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COLLATION OF DATA ON THE FORM AND COMPOSITION OF THE SEA BED IN THE SOUTH-WESTERN APPROACHES TO THE BRITISH ISLES AND THE CELTIC SEA

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INTRODUCTION

In 1977 IOS was commissioned by SMTRB to evaluate and collate existing data on the form and composition of the sea bed in the SW Approaches to the British Isles and the Celtic Sea. The aim of the project was to provide an overall general appraisal of the nature of the sea bed to meet the needs of commercial and engineering requirements. Preceding discussions with Oil Companies and the Post Office made it apparent that, though sophisticated equipment and the necessary expertise was available to carry out detailed route surveys for submarine pipelines and cables and other sea bed structures, there was very little data available upon which to base the initial selection of the route to be surveyed.

Consideration of a comprehensive re-survey scheme to meet the requirements was eliminated on the grounds of cost, available manpower and the time before the results would be available for commercial use. The alternative accepted was to evaluate and collate the wealth of existing data which have been obtained by Government Departments, Research Institutes, Universities and commercial firms. The value of such an exercise is however restricted by both the quality of the data and its distribution. For example, much of the sea bed sample data in the SW Approaches dates back to the latter part of the 19th century (HMS Research, 1889 - 1890). It is difficult to correlate this early data with the systematic geological/geophysical survey data which is being obtained by IGS at the present time. For the earlier data, problems arise in relation to the positional accuracy, the technique of obtaining a sample and the methods of classification.

METHOD OF COMPILATION

Diagrams 1 and 2

Diagrams 1 and 2 were compiled from seabed sample data held in the archives of the Hydrographic Department, MOD. The bottom quality notation recorded by the various data collecting vessels, dating back to 1898, has been simplified into eight bottom types which are based upon grain size. No consideration has been given to other factors, such as colour, which are often recorded.

The original compilation was carried out at a scale of 1 : 770,000 and all available sea bed notations were recorded in their charted positions (Diagram 1). An attempt has then beenmade to summarise the data by enclosing uniform data by boundary lines. In no case has an individual notation been ignored, even if it appeared to be an exception in an otherwise uniform area. An apparent North/South lineation appears in the compilation, this is due to the North/South traverses which were characteristic of the HMS Research (1889 - 1890) sampling survey. There is no sedimentological/geological evidence for such a linearity.

Any assessment of bottom quality based upon this data should be considered in relation to the density of data in that particular area. It should be appreciated that little is known about the spatial variability over a small area. For example, few of the sample positions lie closer than 1km but little is known about the variability within a 1km square.

Diagrams 3 and 4

Diagram 3 is a Track Chart showing the distribution and density of sidescan sonar data obtained by IOS. Most of the data were obtained using short-range ($<$ 1km) sidescan sonar deployed from RRS Discovery II and RRS Discovery between 1958 and 1977. In the more recent years the long range sidescan sonar (Gloria $<$ 30 km) has been used on the upper continental slope and to a limited extent on the shelf. Using sidescan sonar, relief features such as rock, sandwaves and canyons can be readily detected. Bedforms, without significant relief, but showing contrasting grain-size such as sand patches and sand ribbons overlying coarser sediments can also be distinguished. A limitation of sidescan sonar is that only relative grain sizes are differentiated; thus, in order to evaluate the composition of the sea bed, sonographs need to be supplemented by sediment samples.

Diagram 4 is a composite assessment of the form and composition of the sea bed derived from sea bed sample data (Diagram 2) and sidescan sonar interpreted in terms of the geological processes operating on the sea bed. Its preparation required a further redefining of the confused sea bed sample data shown in Diagram 2. In order to gain closer compatibility with sidescan sonar records (and also because of the subjectivity of early methods of classifying samples) 'mud', 'ooze', and 'clay' were grouped together as 'muddy sediments',and 'gravel and 'stones' were similarly combined in a single group. 'Shells' were disregarded as they occur throughout the region (eg Warwick and Davies, 1977) and as an important fraction of the gravel and sand (eg Boillot, 1964)(being found in quantities sufficient to be exploited as a source of agricultural lime near the coast of Brittany).

This regrouping results in four basic bottom types, namely: Rock, Gravel, Sand and Muddy sediments, all of which can, or should be, readily detectable using sidescan sonar.

Diagram 5

Diagram 5 shows the spatial distribution of seabed sample sites recorded in the IGS Geological data bank (May 1978). None of these data has been included in Diagram 4. Data from specific locations is available on request from the IGS data bank.

Comments on the zones of Diagram 4

Rock: The area shown on Diagram 4 is the maximum extent of rough surface outcrops of hard, mainly ancient rocks. Some rock outcrops such as those in the Bristol Channel and around headlands are exposed because they have been largely swept clean of sediments, whereas other rock outcrops, such as the Haig Fras granite and the rocks south of Ireland, are particularly resistant rocks occurring in weak current areas. Thin superficial sediments often occur in pockets between the rock outcrops. Younger, softer rocks, with no expression as relief on the sea bed, can be found by coring where the superficial cover is thin, eg in the western English Channel (Curry, Hamilton and Smith 1970). Some papers giving details of solid geology are listed at the end of the report.

Between the rocky coastal zone and the upper continental slope is a distinctive suite of bedforms arranged in accordance with peak tidal current strength. These bedform zones are described for the Bristol Channel and inner Celtic Sea by Belderson and Stride, 1966. Further additions to the map of bedform zones have been made by Belderson, Kenyon and Stride, 1970, and in this report.

Gravel with Mobile Sand: Sonographs reveal widespread floors of coarser sediments across which thin strips of sandier sediments are being swept by the strong currents (Kenyon, 1970). These sand ribbons are no more than 5-10 cm thick and are oriented parallel to the peak current direction. In areas of strongest currents the mobile sediments may be of gravel size (sensu stricto) and erosional furrows may be formed (Stride, Belderson and Kenyon, 1972) up to 1.5m deep. The thickness of the coarser sediments is unknown.

Large sandwaves occur where peak current speeds near the surface are below about 1m/sec (2 knots) and above about 60cm/sec (1.12 knots). In these flow conditions their existence is mainly dependent upon sufficient mobile sediment being available. Typically sandwave heights are less than 15m, but heights of up to 25m are found in the Western English Channel. The slopes of the steeper side of a large sandwave crest are typically up to 10^{o} though in certain areas slope angles close to the angle of repose of sand in water (28 - 30^{o}) are to be found. Smaller, less stable sandwaves are usually found on the flanks of the larger sandwaves. A distinction has been plotted in Figure 2 between isolated sandwaves on a gravel floor, that are usually crescentic in plan view like desert barchans, and continuous fields of sandwaves with sinuous crests. The former may be indicative of a scarcity of mobile sediments. Seismic profiles near the shelf edge show thicknesses of up to 30m of seemingly continuous sand cover. Adjoining the zone of large sandwaves there is a narrow, but inadequately mapped, zone of small sandwaves with heights of up to about 1m.

Sandwaves are thought to be indicative of unstable areas of the sea bed. Indeed no other naturally occurring bedform, other than slump features, suggests a greater degree of seabed mobility. However, sandwaves with rounded profiles are found in the extreme south western part of the sandwave zone and these may be relatively immobile, or possibly relict features.

Sand/mud sheets: Where the currents are weak (below about 60cm/sec) there are sheets of sand, muddy sand and mud. Their thickness is for the most part not known but is probably generally greater than 1m. The thickest deposits of sand should be found adjacent to the sandwave zones such as outside the southern entrance of St Georges Channel. Other thick sand bodies include the supposed sand banks of the Outer Celtic Sea. These latter are largely inactive sand banks formed at times of lower sea level (Bouysse et al. 1976). Their crests have well sorted, clean white sands stirred up by currents induced by storm waves, whereas muddier sands are found on their flanks.

Muddy sediments are found where the peak tidal current strength near the sea surface is less than 0.25m/sec, and where the floor is out of the reach of wave-induced currents (ie not in shallow parts of the open shelf nor at the shelf edge). The main mud areas are (1) The north Celtic Sea; (2) to the west of Ireland; and (3) on the continental slope. Small areas of muddy sediments occur in some sheltered bays.

Gravel with sand of low mobility: These gravels (s.l.) are of unknown thickness, but in many places are thought to be relatively thin (less than 1m) occurring in extensive sheets. The sand cover is also thin (less than 2m) and found in discontinuous irregular shaped patches. Very little mobile sand should be encountered.

Upper continental slopes: The upper continental slope bounding the Celtic Sea has recently been mapped by long range sidescan sonar (Kenyon, Belderson and Stride, 1978). The regional slope to the south of the Celtic Sea is about 5° to 9° and deeply incised by canyons. The canyon systems are revealed by long range sidescan sonar to have complex branching patterns that are often incorrectly mapped on bathymetric charts. The walls of the canyons are steep, slopes are typically from 15° to 20° and may range up to vertical in the canyon axes. Nearly all the canyon walls are eroded into gullies arranged in dendritic patterns. Occasional slump scars and folds in the superficial sediments are found. It has been possible to map smooth undissected 'interfluves' between some of the canyons, that have the relatively gentle regional gradient and are presumed to be stable.

The slope to the west of the Celtic Sea is gentle (c.2°) and for the most part undissected. However, a branching system of narrow, steep walled channels about 1.5km wide and up to 280m deep, runs into the Porcupine Seabight.

Geological hazards to submarine pipelines and cables: Hard rock outcrops present an obvious nuisance as cables and pipelines cannot easily be buried. The risk of failure and the difficulty of repairs will be the greatest where rocks are swept by strong currents, such as in the Bristol Channel and around headlands. An alleviating factor is that trawlers will usually avoid rough rocky areas. In most areas sediment floored routes for cables may be found if detailed surveys of the rough rocky areas are made.

Burial of cables and pipelines will also be difficult in regions of gravel. The most favourable zones for jetting into sediments to a depth of greater than 1m should be the sand/mud sheets.

Sand waves are a hazard to structures on the sea bed although the degree of sand mobility is still poorly known. If burial is achieved, later exposure due to shifting sand is likely to occur. Information on the crestal orientation of sand waves (held at IOS) may be of use in pipeline and cable routing, as it is presumed to be preferable to lay along the troughs between sandwaves. The majority of sandwave crests are oriented transverse to the main tidal flows, but in an area west of Brittany some longitudinal sediment ridges are found.

Canyoned and channelled continental slopes would be hazardous both because of their steep topography and because of the consequential potential for sediment slope failure. Preferably routes for cables would be along the more gently sloping, undissected portions of the continental slope that have been mapped by long range sonar.

The complex glacial history, that has affected the north Celtic Sea in particular, results in laterally variable deposits. Both subglacial channels and river channels are found that, for the most part, run south westwards and are filled by later sediments. Such features will cause large changes of bearing strength over a short distance.

Coral growths found near the shelf edge (and possibly detectable on sonographs) may prevent telephone cables from lying on the sea bed, resulting in increased danger of breakage by trawls. Also when a cable is raised above the sea bed it is more subject to movement with consequent damage to the protective covering if algal growths are broken off.

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SOUTH WEST APPROACHES: SAMPLING SITES

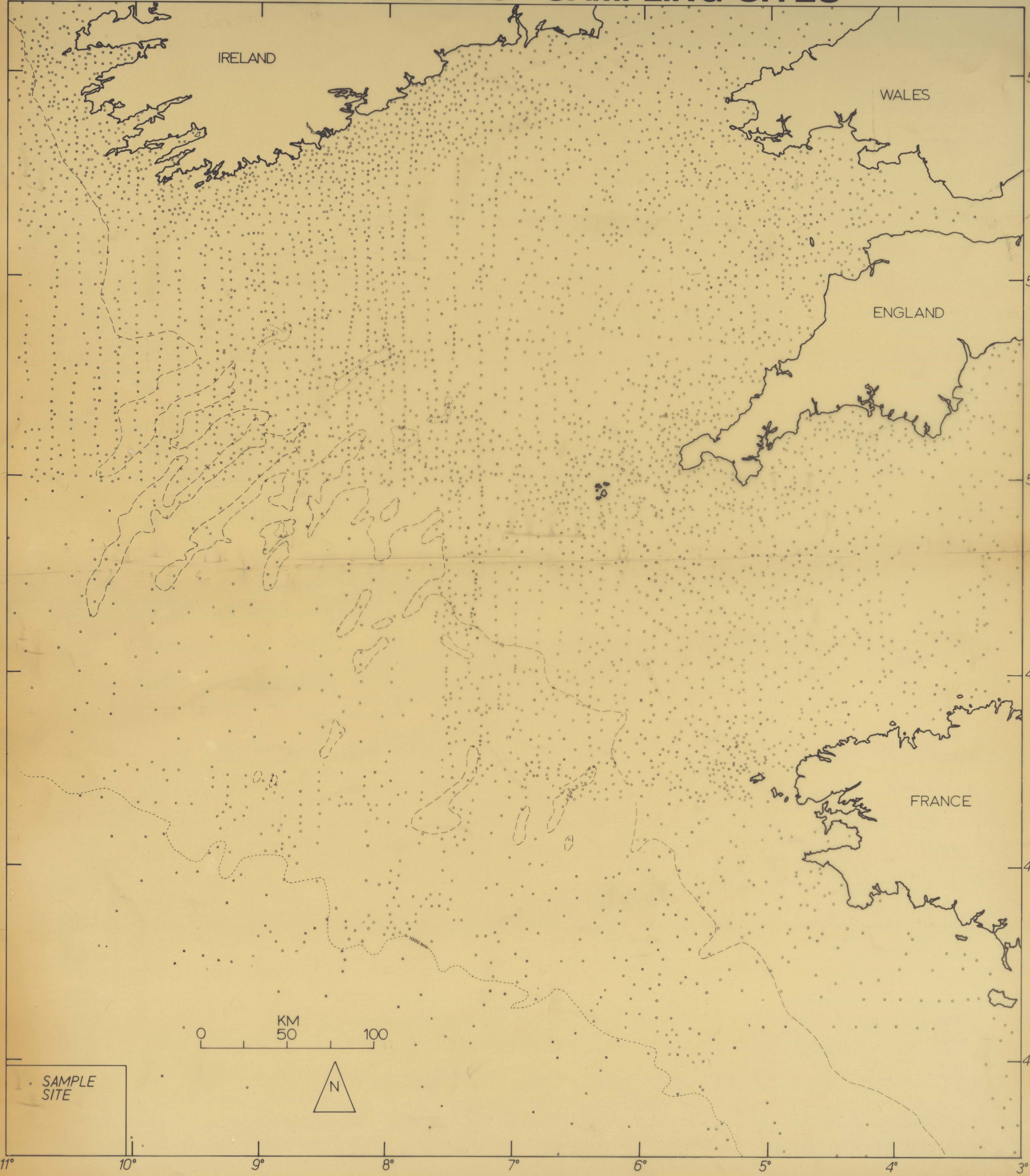

DIAGRAM 1.

SOUTH WEST APPROACHES: SEA BED QUALITY

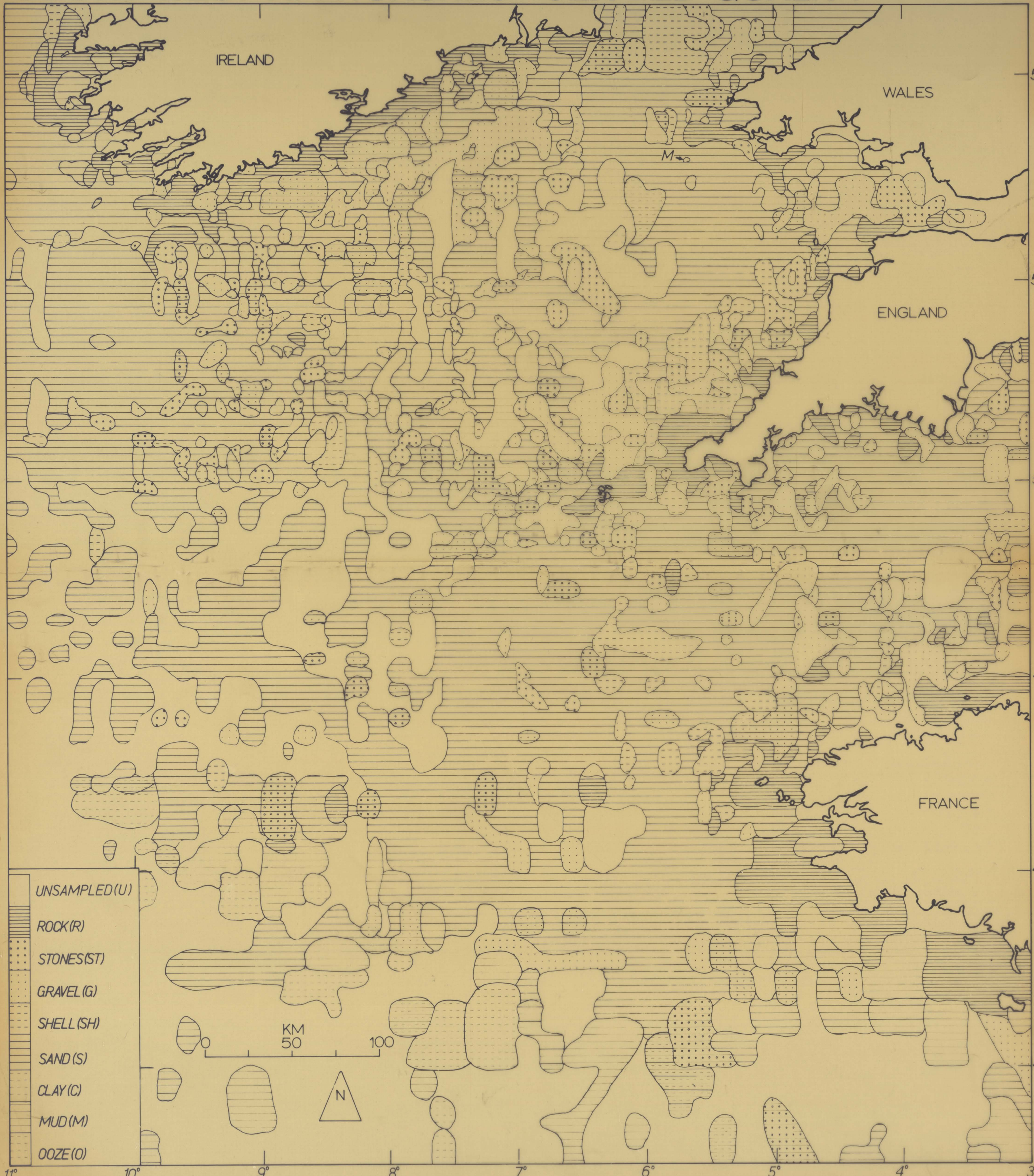

DIAGRAM 2.

S.W. APPROACHES: SONAR TRACK CHART

DIAGRAM 3.

S. W. APPROACHES: COMPOSITION AND FORM

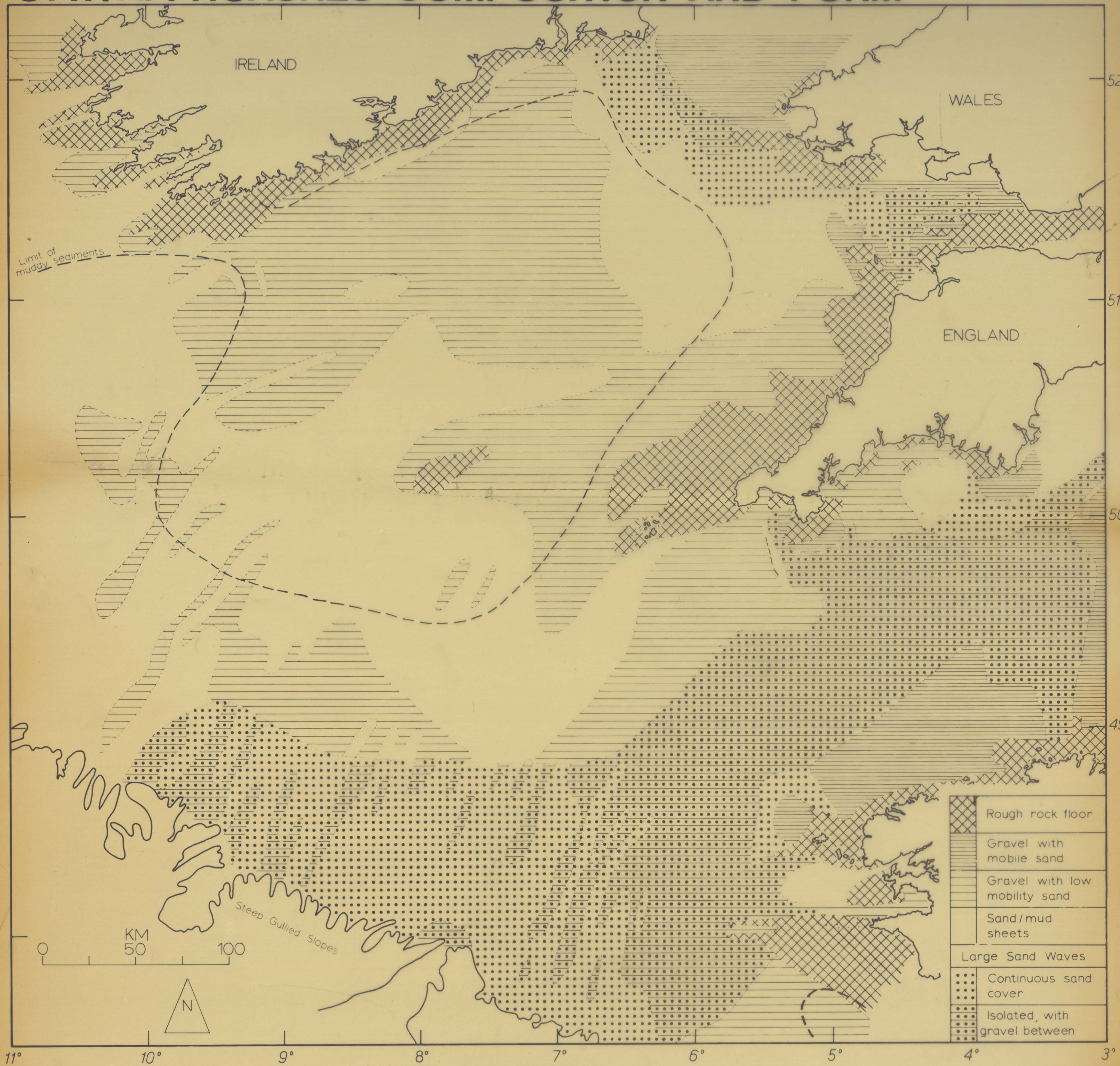

DIAGRAM 4.

SOUTH WEST APPROACHES: SAMPLING SITES IN I.G.S. DATA BANK

DIAGRAM 5.