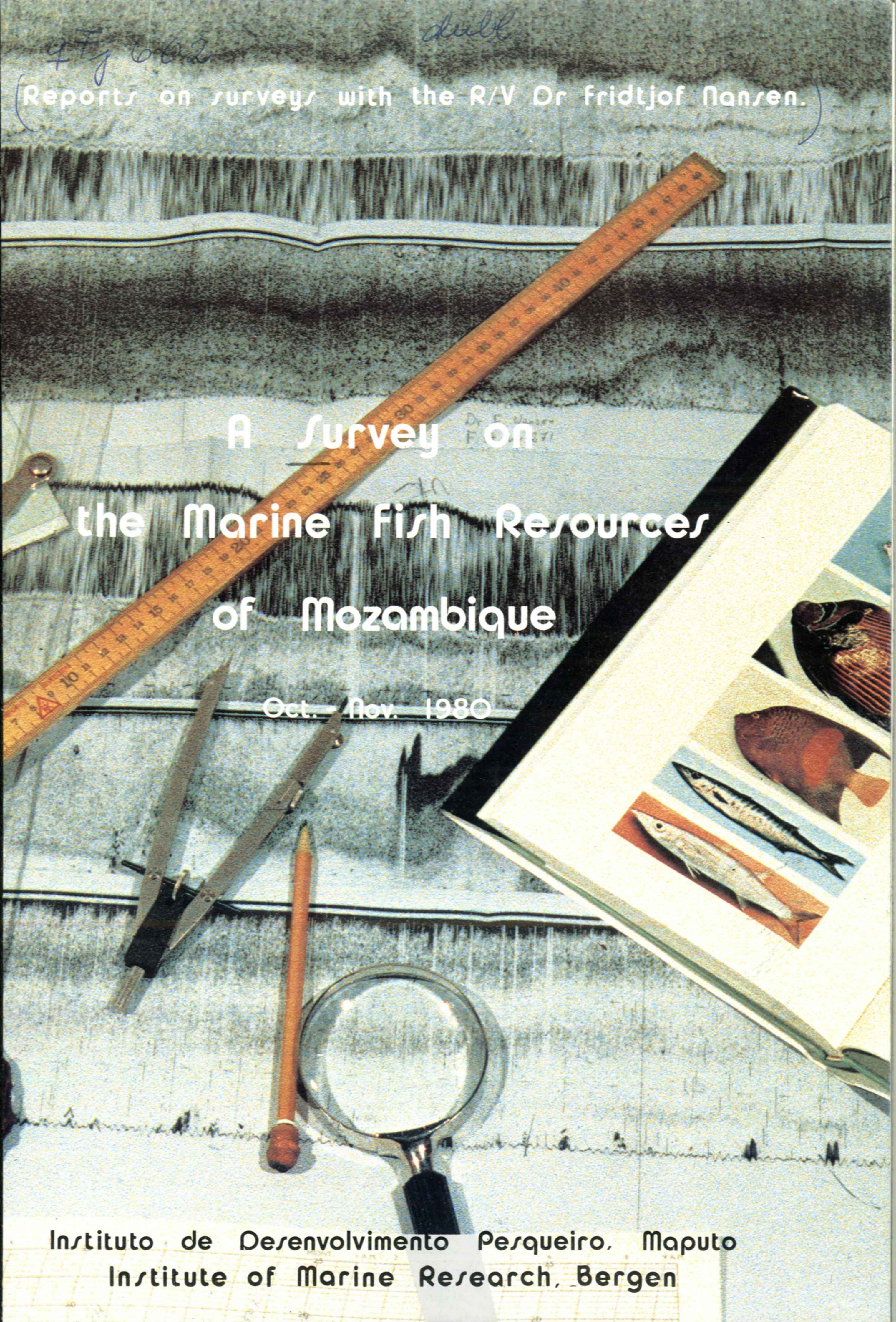

Reports on surveys with the R/V Dr Fridtjof Nansen.

A Survey on the Marine Fish Resources of Mozambique

Oct. - Nov. 1980

Instituto de Desenvolvimento Pesqueiro, Maputo
Institute of Marine Research, Bergen

«Dr. Fridtjof Nansen»

The fishery research vessel «Dr. Fridtjof Nansen» belongs to the Norwegian Agency for Development Cooperation (NORAD). It was designed and built for scientific and exploratory investigations of fishery resources of developing countries, under a joint plan with the Fisheries Department of FAO based on a funding of operation to be shared by FAO and Norway.

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(Reports on surveys with the R/V Dr Fridtjof Nansen.)

A Survey on the Marine Fish Resources of Mozambique

Oct. - Nov. 1980

by

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Bergen - Norway

September 1981

Reklametrykk A/S – Trykkshop

CONTENTS

1. INTRODUCTION

From August 1977 to June 1978 the Norwegian research vessel "Dr. Fridtjof Nansen" surveyed the waters adjacent to Mozambique. The results from this investigation were reported by SÆTRE and SILVA (1979). The report dealt with the pelagic and demersal fish resources as well as the crustaceans. It also included a brief description of the most conspicuous hydrographic features and some comments on whales.

According to an agreement between the government of the People's Republic of Mozambique and the United Nations Food and Agricultural Organization (FAO), "Dr. Fridtjof Nansen" returned to Mozambican waters in October 1980. During the period 10 October - 28 November 1980 an investigation was carried out with the following objectives:

- to study the distribution and abundance of small pelagic fish at Boa Paz Bank in Delagoa Bay,
- to study the distribution and abundance of small pelagic fish at Sofala Bank,
- to study the distribution of shrimps at Sofala Bank,
- to carry out oceanographic studies in Delagoa Bay and at Sofala Bank.

The program was executed by a joint team of Norwegian and Mozambican scientists.

2. METHODS

The R/V "Dr. Fridtjof Nansen" is a 150-foot stern trawler with a main engine of 1500 Hp. The vessel is equipped for acoustic surveying, bottom and pelagic trawling, hydrography and plankton observations.

The net used for bottom trawling was the shrimp trawl "Campelen Super" 1800 mesh with the following specifications:

30 m headline, 19 m ground rope, 40 mm mesh size in the body and 20 mm mesh size in the cod end. The trawl was without bobbins and equipped with a tickler chain. Bridles of 40 m gave it a horizontal opening of about 15 m and a vertical opening of about 5 m at a towing speed of 3 knots.

The 1600-mesh pelagic trawl had dimensions of 30 x 30 m around the trawl mouth. When fishing it was always equipped with a net sonde and the vertical opening was normally observed to be about 13 m. It was operated with 120 m bridles.

Nansen bottles were used for the oceanographic work. Temperature, salinity, dissolved oxygen and nutrients were observed at standard depths to the bottom or maximum 500 m. At some of the hydrographic sections samples for chlorophyll a analysis were collected from six levels between the surface and 50 m depth. The salinity and oxygen samples were analysed onboard. Samples for nutrients were immediately deep-frozen and stored for determinations by means of an autoanalyzer in Bergen. The samples for chlorophyll a were filtered through 0.45 μ pore size membrane filters. The filters were kept frozen for later extraction and fluorometric analysis in Bergen.

The vessel was equipped with two echo sounders, one operating at 38 kHz and one at 120 kHz, connected to echo integrators. Settings and performance of the two acoustic systems were:

	120 kHz	38 kHz
Basic range	0-100 m	0-100 m
Transmitter	1/1	Ext.
Transducer (ceramic)	10^{o} (circular)	8^{o} x 8^{o}
Band width	3 kHz	1 kHz
Pulse length	0.6 m. sec	0.6 m. sec.
TVG and gain	20 log R - 0 dB	20 log R - 20 dB
Integrator threshold	3	3
Integrator gain	30 dB	30 dB

The integrator values from the 38 kHz system were used for abundance estimation of fish, while the 120 kHz values were used as an aid during the daily scrutinizing of the echo recordings.

The acoustic abundance estimate was calculated by the equation:

$$B = \oint P_a \, dA = C \cdot \overline{M} \cdot A$$

where B is the fish biomass, P_a the fish density expressed in weight per unit area, C is a conversion coefficient, $\overline{M}$ is the average integrator reading, and A the corresponding area. The value for C is a function of species as well as of fish length (BLINDHEIM et al., 1980, NAKKEN and SANN AUNG, 1980).

The numerical value of C applied in these calculations was:

$$C = 0.8 \cdot L \ {}^{\text{tonnes}}/_{\text{mm} \cdot (\text{n.m})^2}$$

where L is the average length in cm. A more detailed description of the determination of C is found in Appendix C.

Catches of fish were sorted by species and measurement of total length, weight, sex and maturity stage were carried out for the most abundant species. For identification of fish the FAO Species Indentification Sheet for Fishery Purposes were used and to a minor degree SMITH (1977). Family names are according to NELSON (1976). The group "Pelagic fish" consists of species which usually forms school and have a diurnal vertical migration pattern. The following families have been included in this group: Ariommidae, Carangidae, Clupeidae, Chirocentrida, Engraulida, Leiognathidae, Scombridae, Sphyraenidae and Trichiuridae.

For the identification of shrimps the works of BARNARD (1950), JOUBERT (1965), GEORGE (1970), MOHAMED (1970) and LE RESTE (1978) were used. Catches were sorted by species and measurement of carapace length, sex and maturity stage were carried out for the two main species, *Penaeus indicus* and *Metapenaeus monoceros* during the first cruise at Sofala Bank. The carapace length, defined as the distance between the post-orbital margin and the posterior dorsal midline of the carapace, was measured with a caliper to the nearest 1 mm below. The following maturity scale was used:

Maturity stage	Stage no.
Immature	1
Early maturing	2
Late maturing	3
Mature	4
Spent-recovering	5

3. DELAGOA BAY

Fig. 1 shows the survey routes and the location of the stations. A record of the fishing operations is listed as APPENDIX A. The length distribution of the most important species appears in APPENDIX B.

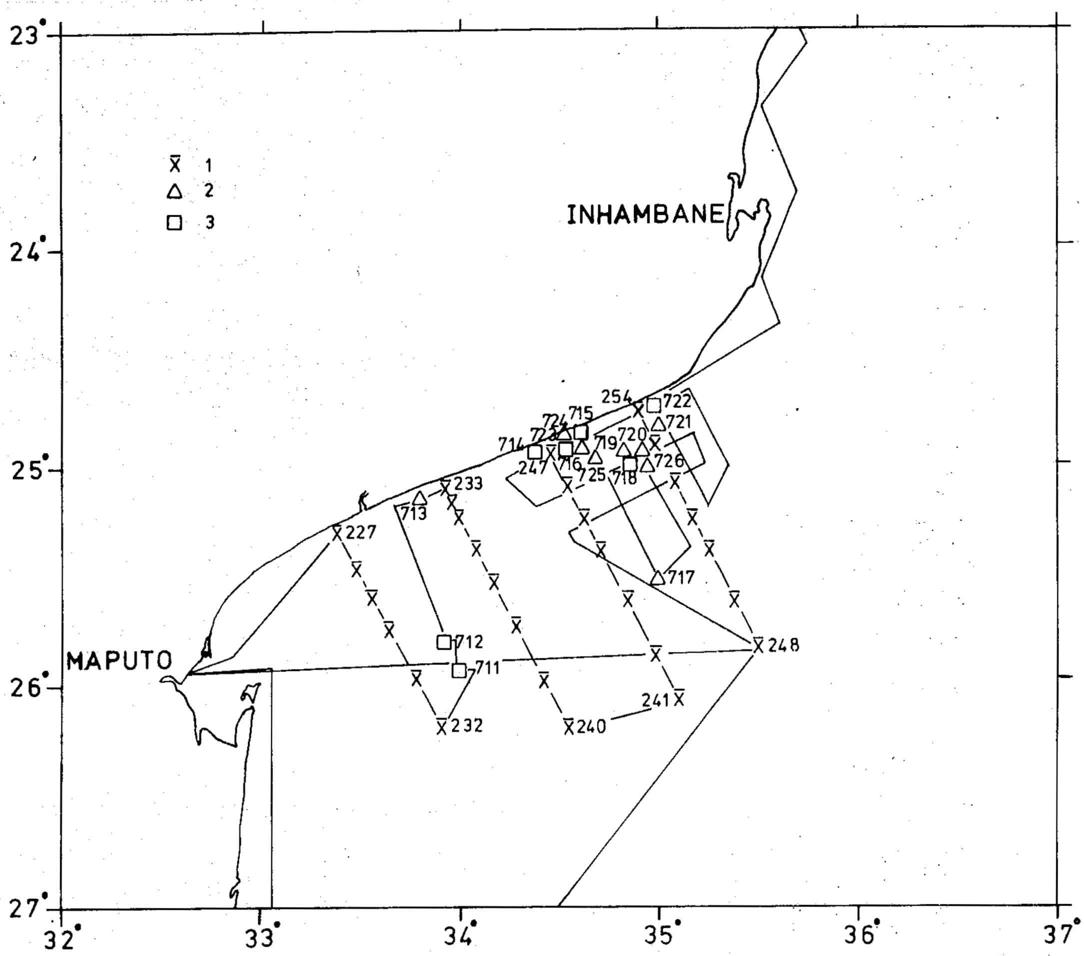

Fig. 1. Survey routes and location of the stations in Delagoa Bay.
1) Hydrographic station, 2) Pelagic trawl, 3) Bottom trawl.

3.1 Hydrography

The distribution of the hydrographical and chemical parameters in SECTIONS I-IV is shown in Figs. 2-6. In the surface layer the highest temperatures are usually associated with the lowest salinities. The subtropical surface water along the coast of Mozambique forms a sub-surface salinity maximum at depths between 100 and 300 m. As can be seen, this water is lifted to the surface along the inner part of the sections. This tendency is most pronounced in SECTION I-III.

The nutrient concentrations were very low in the upper 50 m, especially nitrates. A sharp gradient of increasing concentrations was observed between 75 and 125 m depth or in the upper part of the main thermocline. In SECTION I (Fig. 2) a nitrate maximum was found at about 150 m and a silicate minimum below.

In SECTION III (Fig. 5) a nutrient minimum was detected at the two outermost stations, which seemed to be related to the salinity maximum. Another striking feature in SECTION III was the small nutrient maximum near the bottom at 200 m depth. A similar observation was made in SECTION IV (Fig. 6).

The chlorophyll a concentrations (Fig. 4) showed very low values in the upper 20 m. In SECTION I there was a slight increase in the whole water column at the innermost station. In SECTION IV two maxima at about 50 m depth were observed.

3.2 Fish distribution and abundance

Fig. 7 shows the distribution of echo recordings from pelagic fish in Delagoa Bay. Along the coast there was an area of scattered pelagic recordings from a mixture of species. No concentrations of commercial interest were observed. The total abundance was probably about 20-30 000 tonnes. The catches were dominated by the round herring (*Etrumeus teres*). In addition, the following species contributed to the catches: Driftfish (*Ariomma indica*), cavalla (*Carangoides malabaricus*, scad (*Decapterus* spp.), horse mackerel (*Trachurus trachurus*) and the anchovy (*Stolephorus buccanerii*).

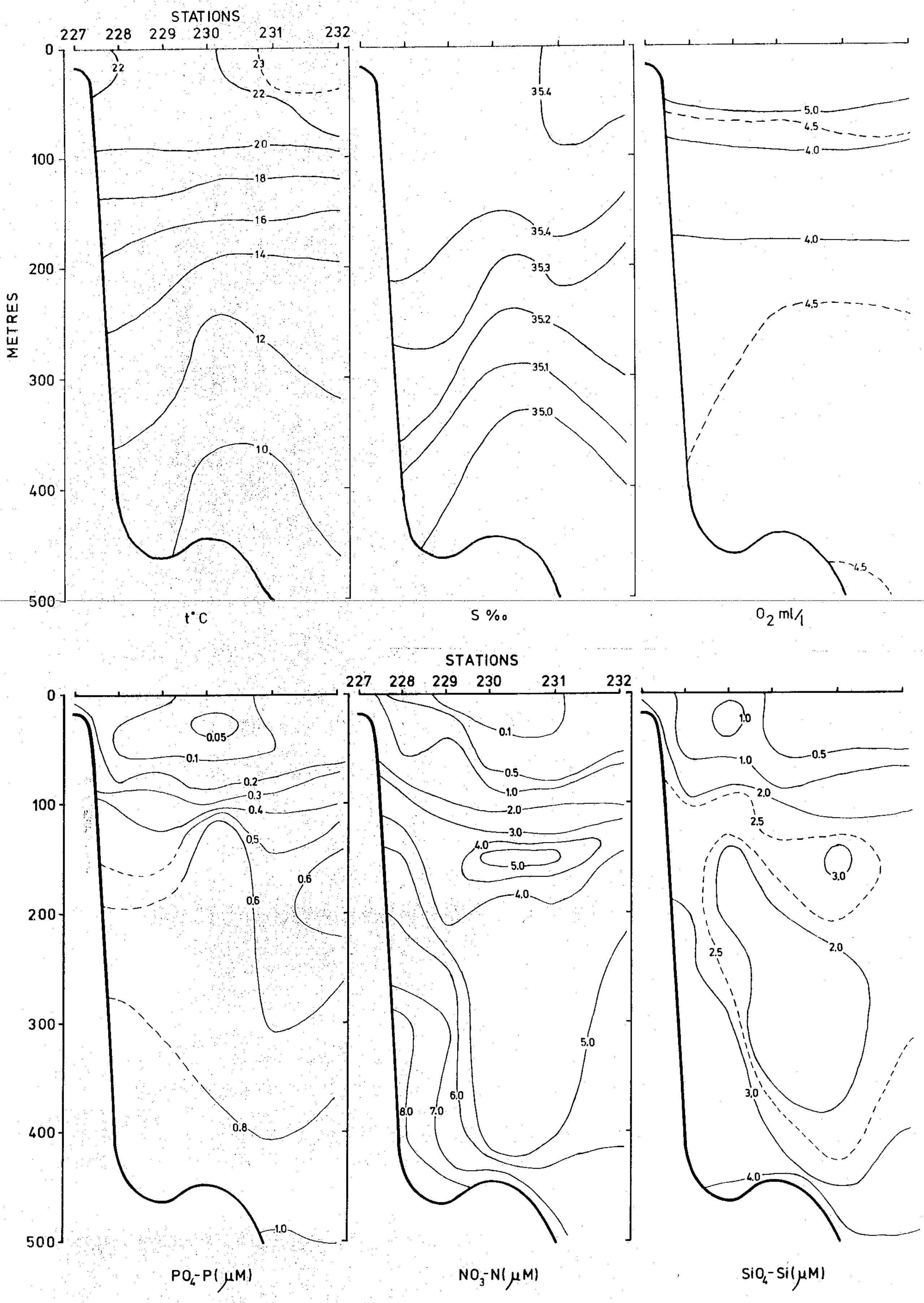

Fig. 2. SECTION I, 11-12 October 1980.

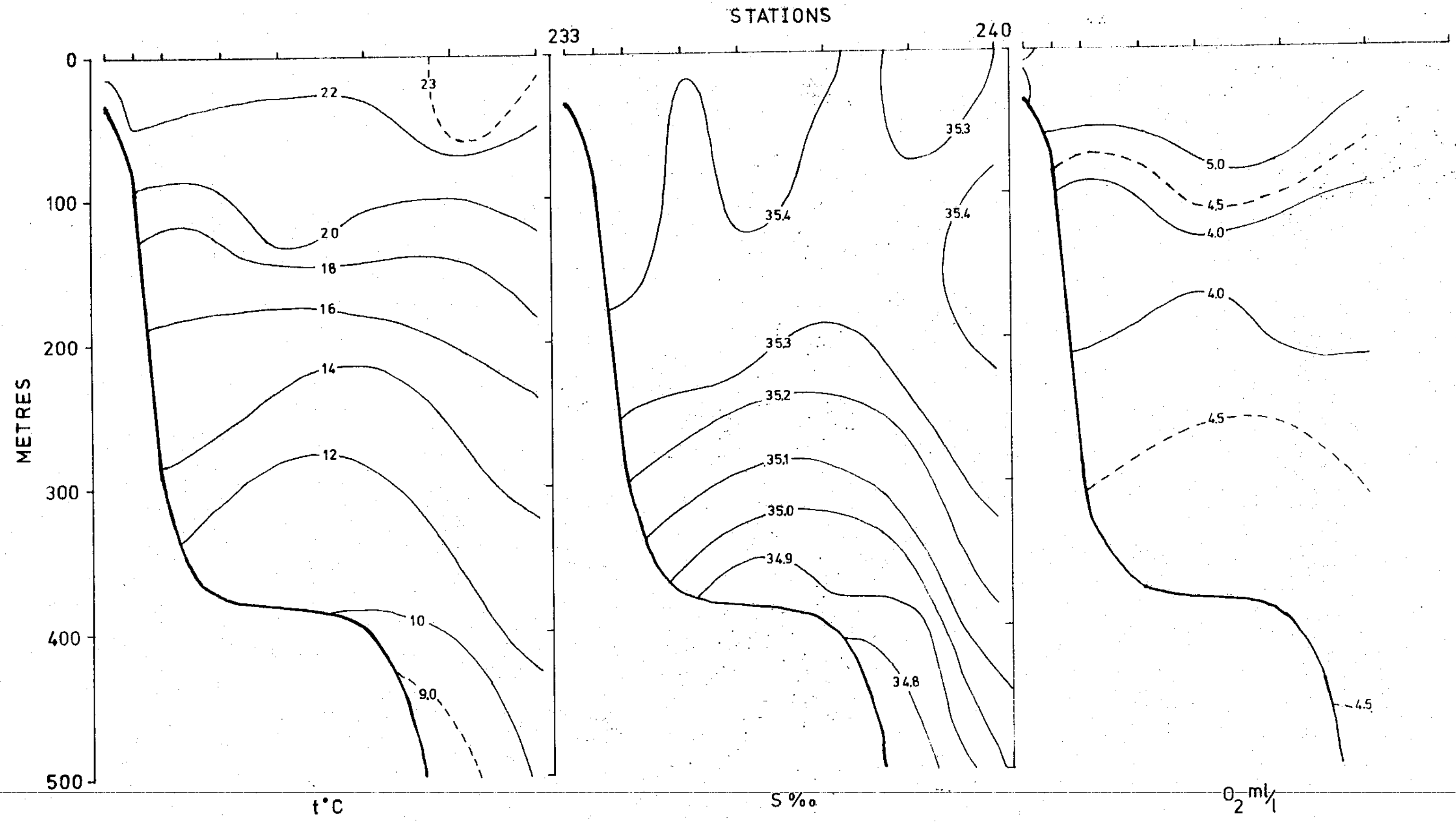

Fig. 3. SECTION II, 12-13 October 1980.

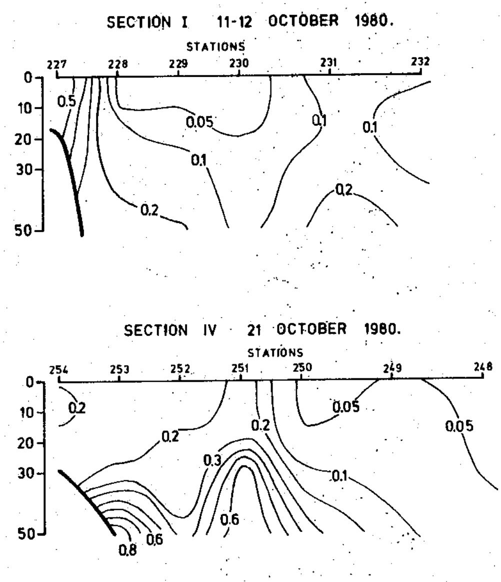

Fig. 4. Chlorophyll a (mg/m^3) content in SECTION I and IV.

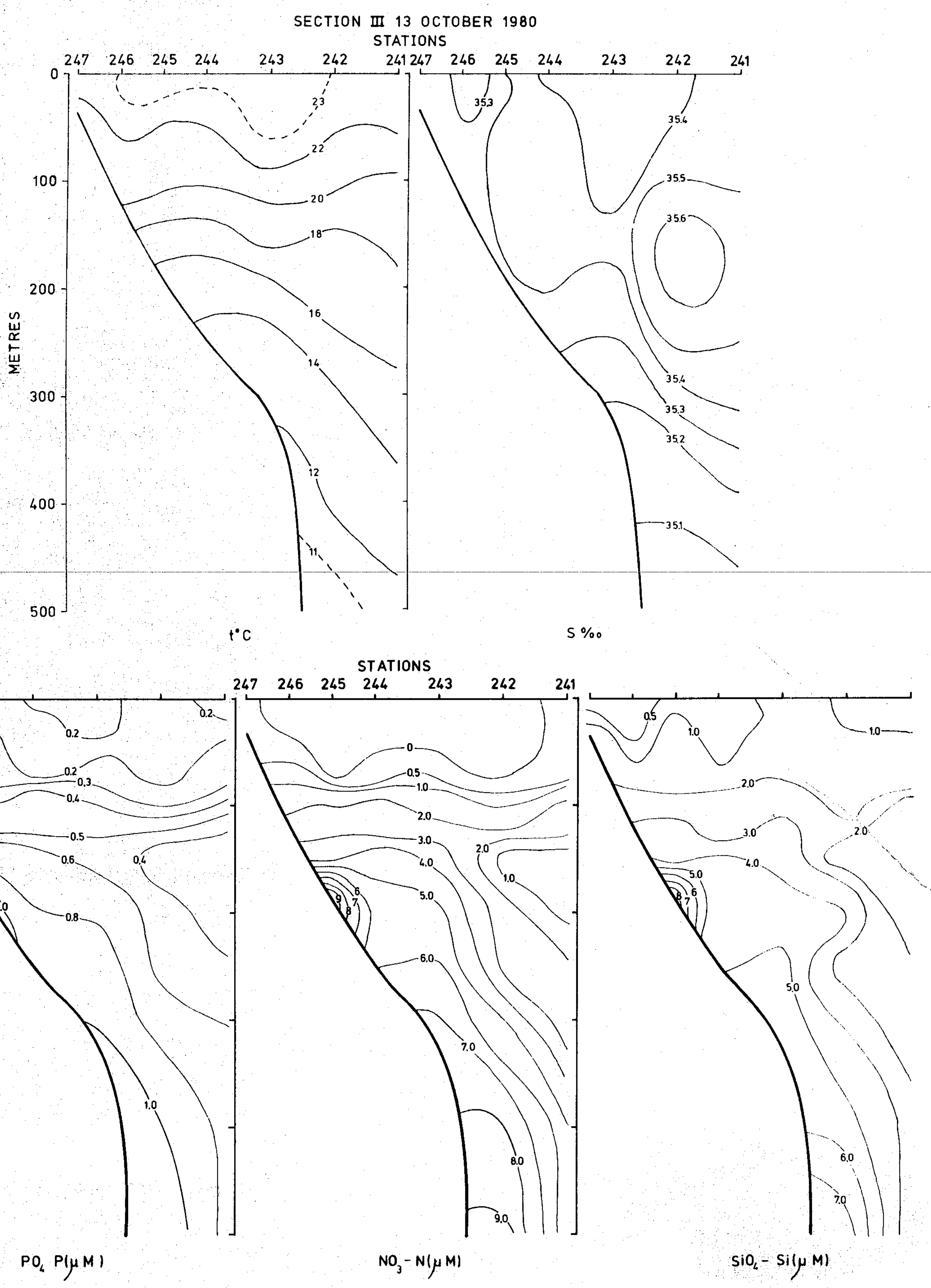

Fig. 5. SECTION III, 13 October 1980.

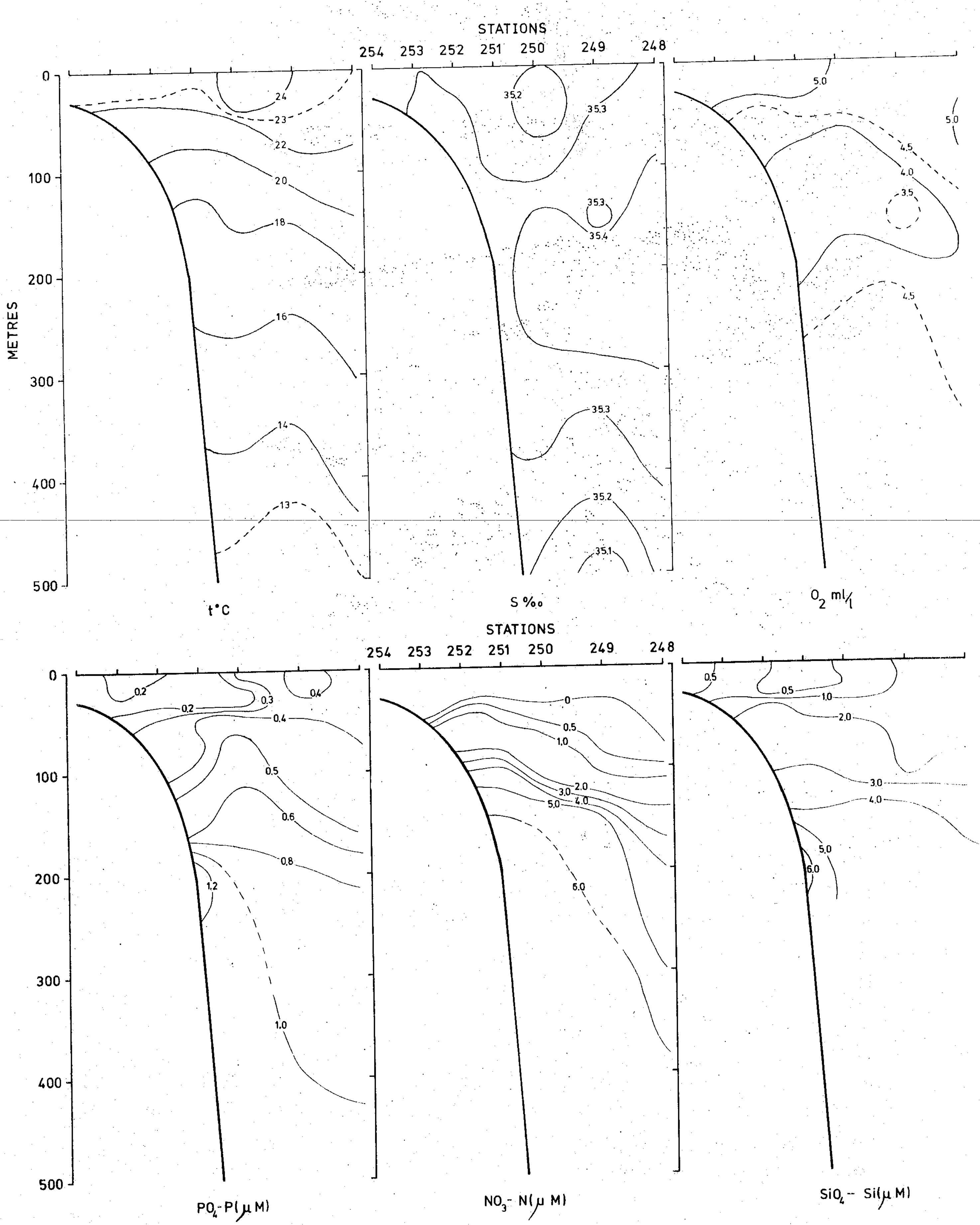

Fig. 6. SECTION IV, 21 October 1980.

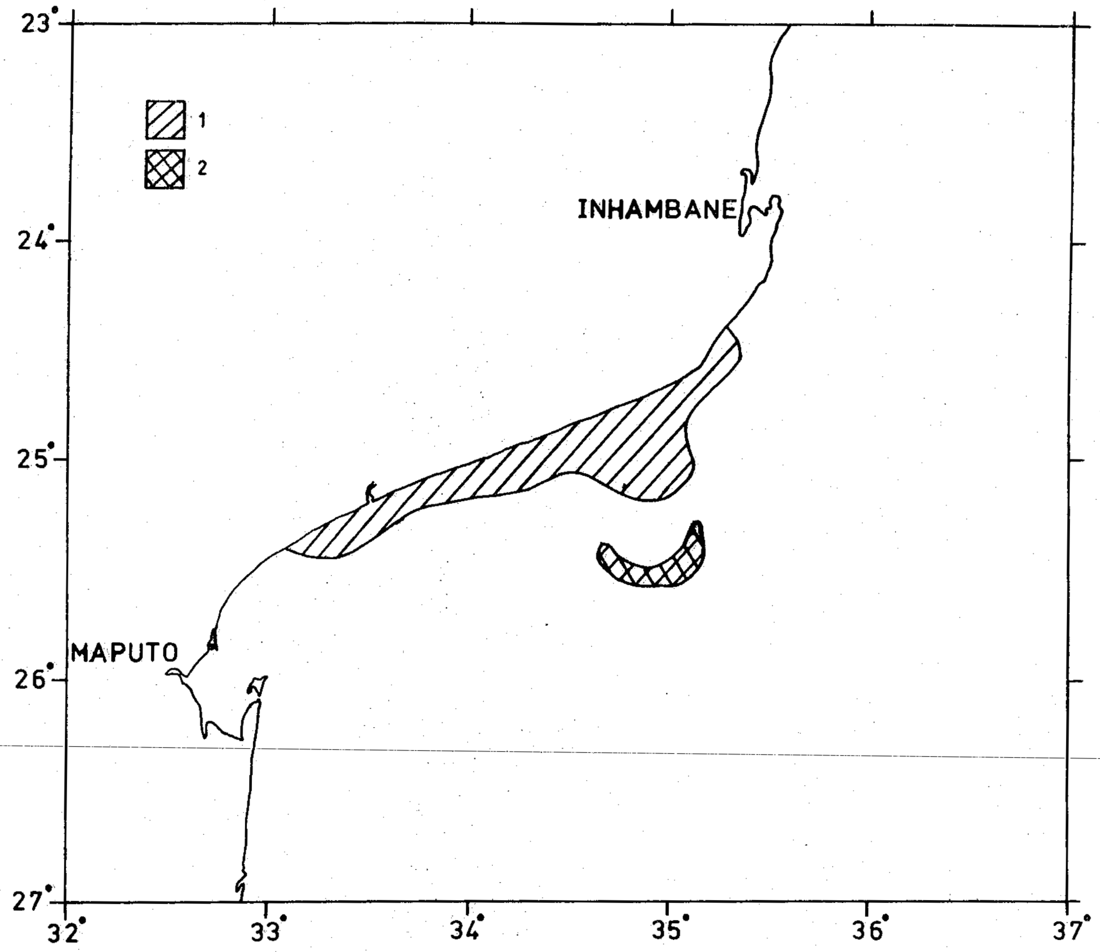

Fig. 7. Distribution of pelagic fish recordings in Delagoa Bay.
1) Scattered, 2) Dense.

At the southern part of the Boa Paz Bank dense pelagic recordings were obtained over bottom depths of 300-350 m. These recordings were exclusively made up by the hairtail (Benthodemus tenuis) at depths of 250-280 m during daytime. The abundance of these recordings were probably in the order of 30-50 000 tonnes.

4. SOFALA BANK

The area between Save River and Angoche was covered three times. Figs. 8-10 show the survey routes and the location of the stations. A record of the fishing operations is listed in APPENDIX A. The length distributions of the most important species appear in APPENDIX B.

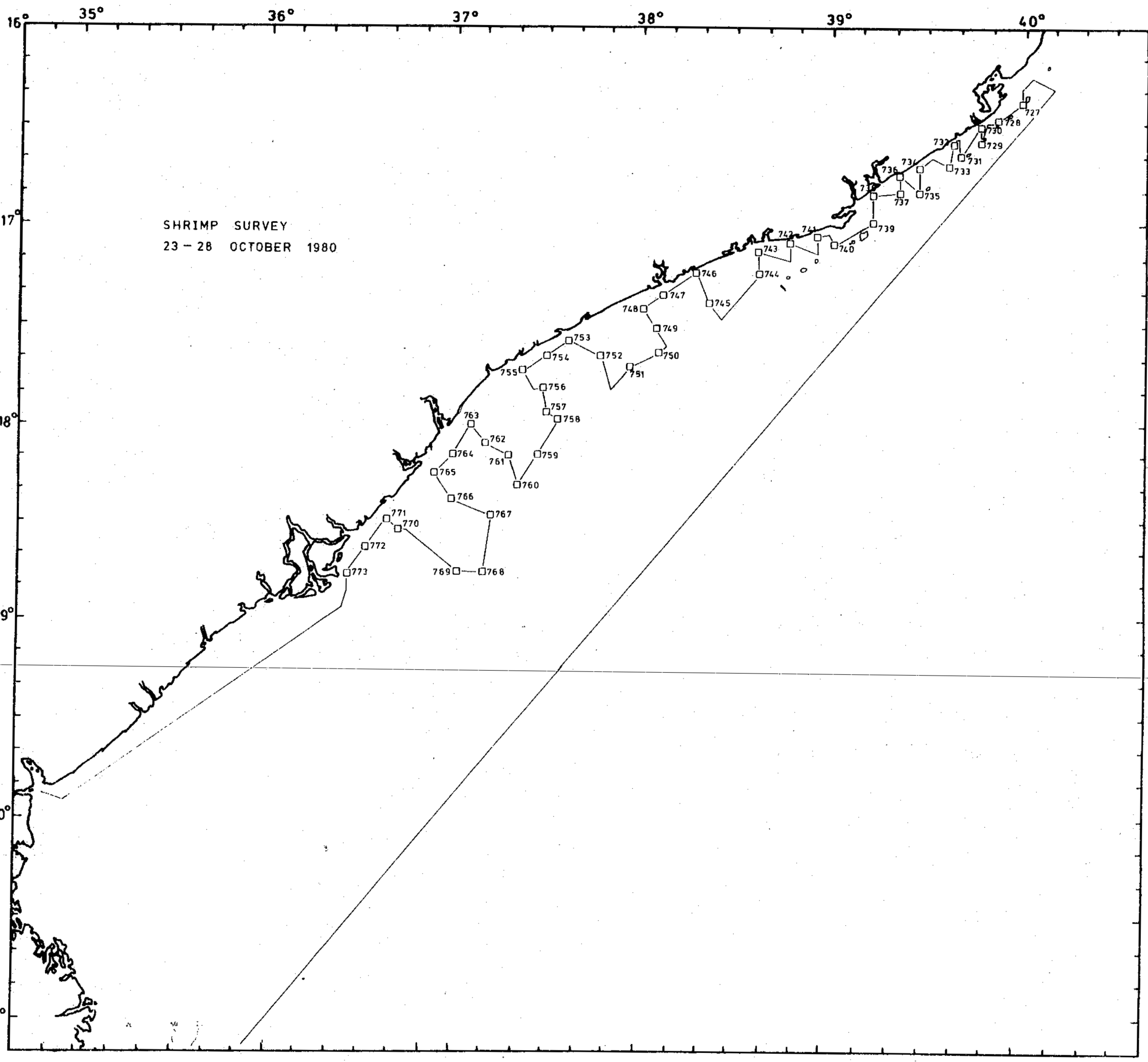

Fig. 8. Survey routes and location of the stations at Sofala Bank, 23-28 Oct. 1980.

4.1 Bottom conditions

The trawl bottom conditions at Sofala Bank are shown in Fig. 11. The continental edge is usually found at depths between 80 and 120 m depth. The continental slope is very precipitous and it seems difficult to carry out bottom trawling at depths between 100 and 300 m.

The mapping of the trawl bottom conditions confirm the description given by SÆTRE and SILVA (1979). The shelf between 19^{O}30'S

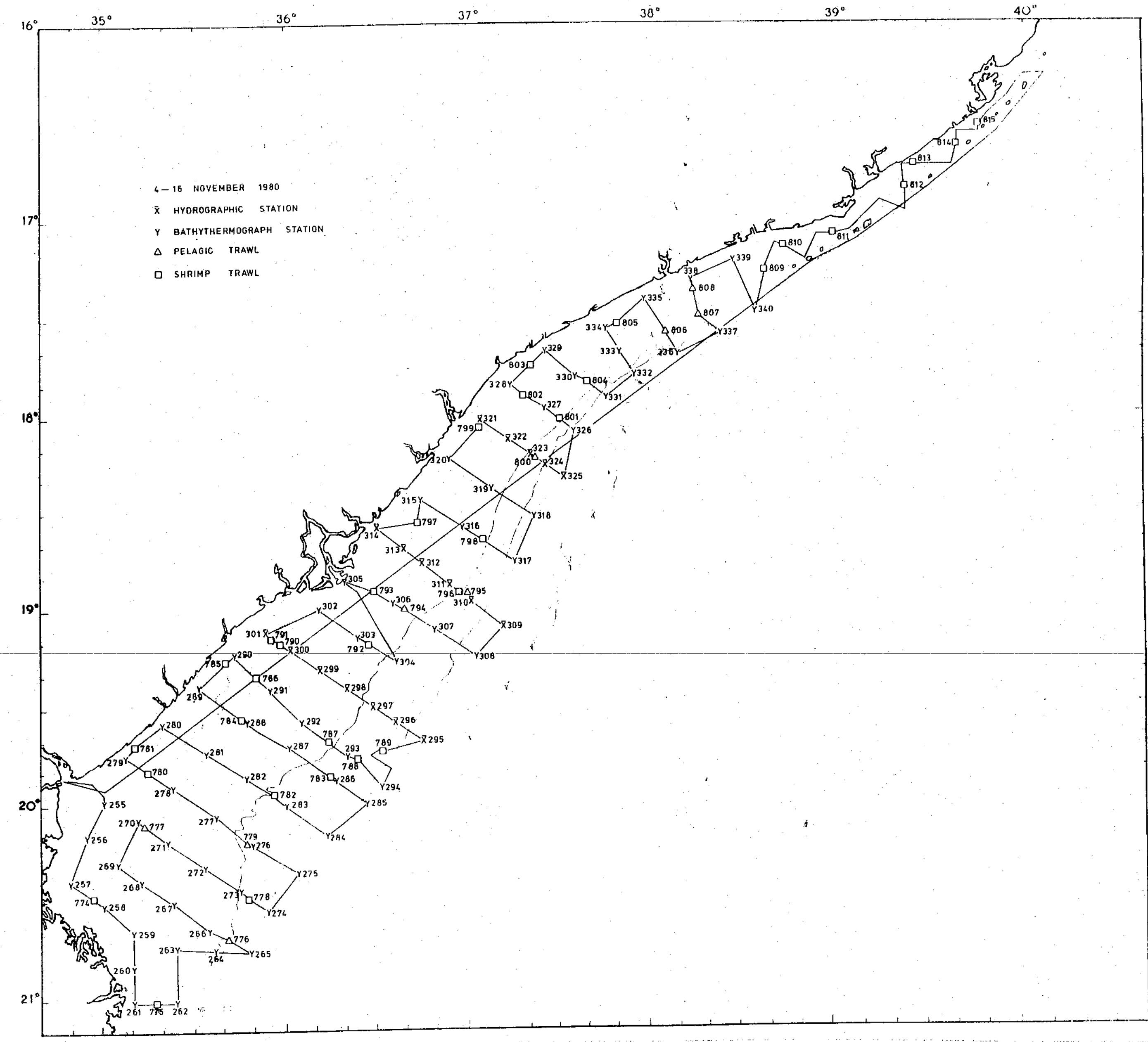

Fig. 9. Survey routes and location of the stations at Sofala Bank, 4-16 Nov. 1980.

and 21°S appears to be unfishable with bottom trawl at depths less than 50 m. This is due to the undulating character of the bottom which is most likely generated by sand waves. In some areas corals and rocky outcrops are observed at depths between 40 and 60 m.

4.2 Hydrography

Figs. 12 and 13 show the surface temperature and surface salinity distribution during the second coverage, 4-16 November 1980.

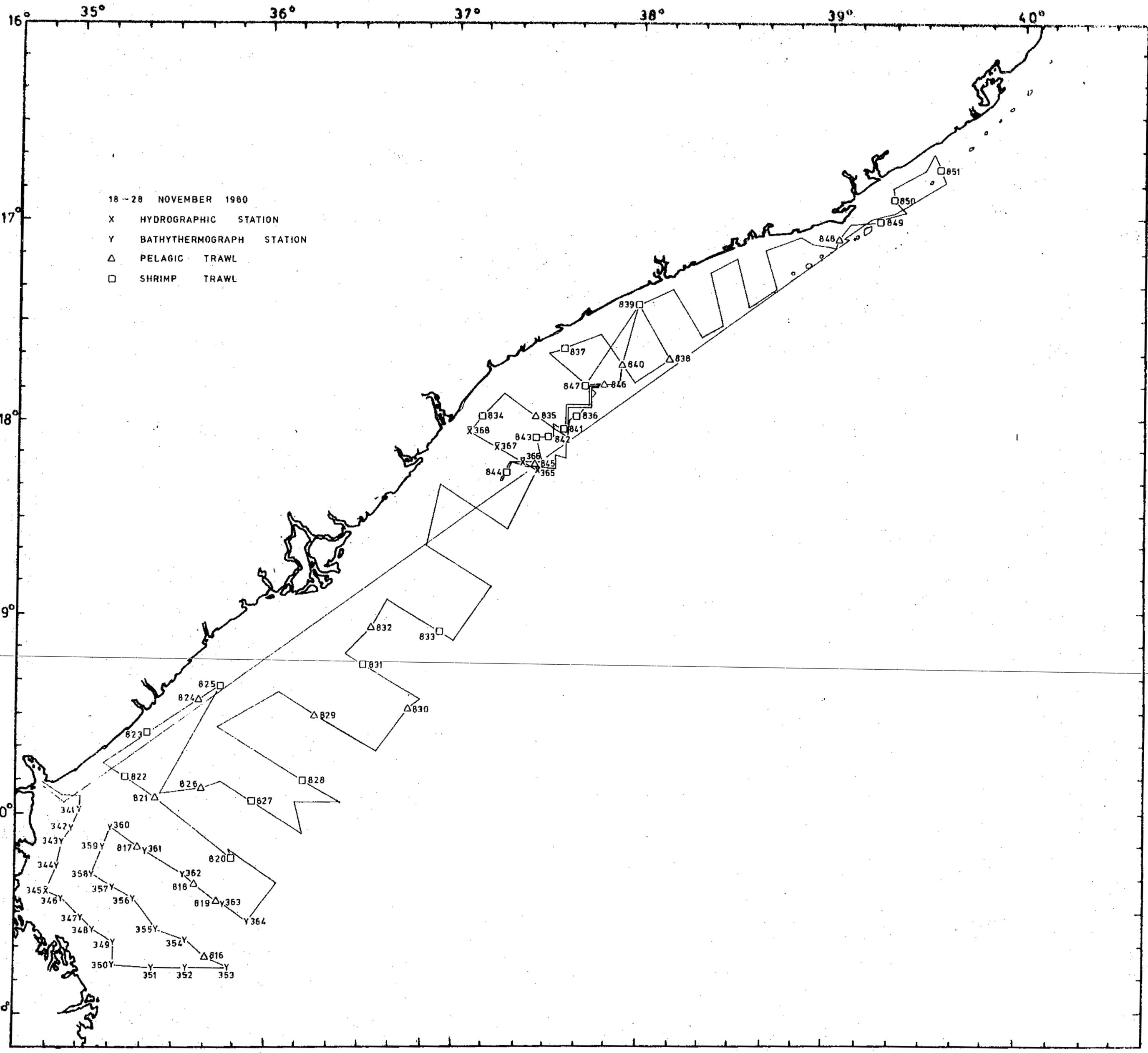

Fig. 10. Survey routes and location of the stations at Sofala Bank, 18-28 Nov. 1980.

A conspicuous feature was the very high salinities at the southern part of the Sofala Bank with increasing values towards the shore. During the third coverage, 18-28 November, this distribution was confirmed, as seen in Fig. 14. The high salinity water was homohaline down to the bottom at 15-20 m. This phenomena has been observed previously (ANTONIO SILVA, pers. comm.) but no satisfactory explanation has been presented.

The distribution of the hydrographic and chemical parameters in SECTIONS A-B-C is shown in Figs. 15-18. In all the sections there seemed to be a lifting of the sub-surface salinity

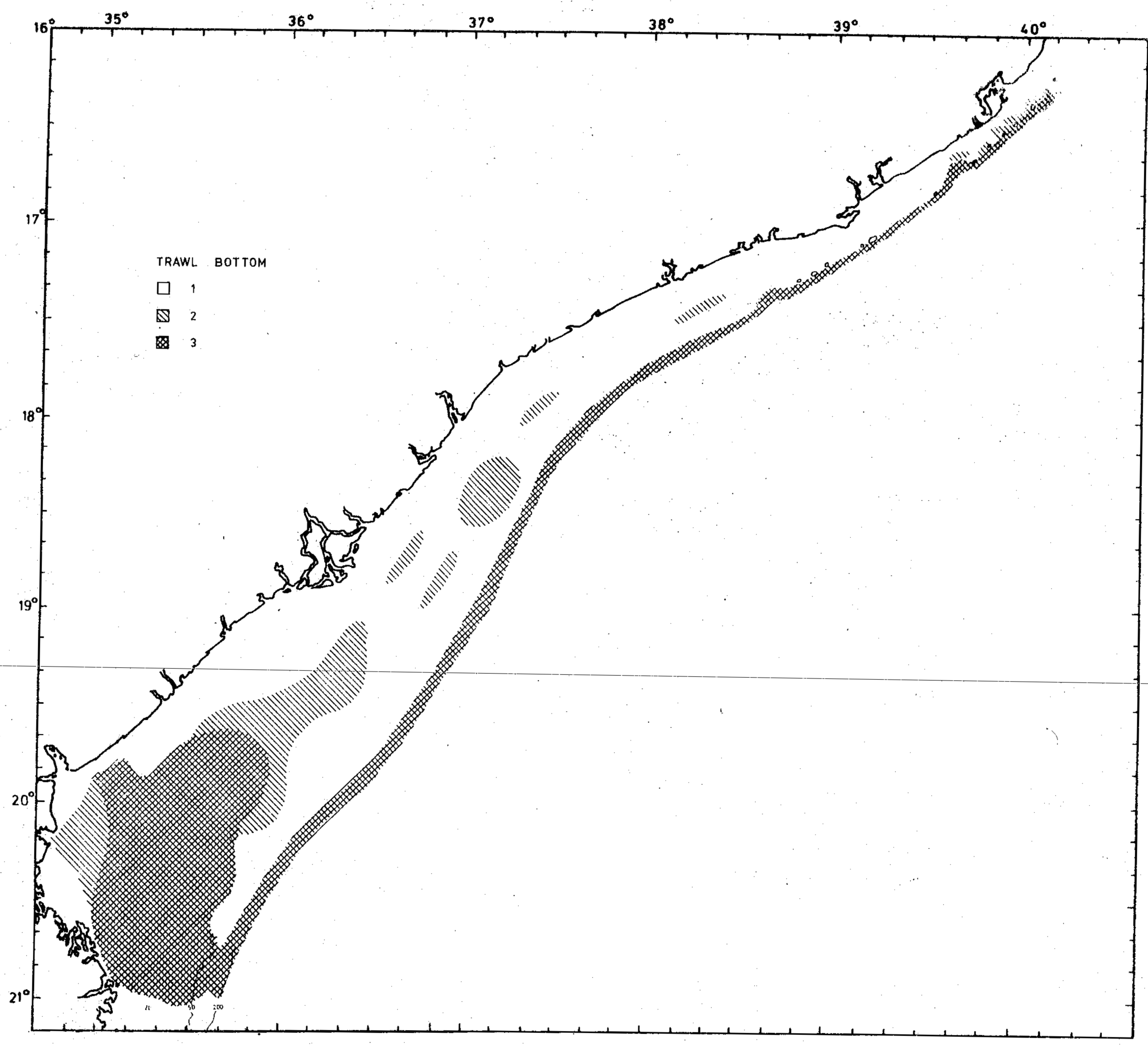

Fig. 11. Bottom conditions at Sofala Bank. 1) Good trawl bottom. 2) Trawlable with caution. 3) Not trawlable.

maximum to the surface near the continental edge. In SECTIONS A and B there was a vertical salinity gradient over the shallow part of the shelf while in SECTION C the water was nearly homohaline.

All three sections were characterized by a similar nutrient distribution pattern. While nitrate concentrations were extremely low, and at some places totally exhausted in the upper 50 m, both phosphate and silicate showed a minimum above the edge of the continental shelf and increasing concentrations toward the coast. This pattern was especially noticeable in

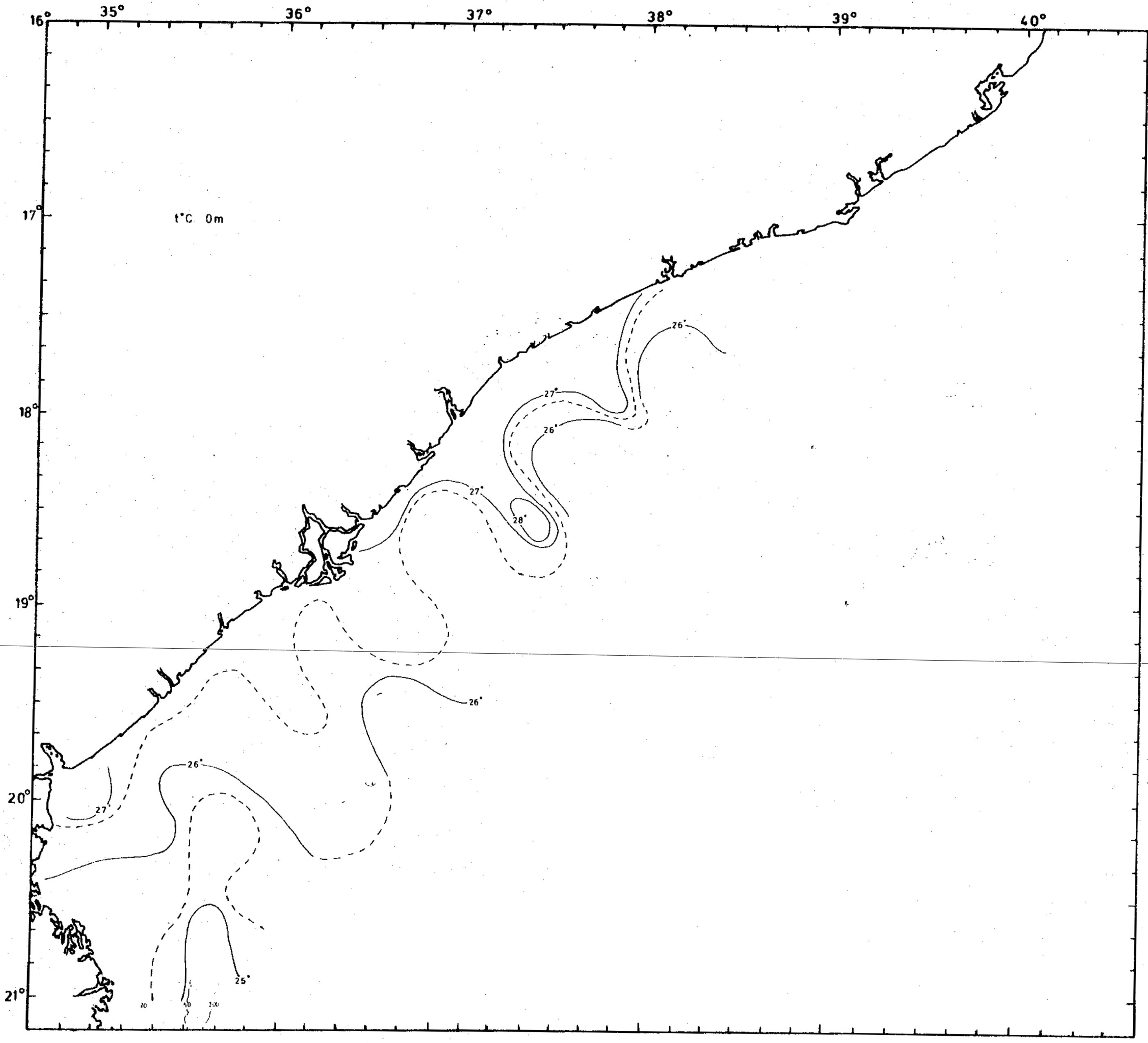

Fig. 12. Surface temperature distribution, 4-16 Nov. 1980.

the silicate distribution. The increase in phosphate and silicate concentrations occurred together with a decrease in salinity, suggesting an influence of the freshwater runoff from the Zambezi River.

A sharp gradient of increasing nutrient concentrations was observed at 100-150 m depth over the upper part of the continental slope. In SECTION C, however, the gradient had a more inclined slope than in SECTIONS A and B. This distribution pattern was probably related to the previously mentioned lifting of the sub-surface salinity maximum.

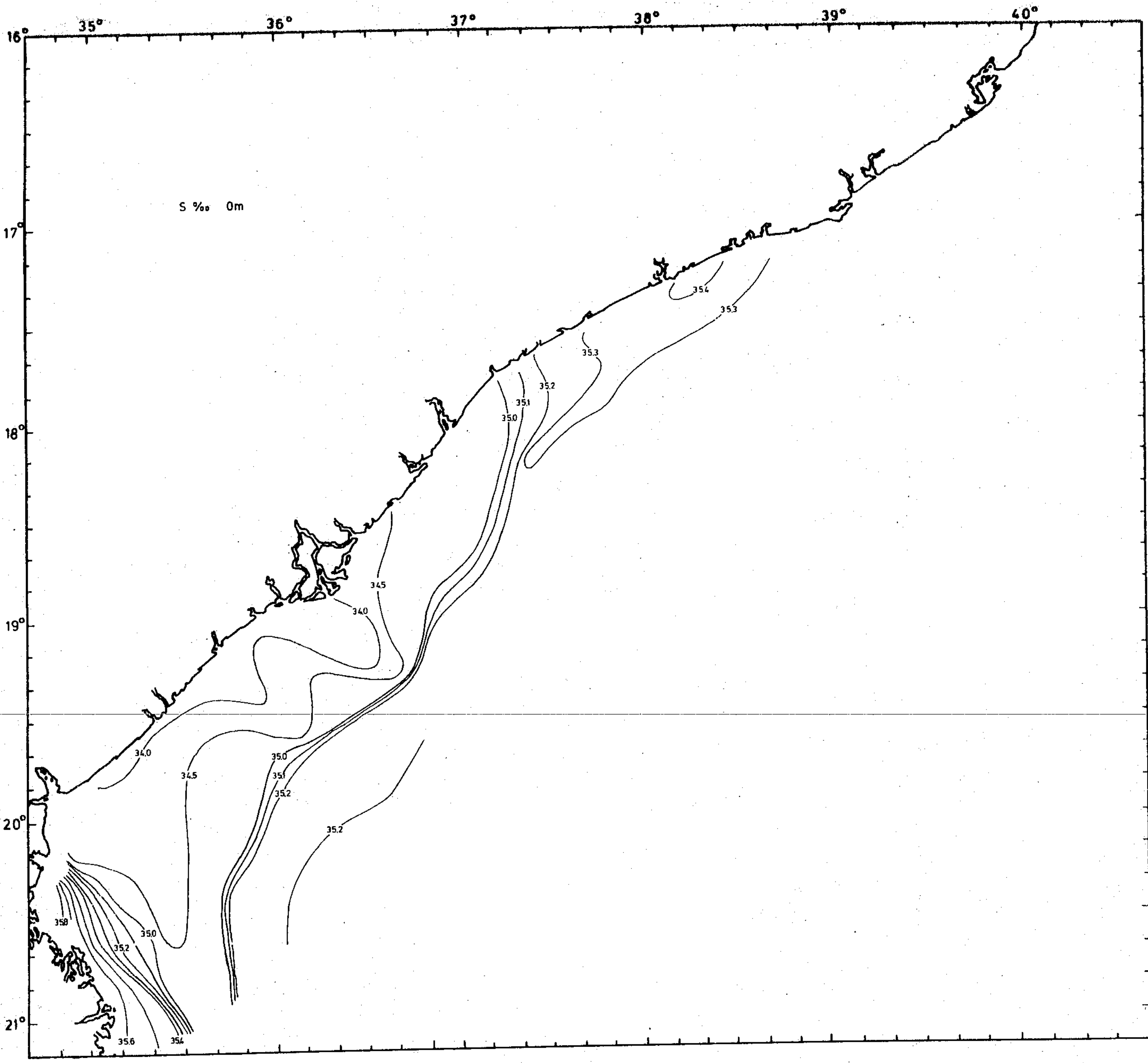

Fig. 13. Surface salinity distribution, 4-16 Nov. 1980.

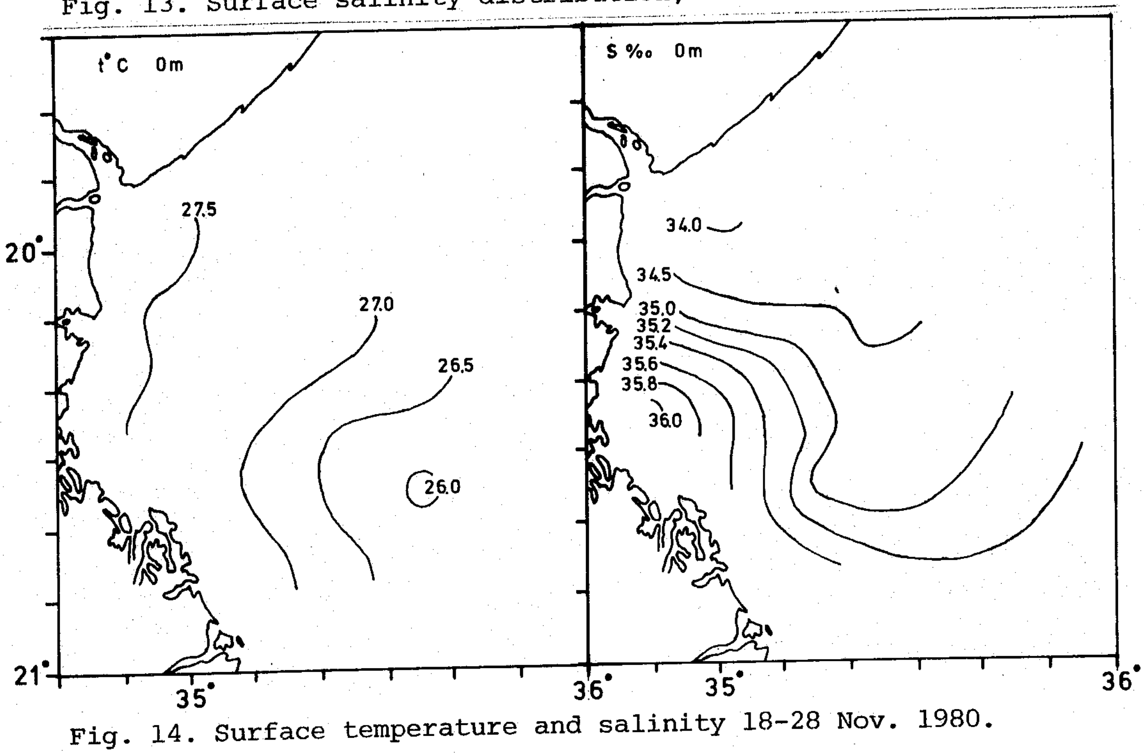

Fig. 14. Surface temperature and salinity 18-28 Nov. 1980.

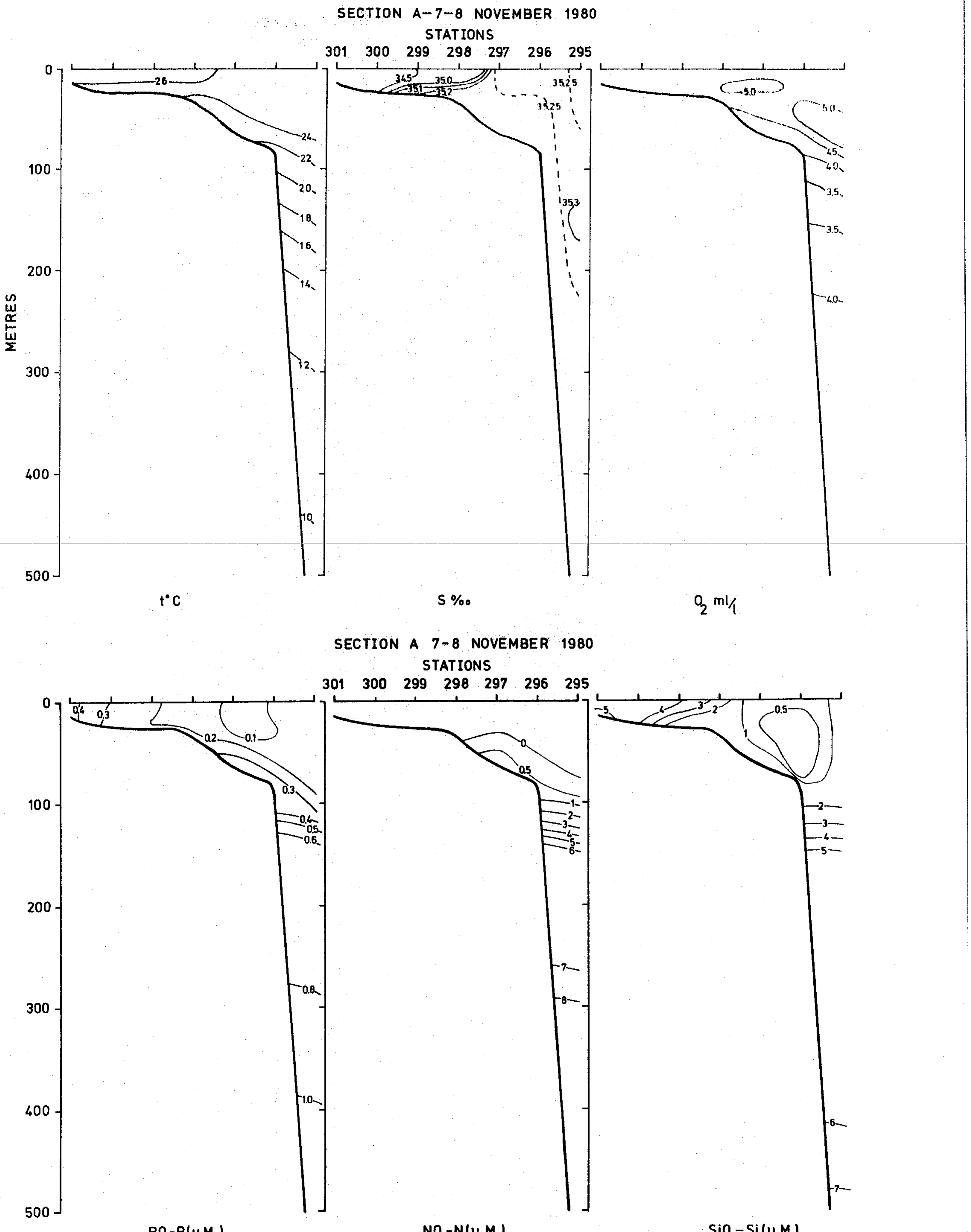

Fig. 15. SECTION A, 7-8 November 1980.

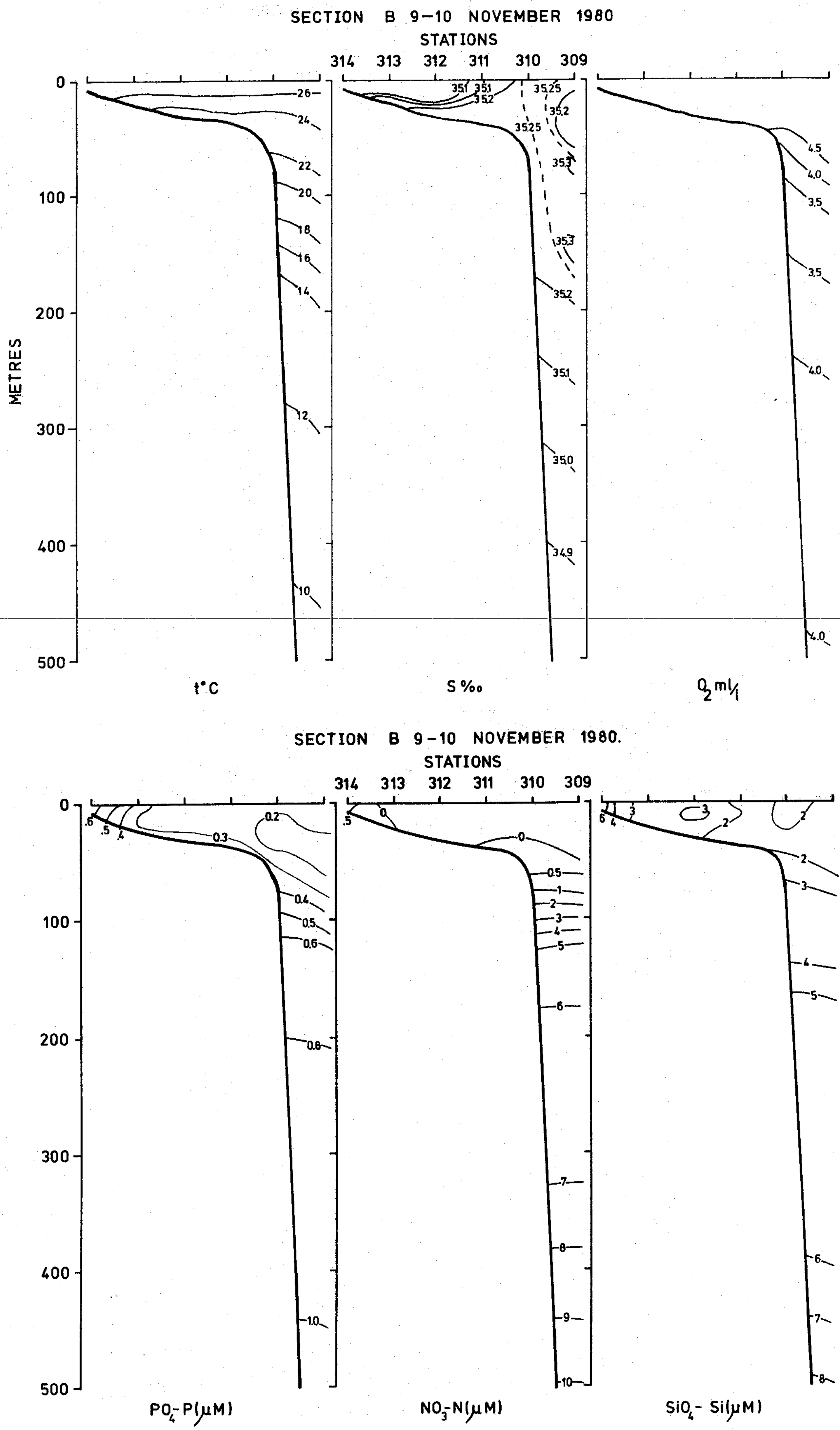

Fig. 16. SECTION B, 9-10 November 1980.

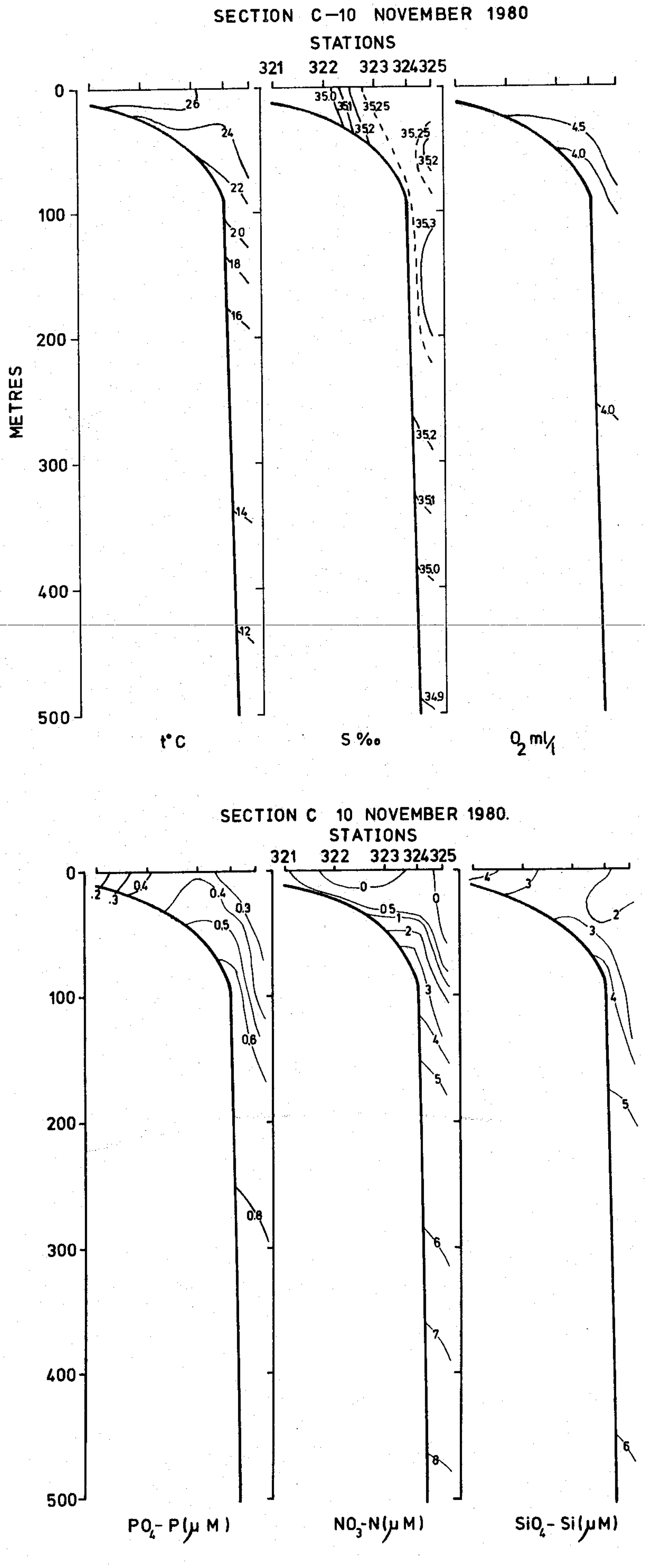

Fig. 17. SECTION C, 10 November 1980.

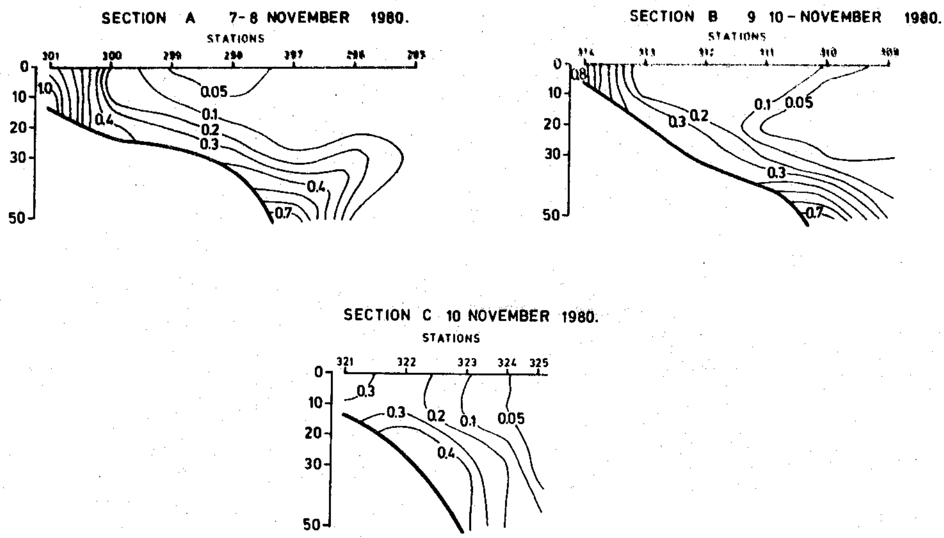

Fig. 18. Distribution of chlorophyll a (mg/m^3).

The distribution of chlorophyll a (Fig. 18) showed more or less the same pattern of distribution for all the sections. Very low concentrations were found in the upper 10-20 m in the middle and outer parts of the sections. At the inner part of the sections an increase in chlorophyll a was observed in the whole water column, in the same region where higher phosphate and silicate concentrations were observed. An increase with depth was also observed below 20-30 m with the highest concentrations at about 50 m. This was the level where the nutrient gradient

Table 1. Number of trawl stations at Sofala Bank.

AREA \ BOTTOM DEPTH	< 25 m	25-49 m	≥ 50 m	Total
A. SAVE - ZAMBEZI				
Pelagic trawl	2	11	2	15
Shrimp trawl	17	9	8	34
B. ZAMBEZI - I. DO FOGO				
Pelagic trawl	1	7	1	9
Shrimp trawl	21	11	6	38
C. I. DO FOGO - ANGOCHE				
Pelagic trawl	1	-	-	1
Shrimp trawl	27	1	-	28
TOTAL Pelagic trawl	4	18	3	25
TOTAL Shrimp trawl	65	19	14	98

started. In SECTION C the increase in chlorophyll a towards the coast and with depth was less marked than in SECTIONS A and B.

4.3 The fishing experiments

Table 1 gives the number of trawl stations at Sofala Bank during the period 23 October-28 November 1980 split into depth zones and areas. Table 2 shows the average catch rates with shrimp trawl at different depth zones and areas. As can be seen, the pelagic fish dominated the catches, except in Area A deeper than 25 m and in Area C.

Table 2. Composition of catch with shrimp trawl ($kg \cdot h^{-1}$) at Sofala Bank for different depth zones.

Area	A. SAVE - ZAMBEZI			B. ZAMBEZI - I. DO FOGO			C. I. DO FOGO - ANGOCHE
Depth	< 25 m	25-49 m	≥ 50 m	< 25 m	25-49 m	≥ 50 m	< 25 m
Pelagic fish	312.4	48.3	43.4	109.7	161.1	200.4	78.5
Demersal fish	177.7	99.9	79.3	84.8	128.7	54.7	90.3
Sharks/Rays	6.7	-	0.3	8.0	11.4	-	8.6
Crustaceans	17.2	9.8	2.9	31.4	13.9	2.0	7.9
Molluscs	2.5	4.4	0.3	2.1	1.4	0.1	0.4
Total	516.5	162.4	126.2	236.0	316.5	257.2	185.7
Number of hauls	17	9	8	21	11	6	27

The maximum average catch rate, 516.5 kg/h, was obtained in the area between Save and Zambezi River at depths shallower than 25 m. The maximum catch was 4172 kg/h with the Indian pellona (*Pellona ditchela*) as the dominant species. Also the anchovy (*Thryssa vitrirostris*) contributed significantly to the catches when the catch rates were high.

4.4 Fish distribution and species composition

Table 3 gives the species composition of the shrimp trawl catches split into depth zones and areas, and Table 4 gives the species composition in catches with pelagic trawl.

Table 3. Species composition from shrimp trawl catches (kg · h^{-1}) at different depth zones at Sofala Bank. (+ indicates presence in the catch).

	A. SAVE - ZAMBEZI			B. ZAMBEZI - I. DO FOGO			C.I. DO FOGO - ANGOCHE
	< 25m	25-49m	≥ 50m	< 25m	25-49m	≥ 50m	< 25m
PELAGIC FISH							
ARIOMMIDAE - Drift fish	5.9	-	-	0.4	3.1	0.2	-
CARANGIDAE - Jack/scad	5.0	44.6	42.0	1.1	73.0	154.1	6.4
CLUPEIDAE - Herring/shad	182.3	0.2	+	55.6	30.3	-	19.4
CHIROCENTRIDAE - Wolf herring	+	-	-	-	-	-	0.6
ENGRAULIDAE - Anchovy	80.5	-	-	34.4	+	-	4.6
LEIOGNATHIDAE - Ponyfish	8.0	0.1	-	3.8	20.0	-	42.5
SCOMBRIDAE - Mackerel	3.7	2.8	0.4	1.8	3.3	44.0	2.9
SPHYRAENIDAE - Barracuda	22.4	0.5	1.0	1.5	31.3	1.9	0.9
TRICHIURIDAE - Hairtail	4.6	0.1	-	11.1	0.1	-	1.2
DEMERSAL FISH							
ANTENNARIIDAE - Frog fish	-	-	-	-	-	0.3	-
APOGONIDAE - Cardinal fish	0.3	-	+	0.1	-	-	+
ARIIDAE - Catfish	3.8	-	-	9.8	-	-	1.4
BALISTIDAE - File fish	+	5.0	13.9	-	0.6	2.9	-
BOTHIDAE - Flounder	0.6	4.4	1.2	0.9	2.2	1.3	0.2
CYNOGLOSSIDAE - Tongue sole	2.6	0.2	-	2.7	0.2	0.2	0.9
DIODONTIDAE - Porcupine fish	-	0.2	0.8	-	-	0.3	-
EPHIPPIDAE - Spade fish	0.1	-	-	1.4	0.8	-	2.8
FISTULARIIDAE - Pipe fish	-	0.1	0.2	-	+	0.4	-
FORMIONIDAE - Black pomfret	3.1	-	-	0.8	0.6	-	0.5
GERREIDAE Mojarra	1.7	-	-	+	0.6	-	2.4
LETHRINIDAE - Scavenger	-	-	0.1	-	-	-	-
LUTJANIDAE - Snapper	0.4	0.2	5.9	+	-	-	-
MENIDAE - Moon fish	-	-	-	0.1	-	-	0.1
MUGILIDAE - Grey mullet	-	-	-	+	-	-	-
MULLIDAE - Goat fish	5.3	33.6	13.4	2.0	22.6	7.9	18.7
MURAENIDAE - Moray eel	-	-	-	0.6	-	-	-
NEMIPTERIDAE - Threadfin bream	-	11.8	13.2	+	13.9	16.1	-
OGCOCEPHALIDAE - Batfish	-	0.3	0.3	-	+	0.6	-
OSTRACIONTIDAE - Boxfish	-	0.6	1.3	0.2	0.1	0.5	-
PLATYCEPHALIDAE - Flathead	1.1	3.9	0.8	0.3	2.0	0.6	0.5
PLEURONECTIDAE - Flounder	-	-	0.5	-	0.1	0.3	-
PLOTOSIDAE - Catfish eel	-	0.1	-	-	-	-	-
POLYNEMIDAE - Threadfin	2.0	-	-	4.2	12.3	-	8.4
POMACENTRIDAE - Damselfish	-	0.2	-	-	-	-	-
POMADASYIDAE - Grunt	49.8	-	2.3	11.9	44.8	-	35.8
PRIACANTHIDAE - Bigey	-	1.3	0.5	+	0.4	1.7	-
PSETTODIDAE - Indian halibut	0.2	0.4	0.2	+	-	1.7	0.2
RACHYCENTRIDAE - Cobia	-	-	-	+	-	-	-
SCIAENIDAE - Croaker	88.5	0.3	-	46.1	-	-	8.0
SCORPAENIDAE - Firefish	1.5	3.8	0.5	+	0.9	2.2	-
SILLAGINIDAE - Sillage	1.1	-	0.1	0.9	1.1	-	4.9
SOLEIDAE - Sole	-	0.3	+	-	0.1	-	-
SPARIDAE - Seabream	-	-	3.0	-	1.2	-	-
SYNANCEIIDAE - Stone fish	-	-	+	+	0.1	-	-
SYNGNATHIDAE - Pipefish/seahorse	+	-	+	+	+	0.1	-
SYNODONTIDAE - Lizard fish	6.7	29.9	11.4	1.8	17.1	15.0	3.1
TETRAODONTIDAE - Puffer fish	0.6	3.3	1.5	0.2	1.0	0.6	0.3
THERAPONIDAE - Tigerperch	8.3	-	0.1	0.8	6.0	-	2.1
TRIGLIDAE - Searobin	-	+	8.1	-	-	2.0	-
SHARK/RAY							
CARCHARHINIDAE - Requim shark	2.7	-	-	0.9	11.4	-	0.4
DASYATIDAE - Stingray	-	-	-	-	-	-	3.7
MYLIOBATIDAE - Eagle ray	-	-	-	-	-	-	-
RAJIDAE - Skate	-	-	-	5.0	-	-	4.4
RHINOBATIDAE - Guitar fish	1.6	-	0.1	1.9	+	-	0.1
SPHYRNIDAE - Hammerhead shark	2.4	-	-	-	-	-	-
SQUALIDAE - Dogfish shark	-	-	-	-	-	-	-
TORPEDINIDAE - Electric ray	-	-	0.2	0.2	-	-	-
CRUSTACEA							
CARIDAE	7.1	-	-	18.1	-	-	-
DECAPODAE	1.5	2.0	1.9	0.1	2.1	-	-
PENAEIDAE	6.8	6.4	0.3	13.1	8.3	1.6	7.9
SCYLLARIDAE	1.8	1.4	0.7	0.1	3.5	0.4	-
MOLLUSCA	2.5	4.4	0.3	2.1	1.4	0.1	0.4

Table 4. Species composition in catches with pelagic trawl over bottom depths of 25-49 m at Sofala Bank (kg · h^{-1}).

	SAVE - ZAMBEZI	ZAMBEZI - I. DO FOGO
ARIOMMIDAE	+	0.3
CARANGIDAE	21.4	61.6
CHIROCENTRIDAE	0.1	-
CLUPEIDAE	6.1	7.1
ENGRAULIDAE	15.4	6.0
LEIOGNATHIDAE (Fry)	-	5.3
SCOMBRIDAE	1.4	5.4
SPHYRAENIDAE	0.2	1.7
BALISTIDAE (Fry)	14.7	-
LUTJANIDAE	-	1.1
MULLIDAE	0.1	3.5
POMADASYDAE	-	1.3
SYNODONTIDAE	-	+
CARCHARHINIDAE	3.1	7.1
TOTAL	62.5	100.4
Number of hauls	11	7

Pelagic fish

At depths shallower than 25 m south of I. do Fogo the catches were dominated by the Indian pellona (*Pellona ditchela*) and the anchovy (*Thryssa vitrirostris*). North of I. do Fogo the most important pelagic species seemed to be the sardine (*Sardinella gibbosa*) and the ponyfish (*Leiognathus equulus* and *Secutor insidiator*).

At depths deeper than 25 m the scad (*Decapterus maruadsi* and *D. macrosoma*) contributed most to the catches. In the shrimp trawl the ratio between the catches of *D. macrosoma* and *D. maruadsi* was about 1:10 while in the pelagic trawl catches (Table 4), the ratio was the reverse. This feature was related to different gear avoidance or different behaviour pattern.

The contribution from the Clupeidae family at 25-49 m depths in Area B was due to some good catches of the rainbow sardine (*Dussumiera acuta*). As can be seen, also the ponyfish (*Leiognathus equulus*) and the barracuda (*Sphyraena obtusata*) made significant contributions. In Area B deeper than 50 m the mackerel (*Rastrelliger kanagurta*) was important in the catches.

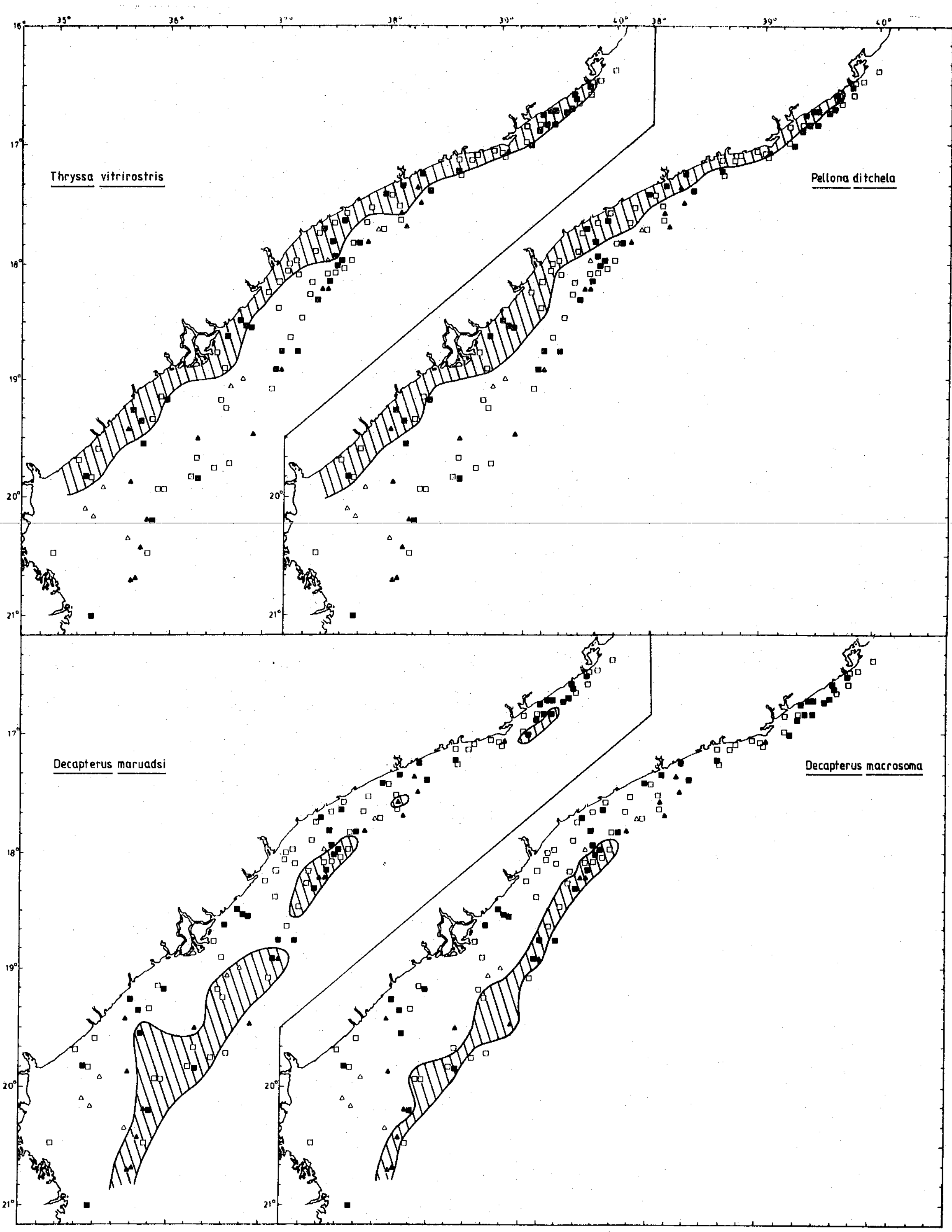

Fig. 19. Distribution areas of some pelagic species.

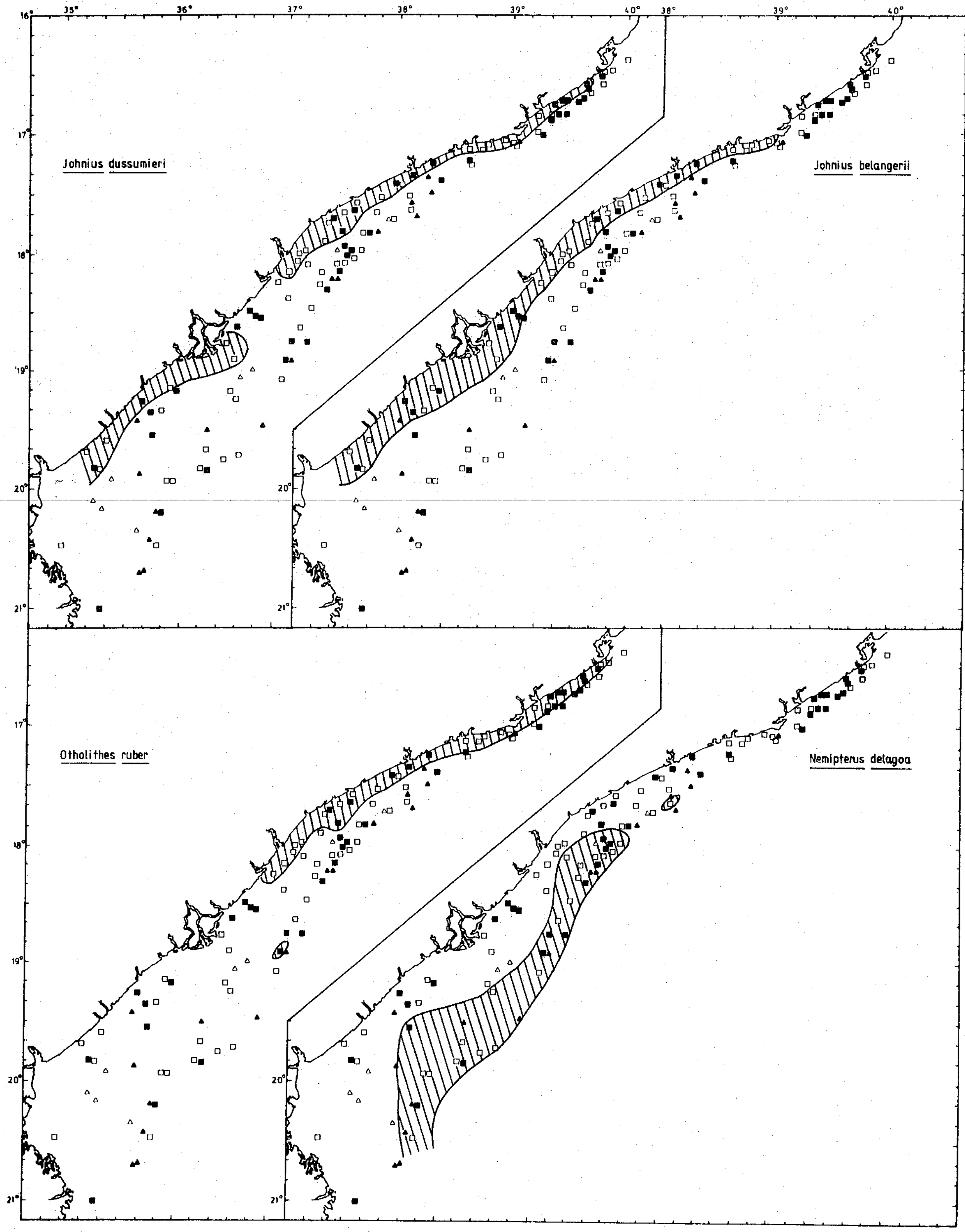

Fig. 20. Distribution areas of some demersal species.

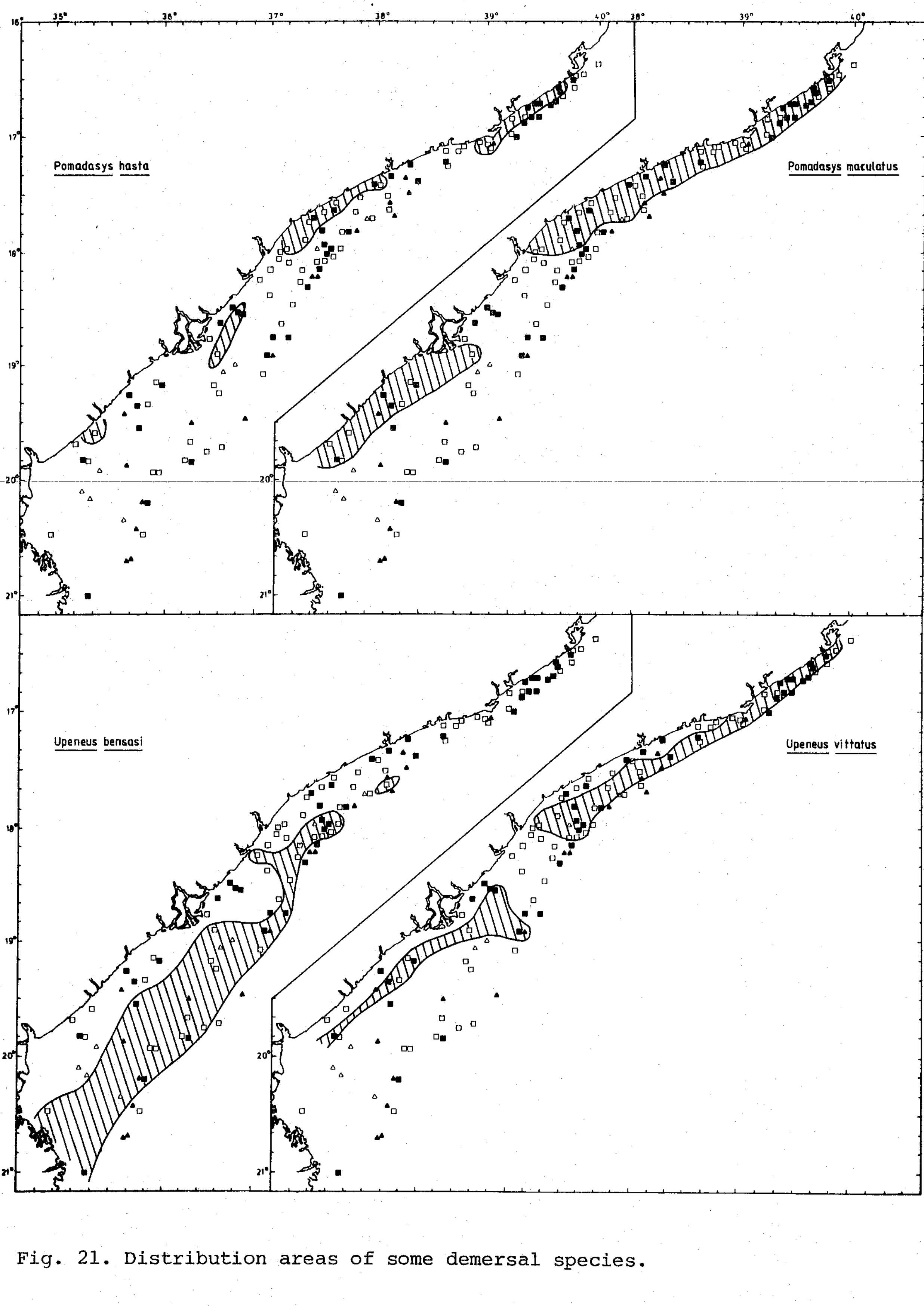

Fig. 21. Distribution areas of some demersal species.

Demersal fish

At depths shallower than 25 m the grunts (Pomadasys hasta and P. maculatus and the croakers (Johnius belangerii, J. dussumieri and Otholithes ruber) were the dominant groups in Areas A and B. In Area C, however, the goatfish (Upeneus vittatus) was more important than the croaker.

At 25-49 m depths the goatfish (Upeneus bensasi) and the lizard fish (Saurida undosquamis) dominated in Area A. In Area B the goatfish (Upeneus vittatus) and the grunt (Pomadasys maculatus) were the most important species. In both Areas A and B the threadfin bream (Nemipterus delagoa) was also of some abundance.

At depths deeper than 50 m the main catch consisted of the goatfish (Upeneus bensasi), the lizard fish (Saurida undosquamis and Trachinocephalus myops) as well as the threadfin bream (Nemipterus delagoa).

Figs. 19-21 show the distribution patterns of some important species at Sofala Bank based on the trawl catches. The positions of the trawl stations are indicated with open symbols for day hauls and filled symbols for night hauls. As can be seen, the anchovy (Thryssa vitrirostris) and the Indian pellona (Pellona ditchela) had approximately the same distribution area (Fig. 19). This was probably also the case for the scad (Decapterus spp).

The distribution of some demersal species, e.g. Pomadasys maculatus, Upeneus vittatus, and Johnius dussumieri, showed an empty area just north of the Zambezi River. This feature was probably related to the hydrographic conditions. As shown previously, this area was characterized by being vertically homohaline, while further south there was a vertical salinity gradient over the shelf.

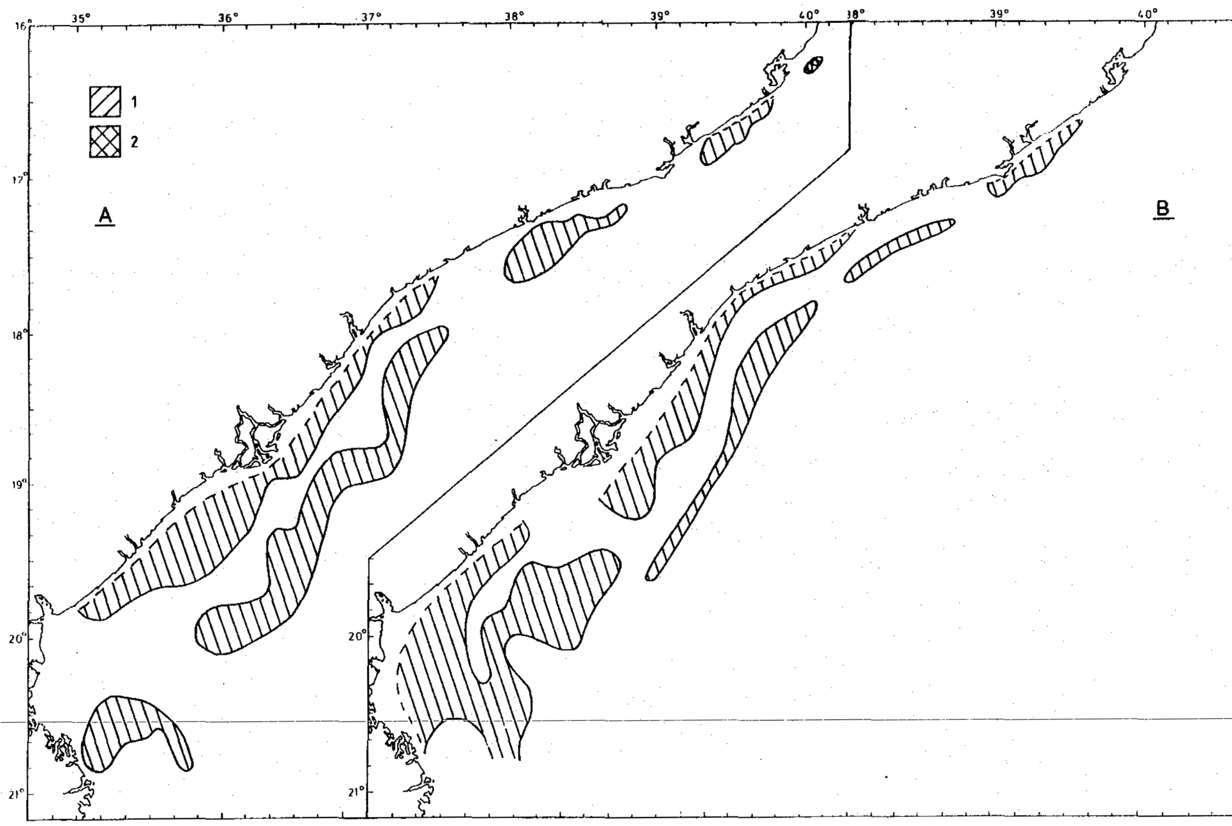

Fig. 22. Echo recordings from small pelagic fish from the A (4-16 Nov.) and B (18-28 Nov.). 1) Scattered recordings, 2) Dense recordings.

4.5 Fish abundance

Fig. 22 show the distribution of echo abundance from small pelagic fish from the two last coverages of Sofala Bank. Indices of echo abundance expressed in mm · $(n.mile)^2$ for the two surveys were 11980 and 11520 respectively. The average length of the main pelagic species was 14 to 18 cm. This gave a total abundance estimate for the small pelagic fish of 130-160 000 tonnes. This agrees very well with the acoustic abundance estimate from the same period in 1977 when 160 000 tonnes were reached (SÆTRE and SILVA, 1979). Based on echo recordings, distribution patterns and catches, this total stock is believed to consist of the following species:

Decapterus spp.	10-20%
Thryssa vitrirostris	10-20%
Pellona ditchela	30-40%
Stolephorus sp.	10-20%
Others	10-20%

A crude estimate of the demersal stock by using the average demersal fish catches in Table 2 can be obtained by the "swept area" method. The average catch rate for the depth zone 10-50 m at Sofala Bank was found to be 132 kg/h. The area of this zone is 38020 km^2 (SÆTRE and SILVA, 1979). This gives a demersal stock of about 120 000 tonnes under the assumption that the efficiency coefficient of the trawl is 0.5. A similar calculation for the summer situation (October-March) carried out by SÆTRE and SILVA (1979) gave 110 000 tonnes.

4.6 Shrimp distribution and abundance.

Two groups of shallow-water shrimp were present on Sofala Bank; the Penaeidea and Caridea. Penaeid shrimps were distributed almost all over the surveyed area and included the species with greatest commercial value. Caridean shrimps, confined to a much more restricted area, were present in very high densities.

Penaeid shrimps

During the present survey penaeid shrimps were found from 5 to 76 m depths but mostly between 5 and 45 m. In waters deeper than 45 m the yields declined with increasing depth. South of the Zambezi River the zero-line distribution seemed to be 65 m, but north of this river, where the maximum depth covered by the present survey was 76 m, penaeid shrimps were still present in the catches with yields generally lower than 1 kg per hour of trawling. The main area of distribution was north of Zambezi River in depths shallower than 15 m.

The distribution of penaeid shrimps north of the Zambezi River is shown in Fig. 22 a. South of this river an estimation of the distribution area was not possible because the stations were too few and far apart. A general picture of the distribution in this area can, however, be given by the catch rates at each trawl station, as shown in Fig. 22 c.

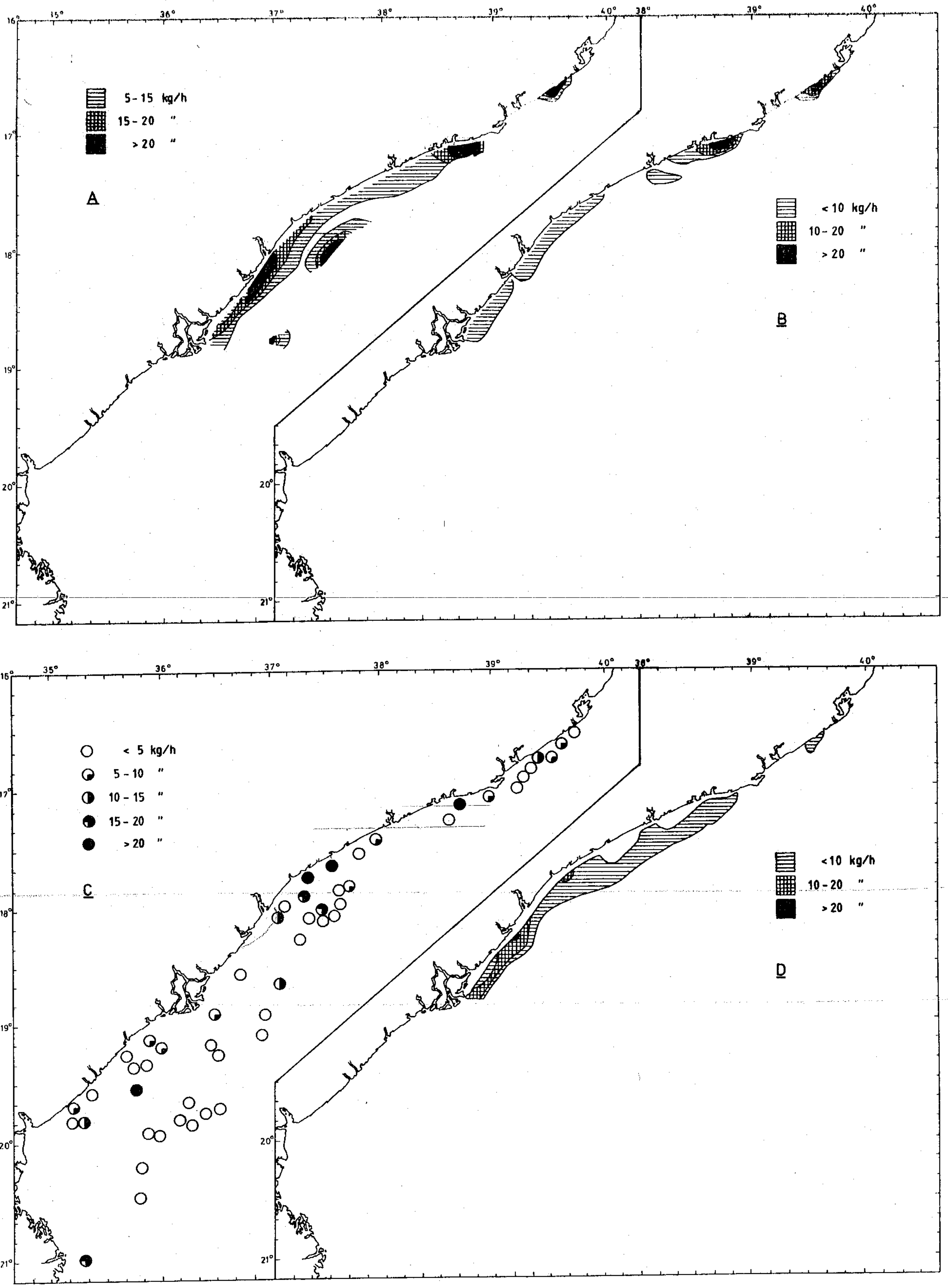

Fig. 22. A) Penaeid shrimp distribution north of the Zambezi based on catch rates. B) Distribution of *Penaeus indicus*. C) Penaeid shrimp distribution. Circles indicate trawl stations and catch rates. D) Distribution of *Metapenaeus monoceros*.

Based on geographic and bathymetric distribution, three areas were considered:

Area 1 South of the Zambezi River
Area 2 Between the Zambezi River and Moma
Area 3 North of Moma

area swept by hour = 3 x 0.0175 x 1,852

Table 5. Penaeid shrimps - Total catch and catch (*kg. h^{-1}*) *of each species* by area and depth zones.

Area 1 - South of Zambezi River.

Depth (m)	5-15	15-25	25-35	35-45	> 45	Total	% weight
Penaeus indicus	1.15	-	-	-	-	0.19	5.35
Metapenaeus monoceros	1.10	2.84	8.00	-	-	1.75	47.30
Penaeus japonicus	-	2.29	0.20	-	-	0.76	21.41
" monodon	-	0.58	-	-	-	0.19	5.35
" latisulcatus	-	0.10	0.80	0.50	0.09	0.19	5.35
Others	-	0.60	3.20	-	0.04	0.47	13.24
Total*	2.25	6.41	12.00	0.62	0.13	3.54	
No. of trawls	4	8	2	3	8	25	

Area 2 - Between Zambezi River and Moma.

Depth (m)	5-15	15-25	25-35	35-45	> 45	Total	% weight
	3329	3401	3072	2196			
Penaeus indicus	7.86	0.78	2.70	0.08	-	2.94	35.37
Metapenaeus monoceros	6.59	3.62	2.14	0.003	-	3.90	35.01
Penaeus japonicus	0.15	0.35	3.32	0.73	-	0.54	4.85
" monodon	1.17	-	0.39	-	0.15	0.85	7.65
" latisulcatus	-	-	0.80	12.07	2.21	1.71	15.35
Others	0.09	0.59	0.40	-	-	0.20	1.80
Total*	16.04	5.15	9.76	12.89	2.35	11.10	
No. of trawls	26	11	5	6	8	56	

Area 3 - North of Moma

Depth (m)	5-15	15-25	25-35	35-45	> 45	Total	% weight
Penaeus indicus	5.63	0.36				2.82	60.13
Metapenaeus monoceros	0.81	0.63				0.72	15.35
Penaeus japonicus	0.59	1.22				0.93	19.83
" monodon	-	0.13				0.07	1.49
" latisulcatus	-	-				-	-
Others	0.13	0.18				0.15	3.20
Total*	7.16	2.62				4.60	
No. of trawls	7	9				16	
TOTAL	12.84	4.72	9.10	8.41	1.25	8.15	
No. of trawls	37	28	7	9	16	97	

*Sometimes the total does not coincide with the sum of kg·h^{-1} for the different species, because some hauls could not be used for species composition.

Table 5 shows the total catch and catch for each species per hour of trawling split into area and depth intervals. The penaeid shrimps included the following species of greatest commercial value: Penaeus indicus, Metapenaeus monoceros, Penaeus latisulcatus, Penaeus japonicus and Penaeus monodon.

P. indicus, M. monoceros and P. latisulcatus were the dominant species. P. indicus was the most important species in the northern part of Sofala Bank and had a near-shore distribution, with the highest yields in depths shallower than 15 m. This species was not found below 40 m. (Fig. 22 b).

M. monoceros dominated the catches over the southern part of Sofala Bank. South of the Zambezi River the highest catches were found between 25 and 35 m; north of this river the main concentrations were found between 5 and 15 m. This species did not occur in waters deeper than 35 m. (Fig. 22 d).

P. latisulcatus was confined to a smaller area than the previous species. The yields increased in waters deeper than 35 m and important concentrations occurred only between Quelimane and Moma.

Standing stock size was estimated by the "swept area" method. All trawl stations without accidents were used. Although the surveys between 4-28 November did not have the objective of estimating shrimp stock size, all stations with shrimp trawls were used in the calculations. As the trawls were carried out mainly on recordings of pelagic fish they could be used as random chosen fishing localities for shrimp species. North of the Zambezi River catch rates and stock size were calculated by depth strata. South of the Zambezi River the scarcity of trawl stations permitted only stock size estimation for the total surveyed area.

The horizontal opening of the trawl was on average 17,5 m (range 15 to 20 m) and the trawling speed was 3 knots. The efficiency coefficient of the trawl was taken as 1. Stock size was calculated by:

Table 6. Penaeid shrimps - Standing stock size in tonnes estimated from mean catch per hour of trawling.

	Area 1			Area 2			Area 3			Total		
Depth (m)	Area km^2	No. of hauls	Stock size	Area km^2	No. of hauls	Stock size	Area km^2	No. of hauls	Stock size	Area km^2	No. of hauls	Stock size
5-15				3329	26	549	484	7	36			
15-25				3401	11	180	375	9	10			
25-35				3072	5	308	-	-	-			
35-45				2196	6	291	-	-	-			
45-100				2343	8	57	-	-	-			
Total	25630	25	933	14341	56	1385	859	16	46	40830	97	2364

$$\frac{\text{total area} \quad \text{x} \quad \text{c/h}}{\text{area covered / hour}}$$

~~The results are shown in Table 6. As can be seen, south of the~~ Zambezi River stock size was 39% of the total, a result similar to that obtained by SIP in a survey carried out during July/-August 1979. However, the shrimp density in this area was only one third of that in the area north of the Zambezi river.

Caridean shrimp

Caridean shrimps were confined to an area north of the Zambezi River with a near-shore distribution. Very high concentrations were found between the Zambezi River and Quelimane in waters from 5 to 15 m deep (Fig. 23). The estimates of caridean stock size by depth strata are shown in Table 7.

Table 7. Caridean shrimps - Standing stock size in tonnes estimated from mean catch per hour of Area 2.

Depth (m)	Area km^2	No. of hauls	Stock size
5-15	3329	26	635
15-25	3401	11	83
25-35	-	-	-
35-45	-	-	-
45-100	-	-	-
Total	6730	37	718

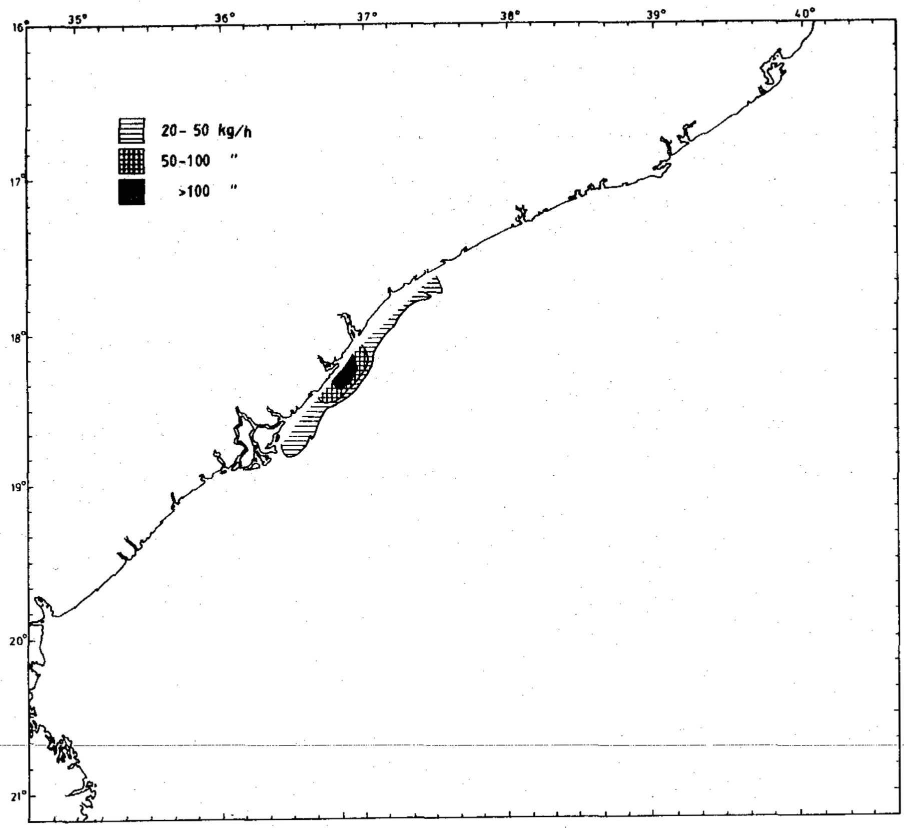

Fig. 23. Distribution of caridean shrimps.

Total shrimp standing stock size was calculated as the sum of penaeid and caridean stock sizes. (Table 8). Caridean biomass was 23% of the total shrimp biomass.

Table 8. Total shrimp standing stock size (tonnes).

Depth (m)	Area 1	Area 2	Area 3	Total
5-15		1184	36	
15-25		263	10	
25-35		308	-	
35-45		291	-	
45-100		57	-	
Total	933	2103	46	3082

4.7 Biological characteristics of shrimps

Fig. 24 gives the carapace length frequency distributions of <u>Penaeus indicus</u> and <u>Metapenaeus monoceros</u>, as well as frequency distributions of late maturing and mature females. Figs. 25 a and 25 b show the trawl stations where biological samples were taken of these species. Percentages of females and maturity stages are indicated except in some small size samples of P.indicus.

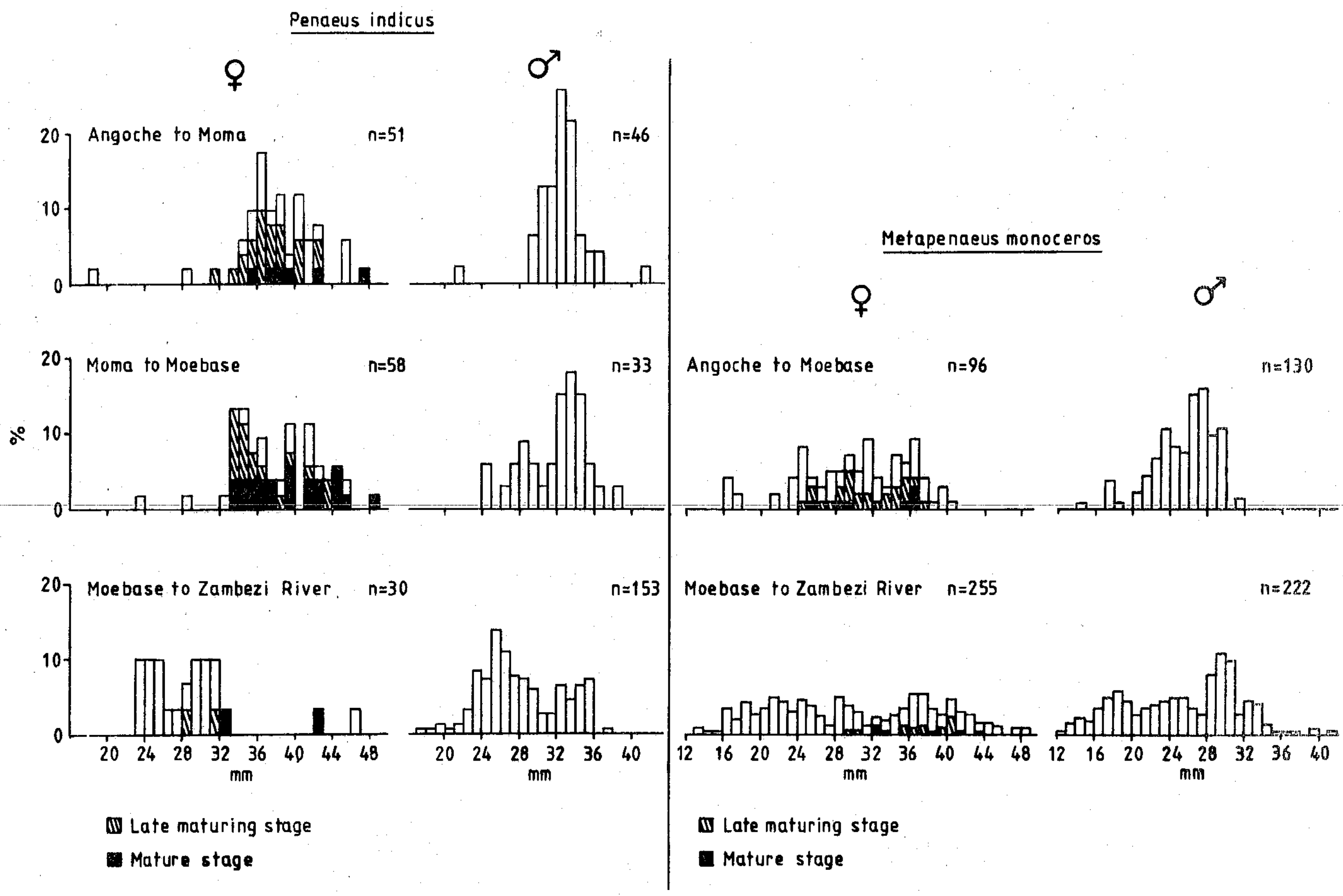

Fig. 24. Carapace length frequency distribution.

Penaeus indicus

The data were grouped according to the similarity of the biological characteristics. For the species P.indicus, three areas were distinguished: Angoche to Moma, Moma to Moebase and Moebase to the Zambezi River. Due to their different growth patterns, the data were processed separately for males and females.

The carapace length distribution of males indicated that the size composition of the stock was different from north to south, the bigger individuals occuring in the northern area. From Angoche to Moma the males were mainly between 28 and

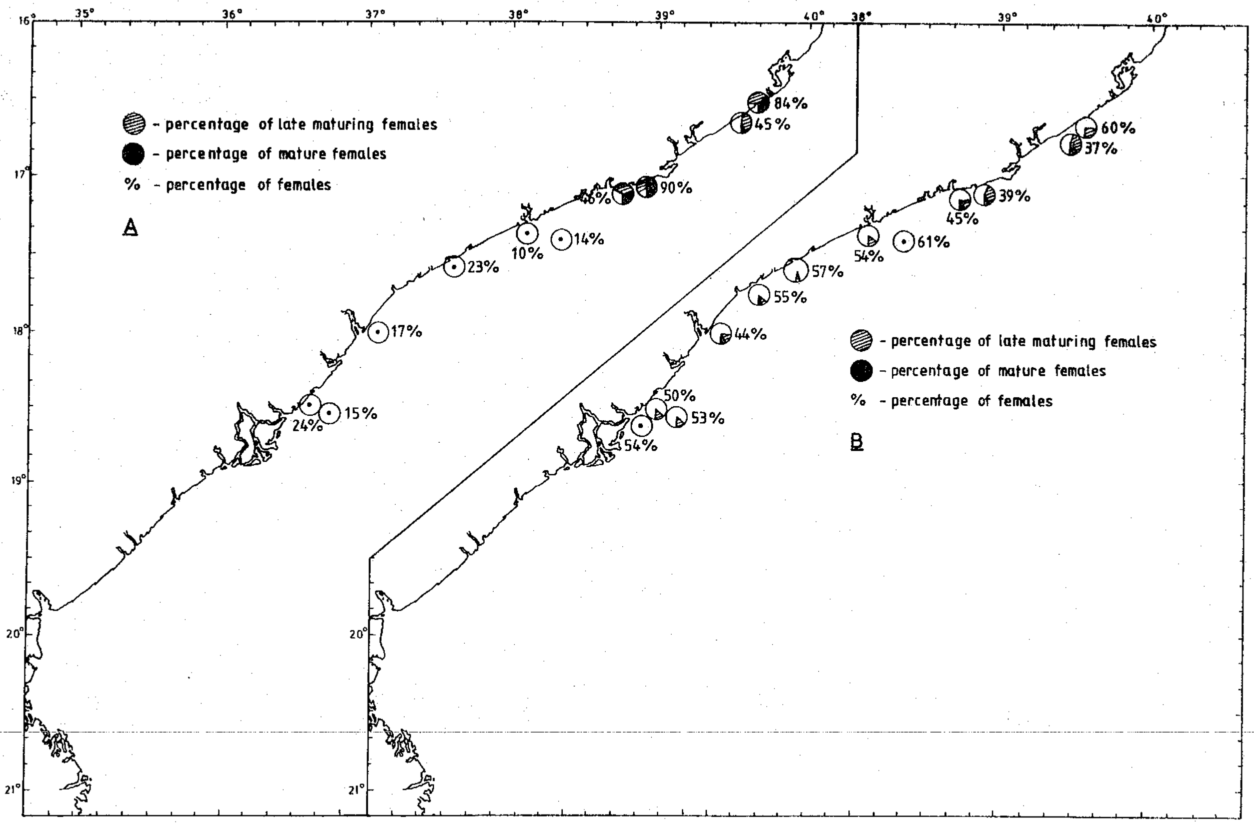

Fig. 25. Positions of the biological sampling.
A) Penaeus indicus. B) Metapenaeus monoceros.

36 mm, the mode being 32 mm. Between Moma and Moebase, although the main distribution was the same, there was another distribution of smaller individuals between 26 and 30 mm with the mode at 28 mm. From Moebase to the Zambezi River the length distribution was bimodal, as in the previous area, but the smaller specimens (with a mode of 25 mm) were dominant.

The same pattern was found for females. North of Moebase, females of P.indicus were mainly distributed between 32 and 48 mm in length. South of Moebase, although females were present in a very low number, they were always smaller than 32 mm.

High percentages of females were found north of Moebase. This seemed to be related to high percentages of the maturing and mature stages, which indicated pre-spawning time. The spent-recovering stage was not recorded because it cannot be clearly microscopically defined. However, if it is assumed that spawning occurs in a short period of time after the mature stage (RAO, 1968), it can be concluded that, spawning was probably taking place in October in two well-defined areas - between 16°30'S and 16°40'S and between 17°00'S and 17°10'S - in very shallow waters (5-15 m). These spawning grounds had high density areas of P.indicus.

Metapenaeus monoceros

Only two areas were considered for M.monoceros: north of Moebase and from Moebase to the Zambezi River. In the whole area the distribution of M.monoceros had several modes, which could indicate that recruitment was more or less continuous. North of Moebase M.monoceros females were mostly between 20 and 40 mm in carapace length. Males were smaller, being mostly between 16 and 28 mm. South of Moebase the population was more heterogeneous. As was observed for P.indicus, the smallest individuals were found in this area. The length varied between 12 and 48 mm for females and between 12 and 40 mm for males. Conclusions cannot be stated on spawning because biological

Table 9. Catch per hour of trawling of the most important families in the area south of the Zambezi River (kg · h^{-1}).

Families	Depth intervals					Average catch	% weight
	5-15	15-25	25-35	35-45	> 45		
Ariidae	23.20	0.27	-	-	-	1.91	0.08
Bothidae	-	1.55	16.00	1.70	0.35	2.29	0.91
Cynoglossidae	20.00	2.41	1.20	-	-	2.84	1.13
Mullidae	-	10.32	6.40	52.60	19.32	17.81	7.10
Nemipteridae	-	-	4.40	10.70	8.45	3.93	1.57
Pomadasyidae	4.00	21.04	-	0.80	-	10.57	4.21
Scianidae	287.20	22.87	-	-	-	32.65	13.02
Sphyraenidae	-	22.96	-	0.60	0.86	10.89	4.34
Synodontidae	-	17.57	20.80	48.30	7.18	18.80	7.50
Theraponidae	10.40	16.39	-	-	-	8.36	3.33
Others	9.00	18.41	14.96	10.26	12.68	14.84	5.92
TOTAL DEMERSAL	353.80	133.79	63.76	124.96	48.84	124.36	49.58
Carangidae	-	16.61	7.20	41.20	18.50	18.83	7.51
Clupeidae	12.40	86.15	-	-	2.56	41.31	16.47
Engraulidae	44.00	107.51	-	-	-	53.00	21.13
Leiognathidae	0.40	11.85	0.08	-	-	5.51	2.20
Scombridae	-	5.12	-	2.20	2.39	3.25	1.30
Others	-	0.10	-	-	-	0.05	0.02
TOTAL PELAGIC	56.80	227.34	7.28	43.40	23.45	121.94	48.62
SHARKS AND RAYS	31.60	4.53	-	-	-	4.52	1.80
TOTAL CATCH	442.20	365.66	71.04	168.36	240.65	250.82	100.00
NUMBER OF TRAWLS	1	6	1	2	3	13	

sampling was carried out only on the first cruise (23-28 October) which did not include the high density area of M.monoceros south of the Zambezi River. It was observed that mature females occurred in low percentages mainly in the northern part, and always at depths shallower than 20 m. Females were dominant, except in the samples where mature females were present.

4.8 Shrimp by-catch

Composition

Fish was the dominant group in shrimp by-catches with over 97% in weight with respect to other groups. For fish composition analysis, only stations with shrimp catches were used. The data were grouped into the same areas as defined for shrimp. Table 9 shows catch per hour of trawling of the most important families in the area south of the Zambezi split into depth intervals and into the three main groups; demersal, pelagic and sharks/rays. Demersal and pelagic fish were present in about equal percentages. The table is based on few trawl stations and the data should be regarded as uncertain.

Table 10. Catch per hour of trawling of the most important families in the area between the Zambezi River and Moma (kg· h^{-1}).

Depth (m)	5-15	15-25	25-35	35-45	> 45	Average catch	% weight
Ariidae	12.35	1.93	3.60	-	-	6.43	4.39
Mullidae	4.67	11.50	19.44	13.44	5.88	8.68	5.92
Nemipteridae	-	-	18.12	10.02	24.14	5.60	3.82
Pomadasyidae	13.89	18.10	34.96	-	-	14.13	9.64
Sciaenidae	56.44	5.45	-	-	0.27	28.87	19.70
Synodontidae	0.33	3.26	18.74	21.65	21.43	7.43	5.07
Others	25.85	13.02	28.10	16.78	23.57	22.57	15.40
TOTAL DEMERSAL	113.53	53.26	119.36	61.89	75.29	93.71	63.94
Carangidae	2.10	3.28	30.52	48.19	49.64	15.40	10.51
Clupeidae	14.90	9.74	-	-	-	9.13	6.23
Engraulidae	22.92	7.31	0.08	-	-	12.65	8.63
Leiognathidae	13.34	13.98	14.44	0.17	-	10.79	7.36
Others	0.59	1.53	0.00	1.00	0.00	0.68	0.46
TOTAL PELAGIC	53.85	35.84	45.04	49.36	49.64	48.65	33.19
SHARKS & RAYS	3.70	0.7	13.30	-	0.30	4.20	2.87
TOTAL CATCH	171.08	89.80	177.70	111.25	236.48	146.56	100
NO. OF TRAWLS	22	8	5	5	5	45	

Table 10 shows the percentage of demersal and pelagic and in the total catch, split into depth intervals in the area between the Zambezi river and Moma. Demersal fish were dominant in the whole area, comprising between 56 and 65% of the total catch.

In all depth strata approximately 70% of the demersal catches were composed of the families included in Table 10. In waters shallower than 25 m the dominant families were Ariidae and Sciaenidae.Deeper than 25 m the most abundant families in the demersal catches were Mullidae, Nemipteridae, Pomadasyidae and Synodontidae.

Among pelagic fish in waters shallower than 25 m the most important families were Clupeidae, Engraulidae and Leiognathidae. The first two families were dominant in catches below 15 m, while deeper than 25 m Carangidae were almost the only pelagic fishes present in the shrimp by-catch.

Table 11 shows the proportions of different groups in the total catch, split into depth intervals from the catches in Area 3 - north of Moma. As in Area 2, demersal fish dominated the shrimp

Table 11. Catch per hour of trawling of the most important families in the area north of Moma ($kg \cdot h^{-1}$)

Depth (m)	5-15	15-25	Average catch	% weight
Mullidae	17.61	32.53	25.07	11.15
Polynemidae	11.69	6.89	9.29	4.13
Pomadasyidae	16.35	82.58	49.46	21.99
Sciaenidae	13.19	0.63	6.91	3.07
Sillaginidae	18.10	0.06	9.08	4.04
Others	31.11	28.80	27.59	12.27
TOTAL DEMERSAL	118.05	146.69	127.40	56.64
Carangidae	11.13	5.65	8.39	3.73
Clupeidae	12.52	10.41	11.47	5.10
Engraulidae	4.82	5.75	5.29	2.35
Leiognathidae	37.27	83.12	60.19	26.76
Others	4.39	2.87	3.63	1.61
TOTAL PELAGIC	70.13	107.80	88.97	39.55
SHARKS & RAYS	-	17.14	8.57	3.81
TOTAL CATCH	178.18	271.63	224.94	100
No. OF TRAWLS	7	7	14	

by-catch. Pomadasyidae and Mullidae were the dominant families in this area, being most abundant between 15 and 25 m. In waters shallower than 15 m these families occurred in almost the same proportions as Polynemidae, Sciaenidae and Sillaginidae. Among the pelagic families, Leiognathidae were dominant all over the area.

The main commercial fishing area for shrimps in October and November was between the Zambezi River and Moma (Area 2) at depths between 5 and 35 m. No data on the composition of the by-catch from the commercial shrimp trawlers are available. An estimation of the the species composition of the by-catch of the commercial fishery using survey data from Area 2 between 5 and 35 m is given in Table 12. These results are probably not representative because it is not known to which degree species composition observed by the research vessel can be compared with that of commercial trawlers.

Table 12. Catch composition from the research vessel of the area between the Zambezi River and Moma at depths between 5 and 35 m.

Family	Most important species	% weight
Sciaenidae	J. belangerii, J. dussumieri, Otholites ruber	23.3
Pomadasyidae	Pomadasys hasta, P. maculatus	11.4
Mullidae	Upeneus vittatus	5.3
Ariidae	Arius spp.	5.2
Synodontidae	Saurida spp.	2.3
Nemipteridae	Nemipterus delagoa	1.7
Others		14.8
Demersal fish		64.1
Engraulidae	Thryssa vitrirostris	10.2
Leiognathidae	Leiognathus equulus Secutor insidiator	8.7
Clupeidae	Pellona ditchela Sardinella gibbosa	7.4
Carangidae	Carangoides malabaricus Decapterus maruadsi	4.1
Others		0.5
Pelagic fish		30.9
Sharks & Rays		5.0

Magnitude of the by-catch

Magnitude of the by-catch was analysed by grouping the data into the same areas and depth intervals defined earlier. All calculations were based on data from stations with shrimp catches. Table 13 shows the percentage of shrimps in the total catch. South of the Zambezi River the data were not split into depth intervals for the reasons defined earlier. The highest percentage of shrimps was found between the Zambezi River and Moma (Area 2) in waters shallower than 15 m, and also between 35 and 45 m.

Table 13. Total catch rates (shrimp + fish) and percentages of shrimp in catches.

Depth (m)		5-15	15-25	25-35	35-45	> 45	Total
Area 1	Total catch rate ($kg \cdot h^{-1}$)						266.82
	% shrimp						2.4
Area 2	Total catch rate ($kg \cdot h^{-1}$)	209.07	96.85	197.02	127.70	129.05	170.28
	% shrimp	16.9	7.4	3.8	12.9	2.9	12.8
Area 3	Total catch rate ($kg \cdot h^{-1}$)	185.34	274.99	-	-	-	230.20
	% shrimp	3.9	1.2	-	-	-	2.3

The main fishing area for the commercial shrimp fishery is north of the Zambezi River. A sampling program of the SIP on board of one of the commercial vessels was started in June 1980. In October and November 1980 samples were not taken from commercial catches, but data from September and December were available and could be compared with data from the present survey. Catch rates were compared with commercial catches by depth intervals but the results obtained were not reasonable. This could be explained by the normal shrimp migrations that occur parallel to the coast, probably in accordance with environmental conditions. As commercial samples were not taken during the same period as the survey data, it seemed more reasonable to compare the data based on shrimp catch rate intervals rather than based on depth intervals. Commercial catch data were grouped into two catch rate intervals - < 50 kg/hours of trawling and > 50 kg/h.

Although commercial shrimp trawls are different from the trawl used in the survey, shrimp catch rates can probably be compared because:

- both trawls have a tickler chain,
- the horizontal opening is similar, and
- commercial trawls have doors attached close to the net wings. This is not the case for the shrimp trawl used in the research survey, but most probably the shepherding effect of the bridles is not as important for shrimps as for fish.

Commercial vessels are double rigged; each trawl has a horizontal opening of ≈ 17 m at a trawl speed of 3 knots. The research vessel worked with a shrimp net with a horizontal opening of ≈ 17.5 m at the same trawl speed. Areas swept by the trawls could be compared and a ratio of 34/17.5 ≈ 2 was expected between commercial and survey catch rates.

Survey data from Area 2 was grouped into two shrimp catch rate intervals - < 25 kg/h and > 25 kg/h, which were assumed to correspond to commercial catch rates of < 50 kg/h and > 50 kg/h. The results are shown in Table 14, and it can be easily seen that the shrimp by-catch was much lower in commercial catches.

Table 14. Shrimp percentage in commercial and research survey catches split into shrimp catch rate intervals.

	Shrimp catch rate			
	$< 50\ kg \cdot h^{-1}$		$> 50\ kg \cdot h^{-1}$	
	September	December	September	December
Commercial catches	36.7%	27.9%	57.5%	46.7%
	$< 25\ kg \cdot h^{-1}$		$> 25\ kg \cdot h^{-1}$	
Research survey catches	7.6%		27.9%	

Comparing the commercial catches and the research survey data for the same month and for both catch intervals, the difference between shrimp percentages seemed constant (≈ 29% in September and ≈ 20% in December). Although the research survey data were not taken at the same time as commercial catch sampling, it seems reasonable to think that in the missing months (October and November) shrimp percentages would also have been higher in commercial catches and probably at the same level as in September and December. This difference can probably be explained by different vertical opening of the nets used by the commercial (≈ 2 m) and research vessels (≈ 5 m).

A preliminary conclusion is that survey data can be useful in providing baseline by-catch information on magnitude and composition of catches. In future surveys, however, gear similar to the commercial trawls should be used and data analysed in connection with information collected by sampling on board the commercial vessels. The use of different shrimp trawls, most likely gives different information on magnitude and composition of the by-catch. The present knowledge is not enough to give reliable information for economic utilization of the by-catch or for management purposes.

5. REFERENCES

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APPENDIX A. RECORD OF FISHING OPERATIONS

BT = Bottom trawl - PT = Pelagic trawl - ST = Shrimp trawl

DATE	ST.NO.	GEAR TYPE	BOTTOM DEPTH (m)	GEAR DEPTH (m)	POSITION SOUTH	POSITION EAST	TOTAL CATCH (kg)	CATCH PER HOUR (kg)	DOMINANT SPECIES	(% weight)
12.10.80	711	BT	526	526	25°59'	34°00'	24	48	Prawns (Penaeidae)	88
12.10.80	712	ST	428	428	25°48'	33°59'	100	200	Sea toads (Chaunax pictus) Butterfish (Cubiceps natalensis) Crabs	33 21 7
12.10.80	713	PT	37	19	25°10'	33°48'	107	214	Ponyfish (Gazza minuta) Anchovy (Stolephorus buccanerii) Snapper (Lutjanus lineolatus)	35 38 8
13.10.80	714	BT	30	30	24°56'	34°29'	112	224	Croaker (Johnius dussumeri) Croaker (Otholithes ruber) Croaker (Argyrosomus hololepiditus	35 22 12
14.10.80	715	BT	25	25	24°52'	34°36'	142	284	Jelly fish Croaker (Otholithes ruber) Lizardfish (Saurida undosquamis)	85 10 5
14.10.80	716	PT	40	20	24°58'	34°41'	1.5	3	Round herring (Etrumeus teres) Puffers (Lagocephalus sp.) Snapper (Lutjanus lineolatus)	35 28 14
14.10.80	717	PT	314	270	25°33'	34°33'	130	260	Hairtails (Benthodemus tenuis)	100
14.10.80	718	BT	42	42	24°58'	34°47'	6.7	13.4	Bluefish (Pomatomus saltator) Horse mackerel (Trachurus trachurus) Cavalla (Carangoides malabaricus)	27 24 21
14.10.80	719	PT	0	50	24°58'	34°51'	1	2	Driftfish (Ariomma indica) Flying fish (Cupselurus bahiensis) Squids	35 35 26
14.10.80	720	PT	49	27	24°57'	34°52'	3.5	7	Round herring (Etrumeus teres) Mackerel (Scomber australasicus) Driftfish (Ariomma indica)	65 27 6
14.10.80	721	PT	40	18	24°49'	35°00'	6.5	13	Round herring (Etrumeus teres) Jellyfish/Squids Horse mackerel (Trachurus trachurus)	46 27 10
15.10.80	722	BT	28	28	24°46'	34°55'	2.5	5	Squids Puffer (Lagocephalus sp.) Lizard fish (Saurida sp.)	78 11 9
15.10.80	723	PT	2	28	24°54'	34°38'	22	44	Jelly fish	99
15.10.80	724	PT	35	25	24°57'	34°29'	1.5	3	Anchovy (Stolephorus buccaneri) Squids Driftfish (Ariomma indica)	63 28 4
15.10.80	725	BT	31	31	24°55'	34°32'	134	268	Jellyfish Cavalla (Carangoides malabaricus)	89 3
15.10.80	726	PT	52	20	24°59'	34°54'	20	40	Round herring (Etrumeus teres) Mackerel (Scomber australasicus)	96 4
24.10.80	727	ST	11	11	16°24'	39°57'	17	34	Mackerel (Scomberomorus commerson) Mojarra (Gerres filamentosus)	50 24
24.10.80	728	ST	11	11	16°29'	39°50'	5	10	Mackerel (Scomberomorus sp.) Flounder (Pseudorhombus elevatus) Lizardfish (Saurida sp.)	45 22 11
24.10.80	729	ST	18	18	16°37'	39°44'	16	32	Mackerel (Scomberomorus commerson) Squids Mackerel (Selar crumenophtalmus)	71 9 6
24.10.80	730	ST	11	11	16°31'	39°45'	250	500	Ponyfish (Leiognathus equulus) Smelt (Sillago sihama) Grunter (Pelates quadrilineatus)	22 22 10
24.10.80	731	ST	20	20	16°40'	39°38'	8	16	Mackerel (Scomberomorus lineolatus) Sardine (Dussumeria acuta) Sardin (Sardinella sp.)	49 15 9
24.10.80	732	ST	10	10	16°38'	39°36'	79	158	Prawns (Penaeus indicus) Anchovy (Thryssa vitrirostris) Shad (Hilsa kelee)	17 10 9
24.10.80	733	ST	18	18	16°44'	39°35'	222	444	Rays Ponyfish (Leiognathidae) Goatfish (Upeneus vittatus)	27 27 15
24.10.80	734	ST	10	10	16°43'	39°27'	92	184	Spadefish (Drepane punctata) Grunts (Pomadasys maculatus) Goatfish (Upeneus vittatus)	21 16 16
25.10.80	735	ST	19	19	16°51'	39°28'	11	22	Mackerel (Selar crumenophtalmus) Goatfish (Upeneus vittatus) Lizardfish (Trachynocephalus myops)	23 12 9
25.10.80	736	ST	12	12	16°47'	39°21	66	132	Ponyfish (Secutor incidiator) Goatfish (Upereus vittatus) Smelt (Sillago sihama)	40 24 5
25.10.80	737	ST	19	19	16°52'	39°20'	483	966	Grunts (Pomadasys maculatus) Ponyfish (Secutor incidiator) Ponyfish (Leiognathus equulus)	23 17 15
25.10.80	738	ST	8	8	16°53'	39°12'	25	50	Grunts (Pomadasys maculatus) Goatfish (Upeneus vittatus) Grunts (Pomadasys hasta)	22 16 15
25.10.80	739	ST	18	18	17°00'	39°12'	40	80	Goatfish (Upeneus vittatus) Mojarra (Gerres filamentosus) Jack (Carongoides sp.)	54 16 12
25.10.80	740	ST	10	10	17°07'	39°00	26	52	Goatfish (Upeneus vittatus) Ponyfish (Leiognathus equulus) Jack (Carangoides sp.)	46 15 11

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DATE	ST.NO.	GEAR TYPE	BOTTOM DEPTH (m)	GEAR DEPTH (m)	POSITION SOUTH	POSITION EAST	TOTAL CATCH (kg)	CATCH PER HOUR (kg)	DOMINANT SPECIES	(% weight)
25.10.80	741	ST	10	10	17°04,5	38°55,5	82,9	165.8	Grunts (Pomadasys maculatus) Grunts (Pomadasys hasta) Ponyfish (Leiognathus equulus)	30 16 14
25.10.80	742	ST	11	11	17°06.5	38°47.5	79.7	159.4	Ginger Prawn (Penaeus indicus) Ginger Prawn (Penaeus hasta) } Scoriginalen Catfish (Arius sp.)	26 17 13
25.10.80	743	ST	11	11	17°08'	38°36.5	24.3	48.6	Ginger Prawn (Penaeus indicus) Catfish (Arius sp.) Anchovy (Thryssa vitrirostris)	30 12 11
25.10.80	744	ST	20	20	17°15.5	38°37.5	88.4	176.8	Ponyfish (Leiognathus equulus) Grunts (Pomadasys maculatus) Prawn (Metapenaeus monoceros)	34 23 5
25.10.80	745	ST	32	32	17°24.5	38°21'	87.5	175	Grunts (Pomadasys maculatus) Ponyfish (Leiognathus equulus) Grunts (Rhonciscus stridens)	48 16 14
26.10.80	746	ST	9	9	17°16.5	38°17.5	50.6	101.2	Croakers (Johnius belangerii) Croakers (Otholites ruber) Guitarfish (Rhinobathus sp.)	26 18 15
26.10.80	747	ST	10	10	17°22'	38°07'	33.5	67	Croakers (Johnius belangerii) Anchovy (Thryssa vitrirostris) Prawns (Penaeidae)	31 16 12
26.10.80	748	ST	14	14	17°26'	38°00'	144.2	288.4	Sardine (Pellona ditchela) Catfish (Arius sp.) Anchovy (Thryssa vitrirostris)	54 10 10
26.10.80	749	ST	27	27	17°32'	38°04'	165.5	331	Jacks (Carangoides malabaricus) Grunts (Pomadasys maculatus) Tiger perches (Therapon jarbua)	27 20 16
26.10.80	750	ST	40	40	17°39.3	38°05	13	26	Jacks (Carangoides malabaricus) Spadefish (Drepane punctata) Triggerfish (Balistes sp.)	58 13 9
26.10.80	751	ST	50	50	17°43.5	37°56.5	408	916	Barracuda (Sphyraena obtusata) Grunts (Pomadasys maculatus) Sardines (Dussumiera acuta)	21 20 17
26.10.80	752	ST	15	15	17°40.5	37°46.5	37	74	Sardines (Pellona ditchela) Grunts (Pomadasys maculatus) Hairtails (Trichiurus lepturus)	30 20 7
26.10.80	753	ST	10	10	17°36'	37°37'	40	80	Croaker (Johnius belangerii) Croaker (Otholites ruber) Hairtails (Trichiurus lepturus)	43 13 10
26.10.30	754	ST	11	11	17°40'	37°29'	49	98	Croaker (Johnius belangerii) Shrimps (Caridae) Anchovy (Thryssa vitrirostris)	31 22 10
26.10.80	755	ST	11	11	17°44.5	37°21.5	93	186	Shrimps (Caridae) Croaker (Johnius belangerii) Anchovy (Thryssa vitrirostris)	27 26 10
26.10.80	756	ST	17	17	17°49.5	37°28'	54	108	Grunt (Pomadasys maculatus) Croaker (Johnius belangerii) Jacks (Carangoides malabaricus)	51 17 6
26.10.80	757	ST	27	27	17°55.5	37°29.5	41.5	83	Lizardfish (Saurida sp.) Lizardfish (Trachinocephalus myops) Ginger prawn (Penaeus japonicus)	25 13 11
27.10.80	758	ST	39	39	18°03'	37°32'	51	102	Brownprawn (Penaeus latisulcatus) Lizardfish (Trachinocephalus myops) Threadfinbream (Nemipterus delagoa)	35 19 18
27.10.80	759	ST	70	70	18°10'	37°27'	39	78	Threadfinbream (Nemipterus delagoa) Lizardfish (Saurida undosquamis) Goatfish (Mulloidichthys flavolineatus)	49 12 6
27.10.80	760	ST	70	70	18°19'	37°20'	95	190	Scad (Decapterus maruadsi) Threadfinbream (Nemipterus delagoa) Lizardfish (Saurida undosquamis)	24 16 8
27.10.80	761	ST	33	33	18°10'	37°17.5'	174	348	Sharks Threadfinbream (Nemipterus delagoa) Scads (Decapterus maruadsi)	35 26 11
27.10.80	762	ST	22	22	18°07'	37°10'	11.5	23	Lizardfish (Saurida sp.) Jacks (Megalapsis cordyla) Squids	44 11 11
27.10.80	763	ST	11	11	18°01'	37°06'	97	194	Shrimps (Caridae) Croakers (Otholites ruber) Croakers (Johnus belangerii)	21 21 13
27.10.80	764	ST	7	7	18°09'	36°59'	207	414	Skate (Rajidae) Croaker (Johnius belangerii) Shrimps (Caridae)	24 24 14
27.10.80	765	ST	10	10	18°16'	36°53'	200	400	Shrimps (Caridae) Croaker (Johnius belangerii) Sardine (Pellona ditchela)	36 15 11
27.10.80	766	ST	24	24	18°23'	36°59.5'	3.2	6.4	Hairtail (Trichiurus lepturus) Lizard fish (Saurida sp.) Tigerperch (Therapon jarbua)	29 22 13
27.10.80	767	ST	38	38	18°28'	37°12'	176	352	Scad (Decapterus maruadsi) Scad (Decapterus macrosoma) Threadfinbream (Nemipterus delagoa)	62 14 7
27.10.80	768	ST	75	75	18°47.5	37°09.5	11.7	23.4	Lizardfish (Trachinocephalus myops) Crabs Goatfish (Upeneus bensasi)	35 10 8
27.10.80	769	ST	39	39	18°47'	37°01.5	69	178	Lizardfish (Trachinocephalus myops) Lizardfish (Saurida undosquasmis) Brownprawn (Penaeus latisulcatus)	17 14 13

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27.10.80	770	ST	16	16	18°33'	36°42'	68	176	Shrimp (Caridae) Anchovy (Thryssa vitrirostris) Hairtail (Trichiurus lepturus)	19 12 9
28.10.80	771	ST	9	9	18°30'	36°38'	55	110	Croaker (Johnius belangerii) Shrimps (Caridae) Catfish (Aries sp.)	33 24 7
28.10.80	772	ST	10	10	18°38'	36°32'	62	124	Croaker (Johnius belangerii) Shrimps (Caridae) Croaker (Otholites ruber)	33 21 11
28.10.80	773	ST	9	9	18°47	36°27.5	144	288	Croaker (Johnius belangerii) Croaker (Otholites ruber) Shrimps (Caridae)	31 17 15
04.11.80	774	ST	17	17	20°28'	34°58'	18.2	36.4	Spanish mackerel (Scomberomorus commerson) Mojarra (Gerres filamentosus) Squids	48 13 10
04.11.80	775	ST	16	16	21°00'	35°17'	39	78	Anchovy (Thryssa vitrirostris) Lizardfish (Saurida sp.) Mojarra (Gerres filamentosus)	13 10 8
05.11.80	776	PT	48	10	20°41.5	35°42'	0.2	0.4	0-group Clupeidae, Gempylidae and Synodontidae	
05.11.80	777	PT	22	0	20°06'	35°14'	5.3	10.6	Spanish mackerel (Scomberomorus lineolatus Anchovy (Stolephorus bucanerii) Squids	84 9 5
05.11.80	778	ST	60	60	20°29'	35°48'	121	242	Triggerfish (Ballistes stillares) Snapper (Lutjanus gibbus) Bream (Pagellus natalensis)	41 13 9
05.11.80	779	PT	51	0	20°11'	35°49'	6.8	13.6	Spanish mackerel (Scomberomorus commerson) Barracuda (Sphyraena japonica) Squids	79 12 6
06.11.80	780	ST	21	21	19°49'	35°17'	141	282	Anchovy (Thryssa vitrirostris) Croaker (Johnius dussumieri) Lizardfish (Saurida undosquamis)	41 19 9
06.11.80	781	ST	10	10	19°41'	35°12'	224	448	Croaker (Johnius belangerii) Croaker (Otholites ruber) Anchovy (Thryssa vitrirostris)	43 20 10
06.11.80	782	ST	50	50	19°57'	35°57'	110	220	Scad (Decapterus maruadsi) Goatfish (Upeneus bensasi) Threadfinbream (Nemipterus delagoa)	53 18 14
06.11.80	783	ST	65	65	19°53'	36°16'	6.3	12.6	Scad (Decapterus maruadsi) Lizardfish (Trachinocephalus myops) Goatfish (Upeneus bensasi)	30 10 8
07.11.80	784	ST	26	26	19°33'	35°47'	68.5	137	Squids & cattlefish Prawn (Metapenaeus monoceros) Lefteye flounders (Bothidae)	21 12 12
07.11.80	785	ST	13	13	19°16'	35°41'	197	394	Sardine (Pellona ditchela) Anchovy (Thryssa vitrirostris) Croaker (Johnius belangerii)	56 13 11
07.11.80	786	ST	20	20	19°20'	35°51'	174	348	Sardine (Pellona ditchela) Cavalla (Carangoides malabaricus) Goatfish (Upeneus vittatus)	30 17 11
07.11.80	787	ST	42	42	19°40'	36°15'	52	104	Goatfish (Upeneus bensasi) Lizardfish (Saurida undosquamis) Threadfinbream (Nemipterus delagoa)	51 15 6
07.11.80	788	ST	66	66	19°46'	36°24'	40.7	81.4	Searobin (Lepidotrigla natalensis) Goatfish (Upeneus bensasi) Lizardfish (Saurida undosquamis)	31 27 13
07.11.80	789	ST	88	88	19°43'	36°32'	3.6	7.2	Crabs Lizardfish (Saurida undosquamis) Searobin (Lepidotrigla natalensis)	28 21 18
08.11.80	790	ST	23	23	19°10'	35°59'	52.5	103	Ponyfish (Secutor insidiator) Tigerperch (Therapon jarbua) Cavalla (Carangoides malabaricus)	19 11 11
08.11.80	791	ST	20	20	19°07'	35°55'	668	1336	Anchovy (Thryssa vitrirostris) Sardine (Pellona ditchela) Grunt (Pomadasys maculatus)	34 27 9
08.11.80	792	ST	31	31	19°11'	36°28'	16.6	32.2	Spanish mackerel (Scomberomoaus commerson) Scad (Decapterus maruadsi) Queenfish (Scomberoides commersianus)	40 32 21
09.11.80	793	ST	20	20	18°54'	36°30'	228	456	Sardine (Pellona ditchella) Anchovy (Thryssa vitrirostris) Grunt (Pomadasys maculatus)	44 36 3
09.11.80	794	PT	35	7	19°01.5	36°41'	0.3	0.4	Anchovy (Stolephorus sp.)	100
09.11.80	795	PT	50	20	18°54'	36°59'	10.2	20.4	Scad (Decapterus maruadsi) Scad (Decapterus macrosoma) Barracuda (Sphyraena japonica)	42 28 12
09.11.80	796	ST	46	46	18°55'	36°59'	52	208	Lizardfish (Saurida undosquamis) Goatfish (Upeneus bensasi) Cavalla (Carangoides malabaricus)	23 13 8
10.11.80	797	ST	20	20	18°33'	36°44'	27.4	54.8	Goatfish (Upeneus vittatus) Spanish mackerel (Scomberomorus commerson) Lizardfish (Saurida micropectoralis)	36 19 12
10.11.80	798	ST	36	36	18°38'	37°04'	40	80		
10.11.80	799	ST	10	10	18°04	37°04.5	159	318	Shrimps (Caridae) Croaker (Johnius belangerii) Croaker (Otholites ruber)	20 15 14

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DATE	ST.NO.	GEAR TYPE	BOTTOM DEPTH (m)	GEAR DEPTH (m)	POSITION SOUTH	POSITION EAST	TOTAL CATCH (kg)	CATCH PER HOUR (kg)	DOMINANT SPECIES	(% weight)
10.11.80	800	PT	50	20	18°14'	37°20'	11	22	Scad (Decapterus maruadsi) Scad (Decapterus macrosoma) Anchovy (Stolephorus bucanerii)	46 44 8
11.11.80	801	ST	40	40	17°58'	37°26'	98	196	Scad (Decapterus maruadsi) Lizardfish (Trachinocephalus myops) Prawn (Penaeus latisulcatus)	49 10 8
11.11.80	802	ST	23	23	17°54'	37°19'	152	304	Sardine (Pellona ditchela) Anchovy (Thryssa vitrirostris) Hairtail (Trichiurus lepturus)	53 10 6
11.11.80	803	ST	12	12	17°46'	37°21'	137	274	Anchovy (Thryssa vitrirostris) Croaker (Johnius belangerii) Hairtail (Trichiurus lepturus)	22 18 14
11.11.80	804	ST	25	25	17°50'	37°39'	21	42	Sandshark (Rhyncobatus djeddensis) Spanish mackerel (Scomberomonus commerson) Lizardfish (Saurida micropectoralis)	37 25 22
11.11.80	805	ST	12	12	17°33'	37°50'	48	96	Croaker (Otholites ruber) Croaker (Johnius belangerii) Anchovy (Thryssa vitrirostris)	31 30 9
11.11.80	806	PT	34	7	17°36'	38°06'	35	70	Anchovy (Stolephorus bucanerii) Spanish mackerel (Scomberomorus commerson) Barracuda (Sphyraena obtusata)	46 13 12
12.11.80	807	PT	31	15	17°30'	38°17'	36	72	Ponyfish (Secutor insidiator) Goatfish (Upeneus vittatus) Grunt (Pomadasys maculatus)	22 17 12
12.11.80	808	PT	14	0	17°22'	36°15'	24	48	Sardine (Pellona ditchela) Shark (Carcharhinus melanopterus) Ponyfish (Secutor insidiator)	64 22 4
12.11.80	809	ST	33	33	17°17'	38°38'	1	2	Cavalla (Carangoides malabaricus) Mackerel (Rastrelliger kanagurta) Sandshark (Rhinobatus schelegli)	48 40 12
12.11.80	810	ST	11	11	17°09'	38°47'	67	134	Prawn (Penaeus indicus) Sardine (Pellona ditchela) Prawn (Metapenaeus monoceros)	18 18 12
12.11.80	811	ST	14	14	17°06'	39°00'	187	374	Ponyfish (Secutor insidiator) Grunt (Pomadasys hasta) Threadfin (Polynemus sextarius)	29 12 12
12.11.80	812	ST	18	18	16°52'	39°22'	49	98	Sardine (Sardinella gibbosa) Anchovy (Thryssa vitrirostris) Sardine (Hilsa kelee)	25 20 15
12.11.80	813	ST	15	15	16°46'	39°25'	196	392	Threadfin (Polynemus sextarius) Croaker (Otholites ruber) Ponyfish (Secutor insidiator)	15 13 8
13.11.80	814	ST	18	18	16°40'	39°38'	133	266	Ponyfish (Secutor insidiator) Ponyfish (Leiognathus equulus) Grunt (Rhonciscus stridens)	23 15 11
13.11.80	815	ST	18	18	16°34	39°46.5	119	238	Sardine (Sardinella gibbosa) Spanish mackerel (Scomberomorus lineolatus) Anchovy (Thryssa vitrirostris)	88 4 2
19.11.80	816	PT	45	5-25	20°43'	35°41'	1.0	2.0	Scad (Decapterus macrosoma) Scad (Decapterus maruadsi) Fishfry	30 30 20
19.11.80	817	PT	30	5-8	20°10'	35°20'	17.1	34.2	Trigger fish juvenile (Monacanthus sp.) Scad juvenile (Decapterus sp.) Fishfry	50 43 6
19.11.80	818	PT	42	3	20°21'	35°38'	0.1	0.2	Fishfry and larvae	100
19.11.80	819	PT	40	20	20°26'	35°34'	216	432	Scad (Decapterus macrosoma) Sardine (Sardinella sirm) Anchovy (Stolephorus buccanerii)	59 12 11
20.11.80	820	ST	55	55	20°12'	35°50'	20.5	123	Threadfinbream (Nemipterus delagoae) Goatfish (Upeneus bensasi) Lizardfish (Saurida micropectoralis)	47 12 11
20.11.80	821	PT	28	0	19°56'	35°26'	35.0	70.0	Anchovy (Stolephorus buccanerii) Triggerfish juvenile (Monocanthus sp.)	65 35
20.11.80	822	ST	15	15	19°48'	35°16'	2086	4172	Sardine (Pellona ditchela) Grunt (Pomadasys maculatus) Croaker (Johnius dussumieri)	47 16 16
20.11.80	823	ST	14	14	19°35'	35°22'	96.3	192.6	Sardine (Hilsa kelee) Black pomfret (Formio niger) Eagle ray (Myliobatis sp.)	42 22 13
20.11.80	824	PT	18	0	19°25'	35°39'	567	756	Sardine (Pellona ditchela) Sardine (Sardinella albella) Sardine (Hilsa kelee)	46 32 11
20.11.80	825	ST	17	17	19°21'	35°46'	104	208	Sardine (Pellona ditchela) Lizardfish (Saurida undosquamis) Tigerperch (Therapon jarbua)	19 18 12
21.11.80	826	PT	33	13	19°52'	35°42'	33.8	67.6	Anchovy (Stolephorus buccanerii) Mackerel (Rastrelliger faughni)	99.7 0.3
21.11.80	827	ST	50	50	19°56'	35°56'	60.4	120.8	Goatfish (Upeneus bensasi) Scad (Decapterus maruadsi) Trigger fish (Monocanthinae)	26 19 14
21.11.80	828	ST	63	63	19°50'	36°12'	180.1	360.2	Scad (Decapterus maruadsi) Scad (Decapterus macrosoma) Goatfish (Upeneus assymetricus)	68 6 5
21.11.80	829	PT	33	0	19°30'	36°17'	66	132	Triggerfish (Monocanthinae) Shark (Carcharhinidae)	91 9

APPENDIX A. RECORD OF FISHING OPERATIONS

BT = Bottom trawl - PT = Pelagic trawl - ST = Shrimp trawl

DATE	ST.NO.	GEAR TYPE	BOTTOM DEPTH (m)	GEAR DEPTH (m)	POSITION SOUTH	POSITION EAST	TOTAL CATCH (kg)	CATCH PER HOUR (kg)	DOMINANT SPECIES	(% weight)
22.11.80	830	PT	97	75	19°28'	36°46'	11	22	Triggerfish (Stephanolepsis auratus) Barracuda (Sphyraena forsteri) Ponyfish (Leiognathus elongatus)	36 32 27
22.11.80	831	ST	45	45	19°15'	36°31	119	238	Scad (Decapterus maruadsi) Lizardfish (Saurida undosquamis) Goatfish (Upeneus assymetricus)	29 22 18
22.11.80	832	PT	30	10	19°04'	36°33'	27	54	Shark (Carcharhinus johnsoni) Anchovy (Stolephorus sp.)	63 37
22.11.80	833	ST	80	80	19°06'	36°56	93	186	Scad (Decapterus maruadsi) Searobin (Lepidotrigla natalensis) Goatfish (Upeneus bensasi)	40 26 13
23.11.80	834	ST	12	12	17°59'	37°09'	517	1034	Sardine (Pellona ditchela) Anchovy (Thryssa vitrirostris) Hairtail (Trichiurus lepturus)	63 28 5
23.11.80	835	PT	31	0	17°59'	37°26'	3.0	4.1	Anchovy (Stolephorus buccanerii)	100
23.11.80	836	ST	65	65	17°59'	37°39'	110	174	Scad (Decapterus maruadsi) Scad (Decapterus macrosoma) Threadfinbream (Nemipterus delagoae)	37 17 14
23.11.80	837	ST	11	11	17°38'	36°35'	193	386	Croaker (Johnius dussumieri) Anchovy (Thryssa vitrirostris) Prawn (Penaeus indicus)	35 17 17
24.11.80	838	PT	>500	0	17°42'	38°09'	0.65	1.3	Lanternfish (Myctophydae) Squids	77 23
24.11.80	839	ST	10	10	17°25'	37°59'	184	368	Anchovy (Thryssa vitrirostris) Threadfin (Polynemus sextarius) Grunt (Pomadasys hasta)	20 17 14
24.11.80	840	PT	31	10	17°42'	37°53'	35	70	Shark (Carcharhinus melanura) Ponyfish juvenile (Leiognathus equulus)	71 29
24.11.80	841	ST	65	65	18°02	37°35'	51	102	Scad (Decapterus macrosoma) Scad (Decapterus maruadsi) Boxfish (Ostraciontidae)	66 22 3
24.11.80	842	ST	67	67	18°06'	37°30'	108	216	Scad (Decapterus maruadsi) Scad (Selar crumenophtalmus) Tiggerfish (Abalistes stellaris)	70 10 6
24.11.80	843	ST	55	55	18°09'	37°27'	412	824	Mackerel (Rastrelliger kanagurta) Scad (Decapterus macrosoma) Scad (Decapterus maruadsi)	32 22 20
24.11.80	844	ST	40	40	18°17'	33°17'	101.6	203.2	Scad (Decapterus maraudsi) Goatfish (Upeneus assymetricus) Goatfish (Upeneus bensasi)	49 12 8
24.11.80	845	PT	35	20	18°06'	37°26'	231	462	Scad (Decapterus macrosoma) Scad (Decapterus maruadsi) Sardine (Sardinella sirm)	70 13 10
25.11.80	846	PT	37	11	17°50'	37°47'	0.6	1.2	Cavalla (Carangoides malabaricus) Driftfish (Ariomma indica)	67 33
25.11.80	847	ST	31	31	17°50'	37°43'	50.2	100.4	Goatfish (Upeneus vittatus) Lizardfish (Saurida micropectoralis) Ginger prawn (Penaeus japonicus)	54 11 7
25.11.80	848	PT	15	0	17°07'	39°02'	126	252	Sardine (Sardinella gibbosa) Ponyfish (Secutor insidiator) Sardine (Pellona ditchela)	25 22 20
25.11.80	849	ST	20	20	17°01'	39°13'	55	110	Sardine (Sardinella gibbosa) Goatfish (Upeneus vittatus) Cavalla (Carangoides malabaricus)	26 24 16
26.11.80	850	ST	17	17	16°54'	39°19'	41	82	Ponyfish (Secutor ruconius) Sardine (Sardinella gibbosa) Goatfish (Upeneus vittatus)	38 20 13
26.11.80	851	ST	21	21	16°47'	39°33'	54.8	109.6	Goatfish (Upeneus vittatus) Threadfin (Polynemus sextaruis) Ponyfish (Secutor insidiator)	30 12 11

APPENDIX B.

Length frequency distribution of some important species. (x indicates scale from 51 to 100 cm).

	St. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
CARANGIDAE																																																			
Carangoides malabaricus	750														4	7	10	15	21	5	3	4	1		1																										
Malabar cavalla	777		10	27	19	2																																													
	786									6	2	4	13	33	27	7	4	3	7	5	2	1	1																												
Decapterus kurroides	716				4	5																																													
Decapterus macrosoma	713									1	1	2		2																																					
Layang scad	767															2	6	21	34	7																															
	800										1	1	1		1	1	9	29	24	26	6																														
	801												1					6	4	1																															
	819											1	1		12	47	30	1	1																																
	828															1	6	14	10	2																															
	836																1	6	17	22	4																														
	841																7	6	19	8	4																														
	842																		13	5	1																														
	843																1	6	13	18	11	1																													
Decapterus maruadsi	713							4	14	2																																									
Round scad	718																		1	4	6		1	2																											
	721											2	11	4	2	1	1																																		
	760															21	38	23	12	2	2																														
	761														1	8	30	10	1																																
	767													1	12	61	45	14	1																																
	782														20	38	34	14	7	2																															
	783														1	12	13	13	6	1																															
	792											1	1	12	21	22	33	18	12	1																															
	800														2	43	64	18	3																																
	801														1	18	62	13	3																																
	828															22	22	2	3	1																															
	833															1	16	16	15	2																															
	836															2	26	17	2	3																															
	841															16	26	7	1																																
	842															4	22	19	4	1																															
	843															14	29	7																																	
Selar crumenophtalmus	735																			1	3	8	6	5		2																									
Bigeye scad	787																			6	5	4	1																												
	843																		1		10	29	4																												
Trachurus trachurus	716				4	4			1									1																																	
Horse mackerel	718																	2	10	6	2	2			1																										
CLUPEIDAE																																																			
Dussumiera acuta	751															5	16	31	14	1																															
Rainbow sardine	808															3	14	6																																	
	812																1	9	22																																
Etrumeus teres	716							1	18	59	10																																								
Herring	720																		5	15	10																														
	721								1		20	34	33	10	1																																				
	726																		7	52	31	10																													
	819												2	40	16																																				
Sardinella gibbosa	811														17	43	29	9																																	
Goldstripe sardinella	812													1	5	16	53	25	7	2																															
	815													2	12	42	47	18		1																															
Hilsa kelee	812														1	7	6	29	16	5	2																														
Kelee shad	823																6	17	19	8																															
	824															5	39	6																																	
Pellona ditchela	743												1	1	10	17	20	2																																	
Indian pellona	748													2	24	34	7																																		
	785												1	11	21	51	18	1																																	
	786							2		1	21	19	14	34	17	17	10	2																																	
	791											2	10	13	6	5	12	2																																	
	802													64	97	22	13	3																																	
	803															8	10	7	5																																
	808													6	38	31	7																																		
	822												8	5	7	18	10	2																																	
	839													6	26	13	5																																		
	848															27	20	3																																	
Sardinella sirm	819																1	3	20	10																															
Spotted sardinella	845																	11	25	13	1																														
Sardinella albella	824																22	20	8																																
White sardinella	839															2	19	22	6	1																															
Sardinella sp.	751													5	12	5	8	5	1																																

APPENDIX B. (contd)

Length frequency distribution of some important species. (x indicates scale from 51 to 100 cm).

	St. No.	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40	1	2	3	4	5	6	7	8	9	50
ENGRAULIDAE																																																			
Stolephorus bucanerii	713				2	16	71	29	3	1																																									
Buccaneer anchovy	716										8	3																																							
	721									3	6	27	1																																						
	724					1	76	20	5	1																																									
	777				5	49	39	1																																											
	800								15	82	32	1																																							
	821				3	34	50																																												
	826					1	5	42	16																																										
	835							3	26	21																																									
Thryssa setirostris	743												1	2	13	13	3	3																																	
Longjaw thryssa	791											10	21	10	1		1																																		
Thryssa vitrirostris	742									1		2	15	42	43	18	3	1	1																																
Orangemouth thryssa	743							2	2	2	2	1	5	15	32	19	13	10	4	2																															
	745							2	1	2			1	9	11	15	9	16	6	1	1		1																												
	780										7	47	22	20	27	17	5	2																																	
	781												3	13	15	21	14	12	11	2	1																														
	785									4	4	8	14	34	24	13	8	7	1																																
	791									1	1	4	7	3	16	7	5	2	3																																
	802									7	27	35	17	11	12	7	11	8	2																																
	803									7	2	2	4	15	26	44	30	6	10	1	2																														
	822										2	5	7	3	11	11	7	2	2																																
	839							1	3	20	21	13	7	16	24	13	4	5	1																																
	848													4	18	14	9	2	3																																
	849													7	26	14	2	1																																	
GERREIDAE																																																			
Gerres filamentosus	739												8	15	8	10	3	1																																	
Whipfin mojarra																																																			
MULLIDAE																																																			
Upeneus assymetricus	831											2	7	23	16	2																																			
	844													12	24	11	3																																		
Upeneus bensasi	783													1	7	7																																			
Yellowfin goatfish																																																			
Upeneus vittatus	738											2	37	34	16	3																																			
Yellowstriped goatfish	739											6	70	41	4																																				
	786									2	6	15	72	37																																					
	851											2	26	12	2	1	3	1		1			1		1																										
NEMIPTERIDAE																																																			
Nemipterus delagoa	760													2	14	42	18	9	1	3	4	4	1																												
Delagoa threadfin bream	778													5	7	8	7	5	4	2	3	3																													
	787												1			2	4	10	2	2			2																												
POLYNEMIDAE																																																			
Polynemus sextarius	811											1	6	32	39	14	9	4	3																																
Blackspot threadfin	813												1	3	6	19	33	9	2																																
POMADASYIDAE																																																			
Pomadasys hasta	733																			1	2						1				1	1																		1	
Lined silver grunt	x		3	1		1																																													
	737																						2	2	2	4	1	3	5	5	8	5	3	1		4		1			1		1	1		1					
	811																				1	2	4	5	12	4	8	4	6		1	1	2	1							1				1						1
	x		2																																																

APPENDIX B. (contd)

Length frequency distribution of some important species. (x indicates scale from 51 to 100 cm).

	St. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Pomadasys maculatus	732								2	7	14	11	5	1																																					
Blotched grunt	733												3	5	4	3				1																															
	734										2	9	12	15	1	1	1																																		
	737													2	5	8	10	13	5	7																															
POMATOMIDAE																																																			
Pomatomus saltator	718																											1				4			1																
Bluefish																																																			
SCIANIDAE																																																			
Johnius belangeri	742										8	15	13	10	2	1		1																																	
Belangeris croaker	745						1	11	7	14	9	21	9	6	3	2	2		1																																
	753							2	2	4	6	8	9	4	4	4	2	3		2																															
	763									3	6	10	9	6	2	7	2	2	2	1																															
	773								1		13	15	9	4	1	1																																			
	781							1	4	7	2	12	13	14	20	10																																			
	803						2		7	6	6	13	14	15	13	11	4	7	3																																
Johnius dussumieri	714														2	1	10	17	23	36	30	7	3	1																											
Bearded croaker	732												1	1	5	2	2	1	1	1																															
	743									3	3	5	8	6	4																																				
	745									2	4	10	4	8	5		2	2																																	
	756													1	5	11	14	8	2	5	1	2	1																												
	822													1	3	12	15	8	1	7	1	1	1																												
	837												4	7	17	8	9	5																																	
Otholites ruber	714																	1	1		2	6	2	6	3	8	5	2		1	1			1							1					1					
Tiger-toothed croaker	741																				2	2	5	4	4	4	3	2	2	3	6	1	2	5	2			1													
	745															1	4		6	9	8	4	3	5	1	2	6	1				1			1																
	753										1		1	2	2	1	2		3	4	4	4	3	5	7	2		3		2	1	1																			
	763															2	1	3	4	11	11	4	4	7	1																										
	773									1	4	4	7	7	9	4	4	1	2	2	2	1				1	1																								
	803											1	1	1	1	1				1			5																												
	813																				2	4	6	3	2	2				1																					
SCOMBRIDAE																																																			
Scomber australasicus	720																		1	2	6	2																													
Slimy mackerel																																																			
Rastrelliger kanagurta	787																				5	5	1																												
Indian mackerel	843																				5	37	8																												
	845																				2	12	4																												
SPARIDAE																																																			
Pagellus natalensis	778															5	12	10	10	1																															
Red grunter																																																			
SPHYRAENIDAE																																																			
Sphyraena obtusata	791																					5	13	2	2																										
Obtuse barracuda																																																			
SYNODONTIDAE																																																			
Saurida undosquamis	787																1	16	20	18	6	8	2	2		4		1																							
Brushtooth lizard fish																																																			

APPENDIX C

The conversion coefficient for fish density, C.

C is a function of species as well as of fish length. Based mainly on a intercalibration between the R/V "Johan Hjort" and R/V "Dr. Fridtjof Nansen" in February 1979, the following numerical value of C was reached for the 38 kHz acoustic system onboard "Dr. Fridtjof Nansen":

$$C = 0.2 \cdot L \ ^{\text{tonnes}}/\text{mm} \cdot (\text{n.mile})^2$$

where L is the average fish length in cm (BLINDHEIM, de BRUIN and SÆTERSDAL, 1979, NAKKEN and SANN AUNG, 1980).

In April 1980 the total receiver sensitivity of the 38 kHz system was reduced by approximately 6 dB. This indicates that the conversion coefficient C from then on should be multiplied by a factor of four.

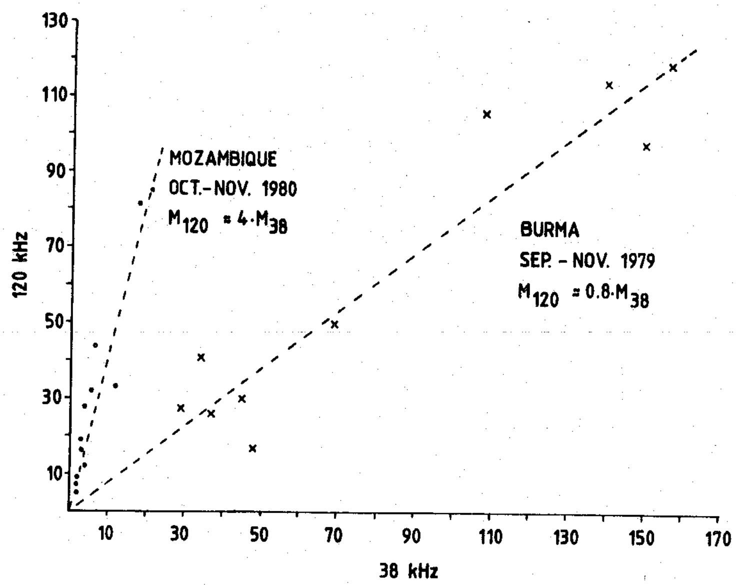
Since February 1979 there has been no change in the performance of the 120 kHz acoustic system. NAKKEN and SANN AUNG (1980) carried out an intercalibration between the outputs from the 38 kHz and 120 kHz system in September-November 1979. For small pelagic fish these observations showed that the two systems gave almost equal integrator output ($M_{120} \approx 0.8\ M_{38}$).

A similar intercalibration between the integrator values from the 120 kHz and 38 kHz systems on small pelagic fish was carried out in Mozambique in October-November 1980 with the following result:

$$M_{120} \approx 4 \cdot M_{38}$$

This calibration indicated that the C value reached in February 1979 should be multiplied by a factor of five from april 1980. The corresponding echo integrator outputs from both these calibrations appear in the figure below together with tentative regression lines.

The present authors have chosen four as the multiplication factor, and consequently C = 0.8 · L is used in this report.



From GEOLOGICAL-GEOPHYSICAL ATLAS OF THE INDIAN OCEAN, Moscow 1975.

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