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REPORT ON A CRUISE BY THE R/V "G.O. SARS"

TO WEST AFRICA 23 OCTOBER - 15 DECEMBER 1972

by

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INTRODUCTION

As part of the research sponsored under the CINECA program, the Norwegian research vessel "G.O. Sars" from the Institute of Marine Research, Bergen, Norway, operated on the continental shelf area between Villa Cisneros (Spanish Sahara) and Rio Casamance (Senegal) in November - December 1972.

The "G.O. Sars" sailed from Bergen 23 October, called at Tenerife 30 October, Nouadhibou 6 November, Dakar 18-20 November and Las Palmas 6 December.

Scientific personnel responsible for the different program subjects were: O.J. Østvedt (scientist in charge), J. Blindheim (physical oceanography), L. Føyn (chemical oceanography), G. Berge (biological oceanography), O. Smedstad (fish biology) and G. Vestnes (acoustics). Other staff members were: O. Annaniassen, P. Eide, H. Kismul, H.P. Knutsen, S. Konglevoll, E. Molvær, S. Myklevoll, K. Seglem. Part of the time S. Myklevoll collected fish samples onboard the factory vessel "Astra".

The following invited scientists participated in the whole or part of the cruise:

Spain, Laboratorio Oceanografico de Canarias:
J. Bravo de Laguna y Cabrera and
E. Santaella Alvarez (30 October - 6 December)

Mauritania, Laboratoire des Peches, Nouadhibou:
Sy Moussa Arouna (6 - 18 November)

Senegal, Centre de Recherches Oceanographiques de Dakar:
T. Boely (30 October - 6 December)

Ivory Coast, Centre de Recherches Oceanographiques:
E. Marchal (19 November - 6 December)

Norway, Institute for Marin Biology and Limnology, Oslo University:
O. Mathisen (19 November - 6 December)

Argentina, NORAD Fellowship
J. Vitullo (23 October - 15 December)

During the first half of the cruise daily contact was kept with the French research vessel "Capricorn".

The main purpose of the cruise was:
1) to study distribution and abundance of fish in relation to environmental factors,
2) to sample the ichthyofauna for biological studies of important pelagic species such as Sardinella spp., Trachurus spp. and Caranx rhonchus, and
3) to study the upwelling area with regard to its effect on the total productivity.

MATERIAL AND METHODS

The cruise tracks for hydrographic, chemical and plankton work was established in accordance with the cruise track planned for the CINECA multi-ship survey in February 1973 but with less offshore sections. During the early part of the cruise, however, few fish were recorded beyond the shelf area, and to allow for more detailed survey on the shelf proper, the offshore program planned was even more reduced.

Most of the hydrographic, chemical and plankton work were completed during the first three weeks of the cruise, and during the second phase more emphasize was laid on acoustic work and exploratory fishing. The complete cruise track and grid of stations are given in Fig. 1.

Physical, chemical and biological oceanography

Temperature and salinity were recorded by Nansen cast at standard depths and/or by STD. The temperature at 5 m depth was recorded continuously. Measurements of dissolved oxygen, phosphate, nitrate and silicate were made at selected stations as shown in Fig. 1.

Oxygen was measured according to Winkler and the nutrients were measured in a Technicon Auto-Analyser. Particle distributions were recorded continuously at 5 m depth using Berge's continuously recording transparancymeter. For calibration purposes and for obtaining information on the vertical distribution of particles, samples from different depths were preserved for later particle size frequency analyses.

Primary production measurements using C-14 as indicator were made with the combined use of the simulated in situ method, and the laboratory incubator method with artificial light and temperature control. In the simulated in situ technique use was made of colour filters matched to the average light filtering qualities of oceanic waters, and quantitatively calibrated with the Jerlov/Nygaard light quanta meter.

Light penetration in the sea was recorded most days at noon using the light quanta meter, and incoming radiation was continuously recorded with the same equipment. The laboratory incubator measurements of photosynthetic rates were made at a light intensity of approximately 7000 Lux for 4 hours, and results given as mg C produced per liter, Lux and hours.

The standing stocks of autotrophic phytoplankton were measured as chlorophyll a in samples from 5 m depth at all stations where primary production rates were recorded.

Zooplankton biomass studies and distribution of fish eggs and larvae oblique hauls from 150 m depth or from 5 m above the bottom were made with 60 cm Bongo at stations 30 nautical miles apart. The Bongo assembly consisted of one net of 0.505 mm mesh size and the other of 0.333 mm . The Bongo net was equipped with a 2 ft fin-depressor and towed with a speed of two knots. As shown on Fig. 1 a total of 38 stations were worked with the Bongo. The material will be analysed by dr. Nellen, Kiel University.

Acoustic survey

The acoustic equipment onboard "G.O. Sars" is listed in Table 1. As a routine program the three integrators were connected with the 38 kHz Simrad Scientific Sounder. During the first phase of the cruise the channels were adjusted to integrate in 25 m depth slices down to 100 m, while the two last channels were integrating from 100-249 m and from 250-449 m. For comparison with other frequencies (120 kHz) and side transducer, slightly different settings were adapted occasionally, particularly in shallow waters when the channels set for deeper waters were "free".

The echo intensities were logged by data recorder per nautical mile and an average per five nautical miles were plotted.

As a routine procedure the echo recordings were analysed every day for correction of false echoes and separation of integrated echo intensity into plankton and fish. Whenever possible the recordings were also separated into pelagic and bottom fish.

The "G.O. Sars" is equipped with satellite navigation system which proved most useful. On an average positions were fixed every third hour. The British charts used were lacking in details and at times incorrect.

EXPLORATORY FISHING

For identification of echo traces and sampling the ichthyofauna frequent trawl hauls were made using either pelagic trawl or bottom trawl (Fig. 1). The characteristics of the three trawls used were as follows:

The mesh size for all the trawls are in accordance with international regulations in the North Sea and/or Arctic, but for sampling small fish a covering net in the cod end was used.

Small pelagic trawl (Harstad trawl): The square opening of the trawl is 117.2 m around, each side 29.3 m. Covering net in the cod end with mesh size 1.4 cm stretched meshes (0.7 cm bar).

Small bottom trawl (soft bottom only): Trawl used for industrial fishing in the North Sea (maximum mesh size allowed is 55 mm). Opening of the trawl, around, is 1300 meshes of 40 mm (= 52.0 m). Covering net in the cod end with mesh size 2.0 cm stretched meshes (1.0 cm bar).

Granton trawl (large bottom trawl with bobbins): Opening of the trawl, 42.7 m groundrope, 29.9 m headline. Covering net in the cod end with mesh size 2.0 cm stretched meshes (1.0 cm bar).

The entire catch of each haul was measured in baskets. Depending upon the size of the catch, up to ten baskets were kept for sorting, weighing and biological samples. The standard procedures followed were as recommended for the CINECA multi-ship survey.

SUMMARY OF RESULTS

Physical oceanography

The aim of the hydrographic program was more to obtain a general picture of the environment in relation to fish distribution than to go into detailed studies of any specific problem.

The temperature distribution in the surface layer, at 20 m depth, during the period 2 - 18 November is illustrated in Fig. 2. It is seen that the typical upwelling features are demonstrated by isotherms more or less paralled to the coast with decreasing temperatures towards the shore. These features are most pronounced in the area around Cape Blanc and Cape Timiris where temperatures below 17^{o}C were observed. The

salinity at 20 m depth is shown in Fig. 3, and demonstrates decreasing salinities towards the coast.

The vertical distribution of temperature and salinity in the upper 200 m along 24°N is shown in Fig. 4. It can be seen that the thermocline is more developed at some distance from the coast than in the area with more intensive upwelling over the continental slope and shelf. In this area, at depths above approximately 50 m, the isolines incline more or less vertically towards the surface. Similar features are typical for all the short sections that were worked off the coast. This is illustrated in Fig. 5 and 6 which show the conditions along 18°40'N and 14°00'N.

The correlation between the distribution of zooplankton and the oceanic stratification was in many cases well demonstrated by the echo recordings, particularly in the southern part of the survey area. Fig. 7 shows the recordings at a pelagic trawl station south of Cape Verde, and it is clearly seen that the plankton, and the fish (mostly mackerel) were found only in the upper layer down to a depth varying between approximately 30 and 45 m. Hydrographic data from the same region show that this depth corresponds to the depth of the transition layer, and the plankton and the fish were therefore mainly concentrated in the mixed layer above the thermocline. Internal waves at the transition layer were very pronounced and is clearly demonstrated by the echo recordings of plankton as shown in Fig. 7 and 8. The amplitudes of the internal waves varied between approximately 10 and 50 m. This is also in good agreement with the observed variation of the depth of the thermocline at the hydrographic stations.

Chemical/Biological Oceanography

The surface distributions of phosphate and silicate, and the dissolved oxygen at 10 m depth are given in Fig. 9, 10 and 11. In Fig. 12 particle distributions are indicated by the attenuation factor of red light at 5 m depth, and Fig. 13 demonstrates

the chlorophyll a distributions at the same depth. The primary production rates per liter, Lux and hour based on the laboratory incubator measurements, and the integrated primary production rates per day and square meter based on the simulated in situ measurements are given in Fig. 14 and 15. It is pointed out that the incubator measurements reported are not corrected for diurnal variations in photosynthesis, and the results are only a brief preliminary indication on the conditions. A model for the above corrections are developed and will later be applied on the material.

A brief evaluation of the combined observations on nutrients and phytoplankton stock together with its productivity, reveals clearly areas of upwelling and interesting features in its dynamics. It is thus observed that "new" upwellings are characterized with high silicate content and low phytoplankton stocks and primary productivity, whereas "old" upwellings show the inverse relationship.

Acoustic survey

A preliminary analysis of the values recorded by the integrators have been made. Fig. 17 shows the relative fish abundance as indicated by integrator deflection obtained from the 38kHz echosounder during the first phase of the cruise. To smoothen the data, five points moving average were calculated and on the basis of the plotted points isolines have been drawn.

The integrator channels were adjusted to integrate in 25 m depth slices but as several species showed marked diurnal vertical migration it proved difficult to split the integrator values according to demersal and pelagic fish. In Fig. 17 is therefore given total fish abundance only.

Three areas of high relative fish abundance were found, off Cape Blanc, off St. Louis and south of Cape Verde mainly off Gambia. Exploratory fishing showed that in the Cape Blanc region horse mackerels (Trachurus trecae and T. trachurus) and sardines (Sardina pilchardus) were most abundant. Off St. Louis, horse mackerel together with anchovy dominated, while off

Gambia most of the schools observed were probably sardinella.

On the return survey during the period 21 November to 6 December the regions of high relative fish abundance were studied in more detail. Fig. 18 shows the integrator deflection obtained off St. Louis, separated into pelagic and demersal fish. The high concentrations in the southern part consisted mainly of anchovy while horse mackerel dominated further north. During the same period the pelagic fishing expedition "Astra" operated at about 18°N and had very good catches of large horse mackerel (Trachurus trachurus).

Fig. 19 shows the relative fish abundance off Cape Blanc. As demonstrated in the figures the highest abundance was recorded close to the coast or along the edge of the continental shelf, while the area with lower fish abundance was recorded in the central part of the shelf. This seems to be a general feature all along the coast of Mauretania. In the Cape Blanc region good concentrations of Sardina pilchardus were found particularly near the coast.

The values plotted in Fig. 17, 18 and 19 are based on both day and night recordings. An overall estimate of day and night signals showed that the night signals exceeded the day signals in strength by a ratio of about 2.4 : 1.0. The day and night variability and sampling error were studied in more detail on anchor stations and by repetition of sections. The results of these studies will be reported separately.

Along the edge of the shelf where there are many canyons of various depths, the integrated deflections were affected by side echoes. The abundance of bottom or pelagic fish were always heavy along the edges of these canyons but the echo traces were often masked by dense layers of myctophids and euphausids at daytime in deep waters ascending rapidly to the surface at sunset.

The allocation of integrator values on fish and plankton were

therefore often problematic. Fishing experiments for identification of the echo traces were frequently made but because of gear selection and avoidance of the net the catch rate and composition may not be representative for the echoreadings. Fast swimming species such as sardinella and the larger horse mackerel proved very difficult to catch with pelagic trawl and the catch rate of these species are definetely not representative for the echoreadings.

Exploratory fishing

The location of the trawl stations is given in Fig. 1. Altogether 30 hauls were made with pelagic trawl and 25 with bottom trawl. The average catch with bottom trawl was 1.3 tons per hour, as compared with 0.7 tons per hour with pelagic trawl. It should be noted that the fishing was primarily made for identification of the echorecordings including recordings of myctophiids and plankton which generally only yielded small catches. Further analysis of the catch data as compared with estimates of relative fish abundance from the acoustic survey will be reported later in a separate paper.

The composition of the catches showed a great diversity of species. The catch per hour of fish separated according to families and areas are given in Table 2. The catch with pelagic trawl was dominated by Carangidae and Myctopidae while Sparidae was the most abundant group in the bottom trawl catches . The large percentage of Myctophids as given in Table 2 is mainly due to one haul which yielded 4.6 tons.

Altogether about 160 different fish species from 74 families were represented in the catches. The largest number of species, about 100, were found in the southern area (between 13°N and 16°N). In the middle area (between 16°N and 20°N) 70 species were found, while 88 species were found in the northern area (between 20°N and 25°N. About 40 species were caught in all areas.

The length frequencies of all the samples of the most important pelagic species are given in Fig. 20. For comparison are also given frequency data from catches taken with purse seine by the "Astra" expedition during the same period.

As shown in Table 3 Trachurus trecae was the most numerous species and the greatest numbers were caught in the southern area with bottom trawl. The length groups 11-17 cm dominated in all the samples but with an increasing mean length northwards. As shown in Fig. 20 only a few fish larger than 20 cm were caught with trawl. Catches taken with purse seine by the "Astra" expedition during the same period consisted exclusively of large fish and were dominated by length groups 36-42 cm.

The greatest numbers of Trachurus trachurus was caught with pelagic trawl in the northern area (between 20°N and 25°N). The length groups 14-19 cm dominated but also a few fish between 22-27 cm were caught. The fish caught with purse seine in the same period, mainly in the middle area (between 16°N and 20°N) were much larger, around 36 cm.

Caranx rhonchus was most numerous in the northern and middle areas and only large specimens were caught. The fish taken with purse seine were of similar lenght (Fig. 20).

Lichia vadigo was caught in small numbers in all areas. Trachurus picturatus were found in the northern area, Lichia amia in the middle area and Caranx senegalus, Decapterus punctatus, Lichia glauca, Vomer setapinnis and Scyris alecandrinus in the southern area.

Sardina pilchardus was the most numerous clupeid fish in the catches (Table 3), but was only caught in the northern area, and mainly with bottom trawl. The length distribution of the catches from bottom trawl and pelagic trawl differ considerably. Only small fish, 12-15 cm, were caught with the bottom trawl while the catches taken with pelagic trawl also contained fish

with modes at 15.5 and 21.5 cm. With pelagic trawl Sardinella aurita were caught in nearly the same numbers in all areas, but the bottom trawl catches were far the biggest in the southern area.

The pelagic trawl catches consisted mainly of fish larger than 20 cm, while the bottom trawl mainly caught fish smaller than 18 cm. The catches taken with purse seine by the "Astra" expedition (Fig. 20) were dominated by fish above 25 cm indicating that the purse seines are mainly exploiting the larger fish.

Apart from a few specimens caught at one trawl station in the northern area all Sardinella eba were caught in the southern area, and the greatest catch was taken with bottom trawl. In the samples from the pelagic trawl catches, all the fish measured 11-13.5 cm, while in the bottom trawl catches the fish were 7-15 cm.

No other clupeid fishes were found in the samples.

Anchoa guinesis was the only engraulid fish caught. This specie was caught in all areas. The highest number caught with pelagic trawl in the southern area (Table 3) refers to one haul consisting of 1.3 tons of Anchoa. The fish caught with pelagic trawl measured 9.5-13.0 cm with a mode at 10 cm, while the fish at the bottom were 8-14 cm long with a mode at 11.5 cm.

Scomber colias were caught in all areas, but was most abundant in the samples from the northern area. The length of the fish in the samples from the pelagic trawl was 20-26 cm with a mode at 22.5 cm, while the bottom trawl samples consisted of fish 22.5 -26.0 cm with a mode at 24 cm.

In the northern area sparid fish contributed with 38.1 % of the bottom trawl catches (Table 2). The most abundant species were Diplodus senegalensis with 19.1 % of the catches, Dentex macrophthalmus and D. polli with 7.7 % and Pagellus coupei

with 4.4 %. Also pomadacyid fishes were numerous. Pomadacys incisus contributed with 9.8 % of the catches and Diagramma mediterransus with 3.4 %. In one haul taken in the northern area Capros aper amounted to 5.4 % of the catch.

In the middle area hake, which amounted to 30.2 % of the bottom trawl catches, was most numerous. Sparid fishes constituted only 16.7 % of the catches, dominated by Pagellus coupei 8.9 % and Dentex macrophthalmus and D. polli 6.5 %.

Also in the southern area sparid fishes were numerous and contributed 26.8 % of the catches (Pagellus spp. 15.9 %, Boops boops 5.1 % and Dentex spp. 4.9 %). However, the most numerous species in the southern area was the pomadacyid fish, Brachydeuterus auritus, which contributed with 24.0 % of the bottom trawl catches. This species must, however, be characterized as semipelagic since it was numerous also in the pelagic catches and contributed 13.9 % of the catches taken in the southern area.

Table 1. Acoustic equipment on board R/V "G.O. Sars".

Type	Make	Year	Freq.	Transd.	Graphic range (m)	Flash displ.	Stab.	Power	Digit displ.	Other relevant information
a) Survey sonar	SIMRAD	1970	18 kHz	12° x 10° 12° x 20°	0-250-500-1250-1750-2500-3500	Yes	Yes	3-4kW-6-8kW	No	Hull mounted transd.,streamlined dome.
b) SK 120 Sonar	SIMRAD	1970	120 kHz	4° x 4°	0-125-250-500	Yes	No	1 kW	No	Hull mounted transd.
c) Scient.Sounder	SIMRAD	1970	38 kHz	5.0° x 5.5° 4.5° x 30° 30° x 4.5° 20° x 10° 20° x 18.5°	0-125-250-500	Yes	Yes Yes Yes No No	10 kW extra transm.	No	External recorder for range expansion.
d) Scient.Sounder	SIMRAD	1970	12 kHz	14° x 17°	0-250-500-1000-2000-4000	Yes	No	10 kW extra	Yes	
e) Scient.Sounder	SIMRAD	1970	50 kHz	25° x 5° 25° x 10°	0-125-250-500	Yes	Yes	1.0 kW	No	
f) Scient.Sounder	SIMRAD	1970	120 kHz	4° x 4°	0-125-250-500	Yes	Yes	1.0 kW	Yes	

All scientific sounders have three phased intervals for each basic range. On board there are three two-channels echointegrators which may be connected to any one of the scientific sounders.

Table 2. Catch per hour in kg for some families caught by R/V "G.O. Sars" on the cruise to West Africa November - December 1972.

	PELAGIC TRAWL								BOTTOM TRAWL							
	20°N - 25°N		16°N - 20°N		13°N - 16°N		Total		20°N - 25°N		16°N - 20°N		13°N-16°N		Total	
	c/h kg	%	c/h kg	%	c/h kg	%	c/h kg	%	c/h kg	%	c/h kg	%	c/h kg	%	c/h kg	%
Clupeidae	70.9	5.6	4.6	2.9	0.9	0.2	30.5	4.4	65.1	5.4	1.5	0.2	75.1	4.5	53.0	4.1
Engraulidae	0.3	+	+	+	185.7	44.6	59.2	8.5	0.1	+	2.7	0.3	+	+	0.7	0.1
Carangidae	430.1	33.9	119.6	76.5	83.2	20.0	235.0	33.9	182.9	15.2	350.0	37.4	327.5	19.5	269.3	20.8
Scombridae	29.4	2.3	0.3	0.2	+	+	12.1	1.7	8.4	0.7	-	-	1.0	+	4.0	0.3
Myctophidae	524.7	41.3	10.0	6.4	50.4	12.1	233.4	33.7	9.6	0.8	-	-	-	-	4.2	0.3
Bramidae	133.3	10.5	5.0	3.2	-	-	55.9	8.1	0.1	+	-	-	-	-	+	+
Sparidae	0.6	0.1	0.2	0.1	+	+	0.3	+	458.2	38.1	156.3	16.7	453.5	26.8	384.2	29.7
Merluccidae	-	-	+	+	-	-	+	+	14.5	1.2	282.6	30.2	9.4	0.6	77.2	6.0
Pomadacyidae	-	-	1.1	0.7	57.7	13.9	18.7	2.7	158.2	13.2	27.0	3.1	409.6	24.2	207.6	16.0
Others	79.0	6.3	15.6	10.0	38.3	9.2	48.8	7.0	305.5	25.4	113.2	12.1	412.0	24.4	293.4	22.7
Total	1268.3		156.3		416.3		693.9		1202.6		935.3		1688.1		1293.6	

Table 3. Catch per hour in number for some pelagic species caught by R/V "G.O. Sars" on the cruise to West AFrica in November - December 1972.

Species	Pelagic trawl				Bottom trawl			
	20°N - 25°N	16°N - 20°N	13°N - 16°N	Total	20°N - 25°N	16°N - 20°N	13°N - 16°N	Total
Sardinella aurita	13	12	12	72	+	44	1 201	395
Sardinella eba	-	-	8	3	+	-	524	168
Sardina pilchardus	499	-	-	217	3 472	-	-	1 528
Anchoa guinensis	38	8	18 750	6 540	14	244	1	65
Caranx rhonchus	96	93	5	64	109	2	4	50
Trachurus trachurus	4 600	-	-	1 999	366	1	20	168
Trachurus trecae	3 002	1 582	3 037	2 705	1 768	12 825	13 388	8 140
Scomber colias	121	2	1	53	50	-	8	25

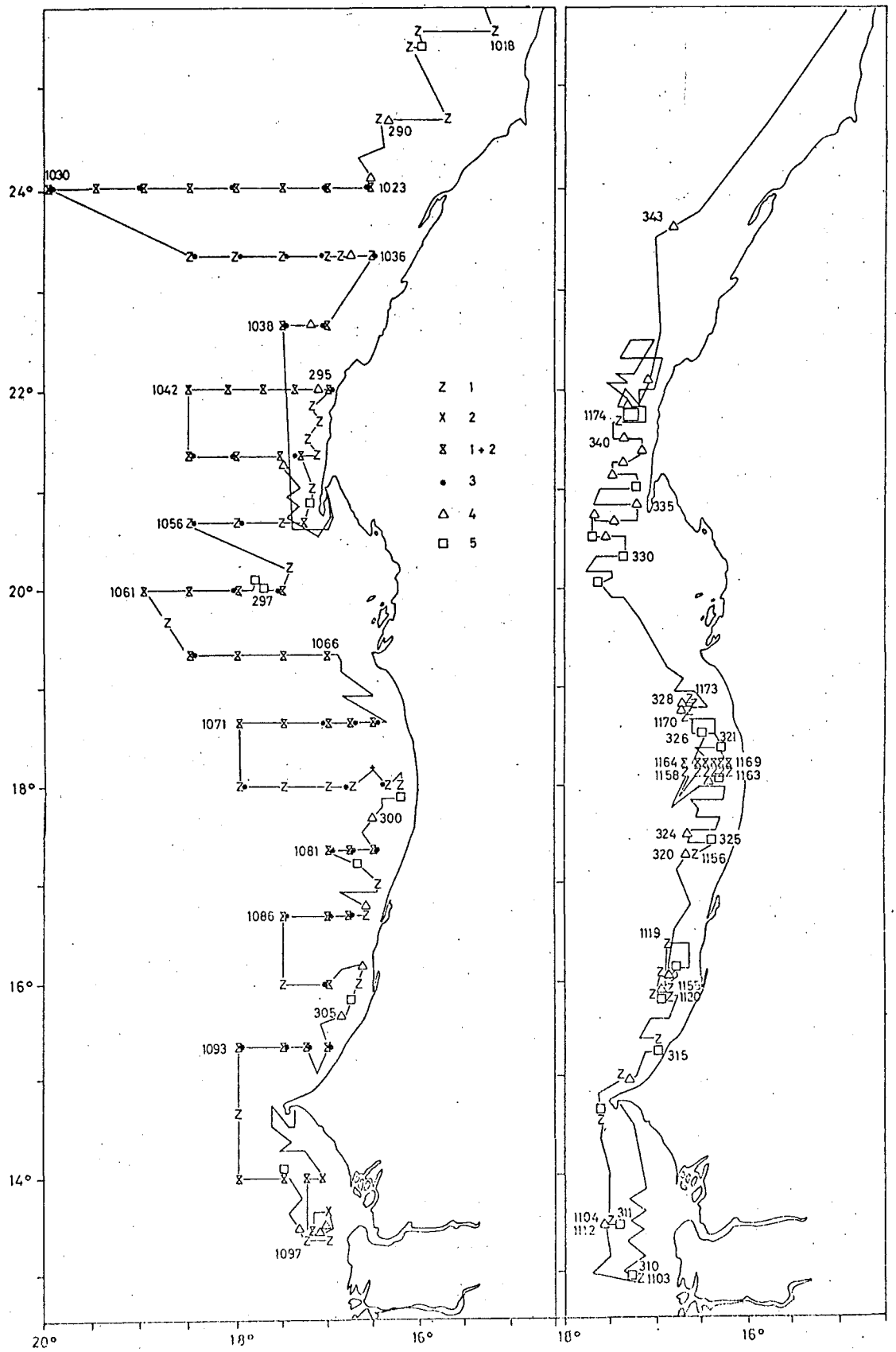

Fig. 1. Survey routes and stations. 1) STD sonde, 2) Nansen cast, 3) Bongo net, 4) pelagic trawl, 5) bottom trawl.

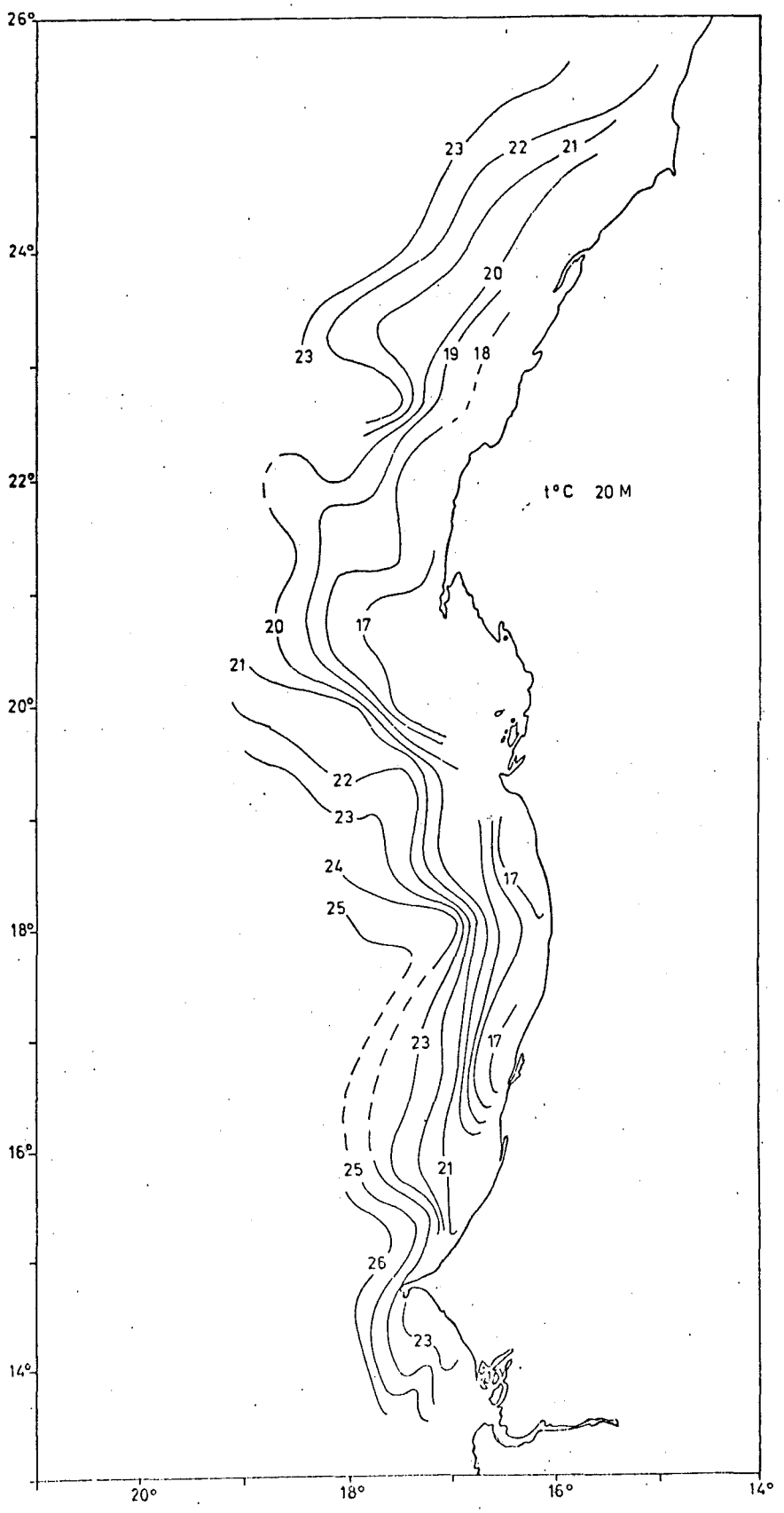

Fig. 2. Temperature, t°C at 20 m, 2-18 November 1972.

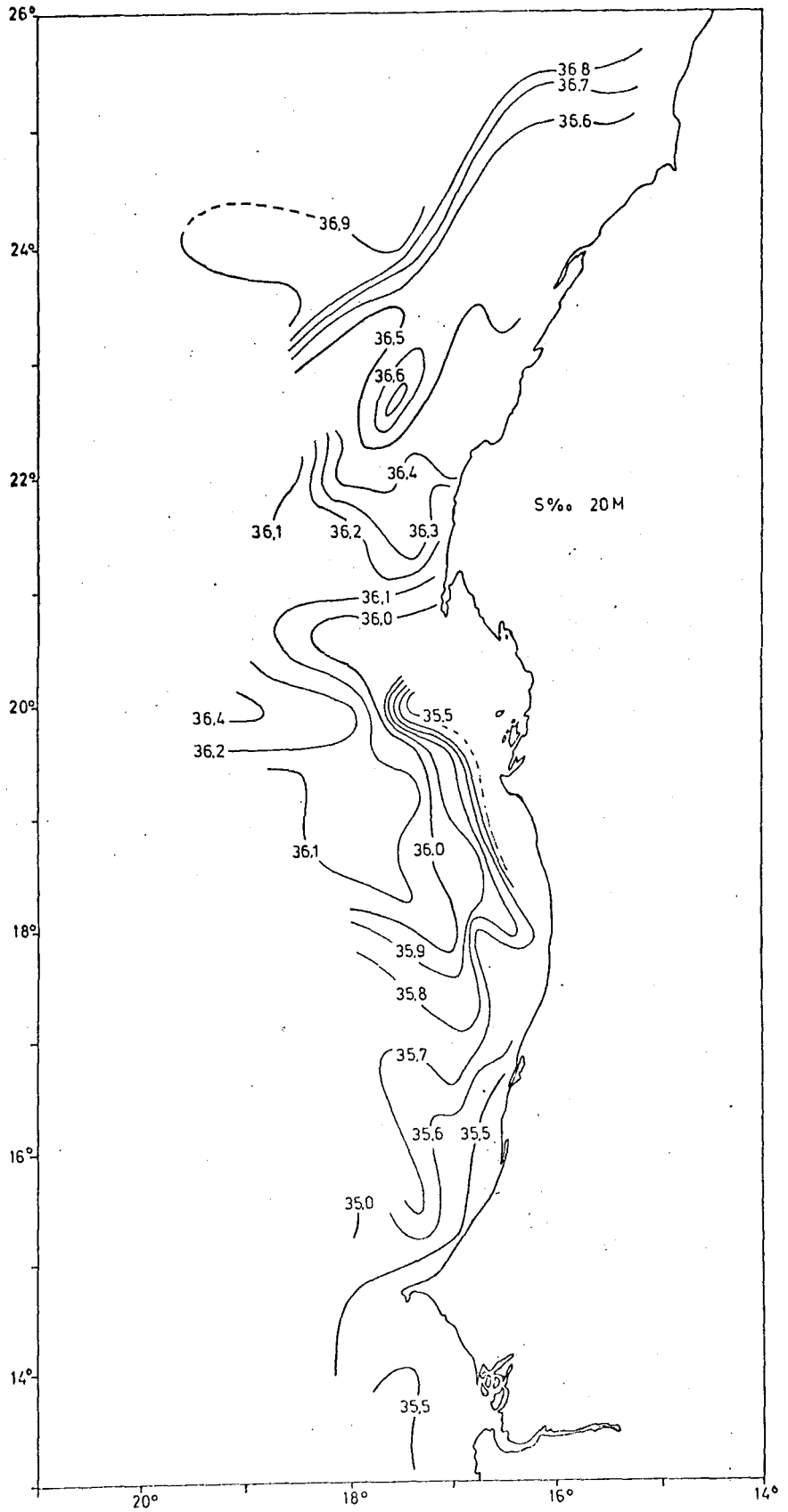

Fig. 3. Salinities, S °/oo at 20 m, 2-18 November 1972.

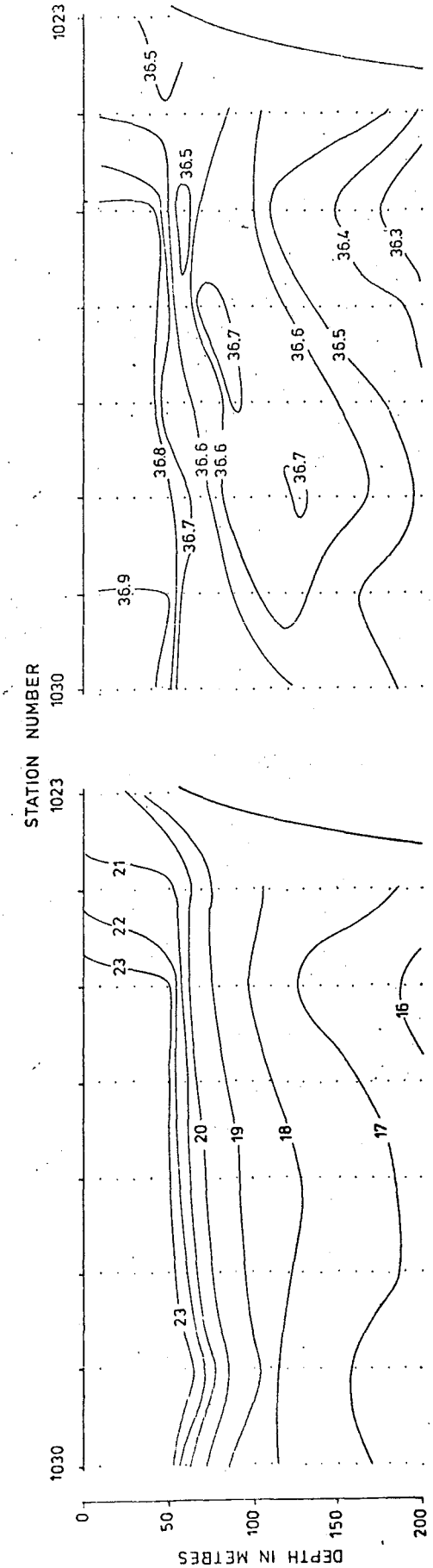

Fig. 4. Profiles of temperatures, t^{o}C, and salinities, S $^{o}/_{oo}$, along 24^{o}00'N.

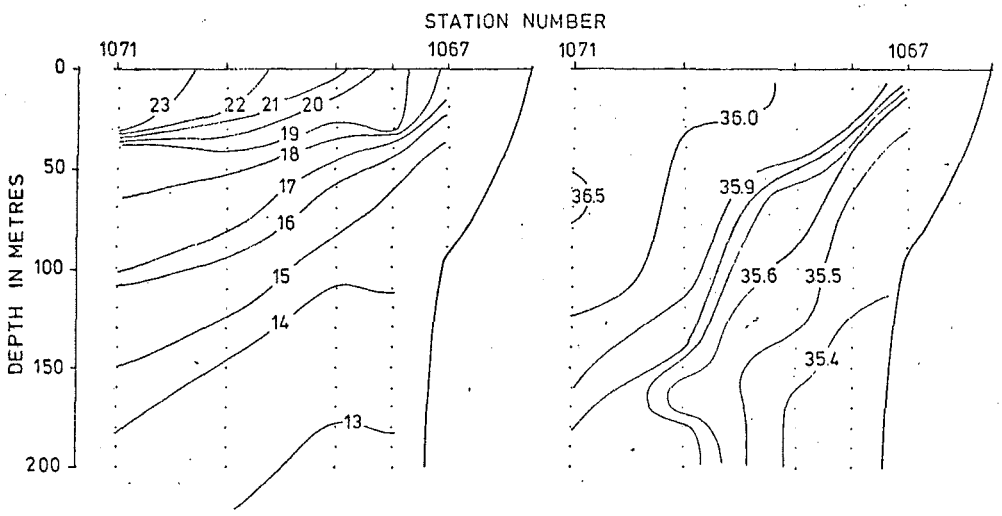

Fig. 5. Profiles of temperatures, t°C, and salinities, S °/oo, along 18°40'N.

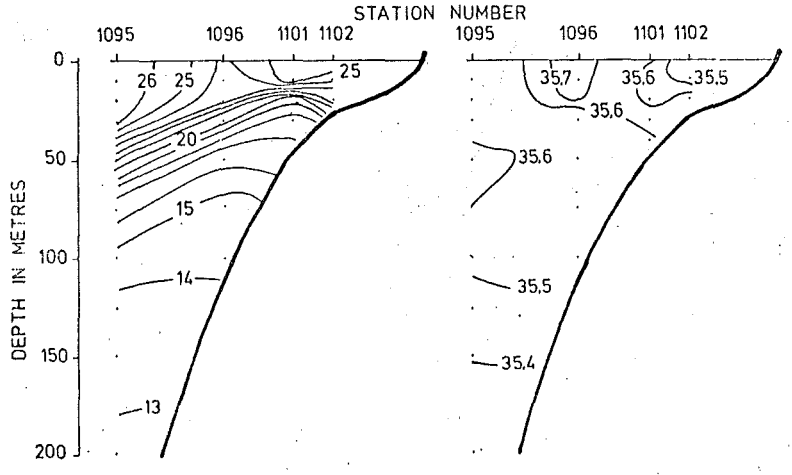

Fig. 6. Profiles of temperatures, t°C, and salinities, S °/oo, along 14°00'N.

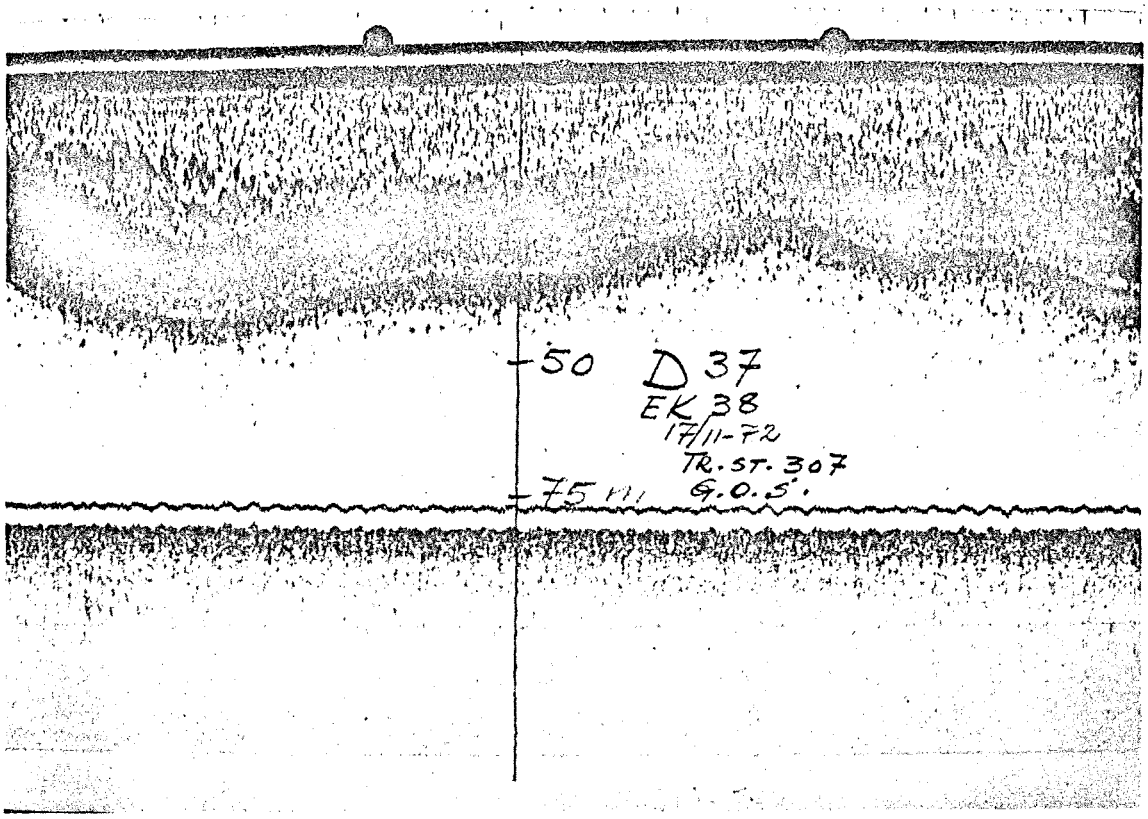

Fig. 7. Echo recordings south of Cape Verde (Simrad echo sounder 38 KHz).

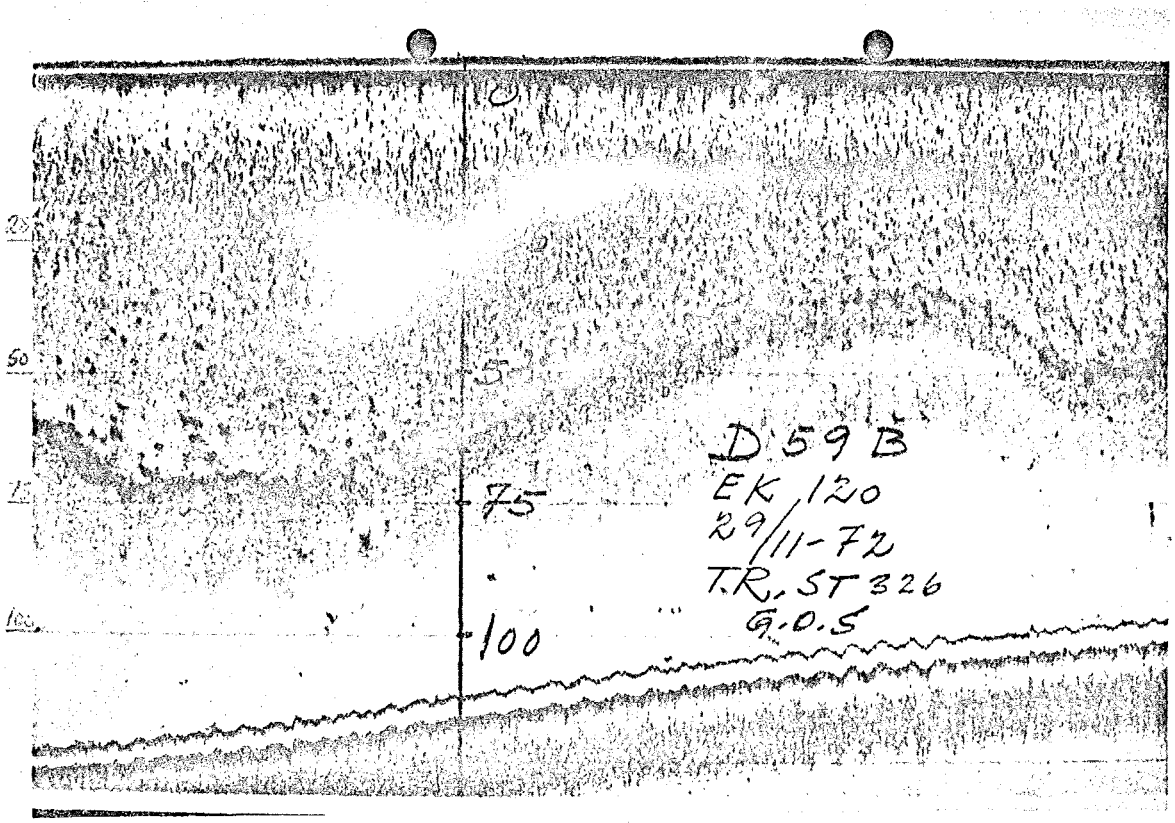

Fig. 8. Echo recordings south of Cape Verde.

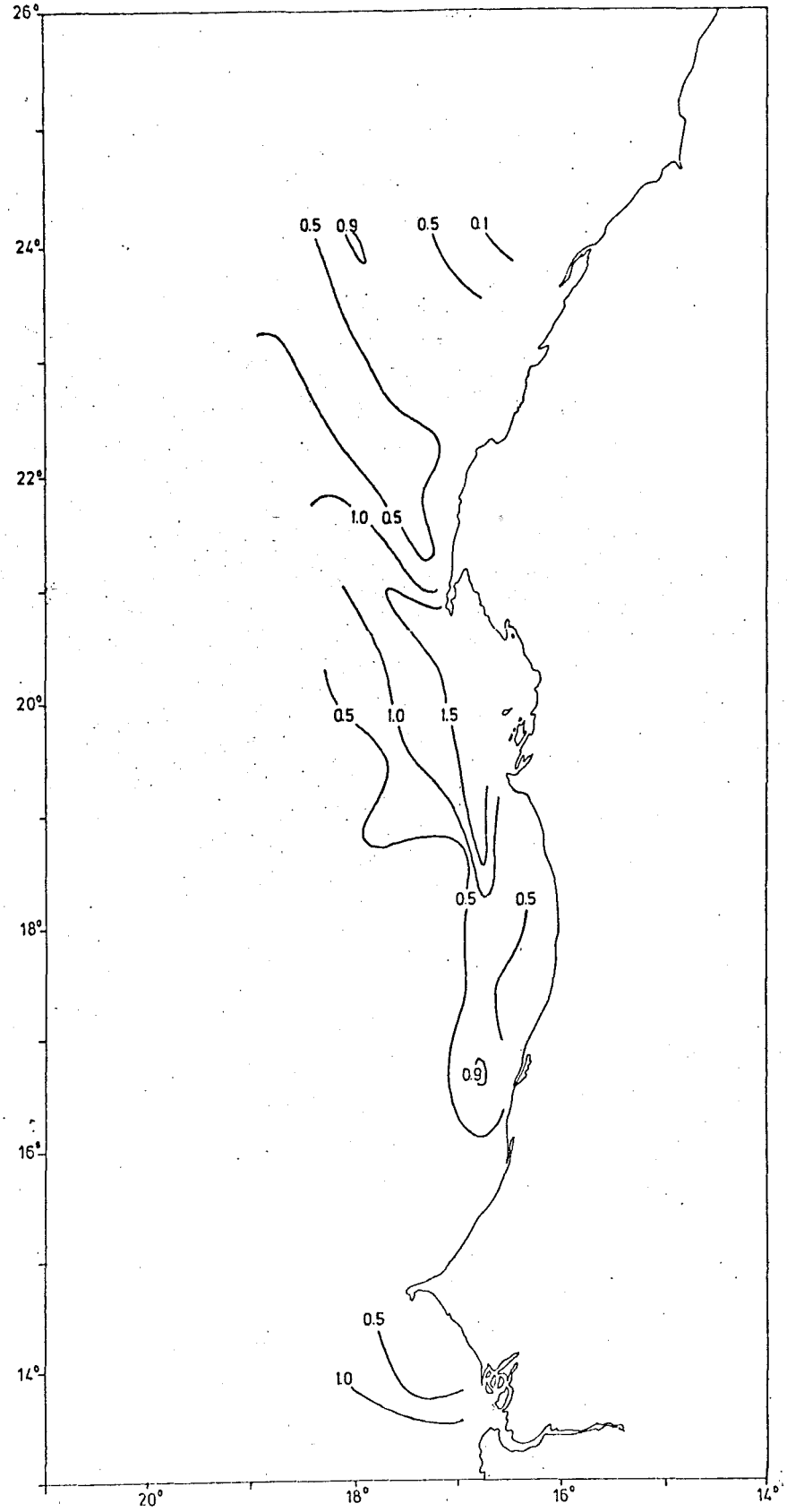

Fig. 9. Distribution of µg-at PO_4-P/l in 0 m.

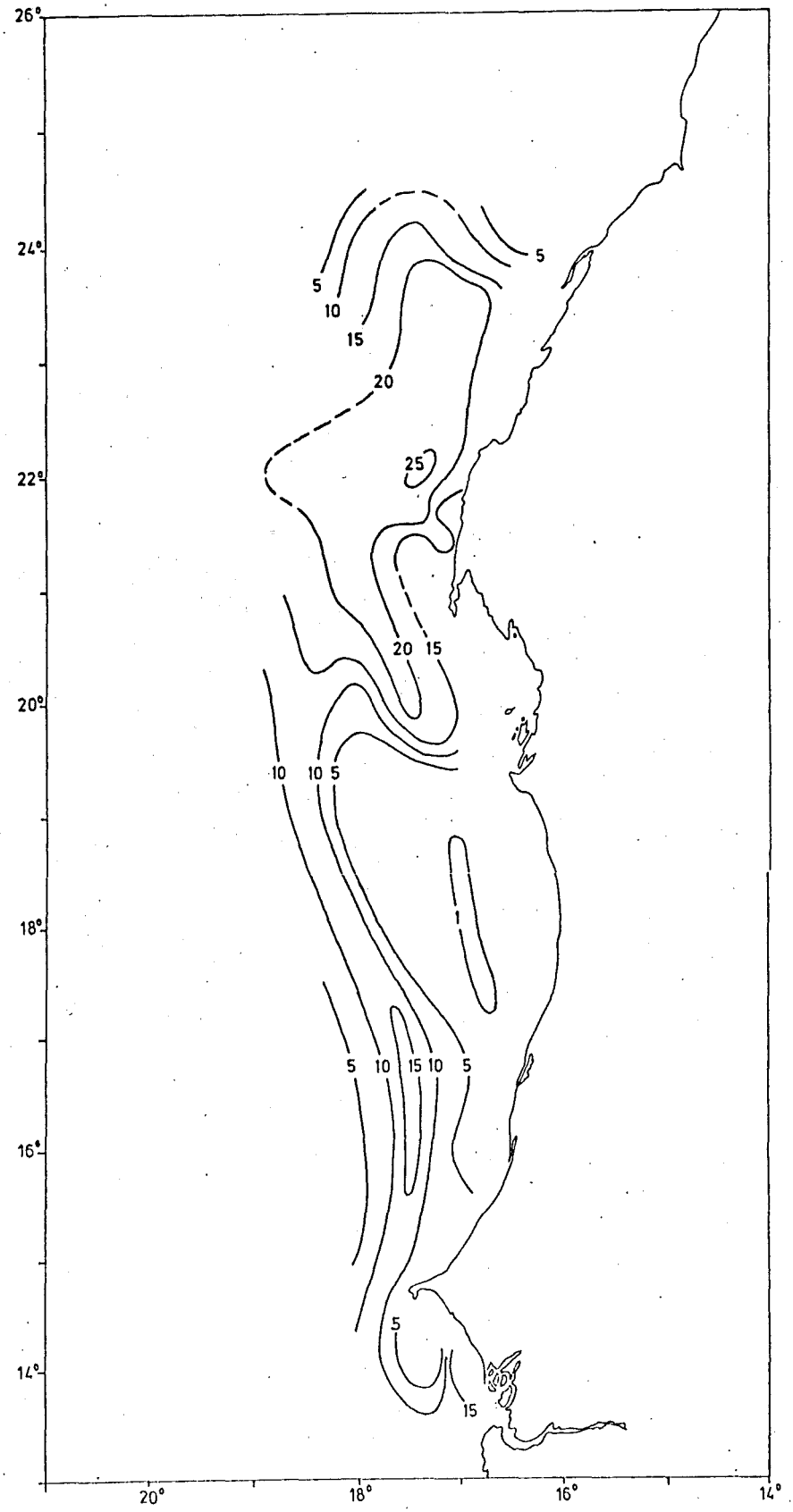

Fig. 10. Distribution of µg-at Si/l in 0 m.

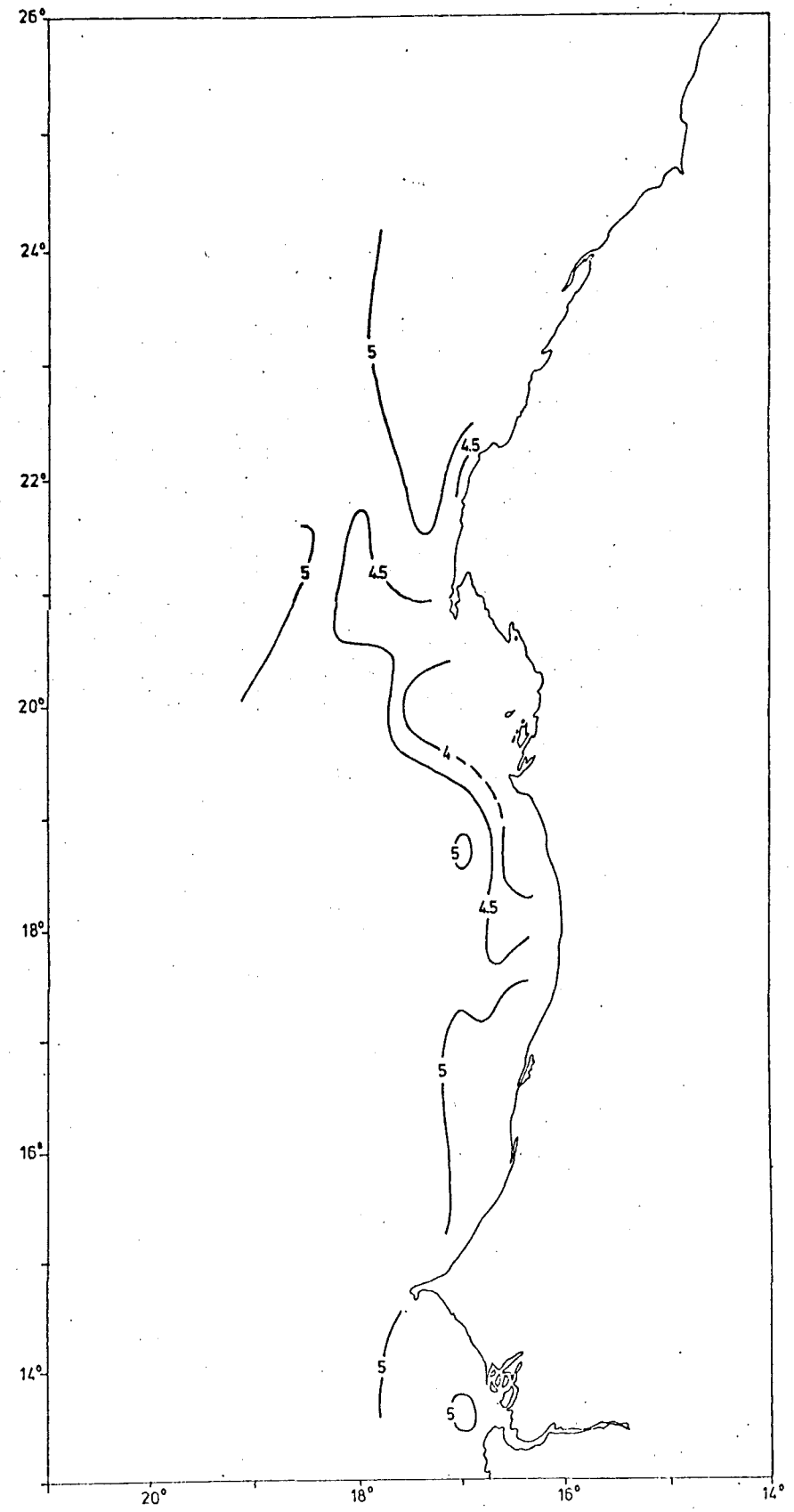

Fig. 11. Distribution of O_2 ml/l in 10 m.

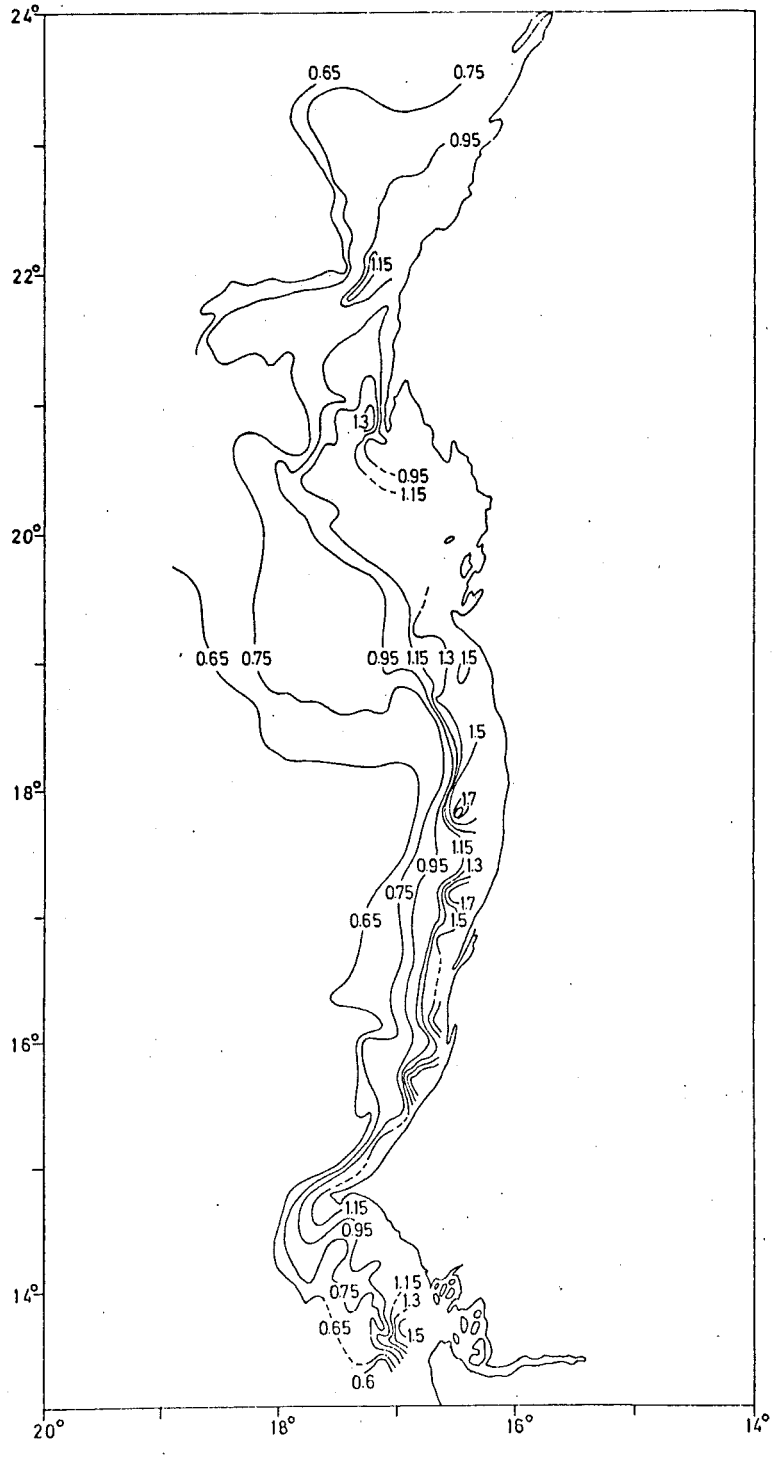

Fig. 12. The particle distribution in 5 m.

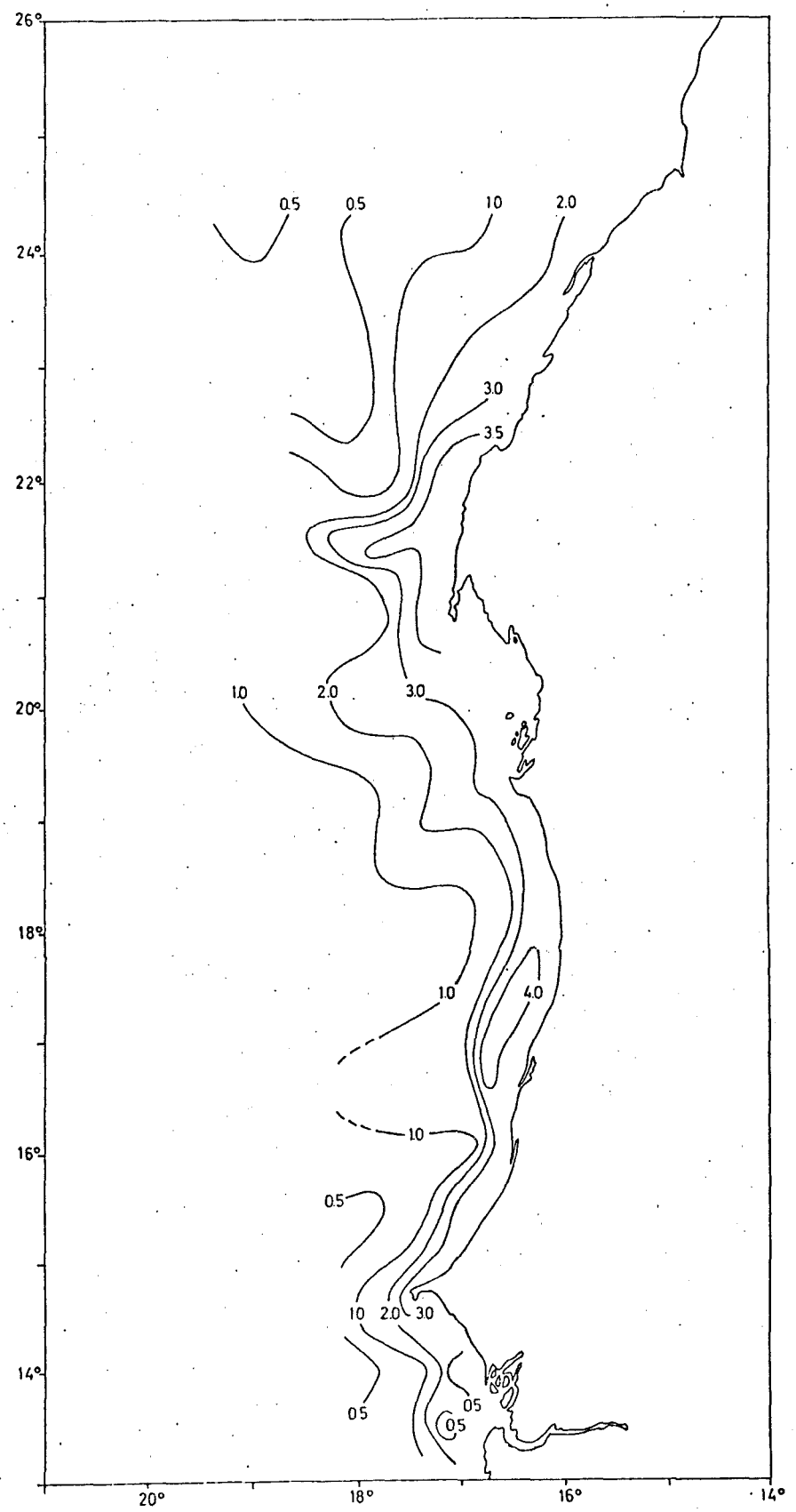

Fig. 13. The chlorophyll a distribution.

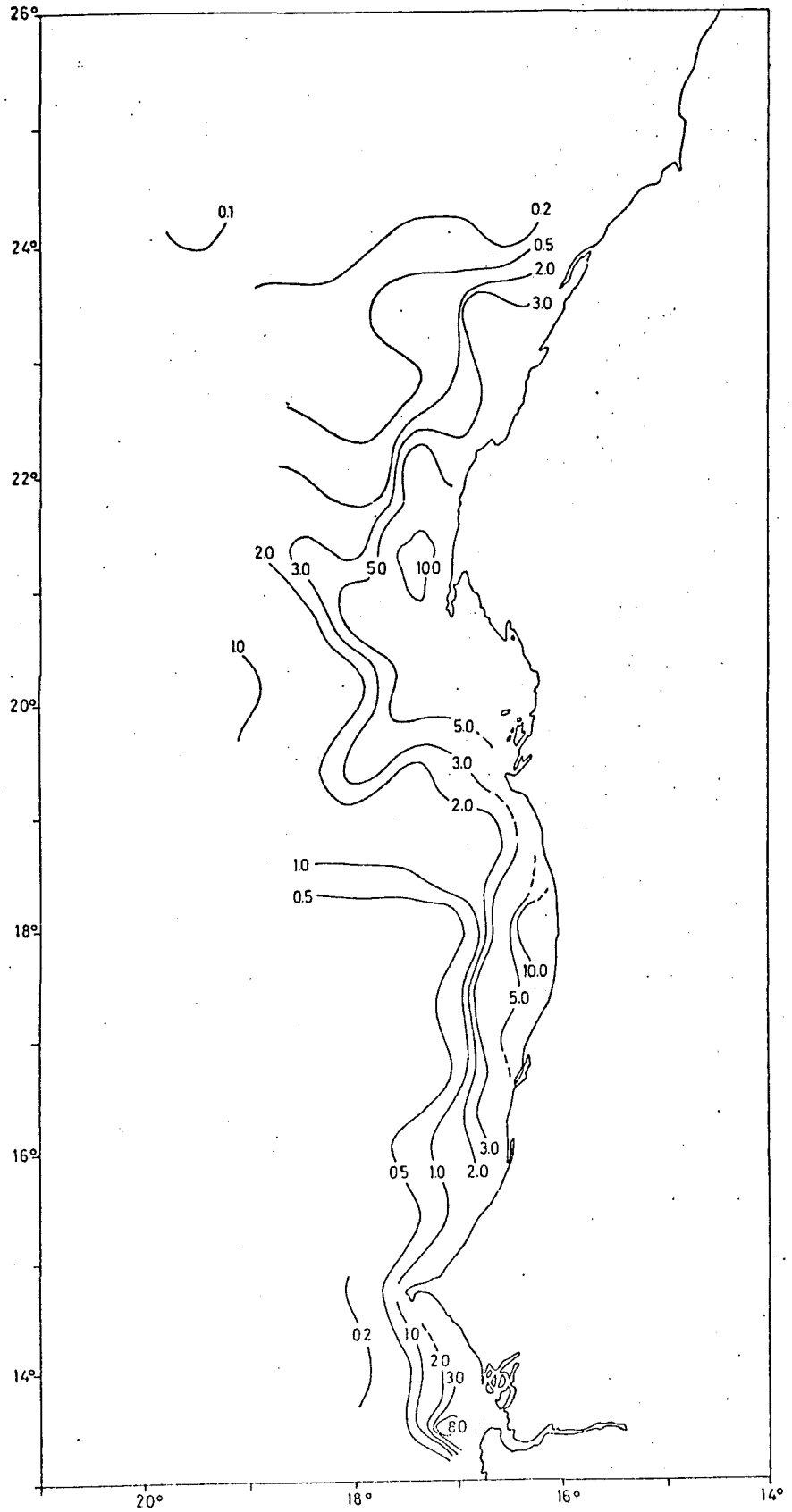

Fig. 14. Primary production rates per litre, lux and hour.

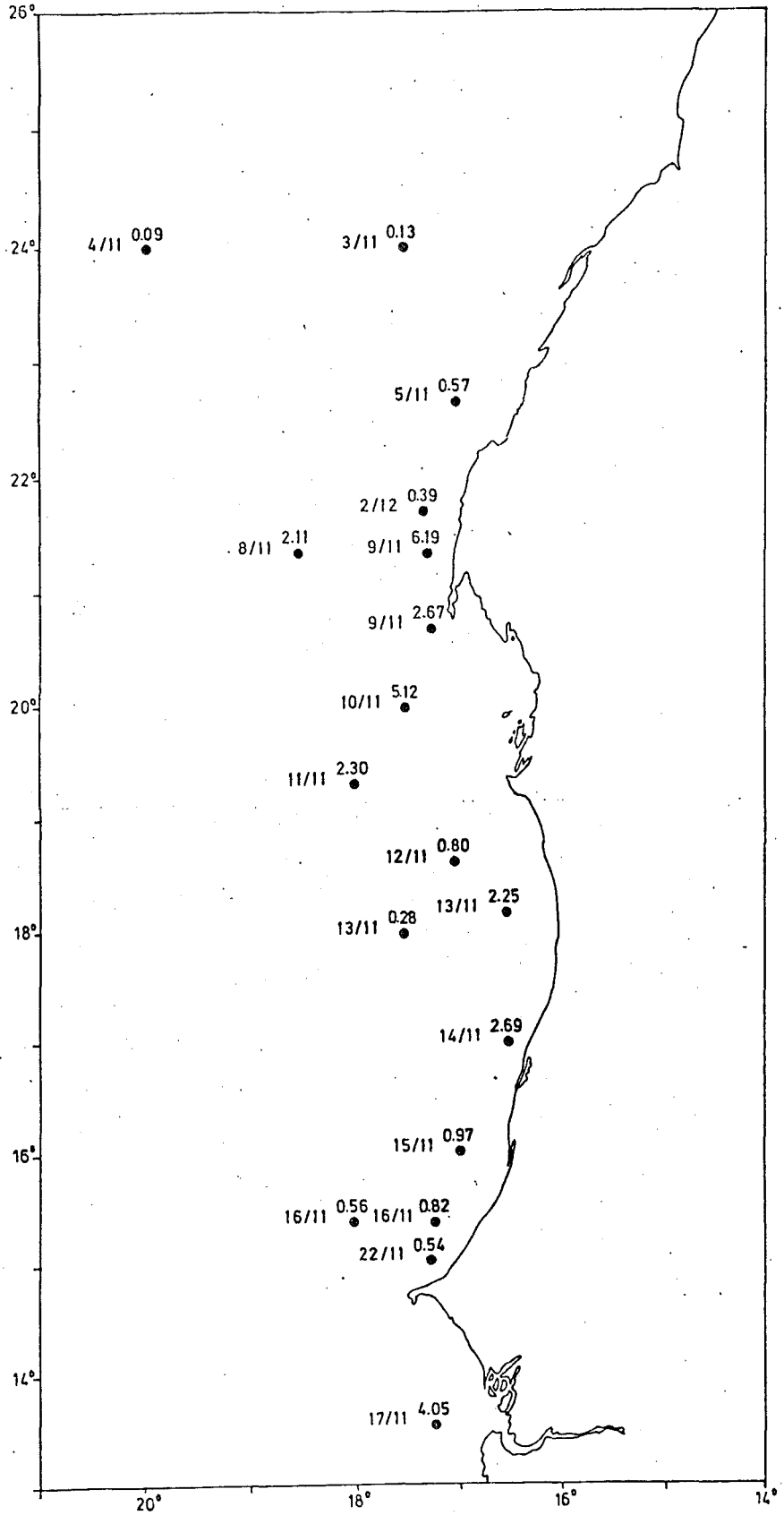

Fig. 15. Primary production g C/m^2 based on simulated in situ measurements.

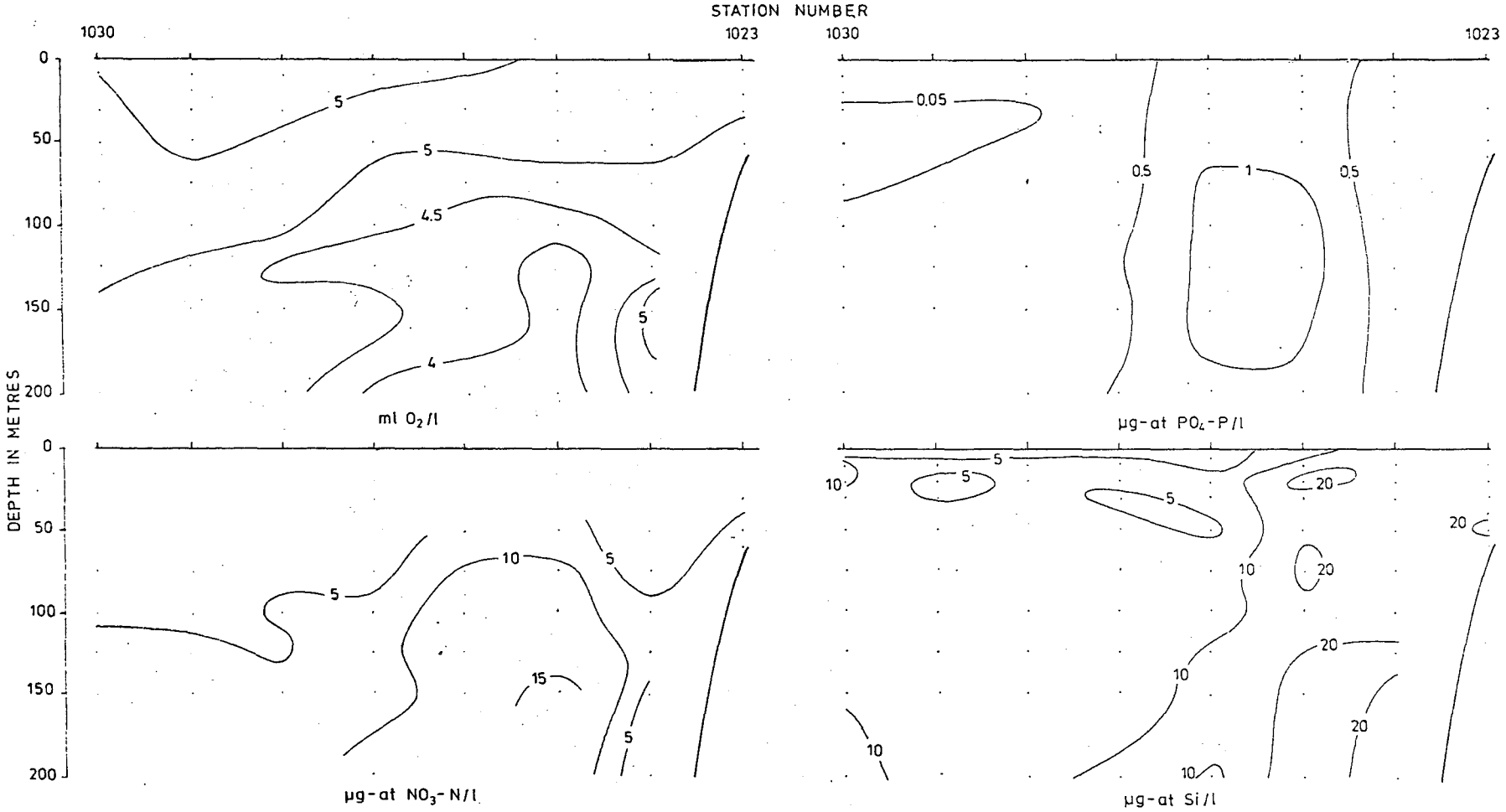

Fig. 16. Profiles of dissolved oxygen, ml O_2/l, phosphate, µg-at PO_4-P/l, nitrate, µg-at NO_3-N/l and silicate, µg-at Si/l at 24°00'N.

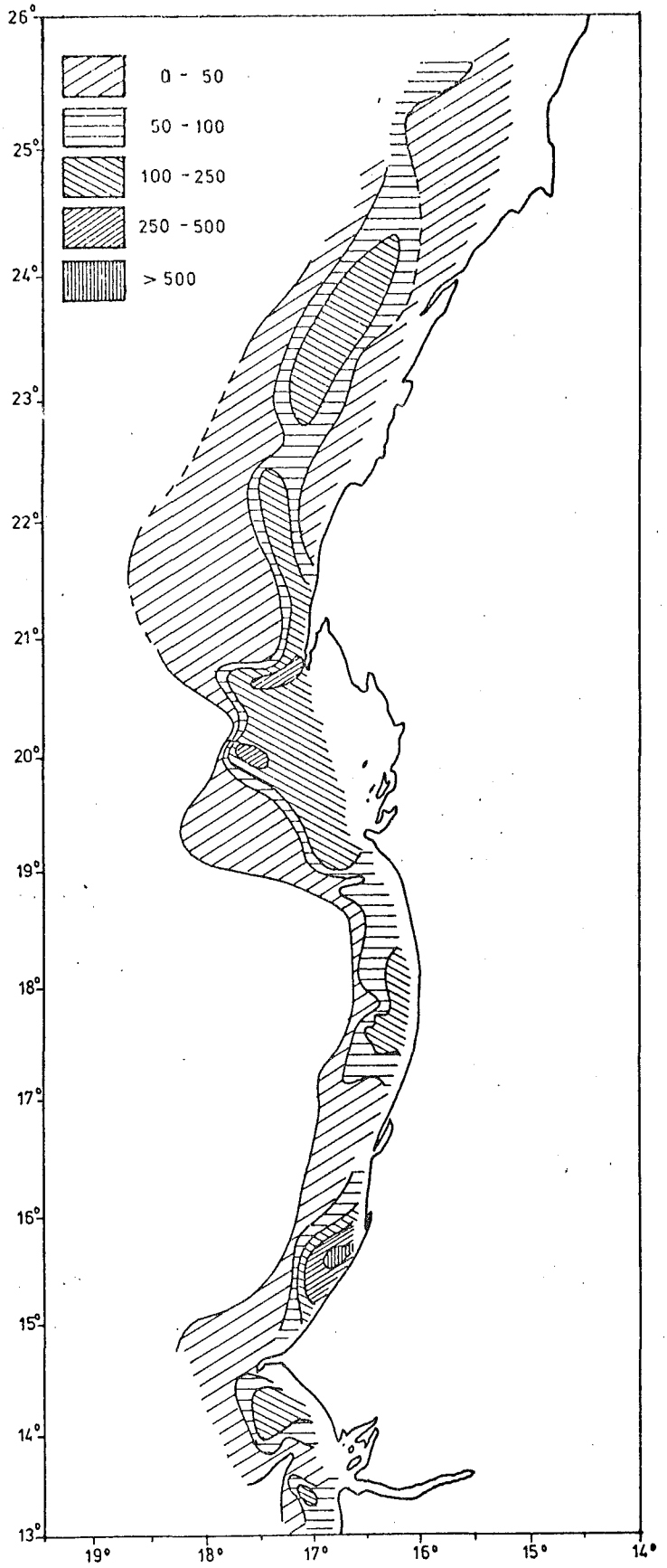

Fig. 17. Fish abundance. Relative units estimated from echo integrator.

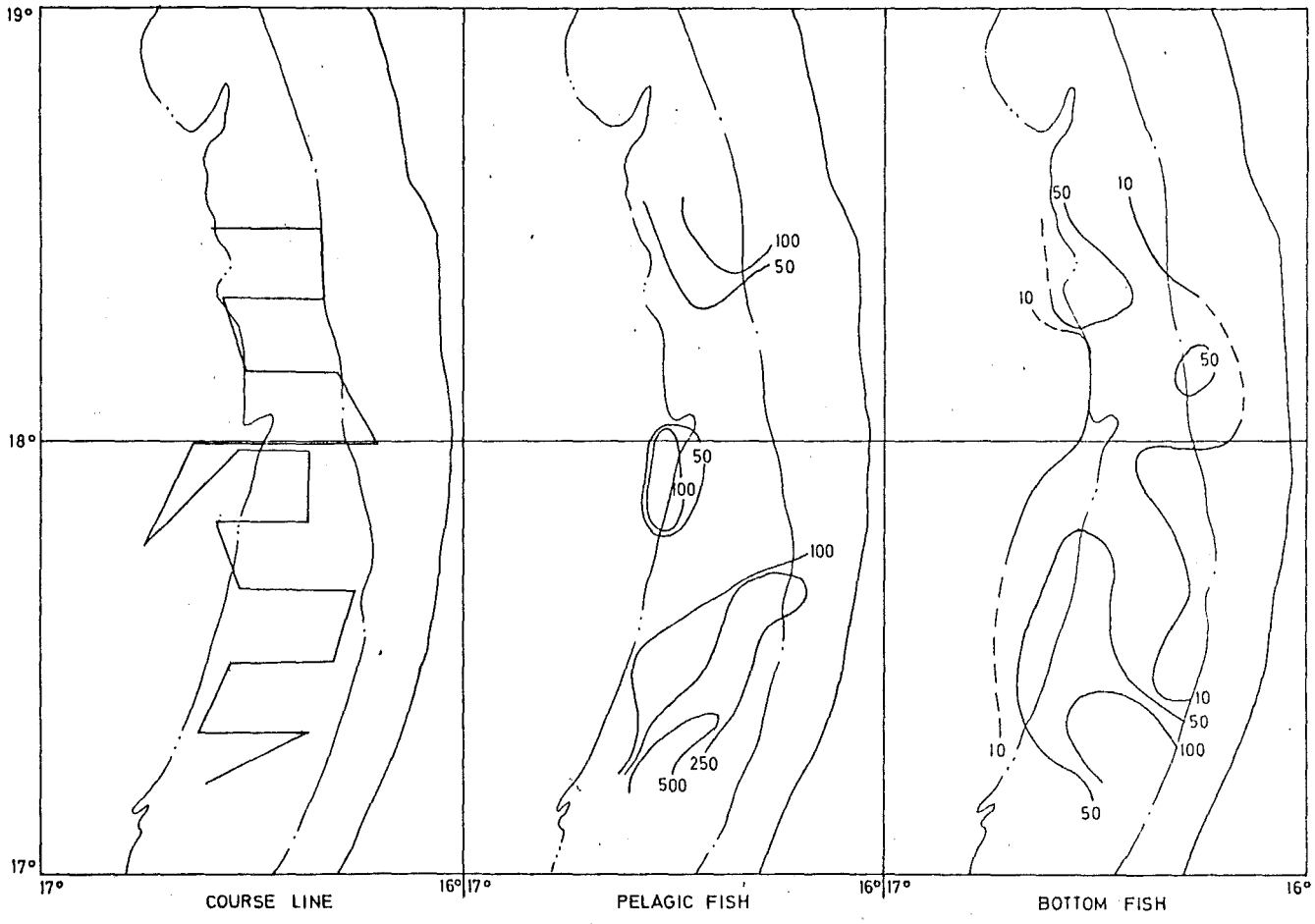

Fig. 18. Abundance of pelagic and demersal fish south of Cape Timiris, 25-26 November 1972.

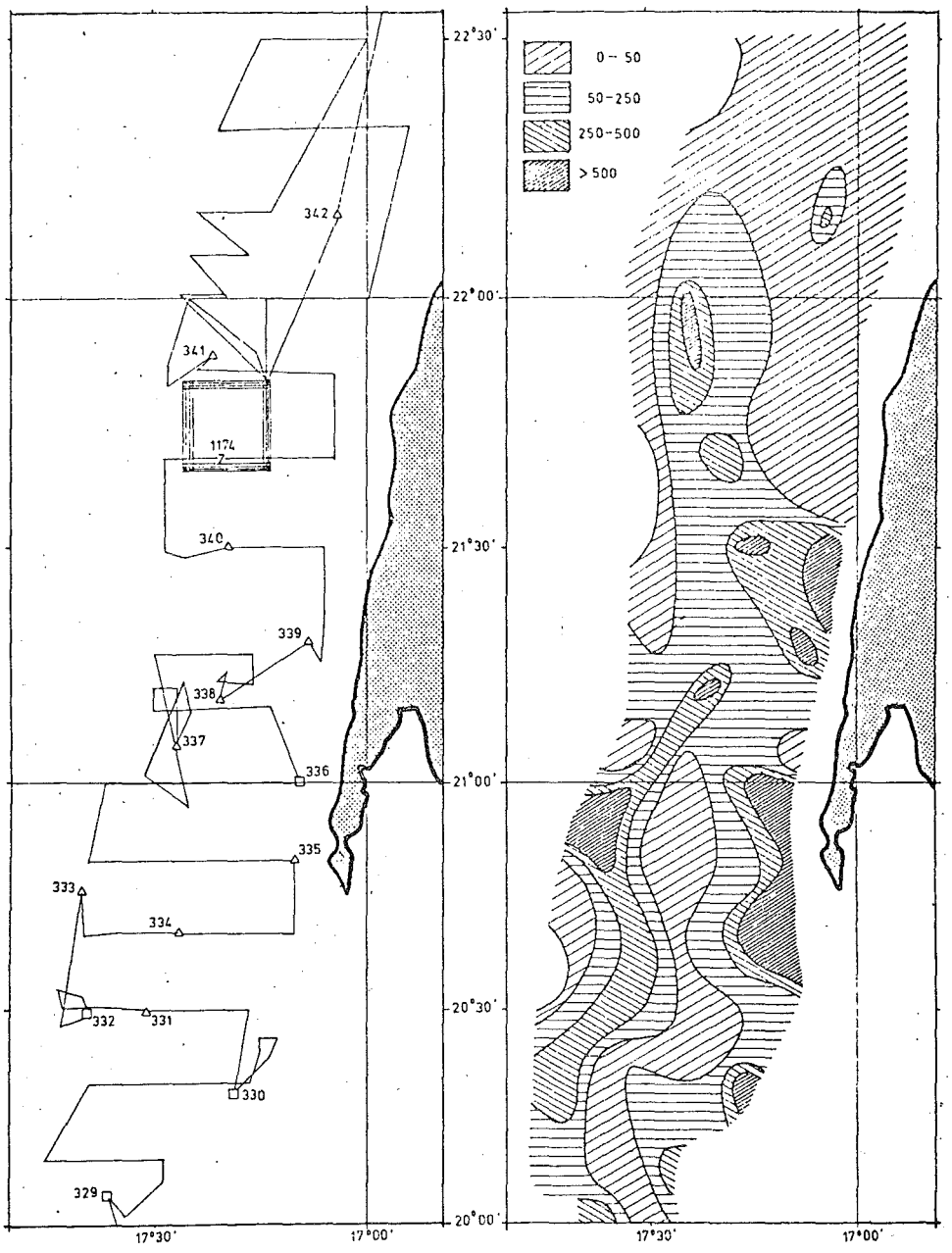

Fig. 19. Fish abundance off Cape Blanc. Relative units estimated from echo integrator.

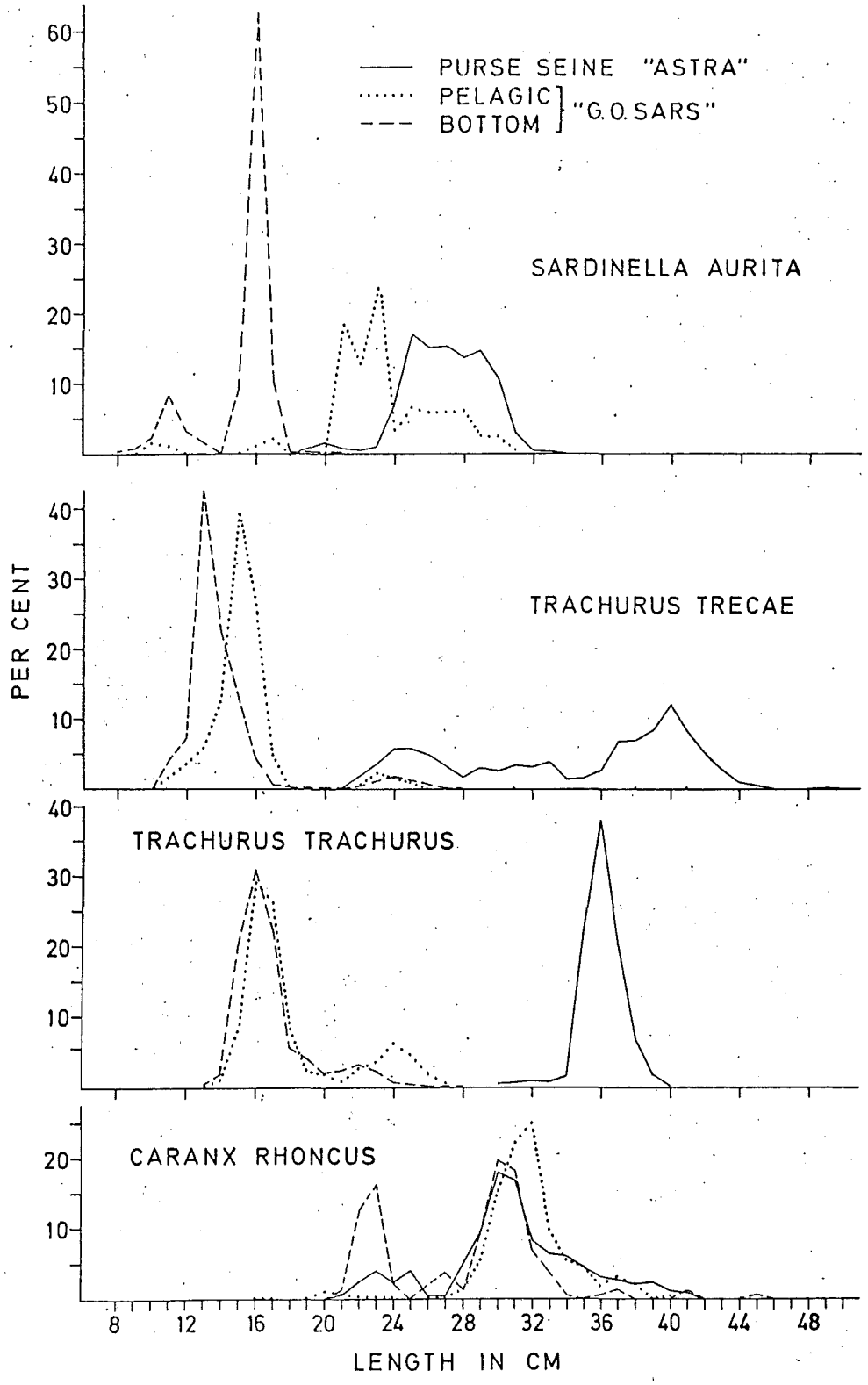

Fig. 20. Length distribution of sardinella and horse mackerel in samples from pelagic trawl, bottom trawl and purse seine, November - December 1972.