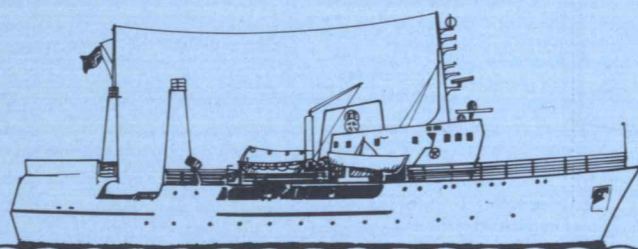


**JOINT NORAD/MOÇAMBIQUE/FAO PROJECT
TO INVESTIGATE THE FISH RESOURCES
OFF THE COAST OF MOÇAMBIQUE**

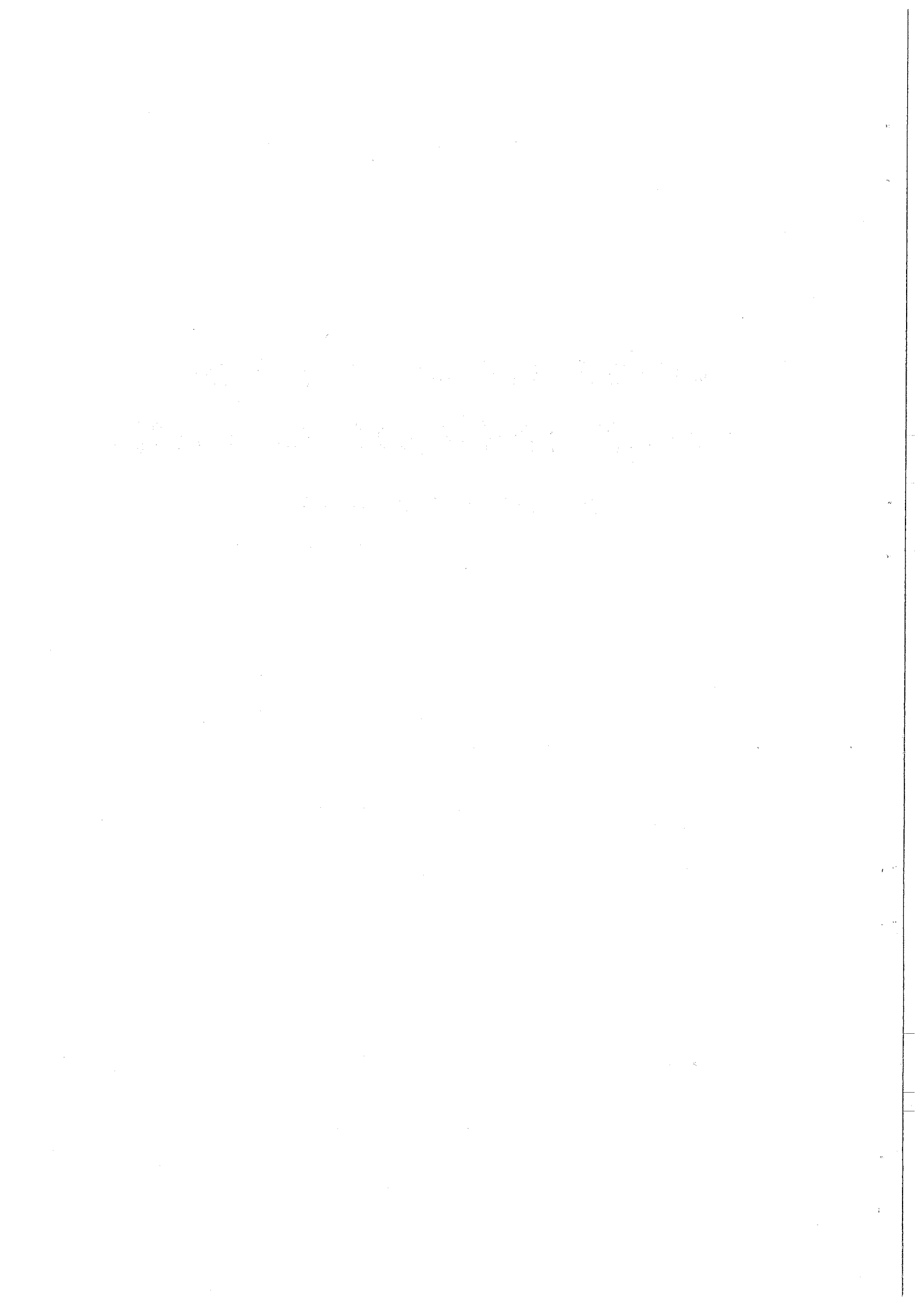
**cruise report no.3 of
R/V «DR. FRIDTJOF NANSEN»**

january – march 1978



**Sub-contractor: Institute of Marine Research
Bergen – Norway**

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INTRODUCTION

This report covers the third cruise of R. V. "Dr. Fridtjof Nansen" to survey the fish resources and fishing potentials in Mozambican waters. The work is part of a cooperative project between the People's Republic of Mozambique and the Norwegian Agency for Development (NORAD). The cruise took place from mid January to the beginning of April 1978.

The main objectives of this survey are described in Cruise Report no. 1, with a few minor changes listed below:

- to map the distribution area of the commercially important fish stocks with special attention to the abundance of fish on the continental shelf,
- to estimate the relative abundance of the important fish stocks,
- to evaluate the efficiency of different fishing gears such as demersal and pelagic trawls, longline and pots, and
- to introduce and instruct Mozambican participants in surveying techniques and methods of acoustic fish stock assessment.

NARRATIVE

Departure:	Mombasa	16 January 1978
Arrival:	Maputo	30 March 1978
Ports of call:	Beira	20 - 21 January
	Beira	24 - 25 January
	Beira	8 - 12 February
	Maputo	25 February - 1 March
	Maputo	17 - 18 March

Durban 19 - 23 March
Maputo 25 March

Captain: G. Haugland

Scientific staff: J. Å. Bjordal, S. Brattås, J. Dalen, H. Gill,
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17 Mar), A. Hogueane (24 Jan - 8 Feb), X. Manussa
(8-25 Feb), A. de Silva (21 Jan - 25 Feb), R. de
Silva (21-24 Jan, 25-30 Mar).

Four Mozambican fishermen joined the ship in Beira on 21 January, three to work on deck and one in the engine-room for the duration of the cruise.

A TV team of five people from the Norwegian Broadcasting System (NRK) and one journalist from the Maputo newspaper "Noticias" joined the cruise from 20 to 24 January.

INSTRUMENTS AND METHODS

Vessel and gear

In addition to the instruments and gear listed in Cruise Report no. 1, pots for fish and crayfish were also used during the last week of the cruise. Compared to the two previous cruises, longline fishing was more extensively carried out. In the beginning of the cruise much experimental fishing took place to find out the best time of day, bottom type and depth for longlining. This is probably the reason for several longline stations with no catch in the northern area.

Acoustics

The instruments used and the applied methods are described in Cruise Report no. 1 from the same project. Where there are some

changes in the set-up this will be mentioned. It should be noted that due to higher and more stable source level of the main echo sounder during this cruise, the echo abundance or integrator readings will now be higher for the same amount of fish than during the two previous cruises.

Due to breakdown of the netsonde during the first half of the cruise it was not possible to operate the midwater trawl as accurately and as often as desired.

The total echo abundance was split into four categories, with some minor changes from those of the previous cruises:

- 1 - pelagic fish including juvenile fish which appeared to be more abundant during this cruise,
- 2 - demersal fish,
- 3 - mesopelagic fish, and
- 4 - plankton and fish larvae.

The echo abundance within each category of fish was classified as scattered, dense or very dense. This corresponds to integrator values of 1 - 10, 10 - 50 and greater than 50, respectively.

Hydrography

At each hydrographic station samples for salinity and oxygen were collected at depths described in Cruise Report no. 2.

At Section II, Zambezi, the outermost station was omitted due to extremely difficult current conditions.

RESULTS

Survey route, fishing stations and hydrographic stations are shown in Figs 1a and 1b. Details from the fishing stations are given in Table 1, while Table 2 gives details of the samples and the length distribution of the most important species.

As on the first cruise, the surface currents were observed by measuring the drift of the vessel as deviation from planned positions. Figs 2a and 2b show the results. Off the coast the current was observed to be mainly south-going, i. e. the Mozambique and the Agulhas currents were dominant. On the shelf and near the shore one often observed a counter current, as on the western and northern areas of the Sofala Bank and in the Delagoa Bay (Maputo area).

South to 18°S the velocities of the offshore currents varied from 2-4 knots. Further south to 27°S the velocity of the south-going current varied from 1-4 knots. The maximum velocities of the currents were observed along the edge of the continental shelf for the whole coastline except in the Cabo Delgado area.

The velocities of the north-eastgoing coastal counter currents were found to be between 0.5 and 1 knot. The velocity and direction of the current can be measured directly from the maps by noting the length and direction of the current arrows.

Figs 13a and 13b show the horizontal distribution of the surface temperatures. The highest temperatures were observed in the central part, i. e. Sofala Bank area, which was different from the observations during cruises 1 and 2. On average the surface temperature was now 4-5°C and 1-3°C higher than during cruises 1 and 2, respectively.

The horizontal distribution of surface salinity is shown in Figs 14a and 14b. The whole surveyed area can be divided into three parts on the basis of the salinity variations. A northern part, north of 18°S, where the salinity variations were moderate, a central part, between 18°S and 21°30'S, where there were considerable variations, and a southern part, south of 24°S, with medium variations. The highest salinity was found off the coast in the central and southern areas. Compared to the salinity distributions observed from cruises 1 and 2 the main deviations were the strong horizontal gradients which now appeared in the Sofala Bank area and in the Delagoa Bay. These peculiarities were caused by the strong river runoff during this period. Rivers to be mentioned here are: the Zambezi, the Pengué and the Save River in the Sofala Bank area, and the Limpopo, the Incomati, the Tempe and the Maputo River in the Delagoa Bay area.

The depth to the specific defined thermocline, or rather the depth of the homogeneous layer, is shown in Figs 15a and 15b. The layer was about 25 m deep along the entire coast, increasing to 50 m further offshore. The thickness of this layer was less than during cruise 1 and rather similar to that observed during cruise 2.

As in cruise 2, four hydrographic sections were taken outside the Zambezi delta. Figs 3-6 show the results. The temperature at the surface was 28-29°C which is 1-2°C higher than from cruise 2. At depths between 50 and 160 m the temperature was 1-3°C lower and below 160 m the temperature was generally higher than during the previous cruise. At Section I, II and IV the salinity was found to have a maximum between 80 and 200 m, while there was no distinct maximum as function of depth at Section III. At all sections the surface salinity was slightly higher at the innermost stations than observed during cruise 2. At sections I and IV the dissolved oxygen had a maximum at 100-150 m. For all depths and sections the amount of dissolved oxygen was higher than observed during cruise 2, with the highest difference of 0.5 ml/l in the surface layer.

Figs 7-12 show the vertical distribution of temperature, salinity and dissolved oxygen in the six hydrographic sections along the coast. The enumeration of the sections goes from north to south.

At the surface the temperature was 28-29°C, which was 3-4°C higher than during cruise 1 and about 1°C higher than during cruise 2. At greater depths, from 200 to 500 m, the temperature was equal to or slightly higher than those observed during cruise 1, and from 50 to 500 m the temperature was lower than in cruise 2. As during the previous cruises, a salinity maximum and an oxygen minimum were observed at a certain depth interval. The location of this interval was now about 150 to 300 m. At greater depths an oxygen maximum was found at about 300 to 500 m. The reasons for these peculiarities are emphasized in Cruise Reports 1 and 2.

Surface observations

Figs 2a and 2b show the surface observations of tunas or tuna-like fish, dolphins and smaller schooling fish.

Except for the observations of one school of tuna between Pemba and Cabo Delgado and one school north of Maputo, the sightings of tuna were restricted to the Sofala Bank area (from south of Beira to Pebane). The abundance of tuna in the different observations varied from single schools (estimated to 10 tonnes) to large schools or several schools over a wide area (estimated to several hundred tonnes). Except for one sighting (south of Angoche), the tuna observations were all in shallow waters.

Schools of small pelagic fish were observed at the surface on two occasions. Both sightings were at the shelf edge north of Inhambane in the area between the offshore south-flowing current and the north-flowing coastal counter current. The species were most likely of the Carangidae, Clupeidae or Engraulidae families.

The observations of dolphins were mainly in the Sofala bank area. The size of the schools varied from a few up to more than 100 animals. One observation of dolphins was close to shore (south of Quelimane), while other dolphin sightings were in the area between the south-flowing current and the north-flowing coastal counter current. The majority of the dolphins observed were most likely bottlenose dolphins (Tursiops truncatus).

Larger whales were not observed during this cruise.

In addition to the survey tracks along the six fixed hydrographic sections, seven offshore survey tracks were made in order to observe tuna or other pelagic schooling fish. During these thirteen survey tracks the sonar was in continuous operation. No sightings or sonar contacts were made outside the continental shelf.

Plankton and fish larvae

The average echo abundance (in mm per nautical mile) attributed to plankton and fish larvae is shown in Figs 16a and 16b. The recordings outside the shelf area also include a minor contribution from mesopelagic fish which was difficult to separate from plankton recordings during night-time. The highest concentrations of plankton were found along the shelf edge with concentrations in the southern area considerably larger than those in the north. Peak values were recorded in the Sofala Bank area off Beira. Generally the plankton distribution showed the same pattern as during cruises 1 and 2.

The wet displacement volumes of plankton along the hydrographic sections are shown in Figs 17 and 18. The values are low, usually less than 5 ml per haul. At a few stations (8, 37, 38) no plankton sample was obtained, mainly due to extreme current conditions.

The displacement volume of night hauls tended to be slightly higher than those of the day hauls. Compared with the results of cruises 1 and 2, values from this cruise seem equal or slightly lower than those from cruise 1 and equal or somewhat higher than those from cruise 2.

The Zambezi sections showed slightly higher values than those of cruise 2.

Pelagic fish

The distribution of the echo abundance of pelagic fish was rather different to that of the two previous cruises.

The most probable factors to explain this are:

- 1 - the abundance of pelagic fish was higher than during cruises 1 and 2,
- 2 - juvenile fish were included in the pelagic fish group,
- 3 - squid: rather small ones, total length 1-2 cm, and larger ones, total length up to 40 cm, were now included in this fish group, and

4 - higher and more stable source level of the echo sounder gave more reliable recordings of scattered abundances.

The echo recordings of pelagic fish showed the highest concentrations on the continental shelf, with peak values in the Sofala Bank area from south of Beira to Pebane and in the Delagoa Bay (Maputo area). Squid and juvenile fish were the main contributors to the scattered recordings off the continental shelf.

Because of bad trawl bottom and breakdown of the netsonde only two trawl hauls, both pelagic, were obtained between Cabo Delgado and Angoche. Off Pemba the catch consisted exclusively of small ponyfish (Leiognathus sp.) ranging from 2-8 cm. Off Angoche the catch was juvenile fish, about 20 different species, though mainly Carangidae.

In the north a trawl catch by bottom trawl east of Pemba turned out to be the largest during the cruise (3280 kg per trawl hour). The dominant species were common ponyfish (L. equulus) 80% of the catch, 2.8 tons per trawl hour, length range 10-17 cm. Other pelagic species were Malabar cavalla (Carangoides malabaricus), about 40 kg per trawl hour and obtuse barracuda (Sphyraena obtusata).

In the shallow waters off the Zambezi delta the contribution to the pelagic recordings were from small pelagic fish of the Leiognathidae, Engraulidae and Carangidae families. Dominant species were: common ponyfish (L. equulus), buccaneer anchovy (Stolopherus buccaneeri) and kingfish (Atule mate). Larger pelagic fish occurring in the trawl and handline catches were: Cobia (Rachycentron canadus), 105-120 cm, narrow-barred Spanish mackerel (Scomberomorus commerson), 86-139 cm and black pomfret (Formio niger), 45-51 cm. Fairly large specimens of black shark (Carcharinus melanopterus) up to 200 cm long and white tipped shark (Carcharinus longimanus) up to 180 cm long were caught by handline.

Off Beira catches of juvenile fish, mainly of the Engraulidae and Carangidae families indicated an important contribution to the pelagic recordings in this area.

One catch by bottom trawl in this area was dominated by porcupine fish (70% of the total catch), mainly the species Diodon maculifer and Lophiodon calori. Porcupine fish were caught mainly by bottom trawl. Catches by pelagic trawl, however, showed that they also appear in mid- and upper waters. For this reason part of the echo abundance is attributed to pelagic fish in this area.

In deeper waters (250 m) slightly south of the Sofala Bank (21°30'S) a good catch of small barracuda was taken by bottom trawl (1863 kg per trawl hour). Most of the fish were immature at maturity stage 2 and the length range was 21-30 cm. Scad (Decapterus sp.) were taken in the same haul (32 kg per trawl hour).

In the shallow waters of Delagoa Bay the pelagic species dominant in the trawl catches were: horse mackerel (Trachurus trachurus), Malabar cavalla (Carangoides malabaricus) and toothed ponyfish (Gazza minuta).

Squid were caught in most hauls their size ranging from 1-40 cm and the catch from less than 1 kg up to 20 kg per trawl hour.

Mesopelagic fish

When observing mesopelagic fish one should consider their specific behaviour while determining the distribution. The fish are mostly in upper waters during night-time and in deeper waters during daytime. This may lead to discontinuities in the recordings from night to day because the main observation depth is the upper 500 m. When greater depths were regularly examined the species were also observed off the shelf during daytime. In addition to the points underlined for the distributions of pelagic and demersal species, this was the reason that mesopelagic fish were observed over a greater area than during the previous cruises.

The echo recordings from mesopelagic fish were almost entirely restricted to deeper waters beyond the shelf edge. In Delagoa Bay however, juvenile mesopelagic fish were recorded in waters up to 150 m during daytime. The highest abundance of mesopelagic fish was found close to the shelf in the central and southern area of the coast.

Catches by pelagic trawl at night were dominated by lantern fish (Myctophidae). Bottom trawl catches in deeper waters (300 - 470 m) showed more diverse species composition. The following species dominated: lantern fish (Diaphus elucens), Psenes indicus, Neoscombrops annectens, Cubiceps natalensis, Chlorophthalmus agassizi, Champsodon capensis and snake mackerel (Thyrstitoides marleyi).

Demersal fish

The echo abundance of demersal fish was also rather different than during that from the previous cruises. The main reasons for this were:

- 1 - the abundance of demersal fish was higher than during cruises 1 and 2,
- 2 - more concentration was put on surveying the continental shelf, and
- 3 - the increased source level of the echo sounder as earlier underlined.

At St. Lazarus Bank longline and handline catches were dominated by twospot red snapper (Lutjanus bohar), length range 50-79 cm, in maturity stage 2, 3 and 7. The following fish of the Serranidae family were caught by longline:

one grouper (Epinephelus sp.) 132 cm/40 kg and several moontail seabass (Variola louti), 63-65 cm.

Off the coast from Cabo Delgado to Angoche longline was used regularly both in shallow and deep waters (350 m), but with negligible or negative results.

One catch by gillnet south of Nacala included demersal species such as humpback red snapper (Lutjanus gibbus), scavenger (Lethrinus nebulosus) and parrotfish (Callyodon guttatus).

In the Angoche - Pembane area small catches of grouper (Epinephelus chlorostigma) and hound-shark (Mustelus canis) were taken by longline.

In the same area relatively good catches of the following species were obtained by bottom trawl: blotched grunt (Pomadasys maculatus) 440 kg per trawl hour maturity stages 2, 3 and 4, tiger-toothed croaker (Otolithes ruber) 40 kg per trawl hour maturity stage 2, blackspot threadfin (Polynemus sextarius) 55 kg per trawl hour, yellowstriped goatfish (Upeneus vittatus) 30 kg per trawl hour and blood snapper (Lutjanus sanguineus).

In the Quelimane - Beira area the catches of demersal fish were mostly taken by bottom trawl in shallow waters (10-55 m). Dominant species were: catfish (Arius niger and A. dussumieri), Delagoa threadfin bream (Nemipterus delagoae), tiger-toothed croaker (Otolithes ruber), Belanger's croaker (Johnius belangerii) and brushtooth lizardfish (Saurida undosquamis). In deeper waters the following species were caught by longline: groupers (Epinephelus guaza, E. morrhua and E. andersoni), sharptoothed snapper (Pristipomoides typus) and silver seabream (Sparus major).

South of Beira (to 23°30'S) the catches by bottom trawl (depth 50-60 m) were dominated by the following species: Delagoa threadfin bream (Nemipterus delagoae), painted sweetlip (Plectorhynchus pictus), porcupine fish (Diodon maculifer, Lophiodon calori), bluntnose lizardfish (Trachinocephalus myops). Scavenger (Lethrinus nebulosus), sharptoothed snapper (Pristipomoides typus) and hound shark (Mustelus canis) were taken by longline (80-89 m depth).

In deeper waters (115 m) off the Zambezi delta different groupers (Epinephelus guaza, E. andersoni, E. morrhua) and sharptoothed snapper (Pristipomoides typus) dominated longline catches.

Off Beira the dominant demersal species were: painted sweetlip (Plectorhynchus pictus), Delagoa threadfin bream (Nemipterus delagoae), greater lizardfish (Saurida tumbil) and hound shark (Mustelus canis).

The catches of demersal species on the coast from Sofala Bank to Inhambane were rather poor. In deeper waters (300 m) crocodile fish (Peristedion adeni) were dominant, while groupers (Epinephelus sp) and mangrove red snapper (Lutjanus argentimaculatus) were the main species at medium depths (40-110 m).

In the Delagoa Bay demersal fish were caught by bottom trawl and pots. The species dominating the trawl catches in shallow waters (30-40 m) were yellowstriped goatfish (Upeneus vittatus), rock grunter (Pomadasys olivaceum) and bluntnose lizardfish (Trachinocephalus myops).

In deeper waters (135 m), the main species were seabream (Pterogymnus laniarius) and red grunter (Pagellus natalensis).

Fish pots were set at depths from 12 to 352 m. Catches were obtained in the depth interval 45 - 130 m, mainly on slopes from 80-130 m. Seabreams (Sparidae) such as Pterogymnus laniarius, longspine seabream (Argyrops filamentosus) and Englishman (Chrysoblephus anglicus) were dominant. Other important species were salmon bass (Johnius hololepidotus), grouper (Epinephelus fario) and sharptoothed snapper (Pristipomoides typus).

Spiny dogfish (Squalus acanthias), length range 49-82 cm, were caught in pots at depths 120-280 cm.

Crustacea

Crustaceans were caught by bottom trawl and pots, mainly in the Sofala Bank and Delagoa Bay area.

In the Sofala Bank area white prawn (Penaeus indicus) was dominant species in shallow waters with a maximum of 20 kg per trawl hour at 10 m depth. Other species in the 20-50 m depth interval were brown shrimp (Metapenaeus monoceros), M. stebbengi, flower shrimp (Penaeus japonicus) and P. semisulcatus. A few shovel-nosed lobsters (Scyllaridae) and crayfish (Nephrops andamanicus) were caught in the same area at 480 m depth.

Eight species of shrimps were caught in deeper waters (430-480 m). Dominant species by weight were Caridea with a maximum of 28 kg per trawl hour and Hymenopenaeus triarthrus, 28 kg per trawl hour. The catch of the other species was negligible.

In shallow waters (35-45 m) in Delagoa Bay small catches (1 - 2 kg per trawl hour) of the following shrimps were taken: flower shrimp (Penaeus japonicus), P. semisulcatus and brown shrimp (Metapenaeus monoceros). Also a few spiny lobsters (Panulirus sp.) were caught in shallow trawl hauls.

Bottom trawl and pots were both used in deeper water. The crustaceans dominating the trawl catches were:

- 1 - shrimp (Hymenopenaeus triarthrus), (20 kg per trawl hour) at 450 m depth.
- 2 - shovelnosed lobster (Scyllaridae), maximum seven individuals (3 kg per trawl hour) at 130 m,
- 3 - spiny lobster (Palinurus delagoa), maximum 40 individuals (15 kg per trawl hour) at 310-340 m, and
- 4 - crayfish (Nephrops andemanicus), maximum 36 individuals (2.7 kg per trawl hour) at 320-345 m.

Crustaceans caught in crayfish pots were:

- 1 - Deep-water crab (Geryon quinquendens), maximum 72 individuals (20 kg per pot) at 320-350 m,
- 2 - spiny lobster (Palinurus delagoa), maximum 12 individuals (3.2 kg per pot) at 280-320 m, and
- 3 - shovelnosed lobster (Scyllaridae), maximum five individuals per pot at 90-280 m.

The percentage of crustacea catches in relation to the total catch in the bottom trawl is given in Table 3. The results should be treated with caution as, in most cases, trawling was not carried out specifically for crustaceans.

Table 1. RECORD OF FISHING OPERATIONS.

BT = Bottom trawl PT = Pelagic trawl GN = Gillnet LL = Longline HL = Handline P = Pots
 Identification literature: J. L. B. Smith, The Sea Fishes of Southern Africa and FAO Species
 Identification Sheets for Fishery Purposes.

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position		Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						North	East			
22.1	0430	1	HL		5	18°41'	36°35'	41		<u>Cobia</u> <u>Rachycentron canadus</u> (31)
22.1	0735	2	BT	20	20	18°41'	36°34'	43	86	Talang queenfish <u>Scomberiodes commersonianus</u> (11), Black pomfret <u>Formio niger</u> (10), Catfish <u>Arius niger</u> (6)
23.1	0755	3	BT	380	380	19°16'	36°34'	120	120	Shrimps <u>Caridea</u> (28), <u>Hymenopenaeus triarthrus</u> (22)
27.1	1050	4	BT	85	85	18°31'	37°16'	<1		
30.1	2000	5	HL	16	16	10°55'	40°39'	0		No catch
31.1	0315	6	LL	55	55	11°46'	40°39'	11		Mangrove red snapper <u>Lutjanus argentimaculatus</u> (7), Two-spot red snapper <u>L. bohar</u> (4)
1.2	0725	7	LL	20	20	12°10'	41°25'	64		Two-spot red snapper <u>Lutjanus bohar</u> (43), Grouper <u>Epinephelus</u> sp. (14)
1.2	0815	8	HL	20	20	12°10'	41°25'	40		Two-spot red snapper <u>Lutjanus bohar</u> (34)
1.2	0855	9	GN	20	10	12°09'	41°25'	0		No catch
1.2	1530	10	LL	19	19	12°12'	41°22'	2		Humpback red snapper <u>Lutjanus gibbus</u> (2)

(Table 1 continued)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position		Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						North	East			
1.2	1545	11	HL	19	19	12°12'	41°22'	11		Two-spot red snapper <u>Lutjanus bohar</u> (11)
1.2	1750	12	GN	22	10	12°12'	41°43'	0		No catch
2.1	0905	13	HL	45	20	12°09'	40°36'	0		No catch
2.2	1115	14	LL	55	55	12°41'	40°39'	0		No catch
2.2	1515	15	PT	250	25	12°55'	40°32'	32	32	Ponyfish <u>Leiognathus</u> sp. (32)
3.2	1450	16	LL	360	360	14°10'	41°28'	0		No catch
4.2	0440	17	LL			14°34'	40°43'	0		No catch
4.2	0835	18	GN			14°59'	40°48'	23		Malabar cavalla <u>Carangoides malabaricus</u> (5)
4.2	0925	19	LL			15°03'	40°48'	0		No catch
6.2	0450	20	LL	90	90	16°01'	40°14'	7		Grouper <u>Epinephelus chlorostigma</u> (5)
6.2	1020	21	PT	1600	30	16°33'	40°04'	<1		
6.2	1550	22	LL	90	90	16°43'	39°41'	27		Hammerhead shark <u>Sphyrna zygaena</u> (12), Hound shark <u>Mustelus canis</u> (9)

(Table 1 continued)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position		Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						North	East			
7.2	0150	23	BT	50	50	17°17'	38°35'	4370	3280	Common ponyfish <u>Leiognathus equulus</u> (3501), Blotched grunt <u>Pomadasyx maculatus</u> (550), Blackspot threadfin <u>Polynemus sextarius</u> (68), Tiger-toothed croaker <u>Otolithes ruber</u> (49)
15.2	1505	24	LL	60	60	17°23'	38°36'	3		Banded barracuda <u>Sphyraena jello</u> (3)
16.2	0240	25	PT	40	20	17°36'	37°58'	66	66	Narrow-barred Spanish mackerel <u>Scomberomorus commerson</u> (33), Buccaneer anchovy <u>Stolephorus buccaneeri</u> (11)
16.2	0843	26	BT	21	21	17°47'	37°33'	13	13	Brushtooth lizardfish <u>Saurida undosquamis</u> (9)
17.2	0450	27	LL	115	115	18°26'	37°22'	30		Yellowbelly <u>Epinephelus quaza</u> (8), Sharptoothed snapper <u>Pristipomoides typus</u> (5)
17.2	0515	28	HL	115	5	18°26'	37°22'	43		Black shark <u>Carcharhinus melanopterus</u> (43)
17.2	0810	29	BT	428	428	18°26'	37°24'	13	13	Shrimps <u>Caridea</u> (2), <u>Plesiopenaeus nitidus</u> (3)
17.2	1535	30	LL	88	88	18°39'	37°13'	6		Brown shark <u>Carcharinus obscurus</u> (5)

(Table 1 continued)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position		Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						North	East			
17.2	1745	31	HL	88	5	18°39'	37°13'	43		White tipped shark <u>Carcharinus longimanus</u> (43)
18.2	0245	32	PT	41		18°55'	36°55'	10	10	Narrow-barred Spanish mackerel <u>Scomberomorus commerson</u> (8), King fish <u>Atule mate</u> (1)
19.2	2045	33	PT	160	30	19°18'	36°54'	19	19	Squid (17)
20.2	1222	34	PT	54	54	19°42'	36°18'	170	170	Kingfish <u>Atule mate</u> (77), Delagoa threadfin bream <u>Nemipterus delagoae</u> (35), Brushtooth lizardfish <u>Saurida undosquamis</u> (23)
20.2	2035	35	BT	10	10	19°28'	35°26'	500	500	Tiger-toothed croaker <u>Otolithes ruber</u> (176), Belanger's croaker <u>Johnius belangerii</u> (103), Large-head hairtail <u>Trichiurus lepturus</u> (57), Catfish <u>Arius dussumieri</u> (37)
21.2	0425	36	LL	80	80	20°17'	36°04'	0		No catch
21.2	1228	37	PT	31	10	19°37'	35°32'	10	10	Anchovy juv. <u>Stolephorus</u> sp.
22.2	0520	38	LL	90	90	20°30'	36°10'	16		Hound shark <u>Mustelus canis</u> (11), Grouper <u>Epinephelus</u> sp. (4)
23.2	1500	39	LL	80	80	21°10'	35°37'	23		White tipped shark <u>Carcharinus longimanus</u> (8), Hound shark <u>Mustelus canis</u> (5), Dogshark <u>Scoliodon vagatus</u> (5)

(Table 1 continued)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position		Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						North	East			
3.3	0745	40	PT	52	52	20°32'	35°47'	1		Squid (1)
3.3	1315	41	BT	58	58	20°02'	36°00'	43	43	Porcupine fish <u>Diodon maculifer</u> (20), Porcupine fish <u>Lophodiodon calori</u> (9)
3.3	1715	42	PT	1100	50	20°22'	36°10'	25	20	Lantern fish Myctophidae (20)
4.3	0002	43	BT	54	54	20°54'	35°39'	140	140	Delagoa threadfin bream <u>Nemipterus delagoae</u> (30), Painted sweetlip <u>Plectorhynchus pictus</u> (23)
4.3	0320	44	LL	150	150	21°15'	35°35'	30		Brown shark <u>Carcharinus obscurus</u> (26)
4.3	0920	45	BT	260	260	21°30'	35°32'	2091	2091	Barracuda <u>Sphyraena japonica</u> (1863), <u>Psenes indicus</u> (135)
5.3	0320	46	LL	80	80	21°42'	35°40'	54		Black tipped shark <u>Carcharinus johnsoni</u> (54)
5.3	1000	47	BT	305	305	22°07'	35°44'	34	81	Crocodile fish <u>Peristedion adeni</u> (28)
5.3	1650	48	PT	185	85	23°02'	35°41'	<1		Squid
6.3	1125	49	BT	590	590	23°30'	35°38'	7	7	Shrimp Caridea (5)
6.3	1505	50	LL	114	114	23°26'	35°38'	0		No catch
6.3	2230	51	BT	95	95	23°45'	35°37'	15	15	Mangrove red snapper <u>Lutjanus argentimaculatus</u> (6), Squid (2)

(Table 1 continued)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position		Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						North	East			
8.3	0315	52	LL	61	61	24°32'	35°19'	38		Stingray <u>Taeniura melanospila</u> (16), Grouper <u>Epinephelus</u> sp. (10)
8.3	2310	53	BT	220	220	25°27'	35°03'	<1		
9.3	1000	54	BT	321	321	25°24'	34°30'	386	386	<u>Champsodon capensis</u> (134), <u>Cubiceps natalensis</u> (49), Rat-tail <u>Coelorhynchus parallelus</u> (42)
9.3	1425	55	PT	305	135	25°38'	34°38'	<1		
10.3	1425	56	BT	448	448	25°49'	33°44'	330	330	<u>Chloropthalmus aqassizi</u> (57), <u>Cubiceps natalensis</u> (53), Shrimp <u>Hymenopenaeus triarthrus</u> (20)
10.3	2130	57	BT	44	44	25°28'	33°13'	100	200	Bluntnose lizardfish <u>Trachinocephalus myops</u> (26), Barracuda <u>Sphyraena japonica</u> (10), Catalufa <u>Priacanthus hamrur</u> (7)
11.3	0022	58	PT	95	75	25°34'	33°10'	91	182	Lantern fish Myctophidae (37), Barracuda <u>Sphyraena japonica</u> (23), Milkshark <u>Scoliodon walbeehmi</u> (19)
12.3	1815	59	BT	72	72	26°27'	32°58'	11	13	Scavenger <u>Lethrinus nebulosus</u> (5)
13.3	1435	60	PT	840	40	26°49'	34°43'	<1		Juvenile fish, Squid
13.3	2030	61	GN	25	20	26°48'	32°54'	<1		
14.3	2155	62	PT	340	30	26°45'	33°06'	9	9	Lantern fish Myctophidae (2), Jellyfish (5)

(Table 1 continued)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position		Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						North	East			
14.3	0330	63	LL	72	72	26°46'	32°56'	6		Hound shark <u>Mustelus canis</u> (4)
14.3	2300	64	BT	314	314	26°34'	33°05'	151	129	Lantern fish <u>Diaphus elucens</u> (73), Spiny lobster <u>Palinurus delagoae</u> (18), Squid (10)
15.3	0810	65	BT	327	327	26°05'	33°06'	162	162	<u>Neoscombrops annectens</u> (53), Snake mackerel <u>Thyrstitoides marleyi</u> (34), Lobster <u>Palinurus delagoae</u> (2)
15.3	1747	66	BT	518	518	25°57'	34°03'	53	35	Shrimps <u>Hymenopenaeus triarthrus</u> (20), <u>Glyphocrangon dentatus</u> (2)
16.3	0610	67	BT	135	135	25°19'	34°57'	343	312	<u>Pterogymnus laniarius</u> (186), Red grunter <u>Pagellus natalensis</u> (39), Hound shark <u>Mustelus manazo</u> (41)
16.3	1530	68	BT	35	35	24°59'	34°32'	1613	1613	Horsemackerel <u>Trachurus trachurus</u> (627), Goldstripe sardinella <u>Sardinella gibbosa</u> (297), Yellow-striped goatfish <u>Upeneus vittatus</u> (227), Barracuda <u>Sphyraena japonica</u> (168)
25.3	1715	69	P	17	17	26°04'	32°59'	1		
25.3	1740	70	P	32	32	26°04'	33°00'	1		Swimming crab
25.3	1820	71	P	90	90	26°04'	33°02'	10		Longspine seabreams <u>Argyrops filamentosus</u> (7), <u>A. spinifer</u> (1)

(Table 1 continued)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position		Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						North	East			
25.3	1850	72	P	282	282	26°04'	33°05'	8		Spiny lobster <u>Palinurus delagoae</u> (4), Spiny dogfish <u>Squalus acanthias</u> (3), Shovelnosed lobster <u>Scyllaridae</u> (1)
26.3	1620	73	P	99	99	26°27'	32°59'	6		Sharptoothed snapper <u>Pristipomoides typus</u> (6)
26.3	1635	74	P	125	125	26°27'	33°00'	3		Spiny dogfish <u>Squalus acanthias</u> (3)
26.3	1715	75	P	287	287	26°27'	33°04'	4		Shovelnosed lobster <u>Scyllaridae</u> (1), Dogfish <u>Squalus acanthias</u> (2)
27.3	2050	76	P	19	19	25°20'	33°15'	1		
27.3	2120	77	P	45	45	25°23'	33°16'	9		Rubalo <u>Chemerius nufar</u> (4)
27.3	2145	78	P	135	135	25°26'	33°18'	21		<u>Pterogymnus laniarius</u> (15)
27.3	2210	79	P	323	323	25°28'	33°20'	7		Crabs <u>Geryon quinquedens</u> (7)
28.3	1530	80	P	352	352	25°29'	33°20'	33		Crabs <u>Geryon quinquedens</u> (33)
28.3	1705	81	P	84	84	25°26'	33°18'	23		Hound shark <u>Mustelus manazo</u> (8), Grouper <u>Epinephelus fario</u> (7), Salmon bass <u>Johnius hololepidotus</u> (7)

SPECIES	St.	G	N	n	xx	LENGTH DISTRIBUTION (in cm)																																																																
						1					2					3					4					5																																												
						1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0																									
CARANGIDAE																																																																						
<u>Trachurus trachurus</u>	68	BT	14933	55							8	27	10	1	3	3	1						1	1																																														
CHAMPSODONTIDAE																																																																						
<u>Champsodon capensis</u>	29	BT	24	24							3	2	7	1	6	3	2																																																					
	47	BT	148	148							1	26	63	41	9	5	1	2																																																				
	53	BT	1	1												1																																																						
	54	BT	11153	100							2	5	29	47	10	7																																																						
	55	PT	1880	103							2	2	4	14	45	29	7																																																					
	58	PT	91	91		3	1	1	1	6	13	31	22	11	2																																																							
	64	BT	64	64							2	5	28	22	6																																																							
	65	BT	71	71							5	5	8	12	22	16	3																																																					
CHLOROPHTALMIDAE																																																																						
<u>Chlorophtalmus agassizi</u>	2	BT	42	42							2	4	2	2	4	2	4	7	1	3	4	3	4																																															
	29	BT	3	3							1	1	1																																																									
	53	BT	2	2												2																																																						
	54	BT	401	31							4	3	3	3	2	3	4	1	1																																																			
	55	PT	1530	127							1	4	1	7	7	11	23	13	20	21	11	9																																																
	65	BT	39	39							9	16	11	2	2						1																																																	
	66	BT	39	39							1	1						1	7	9	18	3	1																																															
CLUPEIDAE																																																																						
<u>Pellona ditchela</u>	35	BT	90	16												1	3	5	3	3																																																		
(Indian pellona)																																																																						
<u>Sardinella gibbosa</u>	68	BT	7067	50												11	12	16	11																																																			
(Goldstripe sardinella)																																																																						
CYNOGLOSSIDAE																																																																						
<u>Areliscus marleyi</u>	64	BT	152	152												1	3	8	17	15	23	7	4	6	4	12	24	19	9	3																																								

SPECIES	LENGTH DISTRIBUTION (in cm)																																																																			
	St.	G	N	n	xx	1										2										3										4										5																						
						1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0													
SCOMBROPIDAE																																																																				
<u>Neoscombropros</u>	29	BT	1	1																																																																
<u>annectens</u>	45	BT	14	1																																																																
	53	BT	14	14		1	4	5	1	1	1	1																																																								
	54	BT	688	52		6	7	7	4	4	4	7	6	4																																																						
	55	PT	750	134		18	45	26	23	5	4	5	3	2																																																						
	58	PT	64	64		9	31	9	8	2	2	3																																																								
	64	BT	47	47			3	3	5	4	1	1	2	4	1	7	3	3																																																		
	65	BT	930	116		2	5	11	21	16	18	7	12	9	10	4	1																																																			
SERRANIDAE																																																																				
<u>Epinephelus</u>	20	LL	3	3																																																																
<u>chlorostigma</u>				x		1																																												1																		
(Grouper)	22	LL	1	1		1																																																														
	23	BT	2	2																																														1																		
<u>E. morrhua</u>	27	LL	1	1																																																																
(Grouper)	67	BT	2	2	x		1																																												1																	
SPARIDAE																																																																				
<u>Pterogymnus laniarius</u>	45	BT	14	1																																																																
	54	BT	1	1	x		1																																												1																	
	67	BT	700	98			3	3	6	3	2	4	9	5	3	6	6	5	3	7	5	6	7	2	6	1	3	1					1																																			
	78	P	20	20		1																																												1	1					1	3	2	1	2	2	4	1					1
				x																																																																
<u>Pagellus natalensis</u>	51	BT	8	8																																																																
(Red grunter)	67	BT	308	44			3	1	1					4	17	9	5	4																																																		
	68	BT	627	71			1	13	43	11	2	1																																																								
SPHYRAENIDAE																																																																				
<u>Sphyraena obtusata</u>	23	BT	68	68																																																																
(Obtuse barracuda)							5	24	24	9	6																																																									
<u>S. japonica</u>	45	BT	15146	100																																																																
(Barracuda)	58	PT	204	100																																																																
	59	BT	5	5																																																																
	68	BT	2237	100																																																																

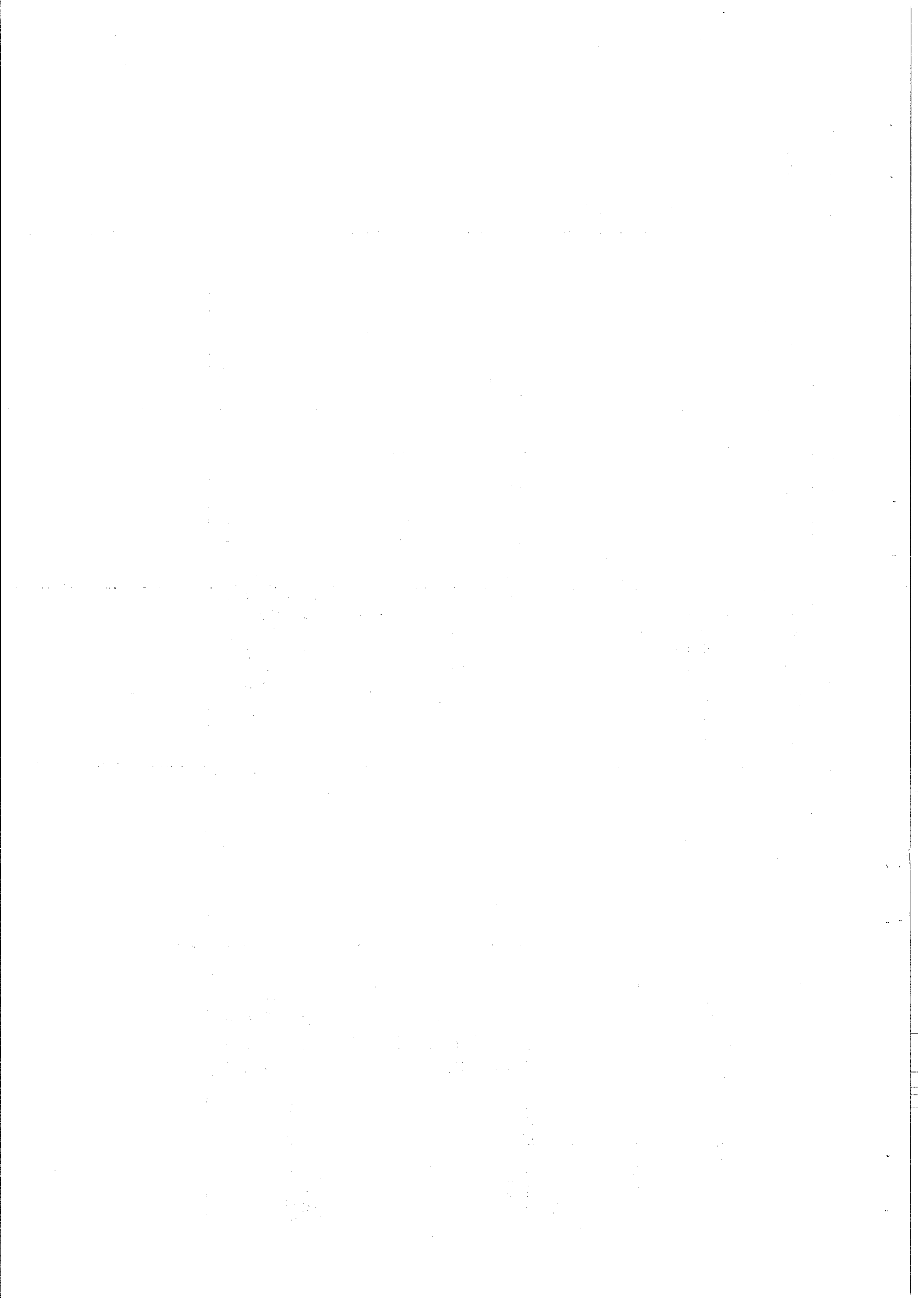


Table 3. Crustaceans - catches as percentage of total catch by bottom trawl. Shrimps (S) and lobster (L)
(Including shovel-nosed lobster and crayfish (Nephrops)).

St. no.	Depth m	Total catch per hour (kg)	Shrimps and lobster catch/hour (kg)	%
3	478	120	50.0 (S)	42.0
23	50	3496	2.2 (S)	0.1
29	428	14	7.9 (S)	56.0
35	10	500	4.0 (S)	4.0
54	321	386	3.9 (S)	1.0
"	"	"	1.4 (L)	0.4
56	448	330	2.7 (L)	0.8
"	"	"	23.7 (S)	7.0
57	44	200	8.8 (S)	4.4
64	314	137	15.9 (L)	12.0
"	"	"	0.6 (S)	0.5
65	341	162	2.2 (L)	1.4
66	531	35	17.1 (S)	49.0
67	135	312	2.8 (L)	1.0

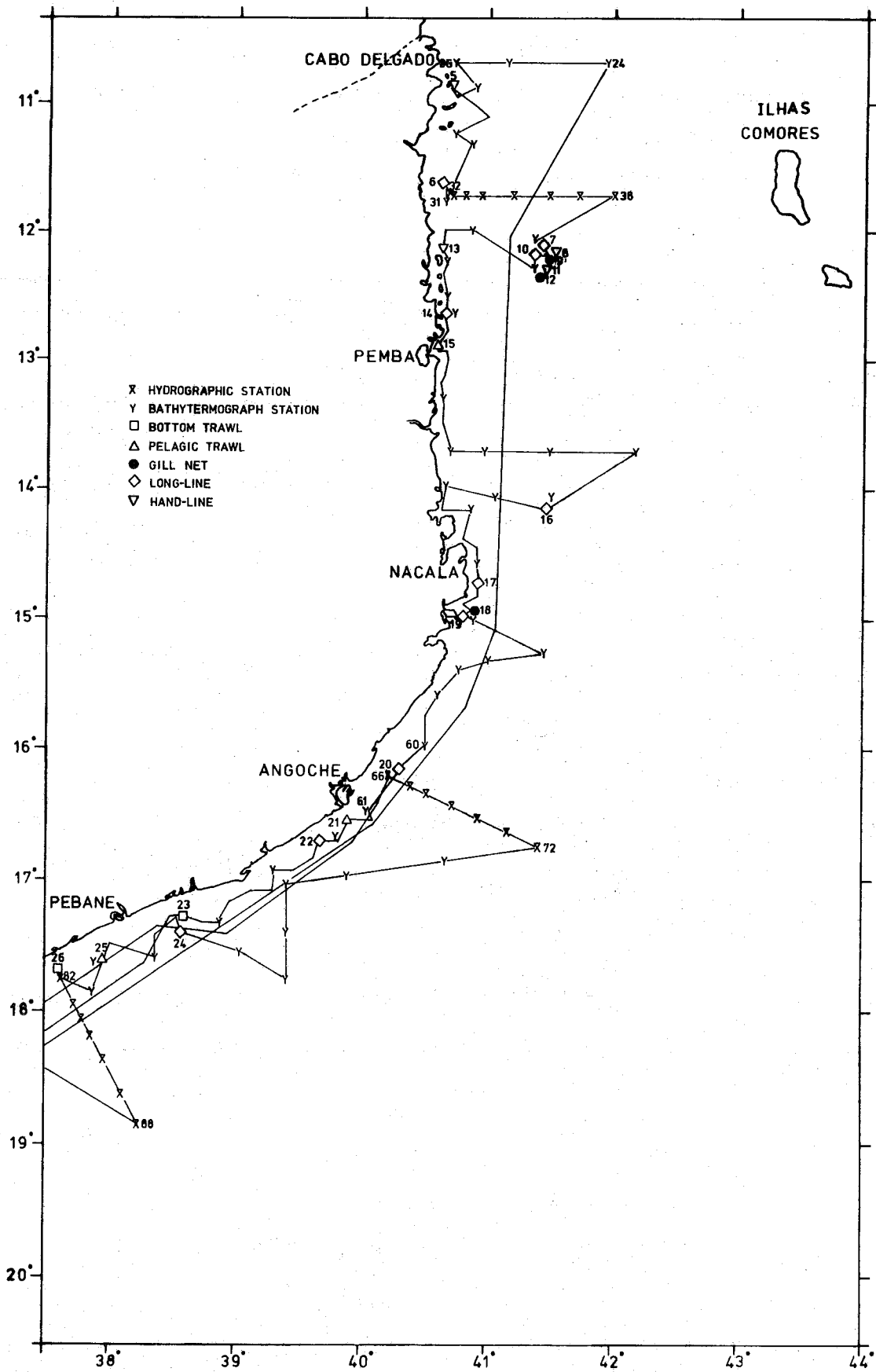


Fig. 1a. Survey routes and stations - northern area.

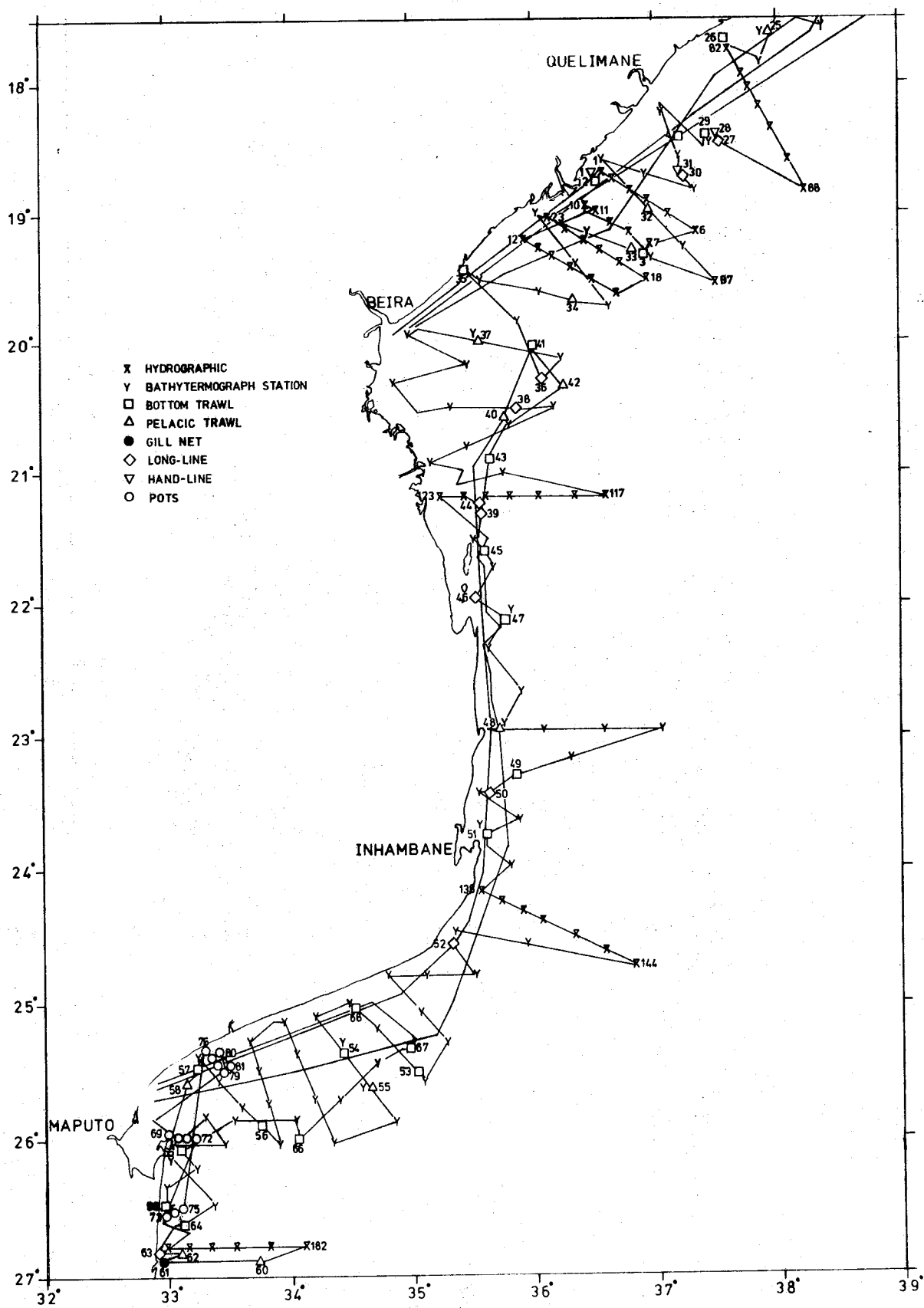


Fig. 1b. Survey routes and stations - southern area.

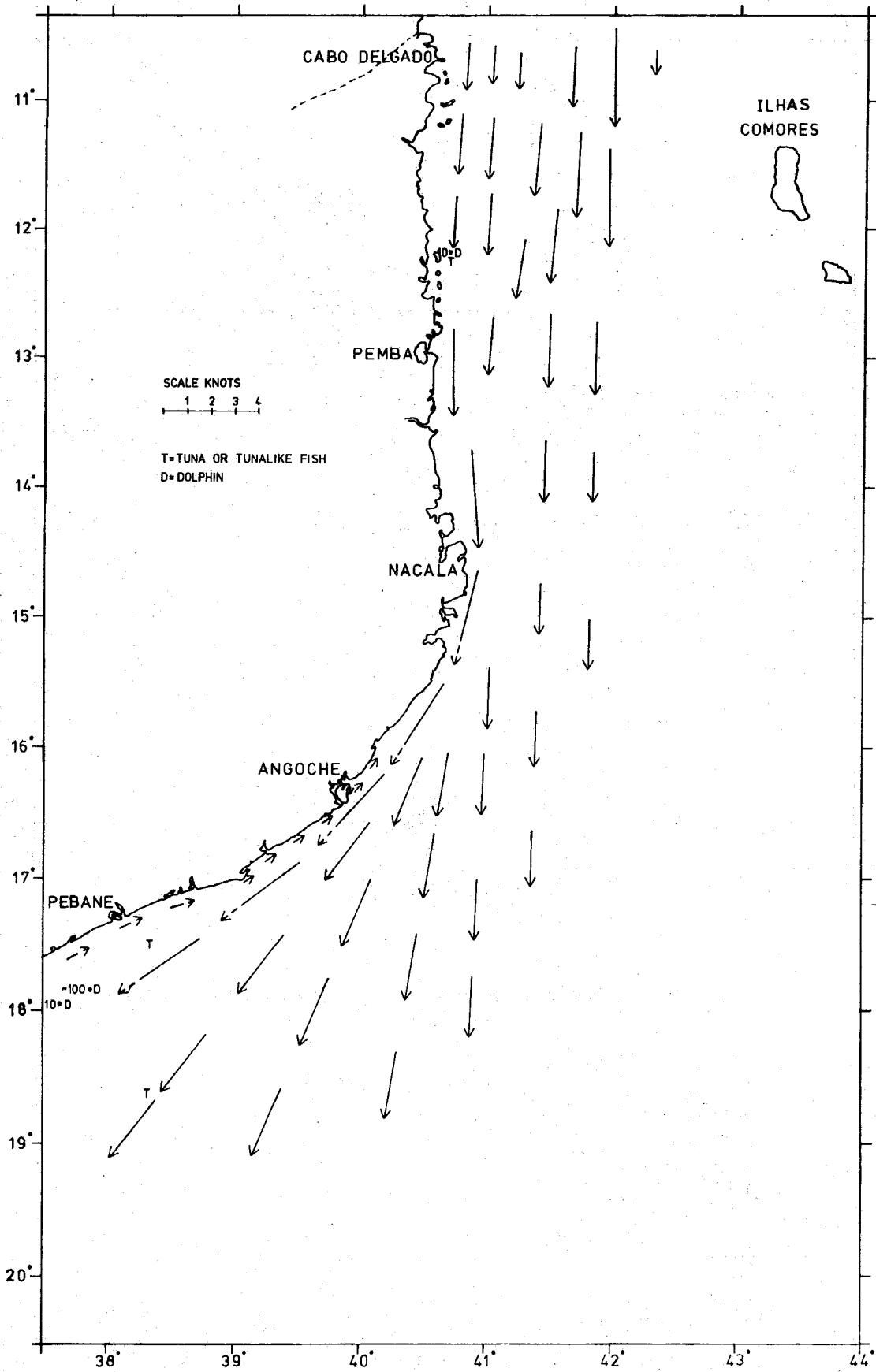


Fig. 2a. Surface and current observations - northern area.

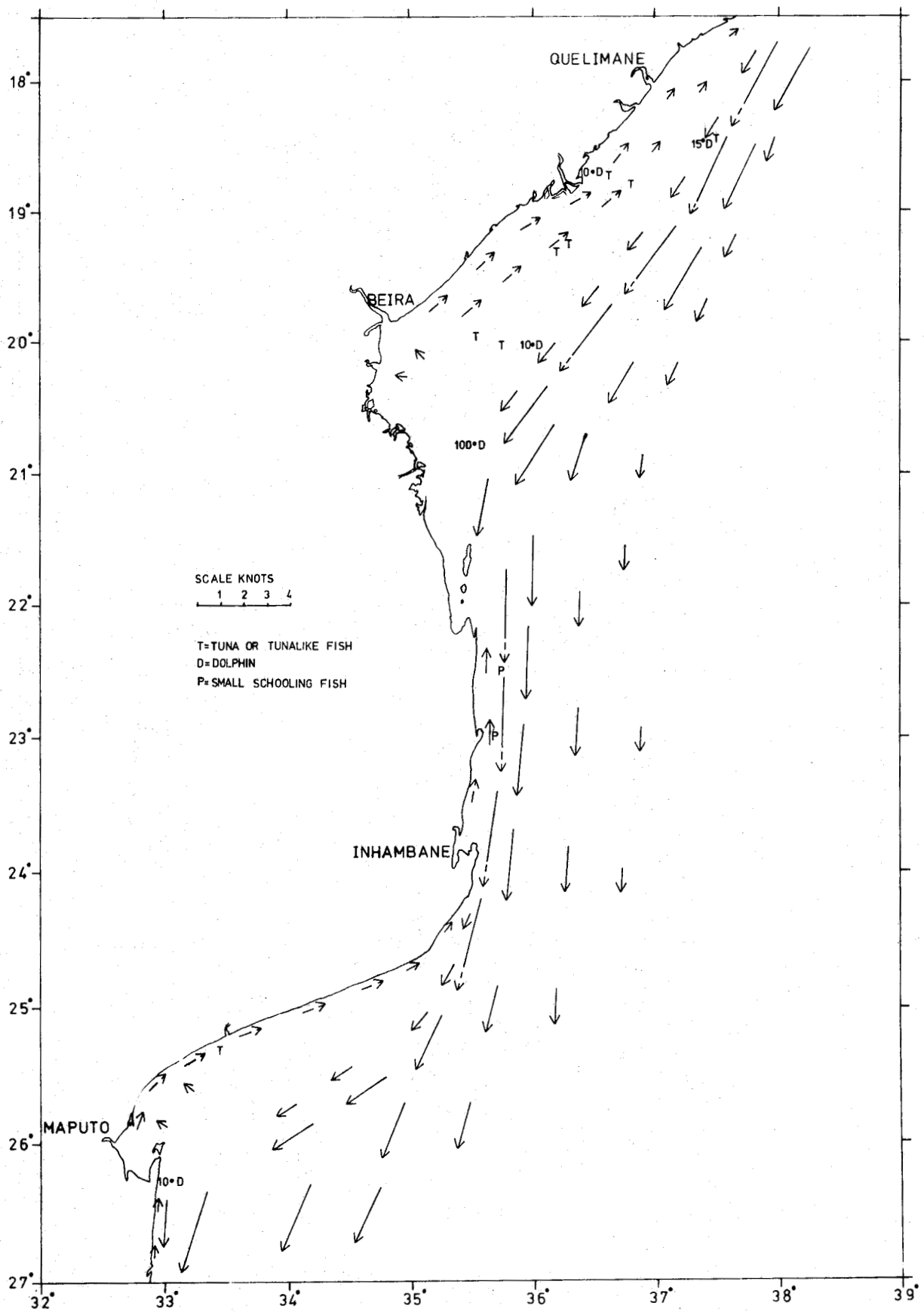


Fig. 2b. Surface and current observations - southern area.

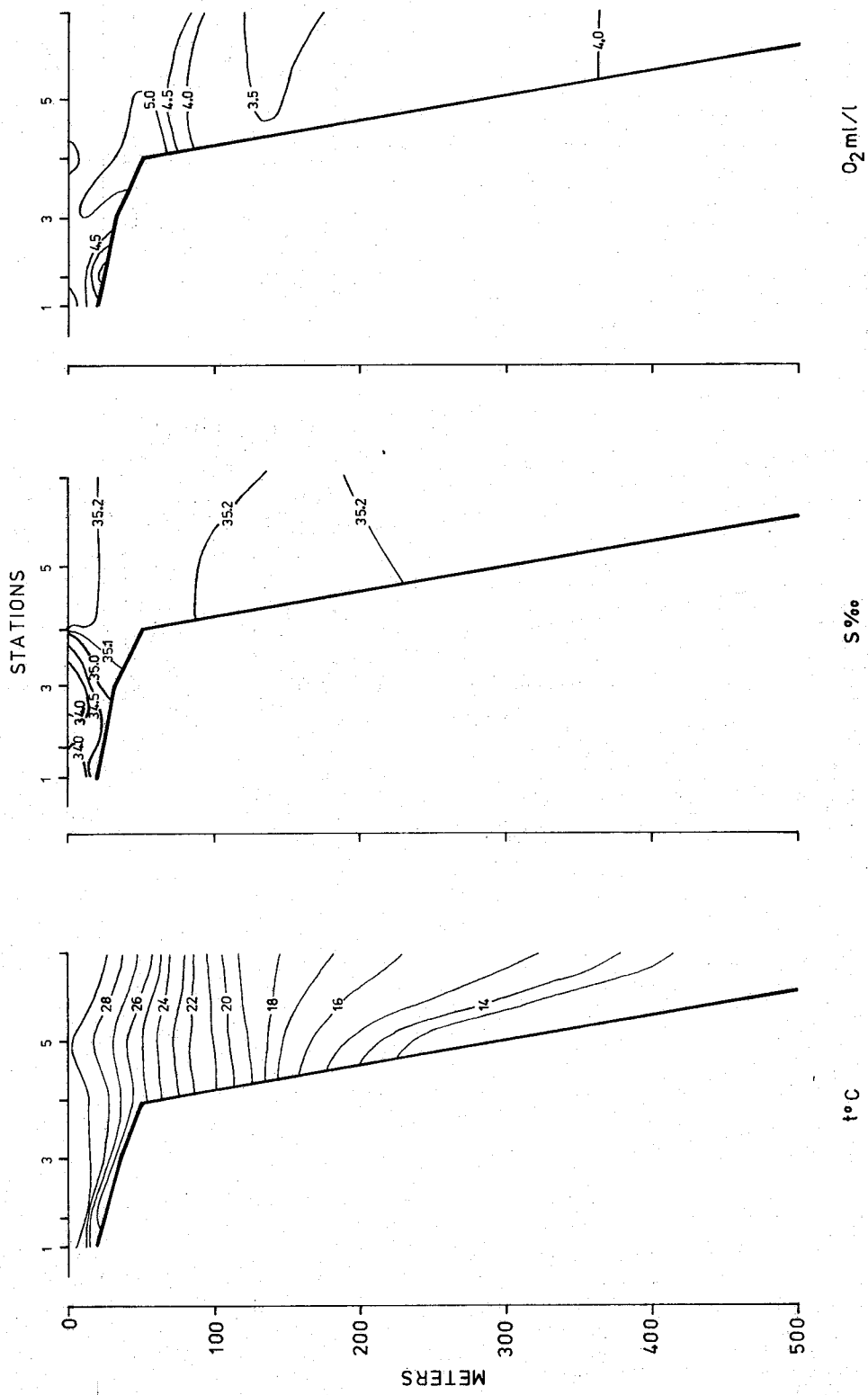


Fig. 3. Zambezi section I, 22 Jan 1978. Vertical distribution of temperature, $t^{\circ}\text{C}$, salinity, S o/oo , and dissolved oxygen, $\text{O}_2 \text{ ml/l}$.

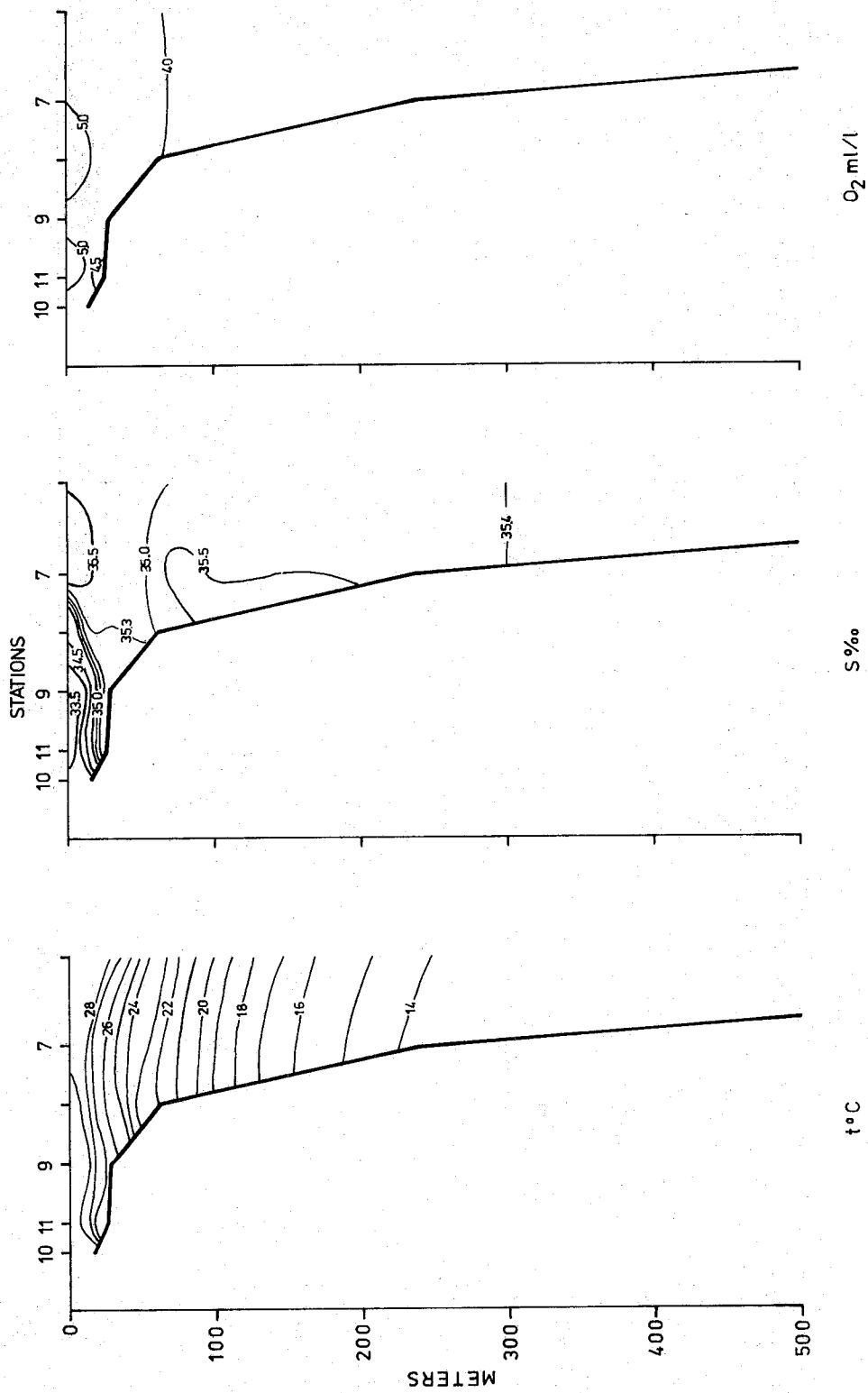


Fig. 4. Zambezi section II, 23 Jan 1978. Vertical distribution of temperature, $t^{\circ}\text{C}$, salinity, $\text{S}\text{‰}$, and dissolved oxygen, $\text{O}_2 \text{ ml/l}$.

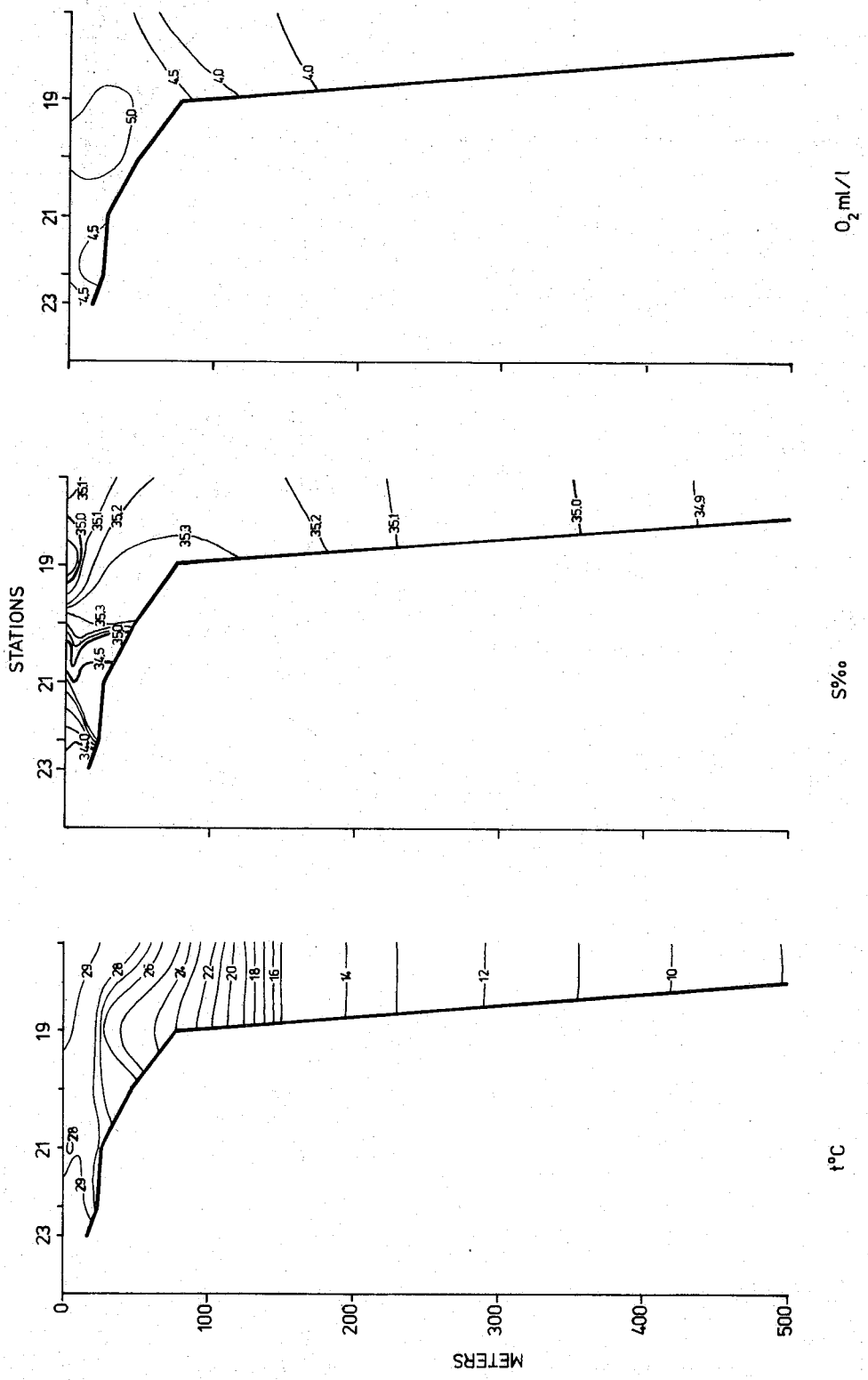


Fig. 5. Zambezi section III, 26-27 Jan 1978. Vertical distribution of temperature, t°C, salinity, S o/oo, and dissolved oxygen, O₂ ml/l.

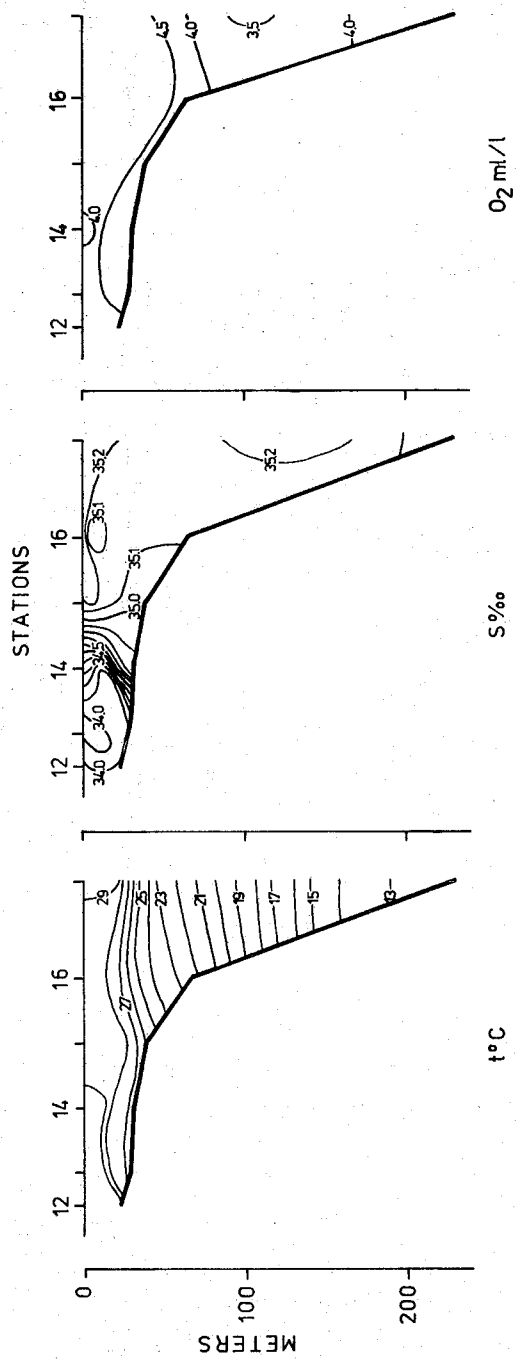


Fig. 6. Zambezi section IV, 26 Jan 1978. Vertical distribution of temperature, t°C, salinity, S o/oo, and dissolved oxygen, O₂ ml/l.

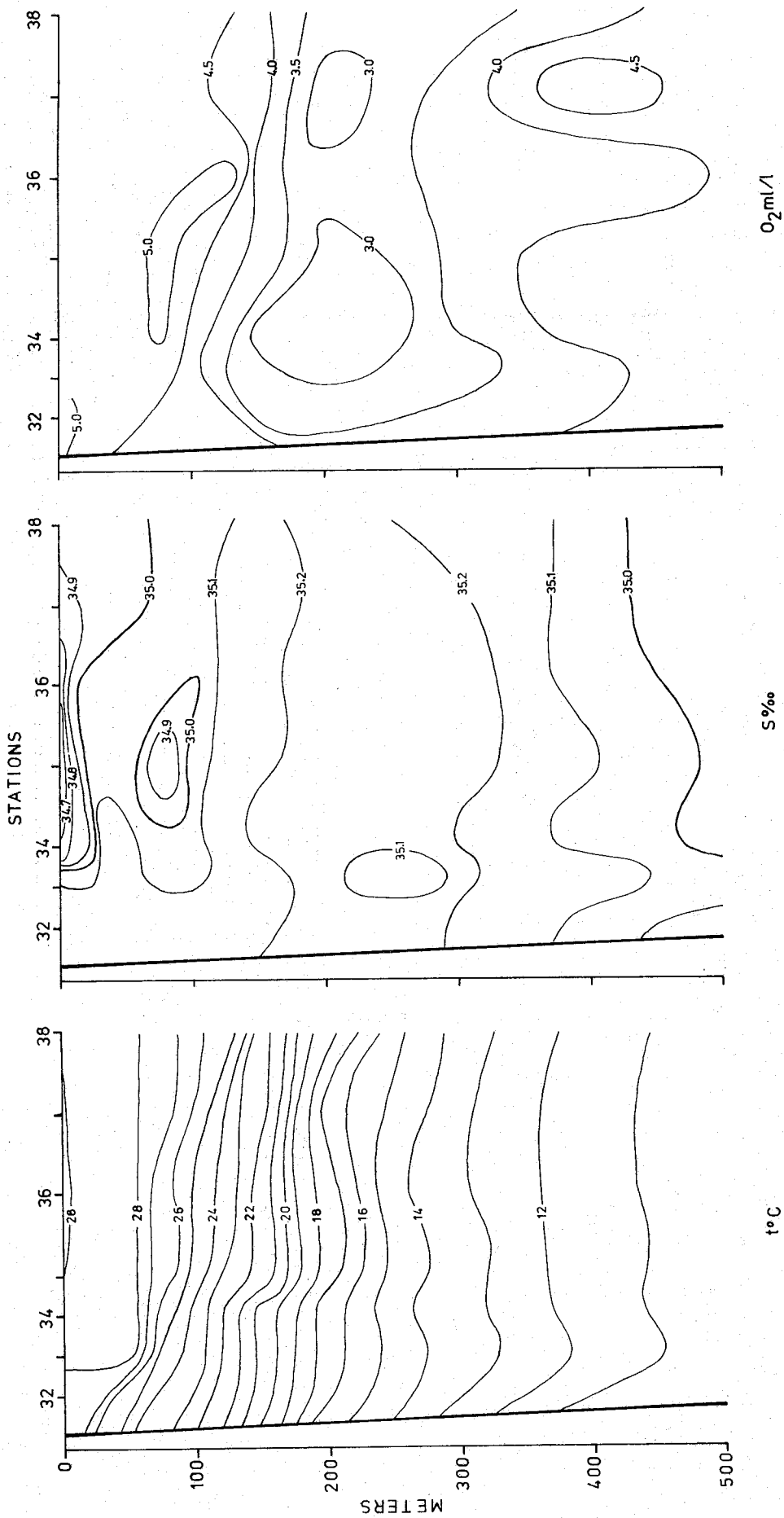


Fig. 7. Section I, 31 Jan 1978. Vertical distribution of temperature, $t^{\circ}\text{C}$, salinity, S ‰, and dissolved oxygen, O_2 ml/l.

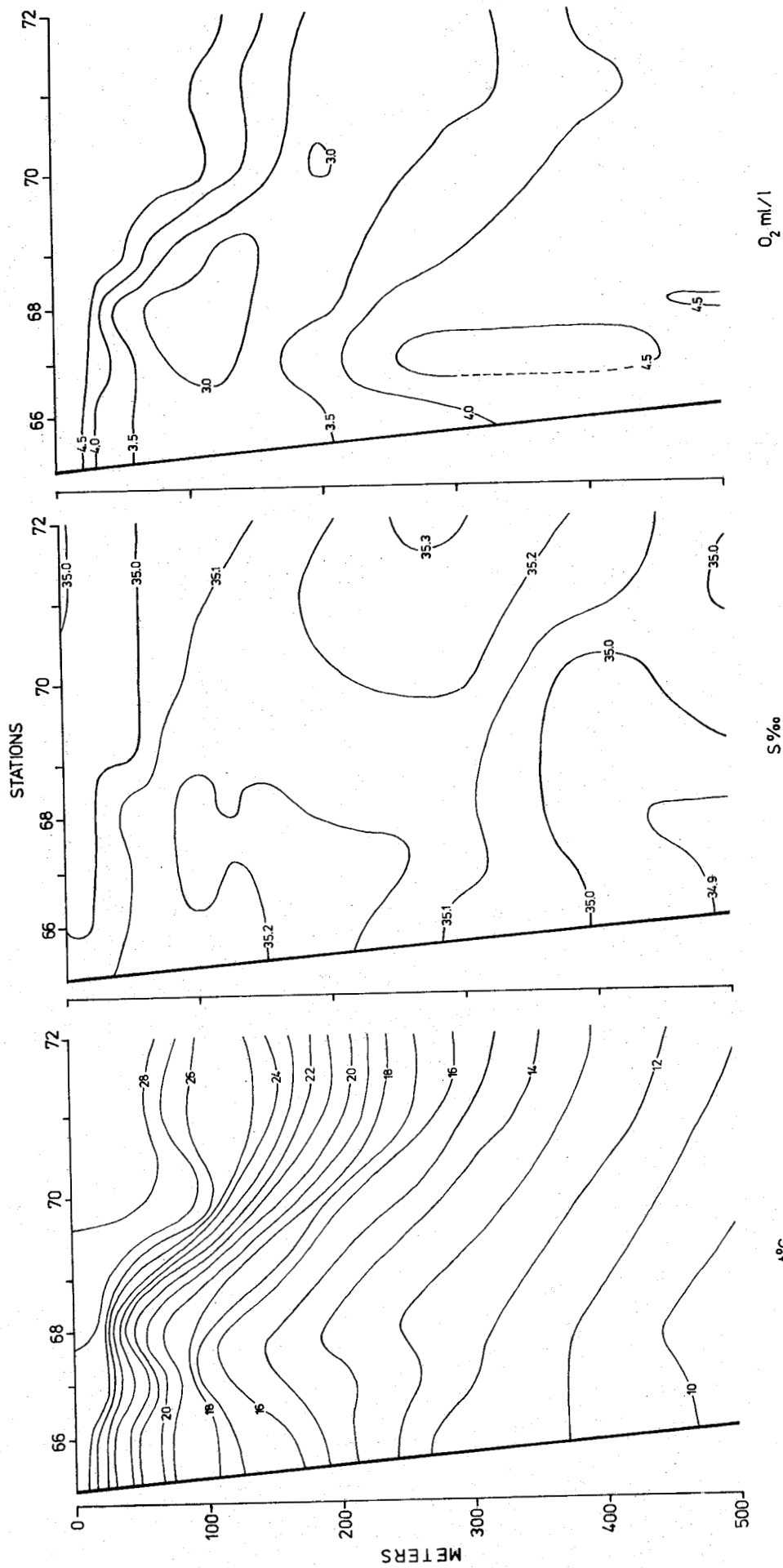


Fig. 8. Section II, 14 Feb 1978. Vertical distribution of temperature, t°C, salinity, S‰, and dissolved oxygen, O₂ ml/l.

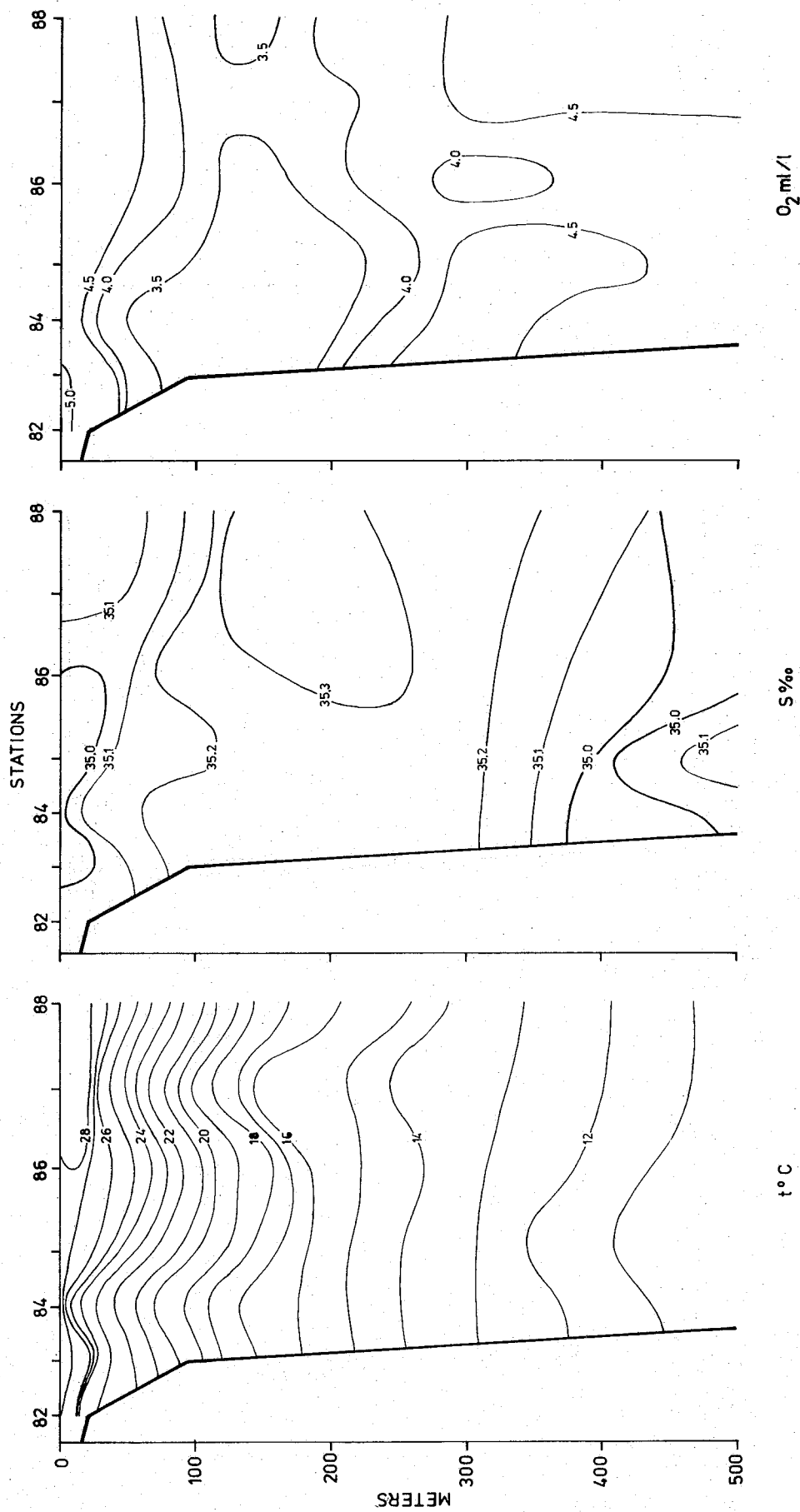


Fig. 9. Section III, 16 Feb 1978. Vertical distribution of temperature, $t^{\circ}\text{C}$, salinity, $\text{S}\text{‰}$, and dissolved oxygen, $\text{O}_2 \text{ ml/l}$.

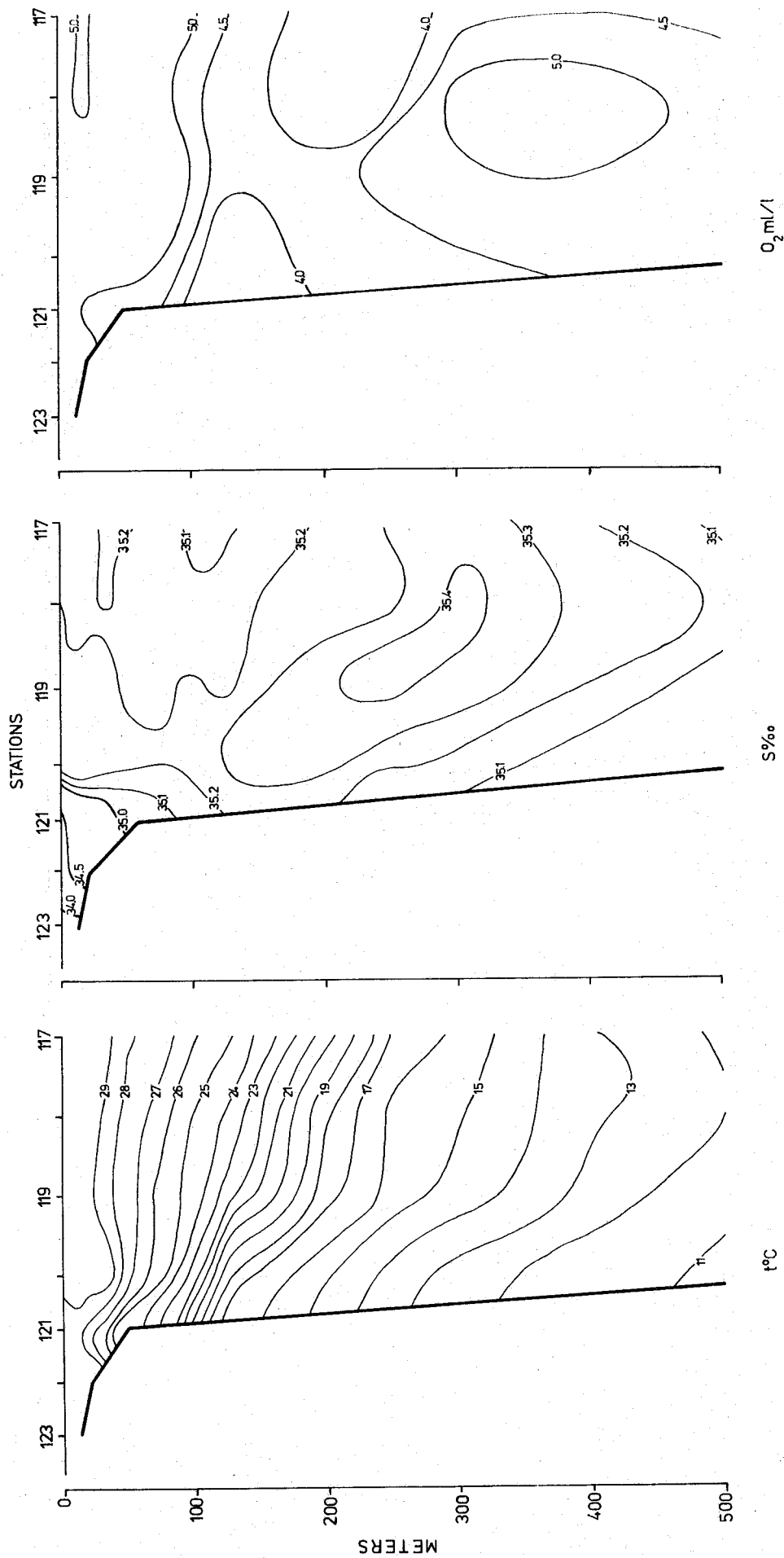


Fig. 10. Section IV, 23 Feb 1978. Vertical distribution of temperature, $t^{\circ}\text{C}$, salinity, $\text{S}\text{‰}$, and dissolved oxygen, $\text{O}_2 \text{ ml/l}$.

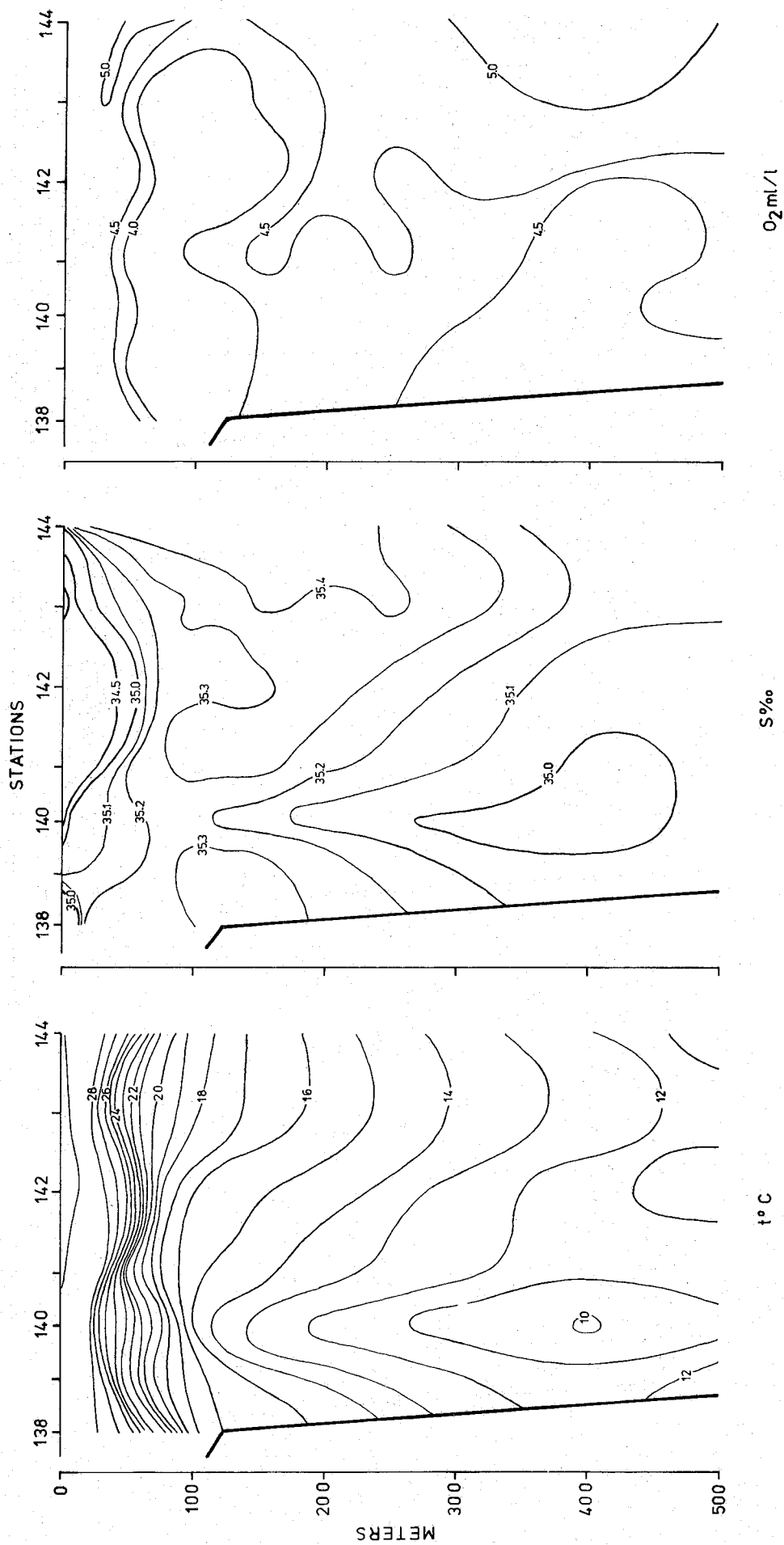


Fig. 11. Section V, 7 Mar 1978. Vertical distribution of temperature, $t^{\circ}\text{C}$, salinity, $S\text{‰}$, and dissolved oxygen, $\text{O}_2\text{ ml/l}$.

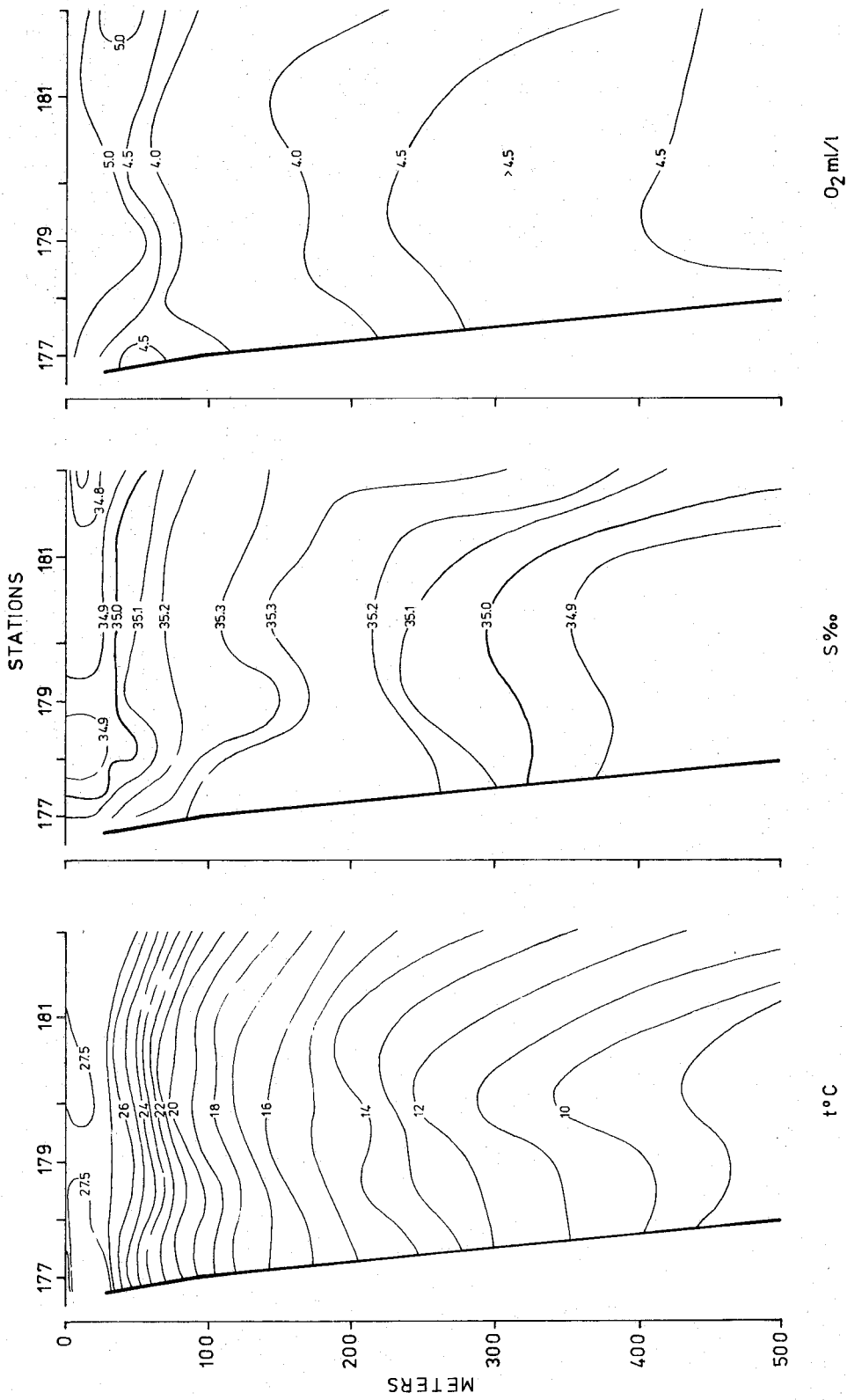


Fig. 12. Section VI, 12-13 Mar 1978. Vertical distribution of temperature, t°C, salinity, S ‰, and dissolved oxygen, O₂ ml/l.

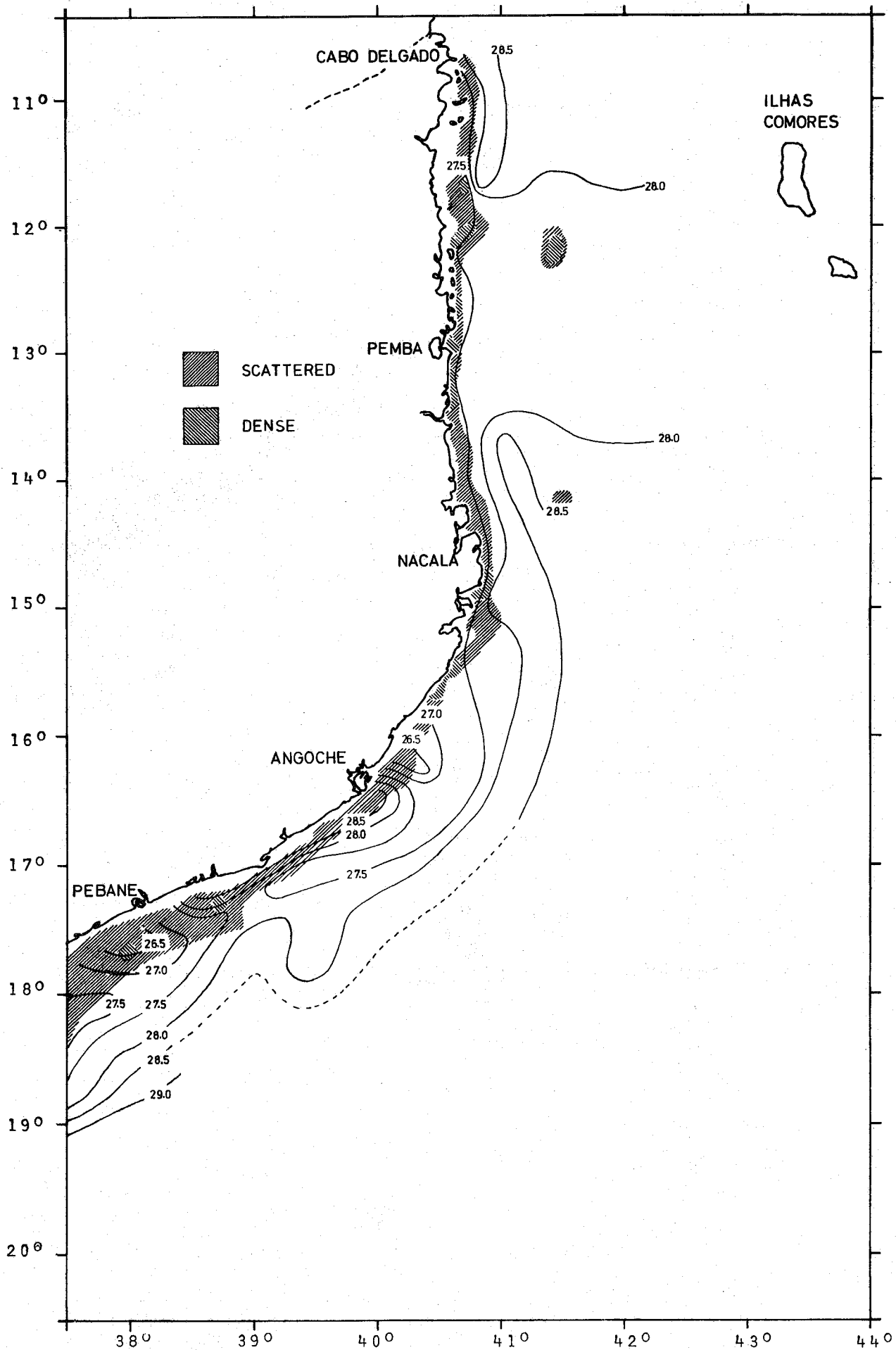


Fig. 13a. Demersal fish recordings and surface temperature, $t^{\circ}\text{C}$, northern area.

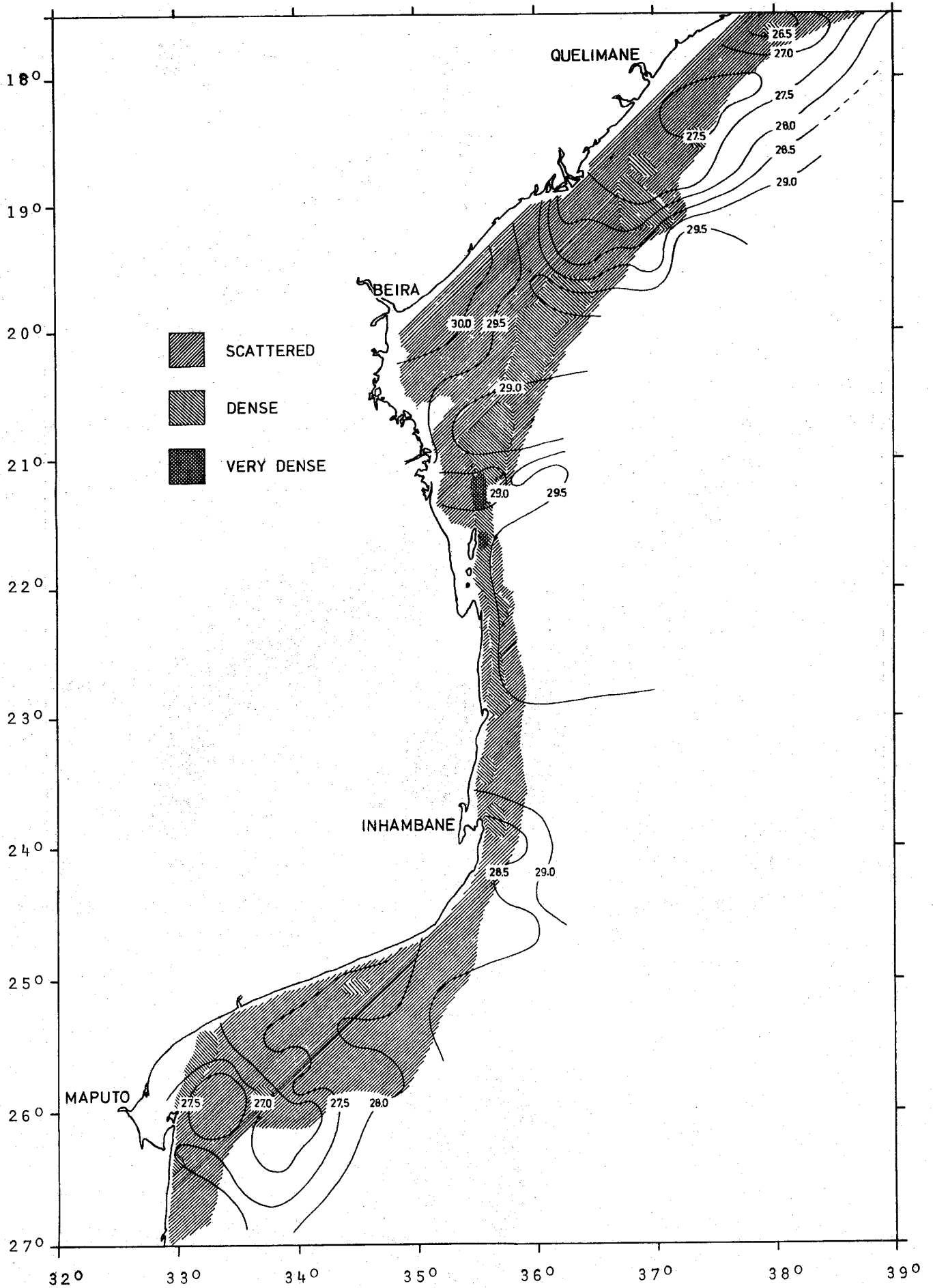


Fig. 13b. Demersal fish recordings and surface temperature, t°C, southern area.

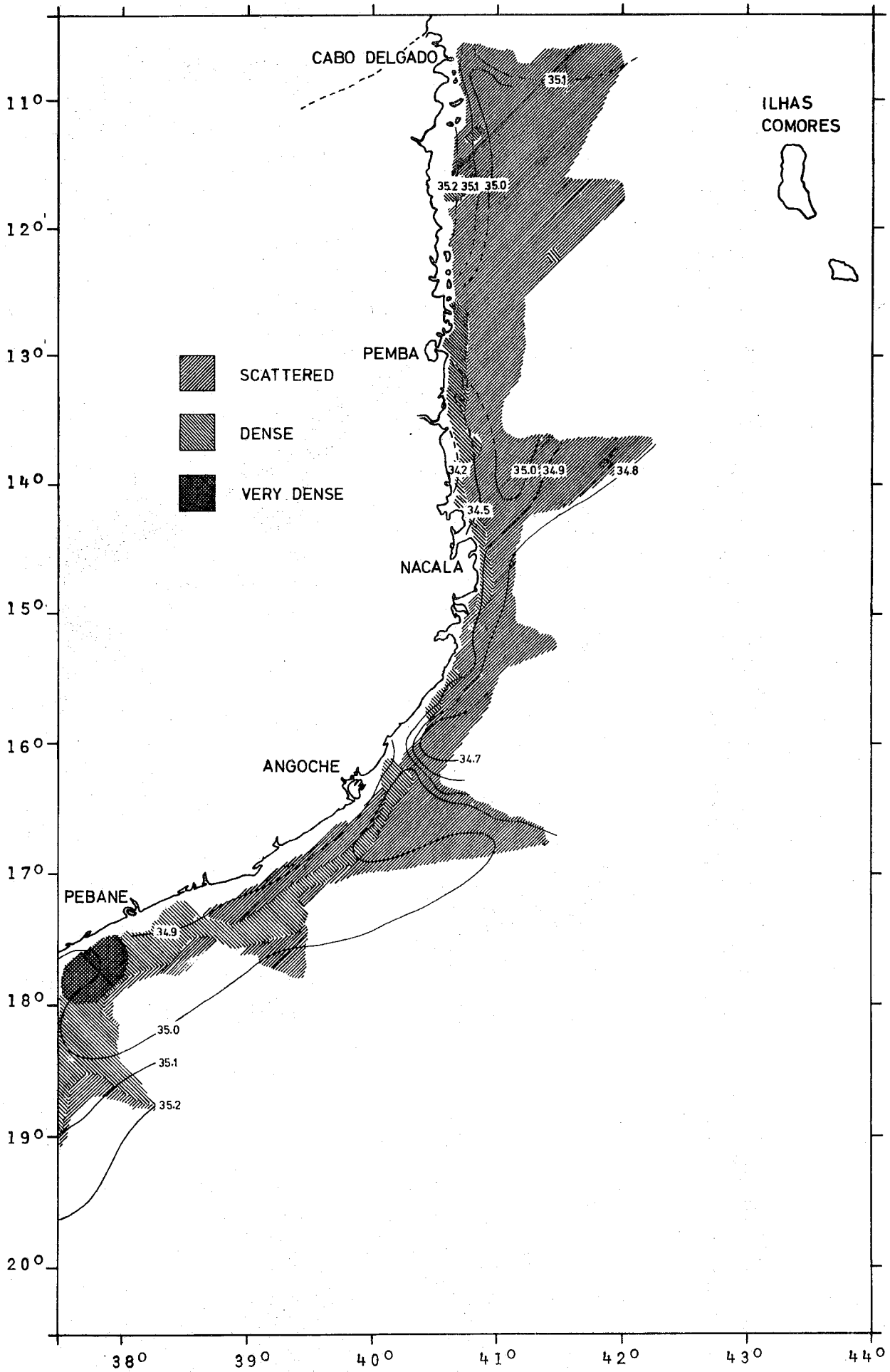


Fig. 14a. Pelagic fish recordings and surface salinity, S o/oo, northern area.

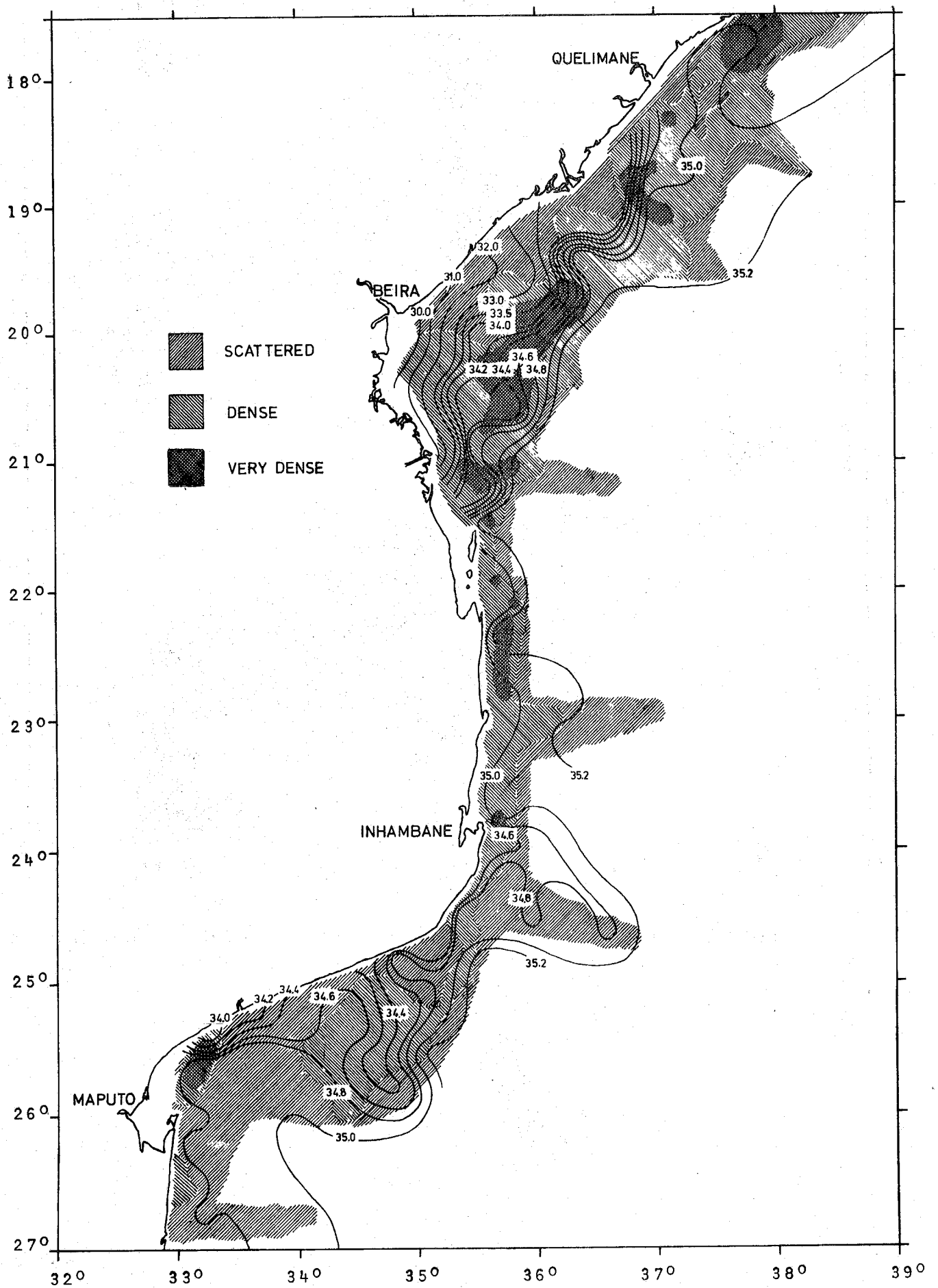


Fig. 14b. Pelagic fish recordings and surface salinity, S o/oo, southern area.

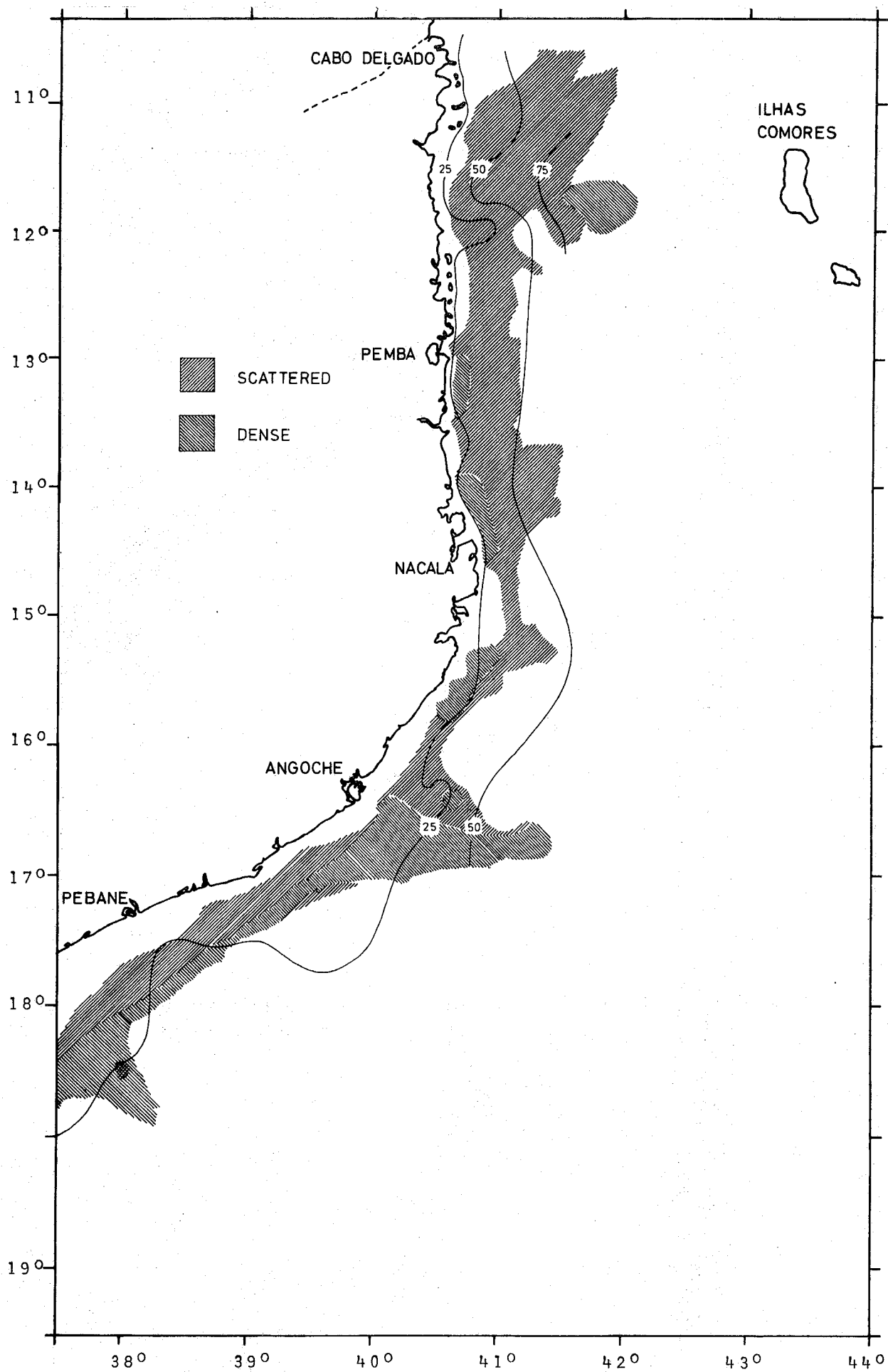


Fig. 15a. Mesopelagic fish recordings and depth of the homogeneous layer - northern area.

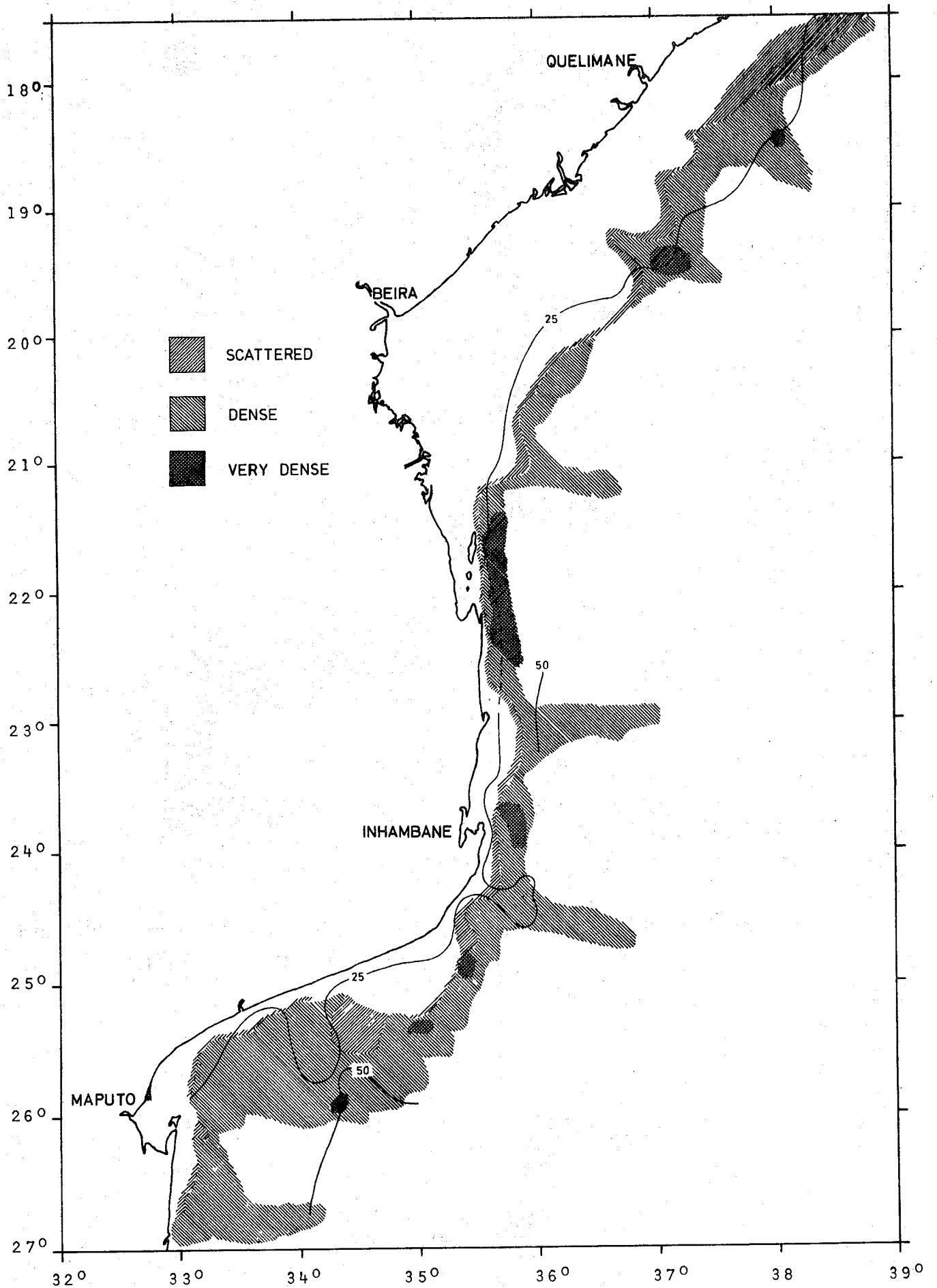


Fig. 15b. Mesopelagic fish recordings and depth of the homogeneous layer - southern area.

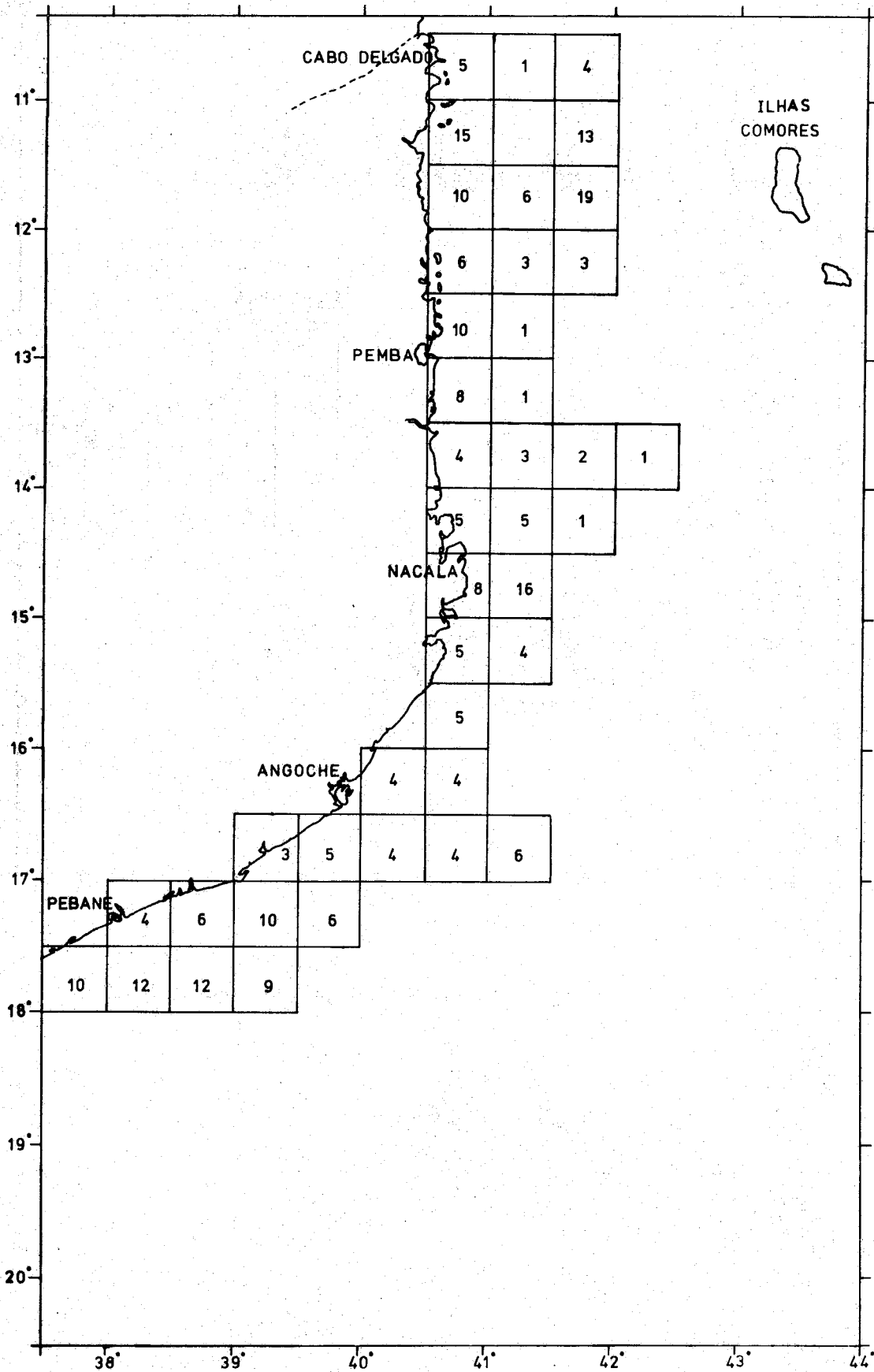


Fig. 16a. Average echo abundance of plankton - northern area.

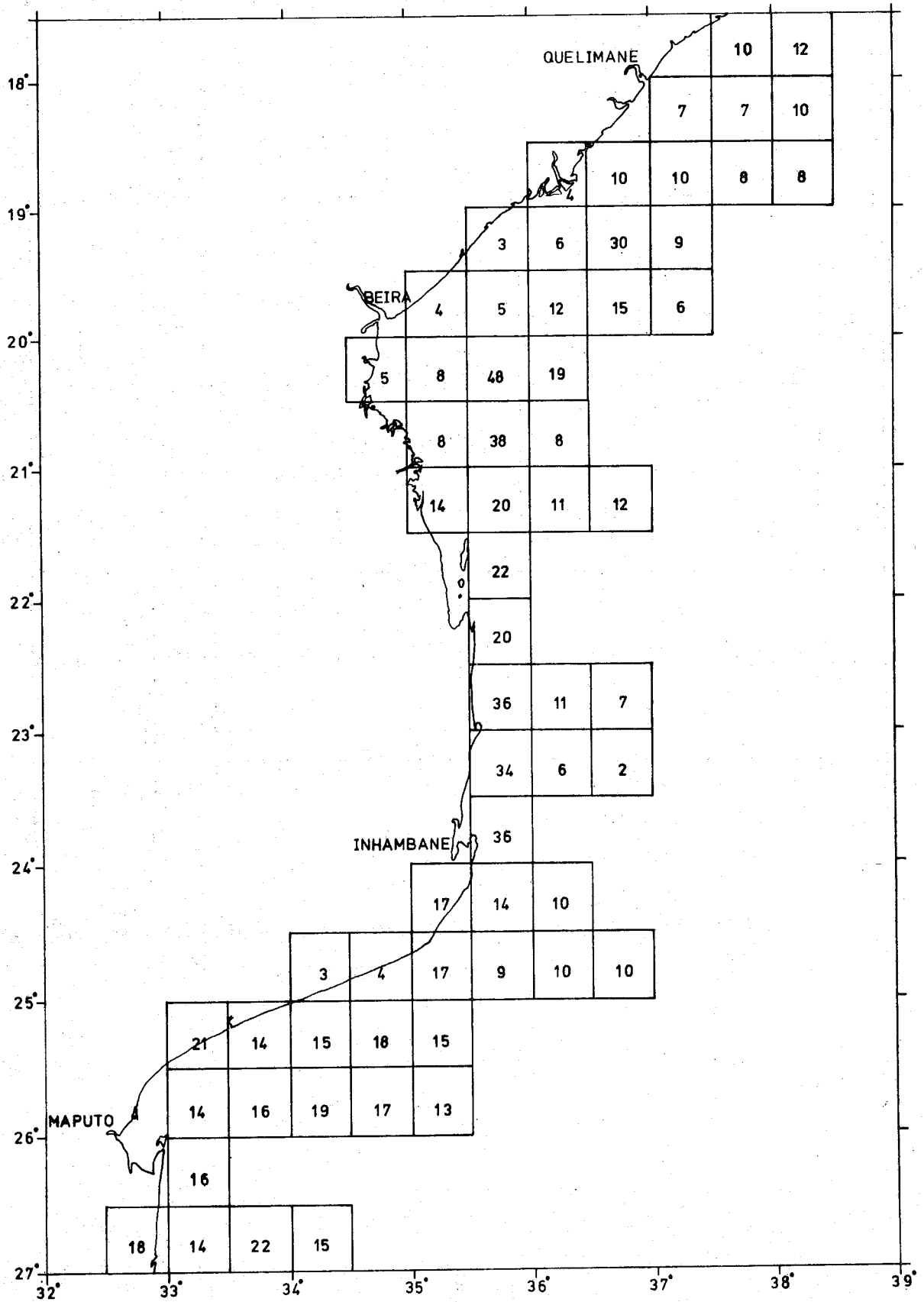


Fig. 16b. Average echo abundance of plankton - southern area.

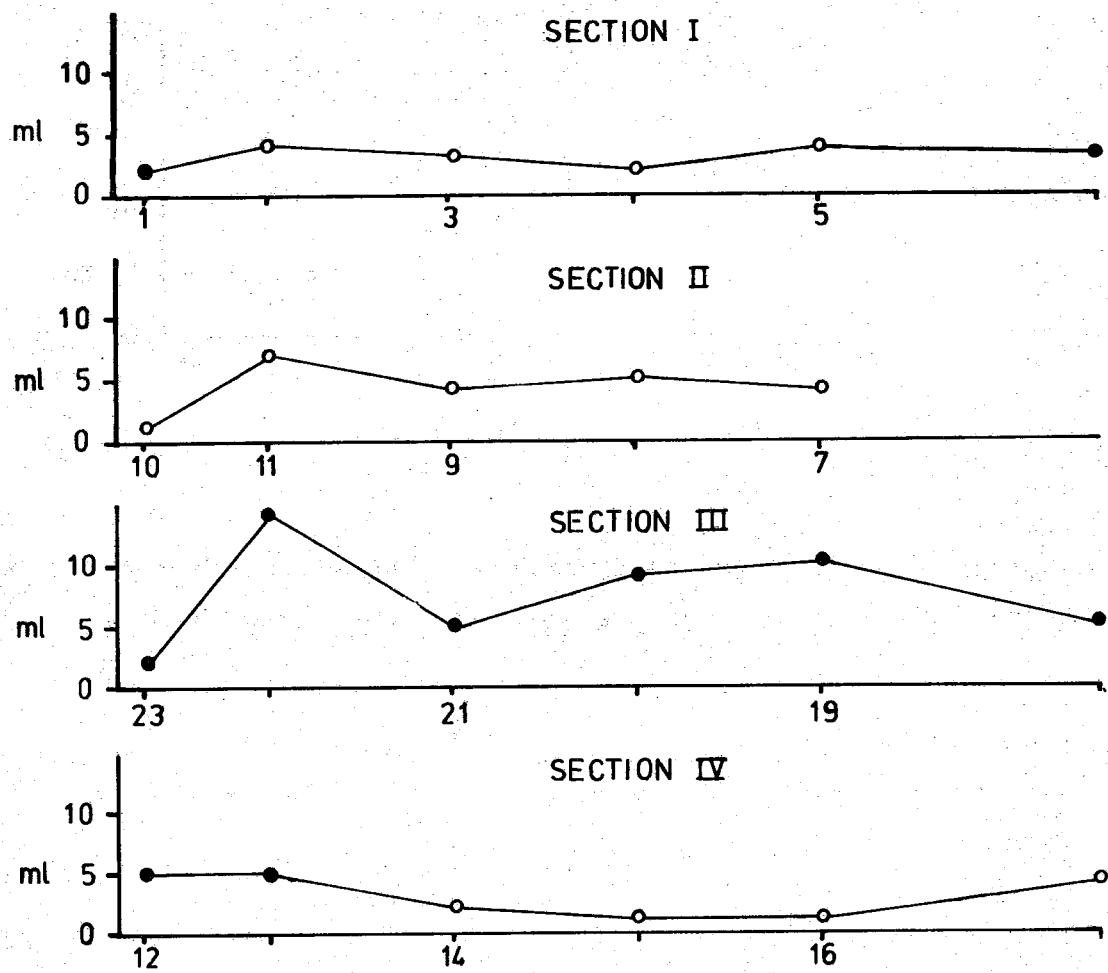


Fig. 17. Wet displacement volume of plankton at the hydrographic sections outside the Zambezi River. o - day haul, ● - night haul.

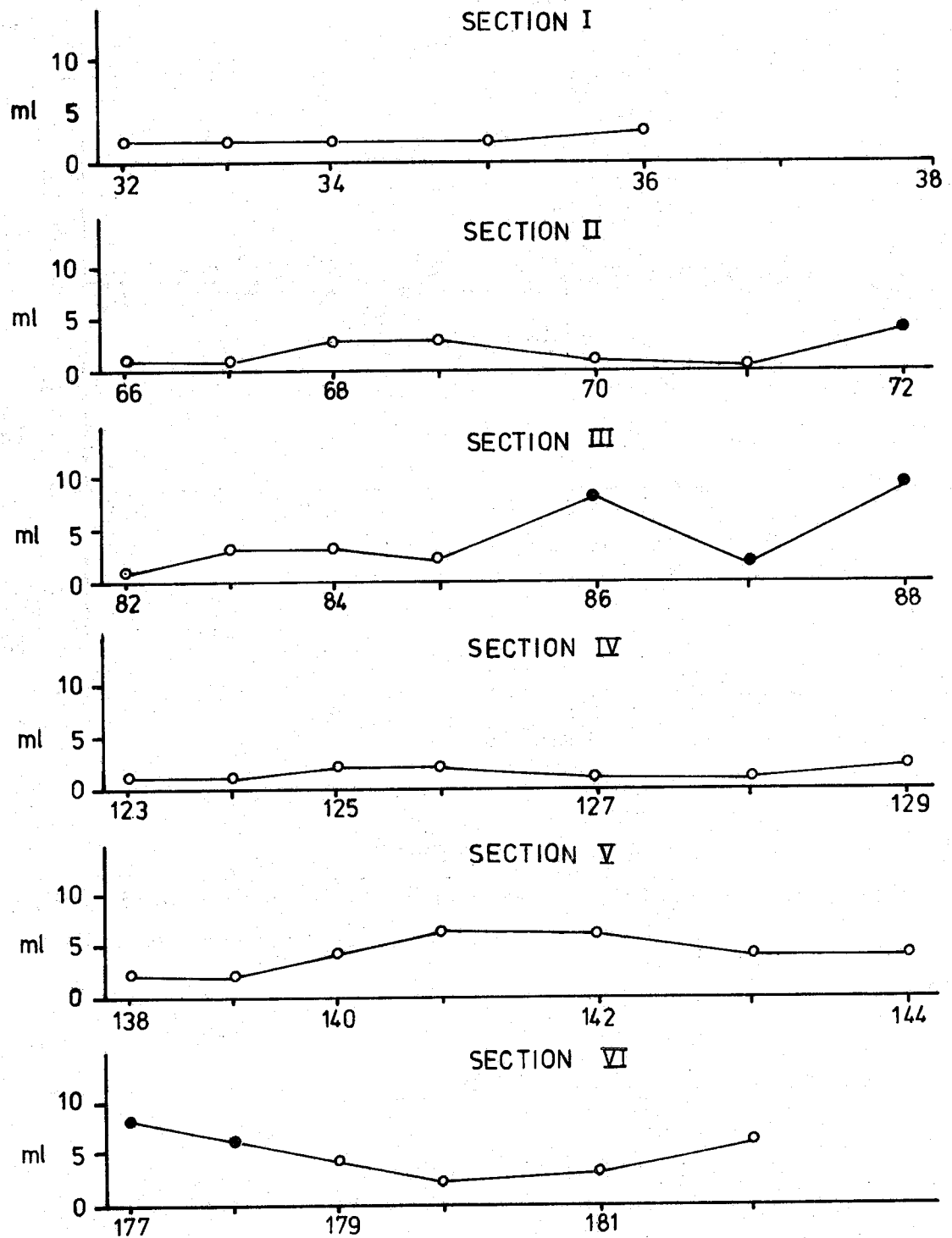


Fig. 18. Wet displacement volume of plankton at the hydrographic sections I - IV. o - day haul, ● - night haul.