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MORPHOLOGY OF PART OF THE CENTRAL NEW SOUTH WALES CONTINENTAL SHELF IN RELATION TO OFFSHORE HEAVY-MINERAL PROSPECTS

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SUMMARY

Bathymetric data acquired by the Division of National Mapping off the central coast of New South Wales in 1972 have been studied with the objective of delineating fossil beaches and other features which may be associated with concentrations of heavy minerals.

The continental shelf is narrow and relatively steeply inclined; there is evidence of fairly extensive outcrops of bedrock on the inner shelf, and the cover of sediments is generally thin to a depth of about 80 m. Bottom currents are likely to be strong on the middle and outer shelf, and large-scale sediment transport probably occurs.

These conditions of shallow or exposed bedrock do not favour the development of distinctive shoreline abrasion platforms and cliffs during the relatively short periods of low sea-level stillstands. Also, the existing high-energy conditions on the shelf must have resulted in destruction or modification of unconsolidated sand bodies. Thus, although notches and changes of slope which may be related to fossil shorelines were identified in many profiles, they are commonly of limited extent and difficult to recognize. The best developed occur at depths of about 105, 84, and 28 m.

The rocky and irregular nature of the inner shelf indicates that conditions suitable for entrapment of heavy mineral accumulations are likely to have occurred locally during low sea level stands. If such deposits exist they may not be suitably placed for mining by large-scale dredging techniques.

INTRODUCTION

Accurately positioned and closely-spaced sounding lines across the continental shelf between the 20-m and 300-m isobaths recently obtained by contractors to the Division of National Mapping provide an important new source of data on the detailed physiography of the shelf. The original echograms have been studied with the objective of identifying submerged shorelines and other features which may be associated with deposits of heavy minerals.

Descriptions of the bathymetric profiles across the southern Queensland shelf, from Fraser Island to the New South Wales border, have recently appeared in the BMR open file Record Series (Jones, 1973 a, b). Part of the sections on offshore heavy-mineral deposits from the earlier papers are reproduced here. The data used in the present paper were collected by Australian Hydrographic Services Pty Ltd during the second contract in July 1972, and cover 280 km of shelf from 50 km north of Coffs Harbour, to Sugarloaf Point, 60 km south of Taree.

Throughout the area of the bathymetric survey, which covers 8400 km , east-west lines were run at a spacing of 3000 m; tie lines along the outer margin of the shelf were also obtained (Fig. 1). Most traverses extend from just inshore of the 20-m isobath to just beyond the 300-m isobath, but in the northern part of the region coverage at both the inner and outer ends was curtailed owing to the existence of adequate Naval Hydrographic Service soundings in the areas. From the northern margin of the area at 29°55'S to 30°22'S the inshore ends of the profiles are at 35 to 40 m depth; from 30°00'S to 31° 20'S profiles terminate offshore at about 250 m. Unfortunately the original echograms from which the Naval soundings were taken were not preserved.

Positioning was carried out by Raydist, a medium-range radio system in which the phases of two continuous-wave signals are compared. Under the terms of the contract, positioning accuracy was required to average 100 m, seldom to exceed 200 m, and never to exceed 300 m. Data compiled by the Instrument Division of the U.S. Coast and Geodetic Survey indicate that the Raydist system achieves a much high order of accuracy than this, and there is no evidence to suggest that positioning errors exceeded those specified.

REGIONAL MORPHOLOGY

The continental shelf is narrow throughout this region; measured from the shoreline to the shelf break the width decreases from a maximum of 42 km just south of Taree to a minimum of 10 km northeast of Kempsey (Fig. 2). These widths compare with the average for the world's continental shelves of about 100 km.

The main morphological elements of the region are illustrated by the profiles shown in Figure 2. The shelf break, which is the point where an increase in gradient at the outer edge of the continental shelf marks the start of the continental slope, deepens southwards from about 100 m off Coffs Harbour to about 140 m off Sugarloaf Point. A further steepening at the top of the continental slope proper occurs seaward of the shelf break, generally beyond the outer margin of the area surveyed.

A single submarine canyon was crossed in the profiles examined; this dissects the upper continental slope off Coffs Harbour at 30°11'S. It is possible that others may be present north of 30°10'S, where no tie line along the edge of the shelf was run, or farther down the slope anywhere in the area. Regional bathymetric contours compiled from the GEBCO[1] Oceanic Soundings Sheets provide some indication that other canyons drain into the Tasman abyssal plain in this area, and one was located on the upper continental slope at 30° 00'S during previous surveys by the BMR.

DETAILED PHYSIOGRAPHY OF THE SHELF

This part of the New South Wales continental shelf is rather narrow, slopes relatively steeply in many places, and rough ground is common. Unfortunately the character of the trace on the echograms collected during the Division of National Mapping contract was of no value in distinguishing different sea bed lithologies, but seismic profiles obtained by the BMR in 1970 and 1972 show that the sedimentary cover is thin or absent locally on the inner shelf, and most areas of rough ground in waters shallower than about 80 m probably represent outcrops of bedrock.

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1. General Bathymetric Chart of the Oceans

These conditions would not appear to favour the development of abrasion platforms and shoreline features owing to the short duration, in geological terms, of the low sea level stillstands of the Pleistocene. Although terraces and nick points have been identified in the area, they are not nearly so persistent and well developed as on the southern Queensland shelf, with its thicker and more extensive sediment cover.

Banks and rough ground

As mentioned above, the extensive areas of rough ground and banks on the inner shelf are nearly all the expression of exposed bedrock. Most seismic profiles are on the outer part of the shelf and data are sparse in shallower water; however, the available shallow-water sections suggest that bedrock does not crop out on the shelf in waters deeper than about 80 m in the northern half of the area (north of Port Macquarie), and not deeper than about 50 m in the southern half of the area.

Banks and rough ground on the outer shelf are probably in the main relics of constructional features, whereas the areas of irregular topography seaward of the shelf break are of erosional origin or reflect slumping. An attempt to distinguish the various types of rough ground is made on Figures 3-7.

Channels

There is no evidence from surface morphology that the shelf is crossed by channels representing an extension of the onshore subaerial drainage pattern. Shallow linear depressions parallel to the coastline are present, particularly in the northern part of the area, but they are much less well developed than on the southern Queensland shelf. They are believed to be relics of drowned coastal lagoons.

Submerged shorelines and terraces

Figures 3-7 show the distribution of nick points and changes of slope which are assumed to be related to submerged strandlines. Terrace and step features are not well developed in this area, and as mentioned above, this is believed to be because periods of erosion during low sea level were too short to produce extensive sculpturing of bedrock, which crops out over wide areas of the inner shelf. Many steps or changes in slope lose their identity when they run into areas of rough ground where bedrock is exposed (eg. Fig. 6).

Even on the outer shelf, where there is a cover of sediments, strandline features are less well developed and less persistent than on the Queensland shelf to the north. The reason for this probably mainly lies in the larger number of sand and gravel banks and areas of rough ground which are present here. Although these are probably relics of near-shore bars and dunes, it seems that they may have been substantially modified during and after the Holocene transgression. The East Australian Current reaches its highest rates on the outer shelf along this stretch of coast, where sets of up to 4 knots have been recorded. Extensive sediment transport must occur, and possibly erosion also, and it seems that there has been considerable modification of ancient nearshore profiles and burial or destruction of fossil shoreline erosional and constructional forms.

The deepest feature interpreted as a submerged shoreline occurs below the shelf break at depths ranging from 160 to 185 m. It was only recognized over a distance of about 40 km in the region of 32°S (Figs 6 & 7), but can perhaps be correlated with nick points or terraces at about the same depth which have been noted at many places off northern and eastern Australia. In one place, off One Tree Island, southern Great Barrier Reef, this feature was proved to be a submerged shoreline by the identification of beach rock _in situ_ at a depth of 150 m (Veeh & Veevers, 1970). This material was dated by the radiocarbon method at 13 860 $\pm$ 220 yr BP. Less conclusive evidence of a sea level at about - 175 m in the Arafura Sea late in the Wisconsin glacial has also been put forward by Jongsma (1970).

In the area under consideration rough ground resulting from erosion, and possibly also slumping, is quite common on the upper continental slope, and in the absence of narrow-beam echosounder and seismic data, it is not possible to identify the origin of these features. Some of the long narrow zones of rough or undulating ground seaward of the shelf break in water depths of 206 to about 280 m (Figs 4 - 7) could well be related to ancient shorelines. Profiles 3 and 6 (Fig. 2) provide examples of these deep-water features.

Off southern Queensland the best developed and most widespread of the submerged shorelines occur at depths of about 100 m and 80 m. In this area notches or changes in slope at these depths are also evident in many places, but they are usually less distinct and cannot be recognized at all in some of the profiles, particularly in the northern and central parts of the region surveyed.

The same is true of the submerged shoreline features at shallower depths, especially the nearshore change in slope at the base of the present-day paralic zone profile which occurs along the Queensland coast but which is less often present on the rocky inner shelf in this area.

Despite the variations in depths which they display, the submerged shoreline features do fall into relatively distinct depth groupings. A plot of the frequency of recorded shoreline depths shows dominant modes at 105 m and 84 m, a subdominant mode at 28 m, and minor modes at 45, 54, and 75 m.

OFFSHORE HEAVY-MINERAL DEPOSITS

This region borders the southern part of the east coast mineral-sands province and it is possible that deposits similar to those onshore are associated with submerged fossil beaches on the continental shelf. The pioneering offshore exploration work of Planet Metals Ltd during the late 1960s was designed to test this possibility, and much of the drilling this company undertook was off the central New South Wales coast in the area considered in this report. Planet Metals Ltd has reported that over 375 million tons of sand averaging 0.20 to 0.22 percent rutile plus zircon have been outlined by drilling off the central coast and a further 500 million tons indicated (Brown, 1971). Full descriptions have not been published, but there are apparently two types of deposit: a blanket type of unknown extent in which heavy minerals are present in the top 1.5 to 4.5 m overlying barren sand; and a seam type 3 to 4.5 m thick, 120 to 490 m wide, and up to 4.9 km long, which underlies 3 to 4.5 m of generally barren sand. Both types of deposit lie in water depths of about 30 m; it is assumed that they are associated with a fossil beach, but the company has not revealed whether this feature has any surface expression on the sea floor.

Reworking of fossil beaches

It is not known how and to what extent any heavy-mineral deposits which may have been associated with beaches now submerged would have been modified during and after the transgression of the sea. It is logical to assume that rising sea level and advance of the shoreline would result in partial destruction of the beach dune system and in some redistribution and dilution of heavy-mineral seams. It is also probable that the bulk of the littoral zone sand, the active paralic sand wedge of Dietz (1963), would migrate landwards with the advancing shoreline, except where the beach dunes are backed by lagoons or swamps. If this is so, then the present-day beach zone is likely to contain a major part of the total east coast heavy-mineral resources, even if large deposits were at one time concentrated in low-level shorelines on the continental shelf.

There is, however, a possibility that substantial deposits exist offshore, and although drilling has not yet revealed any high-grade deposits, they may also be present. Though some reworking of the upper part of the beach profile appears inevitable during a transgressive phase, heavy mineral seams lower in the profile could well be protected by the overburden, particularly if the rise in sea level was rapid. The chances of preservation would also be increased where some induration of the heavy-mineral sand body, or of the overburden, has occurred; this is not uncommon among the lower-level deposits onshore, and indurated horizons were encountered by Planet Metals Ltd during their offshore drilling.

Location of fossil beaches and associated mineral concentrations

In places where a change of slope rather than a notch constitutes the feature related to a submerged shoreline, the base of the change of the slope has been used to plot the shoreline distribution in Figures 3-7, although the actual shoreline during the still-stand was probably at a higher level. Assuming that these features are in fact related to ancient shorelines, and that part of their associated heavy-mineral deposits have been preserved, the question of the probable location of the deposits with respect to the change of slope remains. By analogy with the present coastline it would appear that the slope above the change, and particularly the crest of the slope, is the most likely area. Detailed soundings are not available inside the 20-m bathymetric contour, but the relatively steep gradient at the inshore end of many profiles appears to continue to the present-day shoreline (Fig. 2). This is confirmed by detailed surveys carried out by the Gold Coast City Council in connexion with their recent beach replenishment investigation between Tweed Heads and Southport. Several profiles recorded by the Council in this area show that the relatively steep gradient of the beach at mean sea level continues seawards until it starts to level off at about 25 m depth.

Thus in the present-day near-shore profile the known high-grade concentrations of heavy minerals occur within the beach dune system standing at the crest of a slope which continues seawards for about 2 km before flattening out some 25 m below sea level. If a further rise in sea level were to occur there would be a rapid transgression across the coastal lowland belt, once the beach dune system had been breached; profiles across the drowned area would show a flat or concave terrace bounded seawards by a bank or hummocky zone, marking the remnants of the beach dune system, standing at the crest of a slope representing the present near-shore gradient.

Such a combination of features was recognizable in some of the profiles across the southern Queensland shelf, but even with the eye of faith it cannot be readily identified in this area. Profiles 1 and 2 (Fig. 2) are possible exceptions, in which changes of slope at 84 m and 93 m are surmounted by hummocky zones at the outer edges of terraxes. The hummocky areas may be relics of ancient beach dune systems and the sloping surfaces on their seaward flanks may be fossil equivalents of the present day near-shore slope.

Although the bathymetric profiles do not provide evidence of large fossil paralic sand wedges in the continental shelf, the presence of bedrock at the surface, or at shallow depth, over large areas of the inner and middle shelf could be an important factor influencing heavy-mineral distribution. The advance of the sea during the early Holocene must have been slow across this narrow and sloping shelf, and the areas of rocky coastline would have provided many local traps for the migrating body of sand in the beach zone. However, such deposits might not be readily accessible to the large dredges which would probably be required for a viable offshore mining operation.

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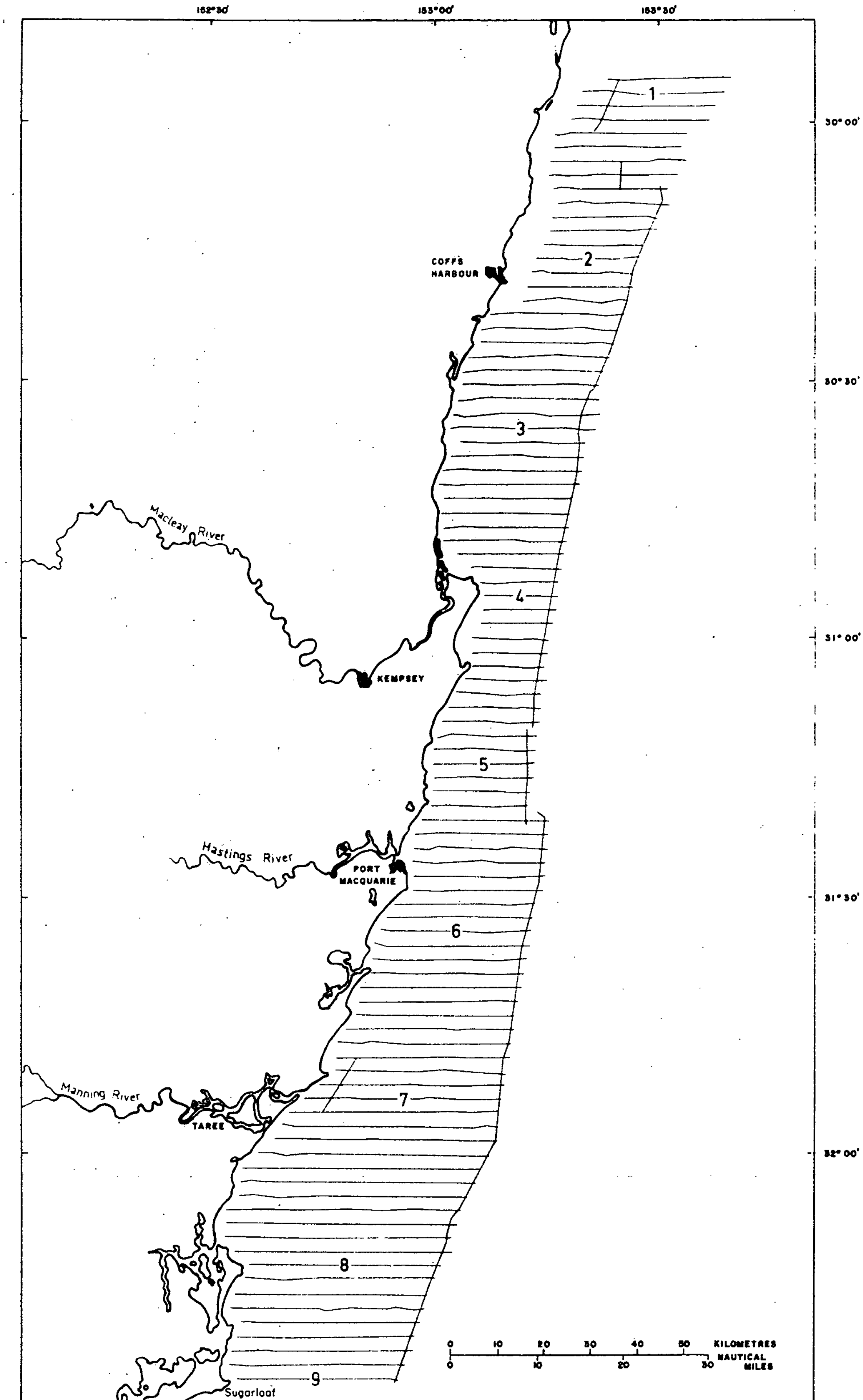

FIG. I. AREA OF BATHYMETRIC SURVEY SHOWING POSITIONS OF SOUNDING LINES.

Profiles along numbered lines are illustrated in Figure 2.

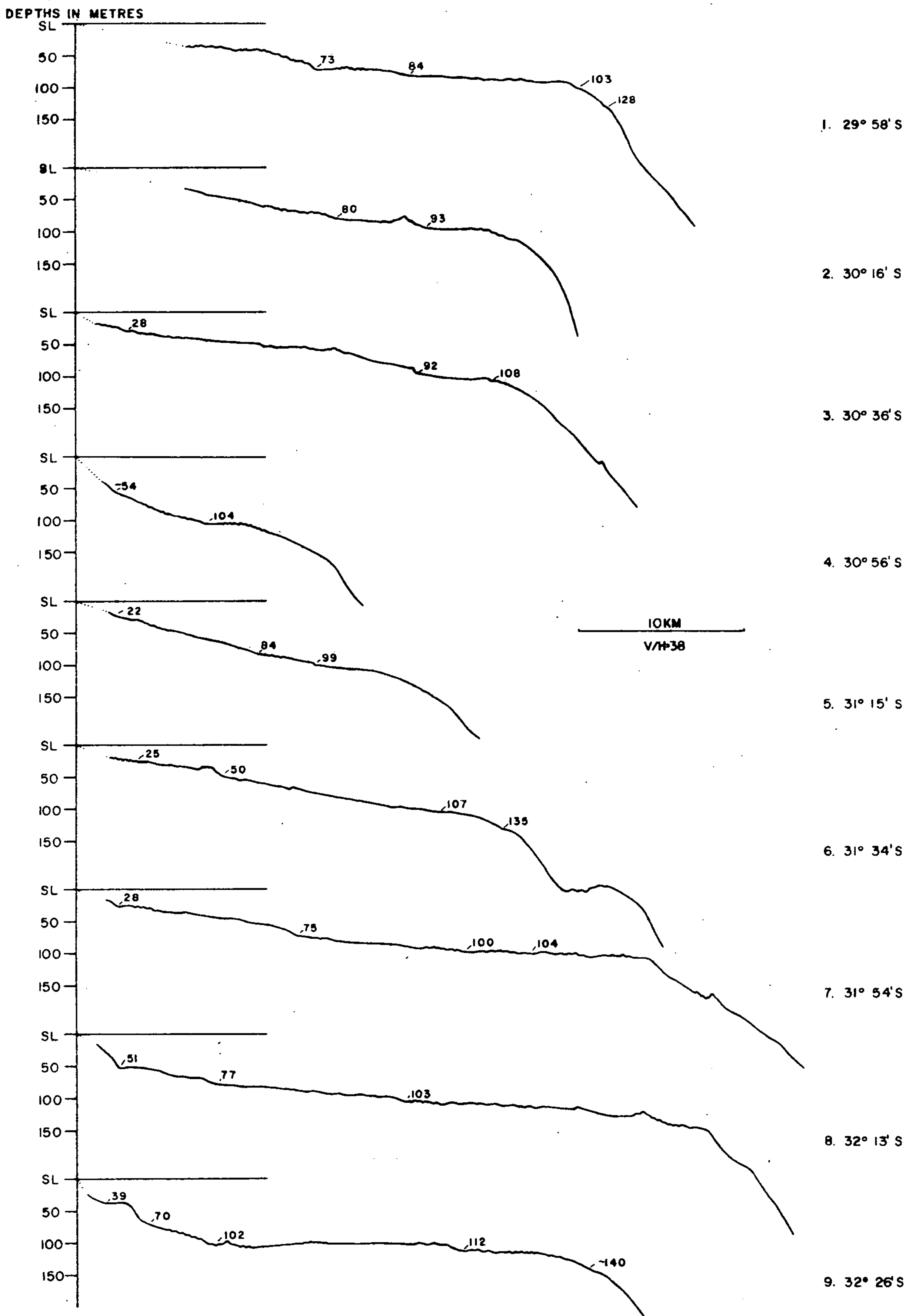

FIG. 2. GENERALISED PROFILES ACROSS THE CONTINENTAL SHELF.

Locations are shown in Figures 1 and 3-7

Depths at indicated points are in metres.

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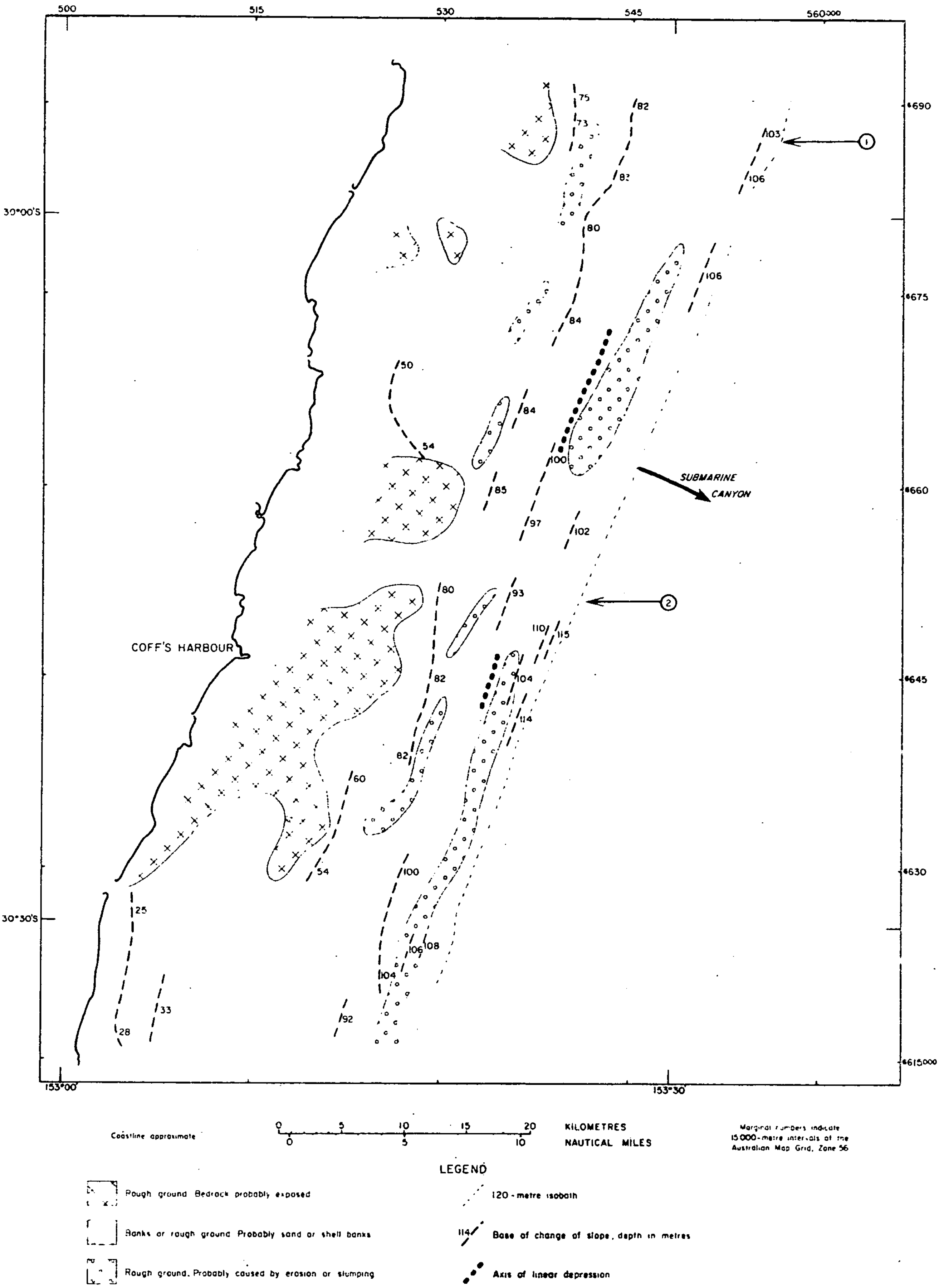

Fig.3. DETAILS OF SHELF MORPHOLOGY, 30°00'S TO 30°30'S.

Numbered arrows indicate locations of E-W profiles illustrated in Figure 2

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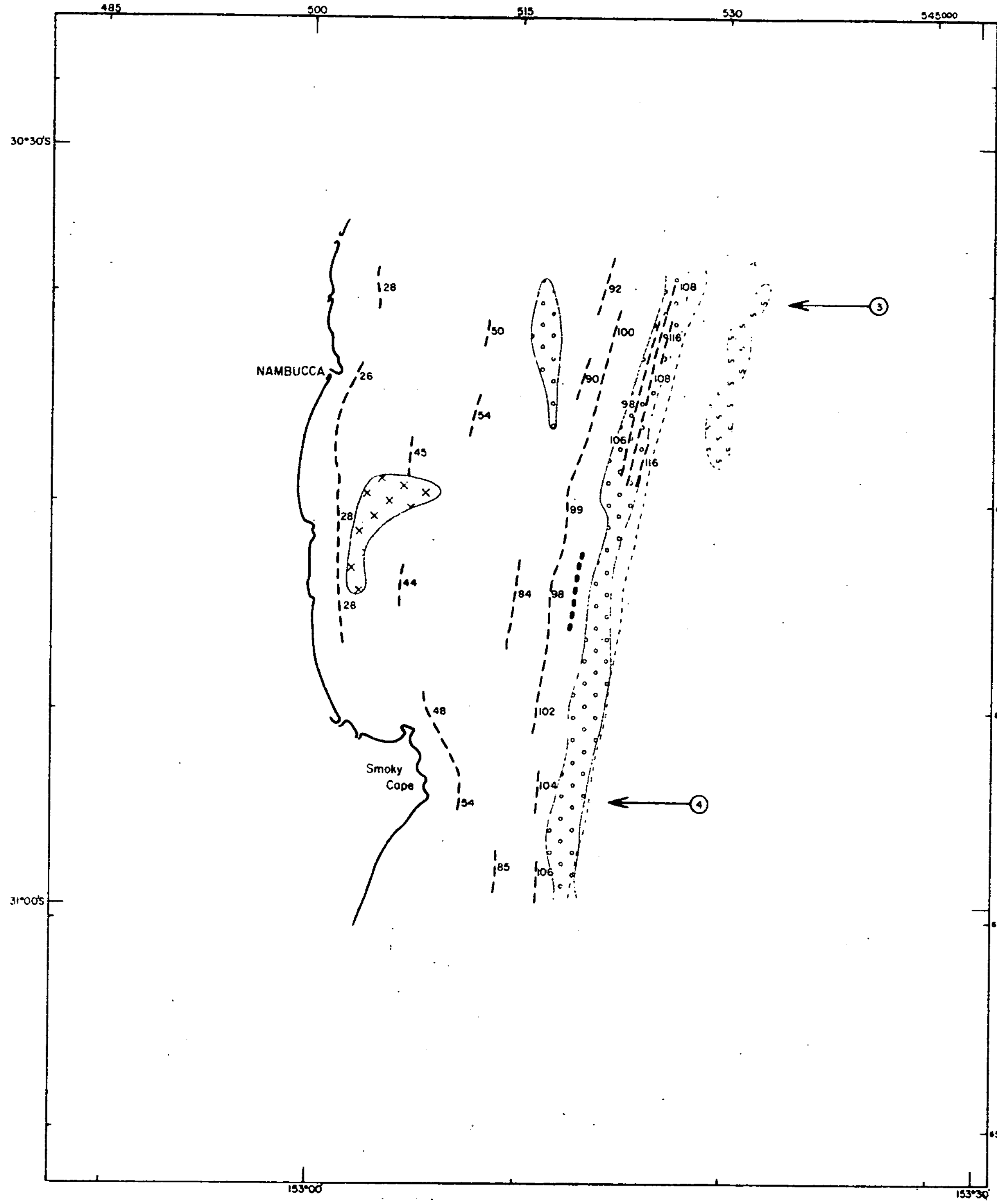

Coastline approximate

0 5 10 15 20 KILOMETRES
0 5 10 NAUTICAL MILES

Marginal numbers indicate 15 000-metre intervals of the Australian Map Grid, Zone 56

LEGEND

Rough ground. Bedrock probably exposed

Banks or rough ground. Probably sand or shell banks

Rough ground. Probably caused by erosion or slumping.

120-metre isobath

114 Base of change of slope, depth in metres.

Axis of linear depression

Fig. 4. DETAILS OF SHELF MORPHOLOGY, 30°30'S TO 31°00'S.

Numbered arrows indicate locations of E-W profiles illustrated in Figure 2.

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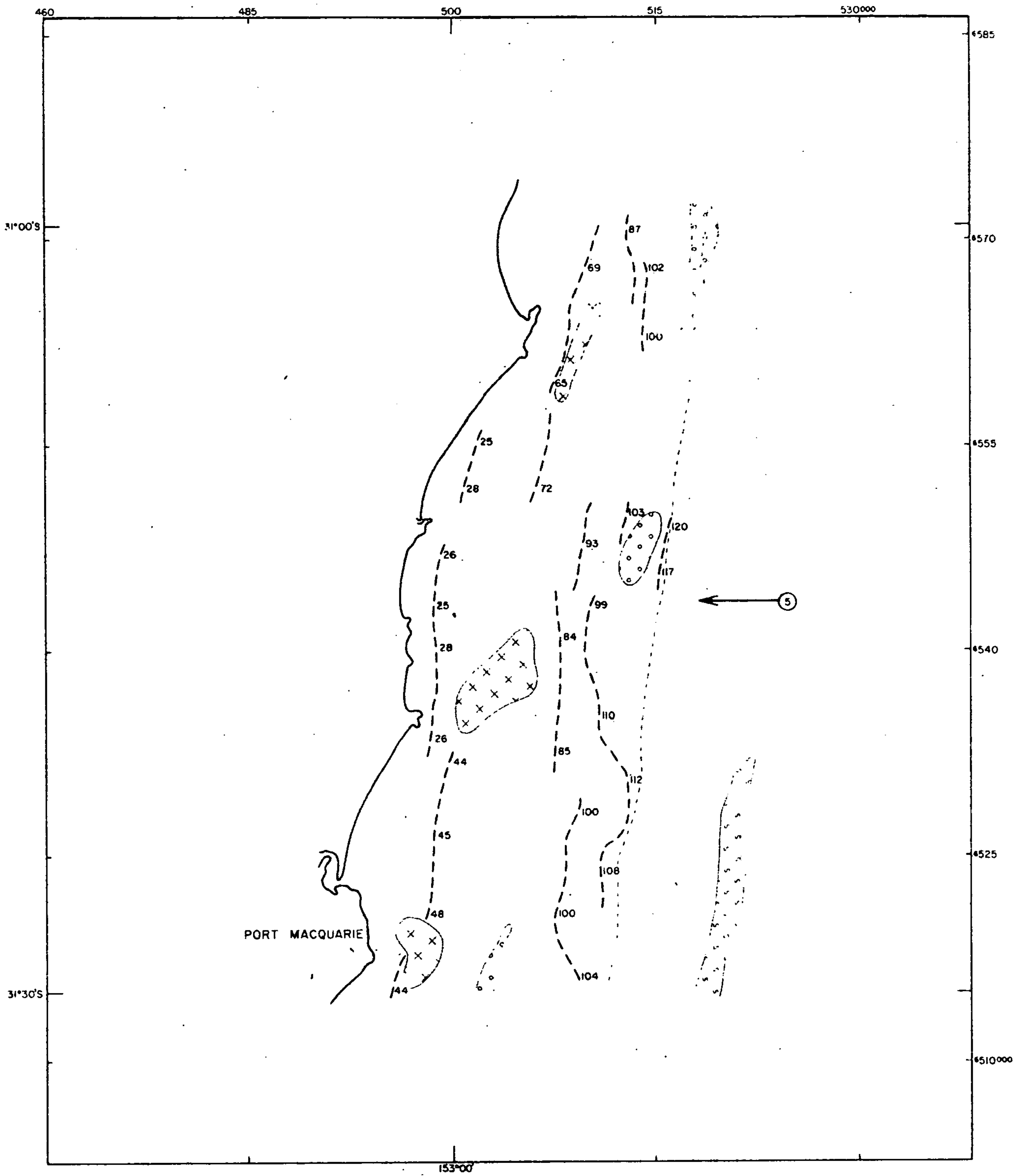

Coastline approximate

0 5 10 15 20 KILOMETRES
0 5 10 NAUTICAL MILES

Marginal numbers indicate 15 000-metre intervals of the Australian Map Grid, Zone 56

LEGEND

Rough ground. Bedrock probably exposed

Banks or rough ground. Probably sand or shell banks.

Rough ground. Probably caused by erosion or slumping.

120 - metre isobath

114 Base of change of slope, depth in metres.

Axis of linear depression.

Fig. 5. DETAILS OF SHELF MORPHOLOGY, 31°00'S TO 31°30'S.

Numbered arrows indicate locations of E-W profiles illustrated in Figure 2

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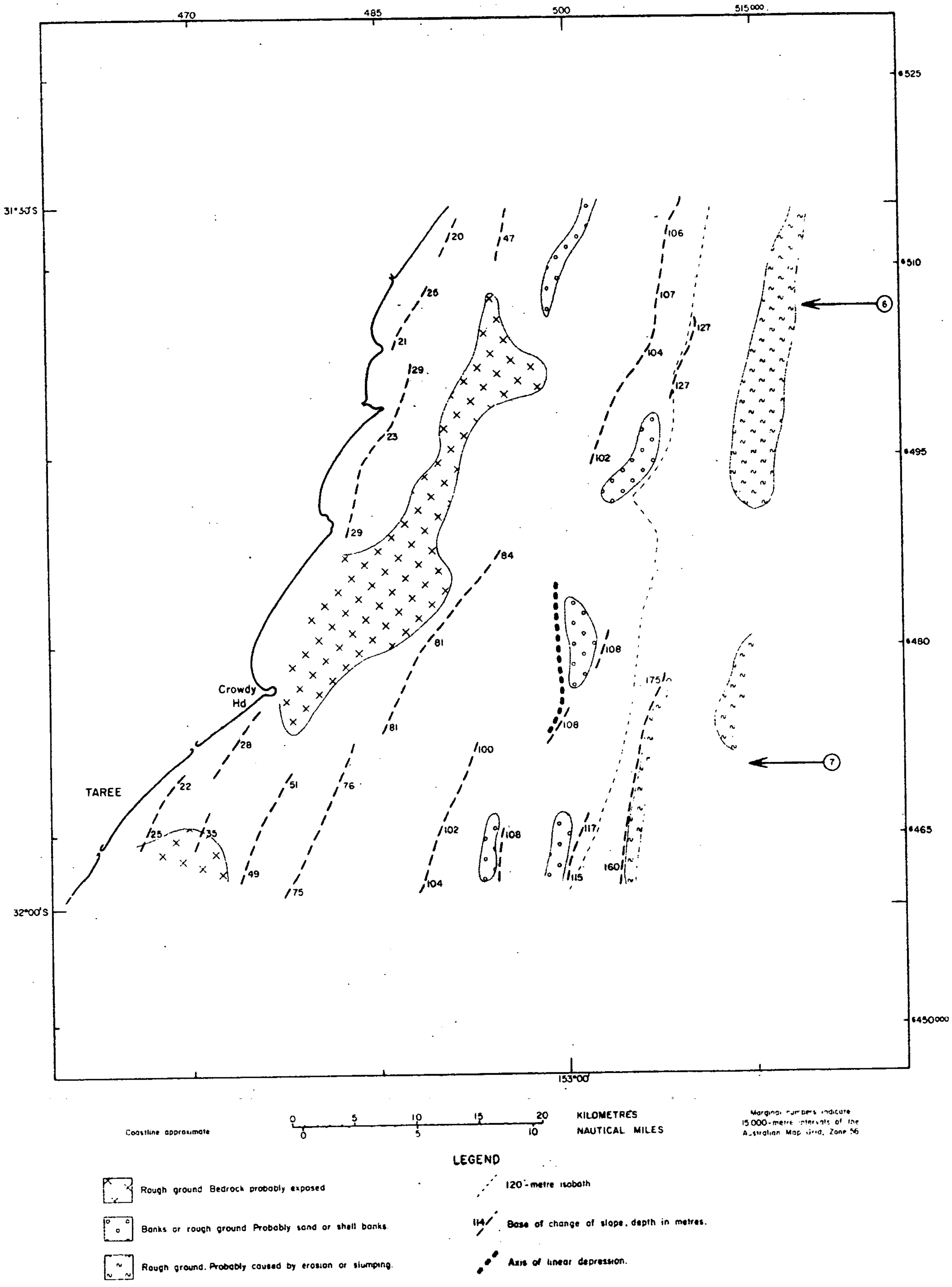

Fig. 6. DETAILS OF SHELF MORPHOLOGY, 31°30'S TO 32°00'S.

Numbered arrows indicate locations of E-W profiles illustrated in Figure 2.

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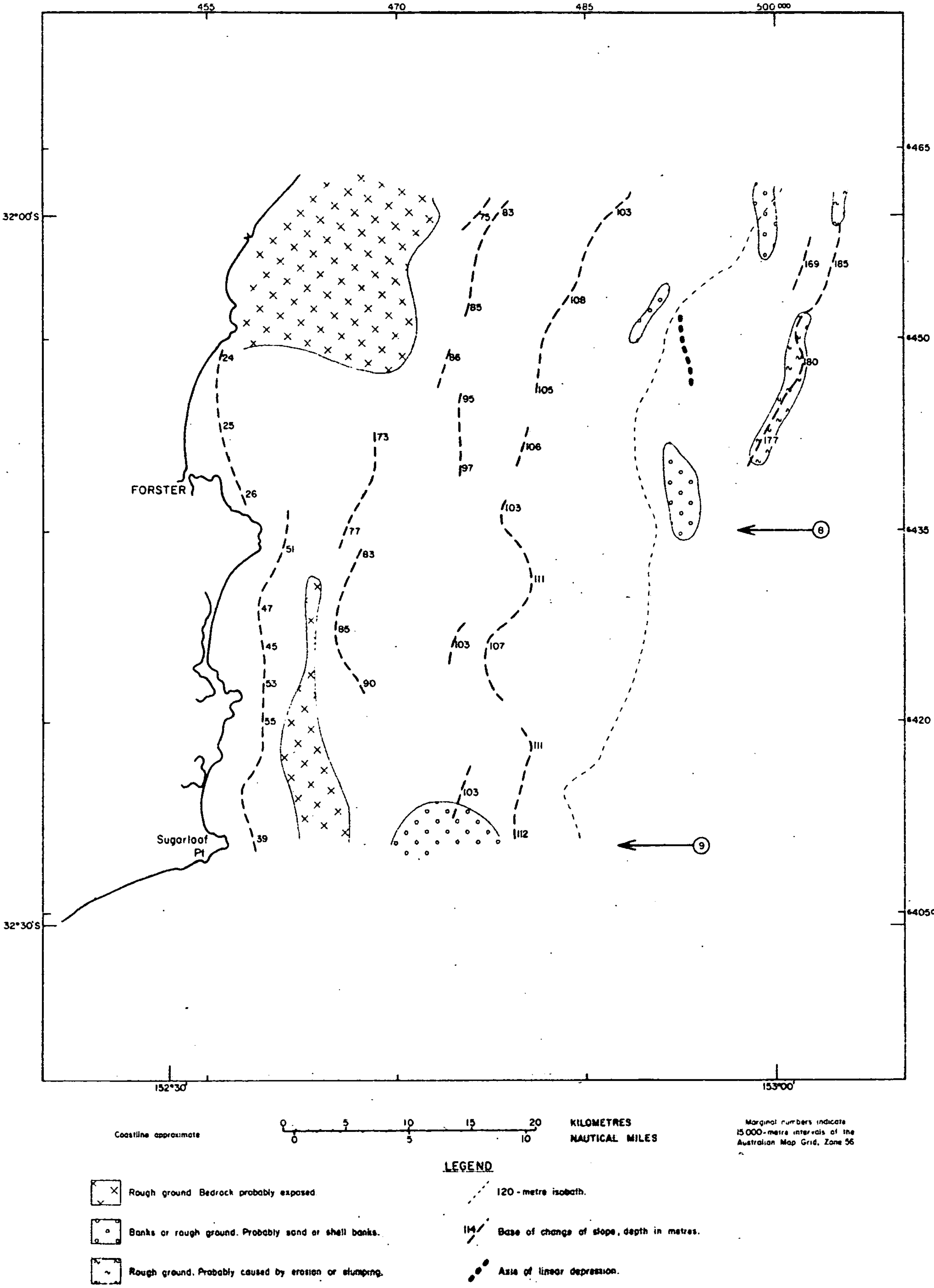

Fig. 7. DETAILS OF SHELF MORPHOLOGY, 32°00'S TO 32°30'S.

Numbered arrows indicate locations of E-W profiles illustrated in Figure 2.

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