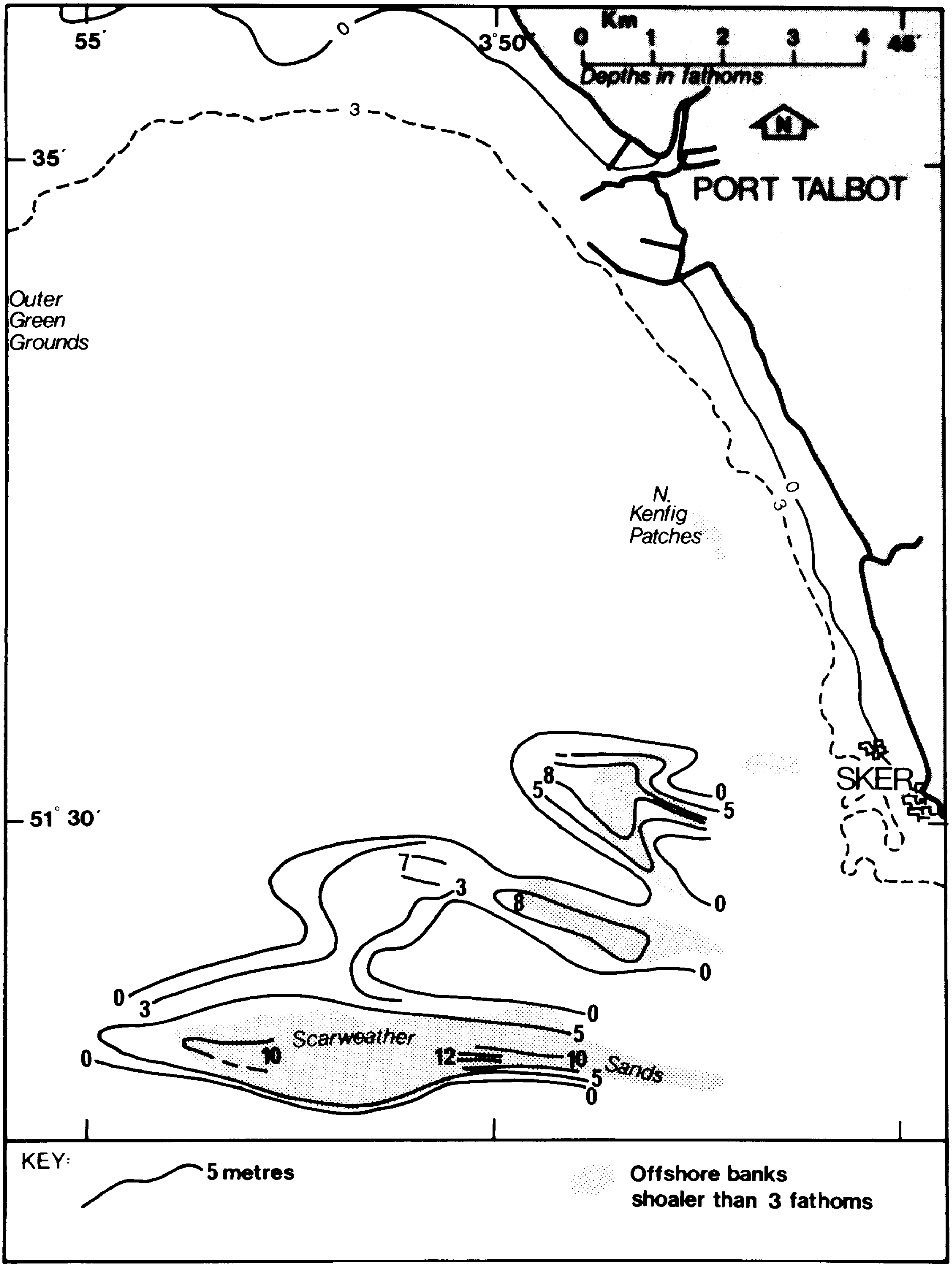
Distribution of Boulder Clay deposits and Buried Channel complex as far as can be determined from C.S.P. records.

Fig. 11



Layered infillings of buried channel complex to the south of the North Kenfig Patches.

Fig.12



Isopachyte map of sediment above flat surface beneath the Scarweather Sands, Hugo Bank and South Kenfig Patches.

Fig. 13