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**NEARSHORE SEDIMENT DISTRIBUTION AND SAND AND GRAVEL DEPOSITS
IN LAGOONAL AREAS, NORTHERN TONGATAPU, TONGA**

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by

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INTRODUCTION

At the request of the Government of the Kingdom of Tonga, a reconnaissance field survey for offshore sand and gravel deposits was undertaken between 20 March and 5 April, 1986. The study was implemented as part of Programme Element CCSP/TG6 "Study of Coastal, Beach and Inshore Sand Deposits Suitable for Construction, Roading, Landfill and Other Purposes."

The present study was designed to aid Tonga in its long-term planning needs and concentrated on a moderately shallow lagoonal area north of Tongatapu roughly bounded by the islets of Fafa, Malinoa, Nuku and Tau (figure 1).

Previous CCOP/SOPAC studies in the lagoonal areas north of Tongatapu have included: Eade (1978) continuous seismic profiling, bathymetry and sampling; Gauss (1980) continuous seismic profiling, bathymetry, and sampling; Gauss and Carter (1982) hand coring/probing, sampling; Gauss, and others, (1983) summary of previous studies; Gauss (1983) vibrocoring and bathymetry; Rubin (1984) side-scan sonar and sampling. Most of these surveys have focused on the area between Fafa Island and the mainland, that is, to the south of the present study area. The present study overlaps only with that of Rubin (1984) whose side-scan sonographs are complimentary to the bathymetric and sampling data presented here.

The objectives of the present survey are:

- (1) to define the surface sediment distribution over a relatively large area paying particular attention to potential construction materials;
- (2) to relate sediment grain-size to bathymetry and sea bed morphology in an attempt to predict depositional environments ; and
- (3) to compare the results of this study with previous CCOP/SOPAC programmes in the area and to incorporate the data in a concurrently run coastal mapping exercise (CCSP/TG.12 - see CCOP/SOPAC Trip Report No.23).

Personnel who participated in the survey and assisted with logistic support are: - Bruce Richmond and Peter Roy (Marine Geologists) with CCOP/SOPAC Technical Secretariat. and David Tappin (Government Geologist), Simone Helu (Geologist). Sione Sokai (Geological Field Assistant), Api Santos (Field Assistant - Boat Operator), and Fini Hame (Field Assistant and Boat Operator) of the Ministry of Lands, Surveys and Natural Resources of the Kingdom of Tonga.

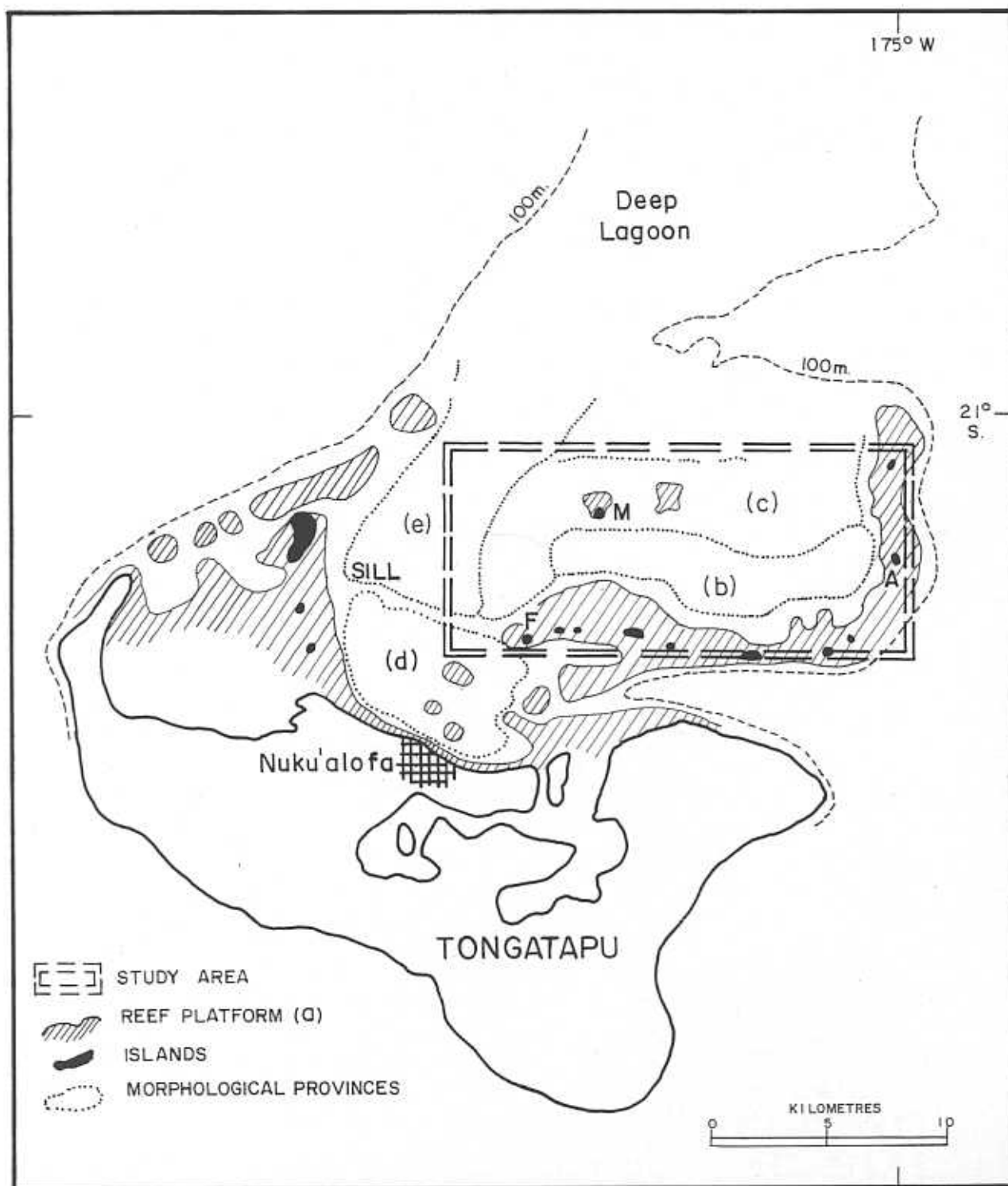


Figure 1: Tongatapu Island showing study area and morphological provinces :

- (a) reef platform,
- (b) smooth-floored sediment zone,
- (c) irregular reef zone,
- (d) deep basin and
- (e) sediment ramp.

F, M and A refer to Fafa, Malinoa and Ata Islands respectively.

The data collected consists of 12 echosounder profile lines totaling 100 line kilometers, 61 sediment samples, 2 diver-collected cores, and brief field inspections of 7 islets (figure 1). The area surveyed covered about 200km extending from beaches to water depths of just over 30m. Echosounder profiles were used to identify areas of sediment (smooth bottom) for dredging and to avoid areas of coral pinnacles.

PRELIMINARY RESULTS

All of the samples collected are sand-rich and many of them are made up primarily of coarse sand (appendix 1). Only seven samples contain more than a few percent of mud (sample numbers 4,25,26,45,54,55 and 61). The composition of the sediments includes coral, mollusk, coralline-algae, foraminifera and other calcareous materials.

The study can be sub-divided into 5 general morphological provinces. These are shown in figure 1.

- (a) A reef platform, mainly less than 3m deep and 1-2.5 km wide, bounded by a relatively steep and jagged slope zone.
- (b) A relatively smooth-floored sediment zone more than 8m deep.
- (c) An irregular sea bottom dominated by coral heads, pinnacles and patch reefs with limited sediment inbetween.
- (d) A deep, enclosed basin more than 25m deep with relatively steep side slopes.
- (e) A gently inclined sediment ramp. This shallows towards the south and ends in a sill 10-12 m deep on the northern side of the deep basin

Profiles 3 and 10 in figure 3 illustrate many of the characteristics of these provinces. In profile 3 the shallow reef platform is mostly covered by sediment as indicated by the smooth bottom. A small reef-flat channel is also present. The northern margin of reef platform is marked by a shallow rim that is exposed at low tide. A steep, irregular slope with scattered coral pinnacles separates the reef platform from the subjacent smooth-floored zone which appears to be sediment-covered. Coral pinnacles increase further north although commonly there are patches of sediment between the coral highs. Profile 3 ends at a small sand cay (Malinoa Island) developed on top of a small reef platform.

Profile 10 extends from Queen Salote Wharf to channel beacon No.1 - a distance of about 15km. Immediately north of the wharf is a deep basin (up to 34m) blanketed by sediment near the mainland but with an irregular (coral) bottom in its deepest part further seaward. The northern edge of the basin comprises a relatively steep slope that rises to a 10m deep sill adjacent to the reef platform. The sill surface is mostly covered by coarse-grained carbonate sediments of an orange/brown colour. It becomes deeper towards the north.

Although sand was encountered at all dredge stations, there are a few areas that are particularly attractive as potential sand and gravel resources. The most notable is the sill area covering at least several square kilometers west of Fafa Island. The coarseness, low mud content and proximity to Nuku'alofa (about 7km) of this deposit are favourable aspects. Perhaps the largest drawback is the water depth - most of the area is deeper than 10m.

Another large area of coarse sands in relatively shallow water (1-9m) occurs on the reef platform and its northern margin in an area between Motu Tapu - Fukave and Ata Islands. However the greater distance to Nuku'alofa (15+ km) and the proximity to active reef ecosystems that might be damaged by dredging possibly limit this areas' potential.

Diver-operated coring was able to penetrate 0.5m and 1.5m at two sites (60 and 61) located in the transition zone between provinces c and e (see figures 1 and 2). In both cases hardground or bedrock was not reached; the limit of coring was more a function of sediment resistance.

Minimum estimates of the amount of sand and gravel present in the above two areas are approximately 4,000,000 m³ (2km x 2km x 1m) and 3,000,000m³ (1km x 3km x 1m) respectively. These estimates are based on the assumption that the sediment thickness is at least 1m. However it is likely to be greater than this for most of the area under consideration.

PRELIMINARY RECOMMENDATIONS

Although final conclusions won't be available until a thorough analysis of all the data has been completed, there are several preliminary recommendations that can be tentatively made to aid Tonga's short-term planning needs.

- (1) There appears to be abundant sand resources in the areas studied. Assuming a sand density of 1.7 tons/m³ and usage at an estimated rate of 8,000 tons/year (Rubin, 1984) the sand body west of Fafa Island could conservatively supply Tongan sand needs for 850 years at the present rate of usage.

- (2) In order for the marine sand bodies to be used, appropriate methods for their extraction need to be identified and the necessary equipment procured. A possible dredging system could consist of a barge-mounted crane with clamshell-type bucket, sand-transporting barge, and a small tugboat. Such a system uses technology currently available in Tonga and has the flexibility to work around coral heads and in very-coarse sediments.
- (3) At the same time the dredging operation is being planned, the sand bodies (especially that to the West of Fafa Island) should be further delineated. Studies should include more detailed surface sampling and geophysical surveys. Consideration should also be given to the environmental effects of the proposed dredging, however these would probably be minimal and extremely localized in this area.

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The views expressed in this report are those of the authors and do not necessarily reflect those of the United Nations.

APPENDIX I

FIELD DESCRIPTIONS OF SEDIMENT SAMPLES

ABBREVIATIONS USED:

SORTING TERMS

ws	=	well sorted
mws	=	moderately well sorted
ms	=	moderately sorted
ps	=	poorly sorted
vps	=	very poorly sorted

GRAIN SIZE TERMS

fs	=	fine sand
ms	=	medium sand
cs	=	coarse sand
vcs	=	very coarse sand
g	=	gravel

MUD TERMS

o	=	no mud present
t	=	trace mud
s	=	slightly muddy
%	=	% mud estimated

SAMPLE	WATER DEPTH *	SORTING/GRAIN-SIZE	MUD	COLOUR
1	11.0	PS/VCS	O	CREAM
2	12.5	PS/CS	T	DARK GREY
3	11.5	PS/CS	T	DARK GREY
4	11.0	WS/FS	5%	LIGHT GREY
5	8.5	MS/MS	S	LIGHT GREY
6	3.0	MS/MS	S	LIGHT GREY
7	Beach	MPS/CS	O	CREAM
8	3.0	MPS/CS	O	CREAM
9	6.0	MPS/CS	O	DARK CREAM
10	9.0	PS/MS	T	DARK CREAM
11	9.5	VPS/CS	T	CREAM
12	4.0	MS/MS	O	DARK CREAM
13	1.0	MS/MS	O	DARK CREAM
14	0.2	PS/CS	S	LIGHT BROWN
15	Beach	MWS/MS	O	LIGHT BROWN

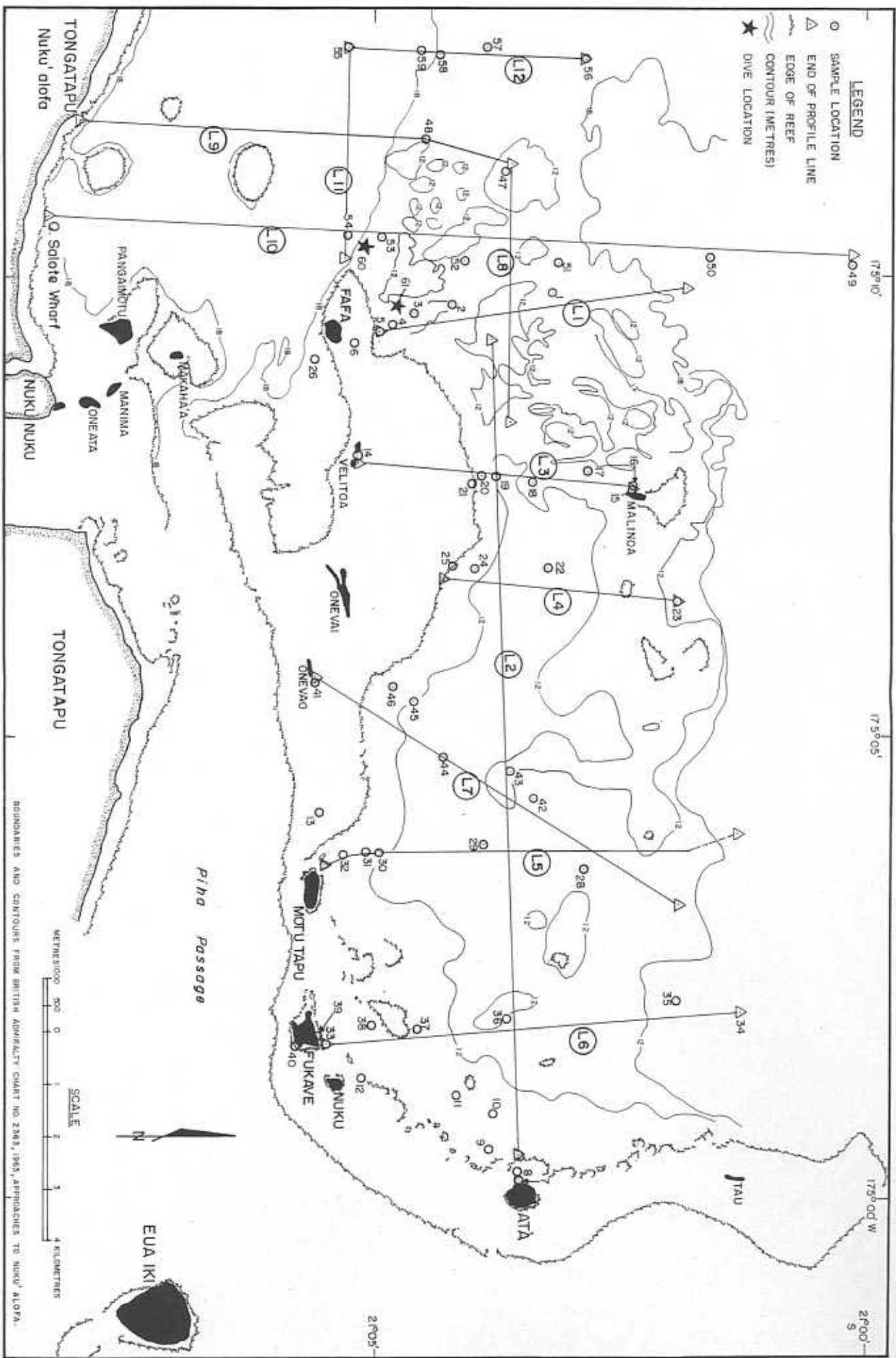
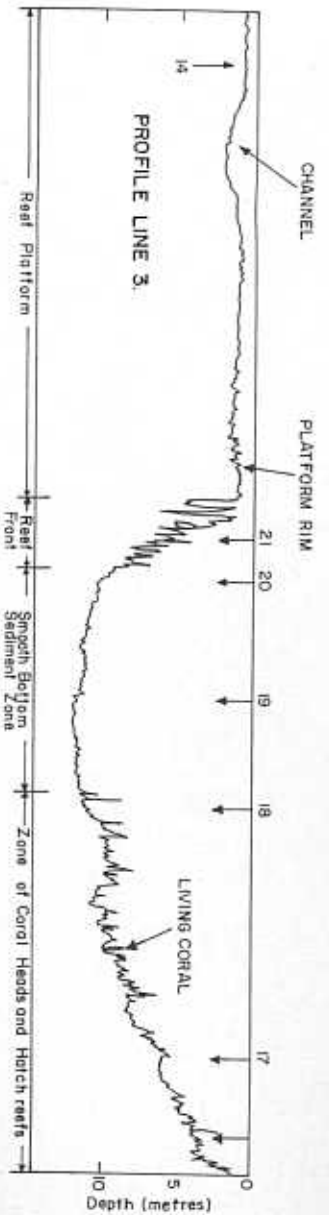


Figure 2. LOCATION OF ECHOSOUNDER PROFILE LINES, SAMPLES AND DIVE SITES WITHIN THE STUDY AREA

SOUTH



NORTH

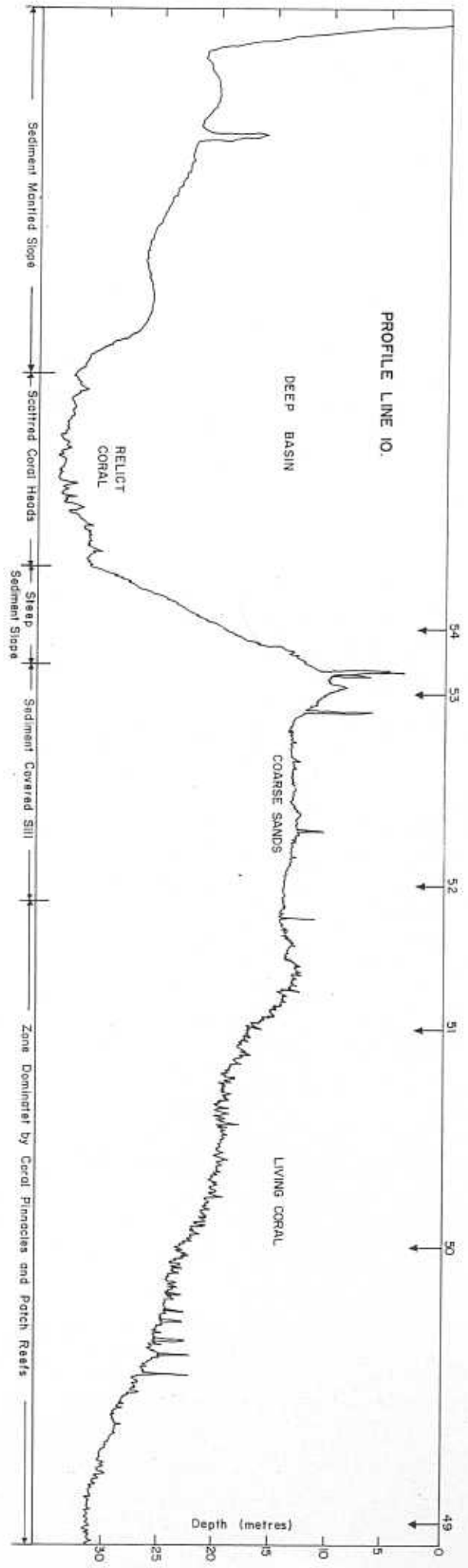


Figure 3. SELECTED BATHYMETRIC PROFILES FROM THE STUDY AREA SHOWING TYPICAL SEA BED MORPHOLOGIES AND BOTTOM TYPES. REFER FIGURE 2 FOR LOCATIONS. SEDIMENT SAMPLING SITES ARE NUMBERED.