

THE UNDERWATER MORPHOLOGY OF PALMERSTON AND SUWARROW ATOLLS

by J. Irwin*

ABSTRACT

Methods used and results of echo sounding surveys of Palmerston and Suvarrow lagoons, Northern Cook Islands, are given in this paper. Notes on the compilation of a bathymetric chart of Palmerston Atoll are given and features of the underwater morphology of each lagoon are described and illustrated.

INTRODUCTION

During September 1981 Palmerston and Suvarrow Atolls in the Northern Cook Islands were surveyed by echo sounder. This work was part of a joint N. Z. Oceanographic Institute and Royal Society of London cruise using the New Zealand Research Vessel R. V. Tangaroa. Sounding coverage was carried out from 5-14 September at Palmerston Atoll but only two days, 20 and 21 September were available for soundings at Suvarrow, allowing only sketch coverage to be made. This note describes the methods and results of the sounding survey and data on water characteristics at the time of survey.

Methods and Equipment:

A 5.5 m aluminium outboard-motor-powered boat and Raytheon survey echo sounder (Model DE 719B) with the transducer mounted overside were used. Additional and comparative echo soundings were made with a Furuno F850 echo sounder. Five stations at Palmerston Atoll and one at Suvarrow Atoll were occupied to collect water samples with National Institute of Oceanography water bottles for salinity readings and water temperatures throughout the water column were recorded using a bathythermograph. Data collected was used to correct echo soundings for

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regional variations to the velocity of sound in water. Foxboro tide gauge stations were established at Home and Primrose Islands at Palmerston Atoll and at Anchorage Island and Suvarrow Atoll, all inside the lagoon. Tidal readings from Home Island were used to reduce soundings to a common datum, near low water. This gauge and the gauge at Suvarrow Atoll were referenced to bench marks.

Field plots were made using Atoll outlines from 1974 aerial photography mapped by photogrammetric methods. Original aerial photographs were also available. Sounding traverses were made between known points at constant boat speed. The low relief and large width of the lagoon made navigation difficult. To aid position fixing and shorten traverse lines two large inflatable iridescent red buoys were positioned in an approximate N-S line near the centre of the lagoon. These buoys aided position fixing, shortened traverse lines and provided end points for sounding traverses. Traverse end points were established at atoll islands, identified on aerial photographs, or by compass bearings of positions inside the atoll edge. Compass bearings were used on long traverses to check position along the line. Navigation Chart (B.A. 1147 Suvorov Islands) was used to plot sounding traverses at Suvarrow Atoll. Positions plotted on this chart showed the south west side of the atoll further northwards than depicted, by approximately 0.2 to 0.7 nautical miles, this was confirmed by ships radar from R. V. Tangaroa anchored inside the lagoon. Figure 3 shows Suvarrow atoll from 1974 aerial photography.

Fifty two traverses approximately 400 metres apart gave coverage of Palmerston Atoll for which a bathymetric chart has been prepared for publication (Irwin and Main 1983). Ten echo sounding traverses provided sketch coverage of Suvarrow Atoll.

B.A. Chart 1147 Suvorov Islands shows soundings from surveys of 1900 and 1920; these spot soundings were made before the advent of the echo sounder. The present survey provides continuous sounding traverses depicting bottom configuration, and in the case of Palmerston Island provides new information.

PALMERSTON ATOLL

Situated 500 kilometres NW of Rarotonga, Palmerston Atoll takes the form of a diamond. Groups of islands are situated about the reef concentrated on the N, S, E and W points. Land area is approximately 400 hectares. The lagoon measures 9 km N-S and 6.5 E-W and the exposed reef averages 0.5 km across. Several boat passages across the reef are situated on the NW side.

Underwater Morphology:

The underwater morphology is best shown by a bathymetric chart, which means depth information from the echo sounder graphs had to be plotted on a collector sheet. The extreme undulating bottom allowed only high and low points to be read off the graphs along each traverse.

A total of 8870 depths from 52 traverses, half highs and half lows were read off, corrected, reduced and plotted on an enlarged outline (scale 1:5,000) of the atoll. Final publication scale is 1:18,000. The volume of information on any one traverse made it impossible to show all the information in chart form. The great variability in depth of coral heads (highs) made the drawing of isobaths impossible. Consideration was given to showing the heads by symbol along each traverse, but their numbers precluded this. The lows, or areas between the coral heads, were contoured to show the bottom shape of the lagoon (Fig. 2), and this data is shown on the bathymetric chart of the atoll (Irwin & Main 1983).

Within the lagoon coral heads rise to the surface close to the SW shore but few do over the main body of the lagoon.

Echo sounder records showed the bottom to be covered with coral heads. Since they were evident on every sounding traverse, which gave good even coverage of the lagoon, the assumption can be made that this very high concentration of coral heads covers the lagoon floor. Figure 1 shows sample echo sounder records at selected positions across the lagoon. The Raytheon survey sounder used operated on a frequency of 200 kHz and has a transducer beam width of 10°. The high sounding rate on the scales used for the survey, 534 and 267 soundings per minute, with fast graph speed through the machine provided high resolution records. Simultaneous soundings using the Raytheon sounder with a Furuno model F850 sounder which has a lower sounding rate of 155 soundings per minute confirmed the Raytheon's superior resolution in these conditions.

The concentration of coral heads appear to be fairly uniform over the atoll basin to the deepest (30 + m) areas. Slightly higher concentrations of heads occur in the shallower areas, particularly the N end of Palmerston atoll. The height of the heads above the general atoll bottom is highly variable. The sounder did resolve small but definite flat sandy areas between the coral heads which were confirmed by first-hand observations and sampling by divers.

The inner edge of the reef is steep sided, the 5 m contour falling close to the inner reef edge. The 20 m contour also lies close to the inner reef edge except in the N sector which is shallower. The area within the 26 m contour, about 4 km x 3 km is comparatively flat, sloping to a low area 1.5 km x 1.2 km within the 30 m contour of similar shape to that of the atoll. This contains the deepest recorded depth of 34.6 m located to the S and E of the centre of the atoll. Isolated highs shown in comparatively deep water appear anomalous but these represent large coral head complexes which lie close to the sounding traverses.

Water Characteristics and Tidal Measurements:

Temperature and Salinity

Measurements were made at Palmerston Atoll on 11 September 1981 at 5 stations. Water temperature varied less than 0.5°C at any one

depth, at any sampling position, and less than 0.8°C from surface to bottom. Average surface temperature was 26.5°C decreasing to 26.2°C at 10 m, 25.8°C at 16 m, 25.7°C at 22 m and to the bottom at 30 m. Surface salinity was 35.47‰ increasing to 35.50‰ at 5 m, 35.54‰ at 10 m, 35.62‰ at 20 m and 35.66 at 25 m.

Tidal measurements

Measurements were made continuously from 4-17 September 1981 at Home Island inside the reef. Semi-diurnal tides recorded a maximum range of 0.51 m and a minimum range of 0.23 m over the period. The gauge on Primrose Island also inside the reef recorded a maximum range of 0.41 m and a minimum range of 0.25 m.

SUWARROW ATOLL

Suvarrow Atoll lies 950 kilometres NNW of Rarotonga. The atoll is near circular in shape with protrusions on the north and east sides, an entrance to the lagoon is located on the north-east side. Islands are situated around the reef except on the south west side. The lagoon is 15 km across E-W and 12 km N-S, the reef averages 0.5 km in width (Fig. 3).

Underwater Morphology:

The 10 sounding traverses run provide a sketch survey but the complex nature of the atoll with many reefs made drawing a bathymetric chart impractical. Figure 3 shows the atoll with sounding traverses, and selected sounder records are shown in Figure 4.

Suvarrow Atoll contains a number of reefs (up to 0.5 km long) which are exposed at low water. Coral patches and heads lie in shallow water areas close to the surface in the W, NW and E sectors inside the reef edge. Elsewhere deep water extends to the inner reef edge as shown by the soundings taken.

Many small coral heads are evident in the shallower areas. In the deep areas, the bottom exhibits highs with small coral heads on top, and relatively flat areas both with and without coral heads. Section 3-4 is a good example of these deeper flat areas. Samples of coral sand were dredged from clear areas.

Suvarrow Atoll with depths of over 60 metres is twice the depth of Palmerston Atoll. Soundings taken at Suvarrow reveal the bottom configuration to be quite different from Palmerston Atoll with a much lesser concentration of coral heads and relatively flat clear areas in the deeper parts (Figs. 1 and 4).

Water Characteristics and Tidal Measurements:

Temperature and Salinity

Measurements at 1 station on 21 September 1981 gave water temperature of 28.0°C at the surface and down to 24 m, decreasing to 27.9°C

at 32 m, to 27.8°C at 40 m and to 27.7°C from 40 m to the bottom at 64 m. Salinity over this depth ranged from 35.51-35.56 ‰.

Tidal measurements

Measurements were made using a tide gauge and semi-diurnal tides were recorded with a maximum range of 0.69 m and a minimum range of 0.51 m over a 48 hour period on 20-22 September 1981. Over a 14 day period a party on the island using a tide pole recorded readings from 9 to 92 cm, a range in excess of 0.80 m, but readings of peaks of high and lows may have been missed (C. Woodroffe pers. comm.).

ACKNOWLEDGMENTS

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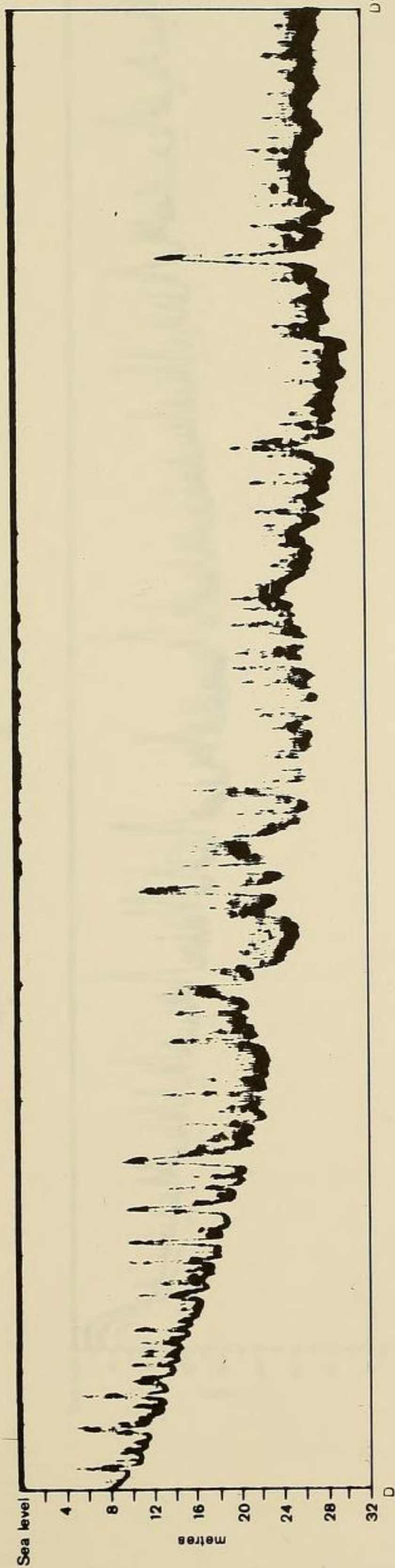


Fig. 1. Palmerston Atoll, Echo Sounder traces DD¹, AA¹, BB¹, CC¹, refers to traverses marked in Fig. 2.



Figure 1: A plot of the signal $x(t)$ versus time t . The signal is periodic with a period of 4 units. The amplitude of the signal is 10. The signal is zero for $t \in [4, 5]$.

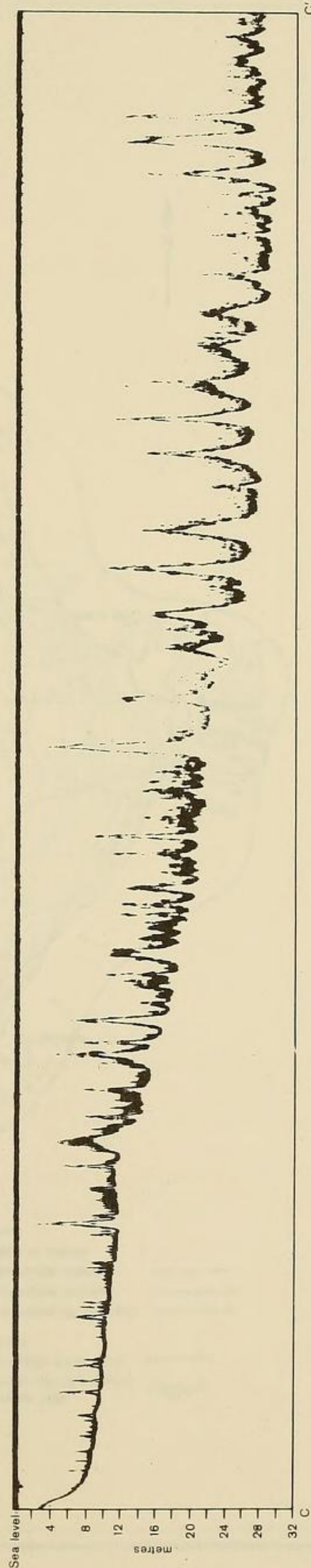
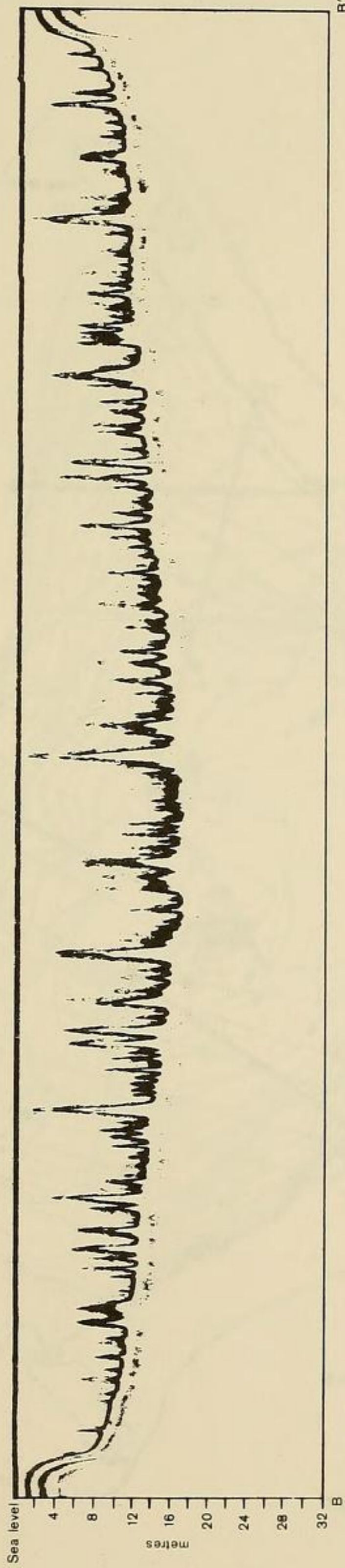
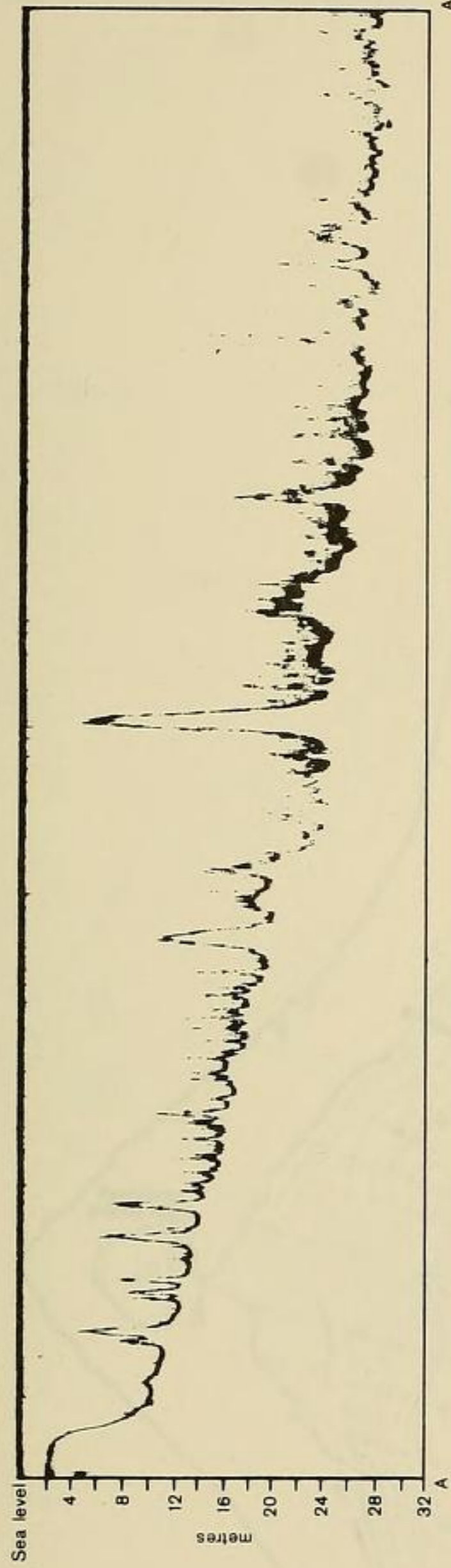


Fig. 1 cont'd.

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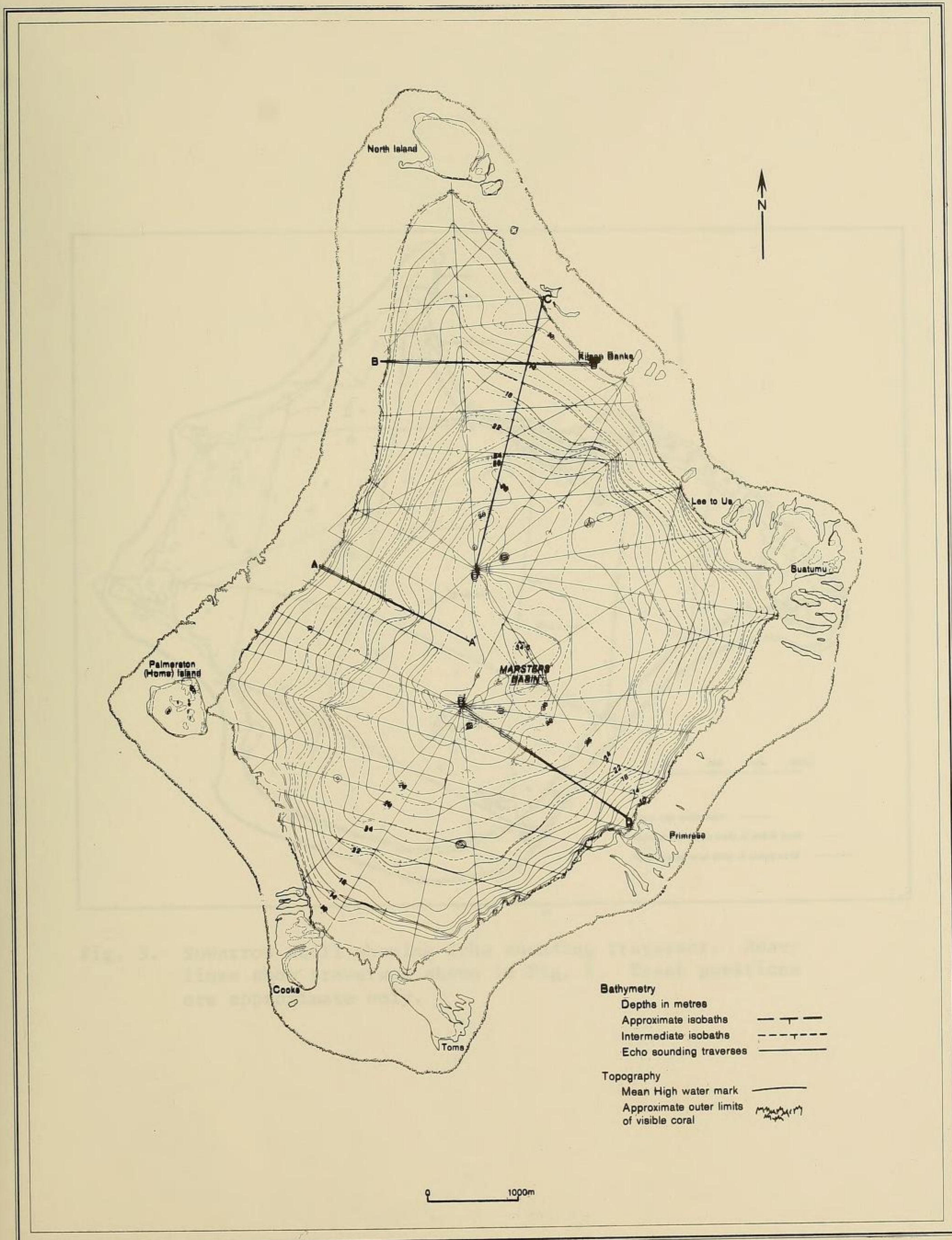


Fig. 2. Palmerston Atoll Bathymetry (m) of "low" areas.



Fig. 1. Fabrication of the "100" series.

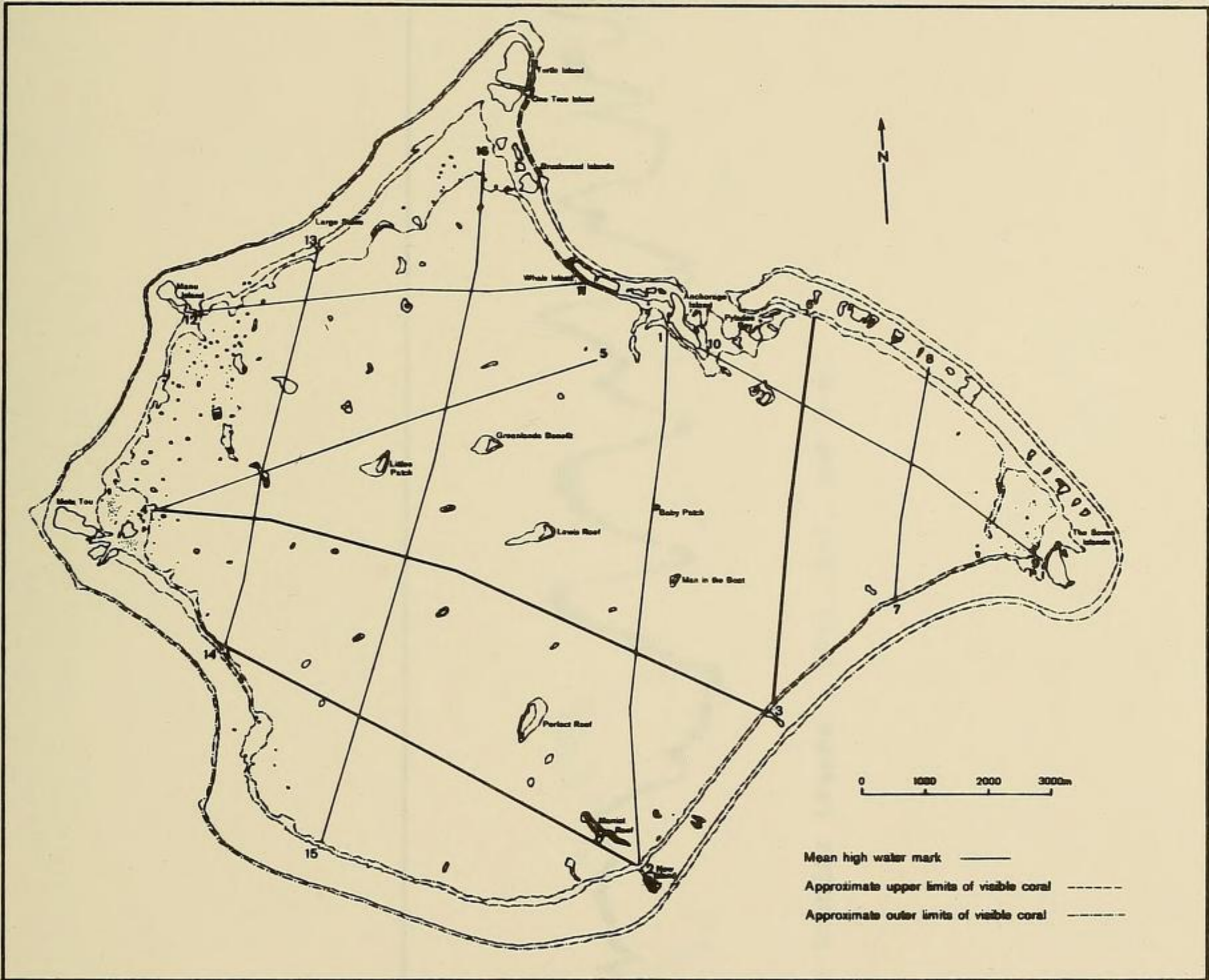


Fig. 3. Suvarrow Atoll showing echo sounding traverses. Heavy lines show traverses shown in Fig. 4. Track positions are approximate only.



Fig. 1. Diagram of fish showing the counting traverses. Heavy lines show traverses shown in the fish position and approximate cells.

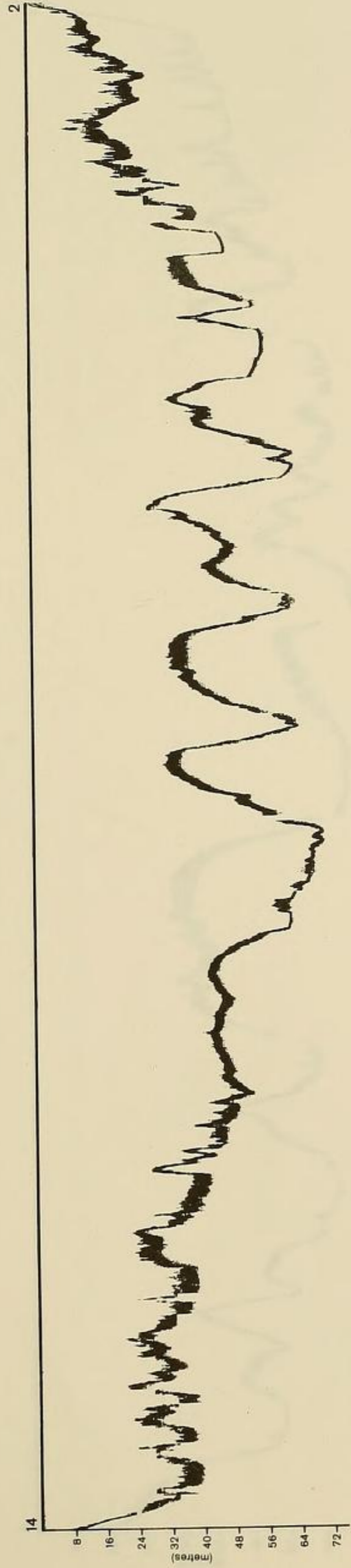


Fig. 4. Suwarrow Atoll Echo Sounder traces. 14-2, 6-3, and 3-4.

Fig. 10. Oscilloscope trace of the output of the amplifier.



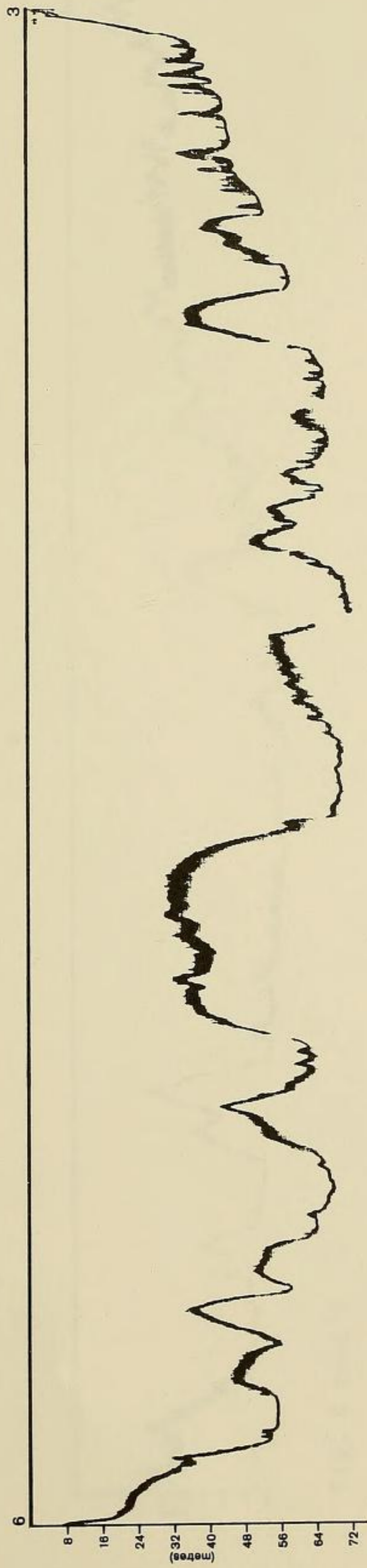


Fig. 4 cont'd.

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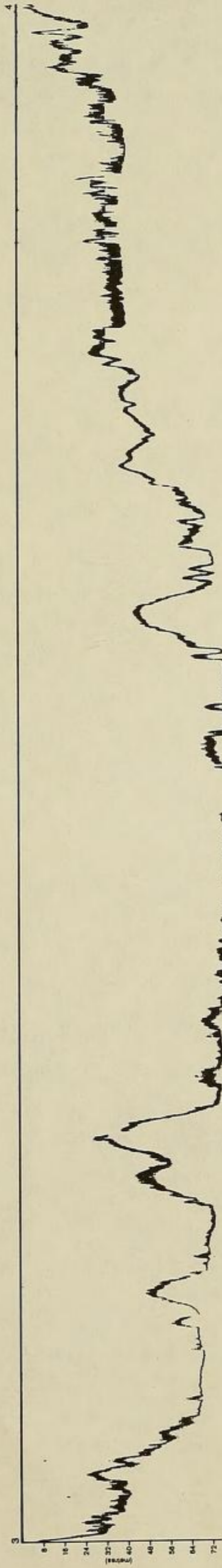


Fig. 4 cont'd.

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