1 INTRODUCTION

1.1 OBJECTIVES

The main purpose of the survey was the same as that of the previous survey; to provide as much information as possible about the composition, distribution and abundance of the components of resources covered by the survey methodology. The main emphasis was on providing the best possible estimates of the biomass of the small pelagic fish in the various regions by individual stocks. The second priority was a swept area trawl survey for demersal species conducted by depth strata. In addition some test hauls for hake down to about 400 m of depth was carried out. The hydrographic programme comprising surface temperature distribution and profiles in standard positions was likewise carried out as before.

The second survey follows the same procedure as the foregoing survey and was done in order to support the analysis of the results from the first survey and allow for evaluation of seasonal effects.

1.2 PARTICIPATION

The scientific staff from CIP, Luanda was:

Until 28 August: Filomena Vaz-Velho, Maria de Sardinha,
Geraldina Salvador, Gizela Ramos, Francisco Almeida,
Tomatima M'Bengui.
From 28 August: Jose Constanca Lourenco, Antonio Vunge,
N'Kossi Luyeye, Kumbi Kilongo N'Singui, Antonio Buco, Pina Fernandes.

The scientific staff from IMR was:

Else Torstensen (until 28 August), Tore Strømme (from 28 August),
Helge Ullebust, Åge Høynes, Martin Dahl and Magnar Mjanger.

1.3 NARRATIVE

The vessel called on Luanda 5 August for embarking scientific crew and left in the afternoon 6 August, heading for the northern border of Angola. The sampling programme consisted of acoustic transects approximately 10 nm apart, and with semi-random swept area hauls carried out during daylight hours. Between Cabinda and Luanda four hydrographic sections were sampled; off Pta de Moita Seca, Cabinda, Ambriz and Luanda. The three latter sections are standard CIP transects.

The work progressed ahead of schedule, and the shelf down to Pta de Morro was surveyed before the vessel called on Luanda on 28 August for change of crew and refuelling. On 29 August the survey proceeded covering again the shallow waters between Pta das Palmeirinhas and Pta do Morro, where sardinellas had been observed during the previous coverage. The work continued southwards with the standard grid pattern.

During the transfer of the vessel from Walvis Bay to Luanda before the start of the survey, the crew observed surfacing schools in oceanic waters about 60 nm north-west of Cabo de Santa Marta. During the southward survey about 24 hours were spent in this area without tracing any pelagic fish.

Between Namibe and Tombua horsemackerel were observed close to the bottom, and a detailed survey net were laid out. The vessel passed Tombua on 8 September. The area between Tombua and Cunene was surveyed more intensively with transects 5 nm apart, and when major concentrations were found, these were resurveyed.

Baia dos Tigres held, as during the previous survey, dense concentrations of pilchard. These were covered both day and night in a detailed survey net with 1nm-readings from the integrator. The acoustic equipment was calibrated in Baia dos Tigres on 11 September. Three hydrographical profiles were worked out south of Pta das Palmeirinhas; off Lobito, Namibe, and Baia dos Tigres. The section off Nabibe is not a standard section, but were done on basis of verbal reports of environmental anomalities in the area. The vessel arrived in Walvis Bay on 18 September.

1.4 SURVEY EFFORT

The cruise track with fishing stations and hydrographic sections are shown in Figure 1a-c. The survey effort can be summarized as follows:

	Swept-area hauls 0-200 m	Swept-area hauls 200-600 m	Other hauls	Distance surveyed
Cabinda-Luanda	64	25	12	2 300 nm
Luanda-Benguela	44	13	12	2 600 nm
Benguela-Cunene	48	2	5	2 000 nm

2 HYDROGRAPHY

Six hydrographic sections were worked during the cruise. Their position are shown in Figure 1a-c. In addition, surface temperature was recorded by the vessel's thermograph at 4 m depth (Figure 2a-c).

The surface temperatures in coastal waters has declined considerably since the previous cruise in May-June, and was around 19°C between Pta. da Moita Seca and Benguela. This is 2-3° lower compared to August 1985, the only other Nansen-survey from the same season in Angola. Southwards from Benguela the coastal temperature decreased gradually to 14°. The Benguela front reached halfway between Tombua and Namibe.

The oxygen values in the surface and sub-surface coastal waters have declined considerably since the last survey, though in most cases the values are not likely to limit the distribution of fish. The hydrographic profile off Lobito, however, shows the 2 ml/l oxycline raising almost to the surface, and that the shelf area from about 30 m bottom depth and downwards are covered with waters with less than 1 ml/l oxygen content. The total absence of sardinella between Cabeca da Baleia and Benguela should be interpreted in this context. Also during the August survey in 1985 the same oceanographic features were registered and there was likewise no sardinella registered in the area.

3 DISTRIBUTION AND ABUNDANCE OF PELAGIC FISH FROM THE ACOUSTIC SYSTEM

The unit of acoustic reflection used by the echo integrator is m^2/nm^2 reflecting surface. In the maps (Figure 4-6) the integrator units have been divided by 10 to allow comparison with the maps from the 1985, 1986 and 1989 surveys. An arbitrary scale has been used to illustrate different levels of density. The integrator values were allocated to the standard groups Pelagic fish type 1 (clupeids and anchovies) and Pelagic fish type 2 (carangids, scombrids, barracudas and hairtails).

3.1 CABINDA - LUANDA

Figure 4 shows the distribution of the Pelagic fish type 1 in this region. There were no sardinellas detected north of the Congo River. South of the Congo sardinella were registrated in most of the coastal waters, especially between N'Zeto and Luanda. These occurrences were heavily mixed with large-eye grunt *Brachydeuterus auritus*, making the separation of the integrator values complex. Close to the shelf edge scattered occurrences of sardinella were registrated at several locations (Figure 4). During the August survey in 1985 similar offshore registrations of sardinella were located off Pta da Moita Seca. It is unclear whether the sardinella close to the shelf edge are in a feeding area or in a migratory phase.

The size compositions of the pooled samples of the two sardinella species from the area of main distribution, Ambriz to Luanda, show exclusively adult fish bigger than 20 cm, see Annex II.

Biomass estimates based on judged integrator readings and assuming a target strength similar to that of North Sea herring (TS = 20 log l-72) gives the following results:

Coastal registrations	105 000	tonnes
Offshore registrations	49 000	"
Total	154 000	tonnes

This is close to 30 000 tonnes or 30% higher than the estimate from the previous survey. In addition, considerable registrations of surface schooling sardinella were visually observed north of Luanda. These were not detected by the acoustic system and the above estimate is thus an underestimate.

Pelagic fish type 2, mostly Cunene horse mackerel, were found in bands close to the shore and close to the shelf edge, see Figure 4. Most registrations were scattered, but off Pta das Palmeirinhas a dense concentration was found. The single and very dense schools in the map located off N'Zeto and Ambrize, are probably not the only ones in the area. Due to their very limited area distribution, these schools are not all detected, but are only represented statistically in the total estimate.

Biomass estimates from the integrator readings gives a total of 35 000 tonnes of which about 5 000 tonnes is from hairtail and the remaining 30 000 is mainly horse mackerel. The offshore registrations make up 45% of the total estimate with the remaining 55% in the coastal zone. The dense to very dense areas make up 57% of the total.

The pooled size samples of the horse mackerel, see Annex II, show a predominance of young fish. Two, maybe three cohorts of modal lengths 6, (15) and 18 cm make up the main part of the catch, while bigger fish are sparsely represented. This is the same picture as during the previous survey, except that a new cohort has now entered into the catches. The youngest cohort from 4 to 9 cm makes up 50% of the biomass estimate in numbers, but only 2.6% in weight, and has a considerable growth potential. Due to the selectivity of the trawl gear the youngest cohort's share of the total biomass is probably significantly underestimated.

3.2 LUANDA - BENGUELA

Figure 5 shows the distribution of pelagic fish type 1, nearly all sardinella, from Luanda to Benguela. Most of the sardinella was found in the coastal waters between Pta das Palmerinhas and Pta do Morro. Sampling indicated a predominance of flat sardinella in most of the region as it made up 75% of the sardinella catch.

A striking feature is the absence of sardinella in the southern part, between Cabeca da Baleia and Benguela. This is probably related to the oceanographic conditions with large part of the shelf and the coastal subsurface holding waters with low oxygen content. It is unclear whether this low oxygen is due to penetration of water from the deep, or if it is due to

intensive production in the area. The same feature occurred in August 1985 which is the only survey of this season we can compare. At that time the sardinella were also absent from the area.

The size sampling, see Annex II, shows for both species mostly large sized fish between 25 and 35 cm of length, as during the previous survey. In the samples from the flat sardinella some younger fish were found, but generally there is no indication of younger cohorts recruiting for the sardinellas.

The biomass estimates give 65 000 tonnes between Pta das Palmeirinhas and Ponta do Morro and only 3 000 tonnes further south.

Figure 5 shows the distribution of the Pelagic type 2 fish. The registrations were from very scattered to scattered, and no major aggregations were located.

The size composition of the horse mackerels is shown in Annex II. Compared to the size distribution north of Luanda the Luanda-Benguela region shows absence of the strong young cohort 4 to 7 cm but has stronger components of fish beyond 25 cm.

Biomass estimates of horse mackerel give 70 000 tonnes for the region.

3.3 BENGUELA - CUNENE

Figure 6 shows that the distribution of pelagic fish type 1 in this region was restricted to the southern part. A major concentration was found in Baia dos Tigres, as during the previous survey. The concentration was covered with a special detailed survey grid. Conditions were very good for acoustic assessment and sampling. The biomass in the bay was estimated to 34 000 tonnes, which is 8 000 tonnes higher than the estimate from the May-June survey. North of the bay another concentration was found which is estimated to 31 000 tonnes. Between Baia dos Tigres and Cunene dense registrations of pilchard was found in the shallow waters. This aggregation was estimated to 66 000 tonnes. The total estimate on pilchard thus sums to 131 000 tonnes, signifying a major migration in the order of 100 000 tonnes in from Namibia since the May-June survey. The June estimate on pilchard in Angola was 26 000 tonnes, all from Baia dos Tigres. Sardine has been found in six of the nine previous surveys with estimates from 5 000 to 120 000 tonnes. The previous maximum estimate was from August 1985. The third quarter of the year, which corresponds to the northmost position of the Benguela front, also shows the peak presence of pilchard in Angola. The size composition with a modal length around 25 cm, see Annex II, indicates the presence of only one yearclass.

Due to rough weather conditions it was not possible to trawl-sample properly the southern concentrations south of Baia dos Tigres and north of Cunene, but they are assumed to belong to the same yearclass as the pilchard found more north.

The pelagic fish type 2 species are, as shown in Figure 6, widely distributed over the shelf to about 200 m of depth. The main species are the Cape and Cunene horse mackerels.

The size composition of pooled samples of the two horse mackerel species are shown in Annex II. The Cape horse mackerel consisted of medium sized and larger fish while there was also a component of juvenile fish of the Cunene species present. The size distributions are very similar to the ones recorded in the previous survey.

Biomass estimates from the acoustic observations gave a total of 195 000 tonnes, 95 000 for the Cape, and 100 000 tonnes for the Cunene species. The estimate on the Cape species is thus drastically reduced from 310 000 tonnes from the previous survey, while the Cunene species is estimated to the same stock size as previous. The sudden decline in the estimate of the Cape horse mackerel is probably due to an early return migration into Namibia. The Cape horse mackerel in Angola is just a fraction of the large stock in Namibia. Table 1 shows the time series of these estimates by surveys since 1985. The Cape horse mackerel is part of the Benguela Current ecosystem and migrates with the movement of the front. The abundance of Cape horse mackerel in Namibia was known to be high in 1990-1991.

Table 1. Cunene-Benguela. Estimates of the biomass of Cape and Cunene horse mackerels by surveys. 1 000 tonnes.

		Cape h.m.	Cunene h.m.	Total
Survey	1/85	170	30	200
"	2/85	75	55	130
"	3/85	220	50	270
"	4/85	270	70	340
"	1/86	40	130	170
"	2/86	10	30	40
"	1/89	125	35	160
"	2/89	135	25	160
"	3/89	240	170	410
"	1/91	310	100	410
"	2/91	95	100	195

4 RESULTS FROM THE TRAWL SURVEY, CATCH COMPOSITIONS AND SWEPT AREA BIOMASS ESTIMATES OF DEMERSAL FISH

4.1 CABINDA - LUANDA

71 swept area stations were successfully carried out. These were distributed as follows: 0-50 m 30 hauls, 50-100 m 25 hauls and 100-200 m 16 hauls.

The swept area estimates are shown in Annex I. Table 2 shows the mean densities by main groups. Red pandora and Angola dentex were most common among the seabreams and African weakfish and Cassava croaker among the croakers. One should note the high abundance of the big-eye grunt.

The total biomass of the demersal species with highest economic value is estimated to 36 000 tonnes. During the previous survey the corresponding estimate was 16 000 tonnes, which constitutes a drastic decline in the time series from 1985. With the recent estimate the commercial groundfish is back to the normal level of the period 1985-1989. The survey in May could have picked up an irregularity in the distribution pattern, with considerable parts of the stocks outside the surveyed area, perhaps in the very shallow waters or into Congo.

Table 2. Cabinda-Luanda. Mean densities and biomass estimates of main groups.

	Density t/nm²	Biomass 1 000 tonnes
Seabreams	2.11	16 500
Grunts*	0.37	2 900
Croakers	2.00	15 600
Groupers	0.12	940
Sum demersal val.	4.60	35 940
Big eye grunt	2.52	19 700
Horse mackerel	1.53	12 000
Other carangids	0.11	860
Barracudas		
Hairtail	1.06	8 300

* excluding big-eye grunt

4.2 LUANDA - BENGUELA

The shelf down to 200 m was covered with a total of 41 swept area hauls: 18 in 10-50 m, 13 in 50-100 m and 9 in 100-200 m. The swept area calculations are shown in Annex I and gives the density estimates by species. Table 3 shows the densities and biomass estimates by main groups. The main seabream species were large eye dentex, red pandora, and Barnard dentex. The main croakers were Canary drum and African weakfish.

Table 3. Luanda-Benguela. Mean densities of main groups and biomass estimates over the shelf to 200 m.

	Density t/nm²	Biomass 1 000 tonnes
Seabreams	4.96	24 580
Grunts*	1.14	5 500
Croakers	3.94	19 000
Groupers	0.21	1 000
Snappers	0.00	0
Sum demersal val.	10.25	50 080
Big eye grunt	3.82	18 500
Horse mackerel	9.93	48 500
Other carangids		290
Barracudas		
Hairtail	0.85	4 100

* excluding big-eye grunt

4.3 TOMBUA - CUNENE

The coverage down to 200 m depth, was made with 47 swept area hauls, distributed as follows: 0-50 m 10 hauls, 50-100 m 18 hauls and 100-200 m 19 hauls. In addition 2 hauls were made on the slope down to 250 m in the south where it is possible to trawl. The swept area estimates for all species are shown in Annex I. Table 4 shows the mean densities and biomasses of the main groups. The seabreams are mainly large eye dentex with some red pandora and Angola and Barnard dentex. The croakers are mainly African weakfish and some Canary drum.

Table 4. Cunene-Tombua. Mean densities of main groups and biomass estimates over the shelf to 200 m.

	Density t/nm²	Biomass 1 000 tonnes
Seabreams	15.72	26 600
Croakers	0.97	1 600
Hakes	4.86	8 200
Sum demersal val.	21.55	36 400
Cape horse mck	15.77	26 700
Cunene hrs.mck.	7.32	12.700

5 RESULTS OF THE FISHING EXPERIMENTS ON THE SLOPE, CABINDA TO BENGUELA

The swept area hauls on the slope were distributed by depth as follows:

	Cabinda-Benguela	Benguela-Cunene
100-200 m	25	19
200-300 m	25	2
300-400 m	10	
400-500 m	5	

The swept area estimates of all the main species caught at these depth ranges are shown in Annex I.

5.1 BENGUELA HAKE

Table 5 shows the mean catch rates of hake by depth ranges. Compared with the results of the previous survey the hake has a more shallow distribution with the maximum catch rates in the 300-400m depth range (previously in the 400-500m depth range).

Table 5. Mean catch rates of hake by regions and depth ranges. Kg/hour.

	Cabinda-Benguela	Tombua-Cunene
100-200 m	3	97
200-300 m	165	2250
300-400 m	520	-
400-500 m	245	-

The biomass of hake is estimated to 32 700 tonnes, only slightly higher than the estimate from the May 1991 survey (29 000 tonnes).

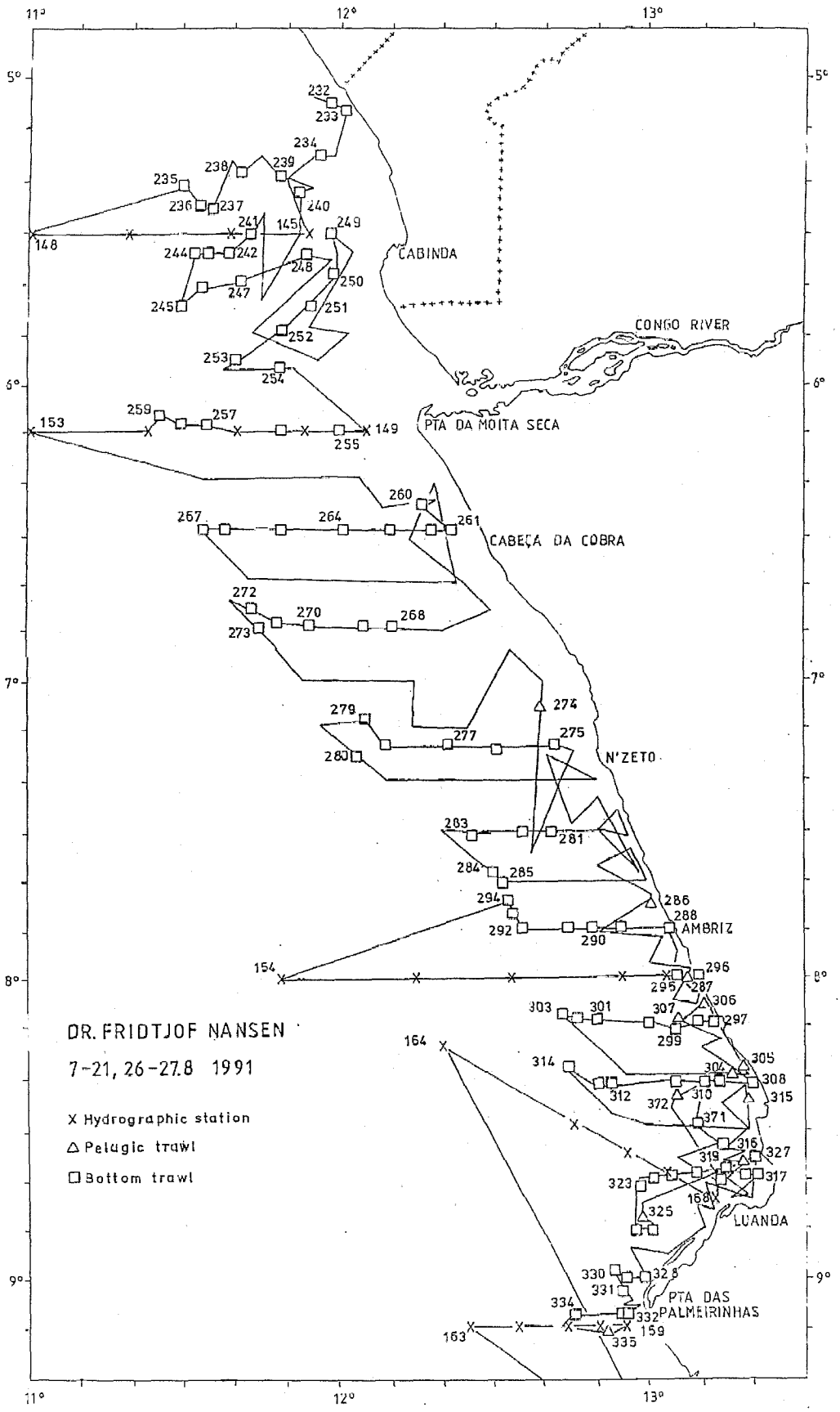


Figure 1a Course tracks with fishing stations and hydrographic profiles, Cabinda - Luanda.

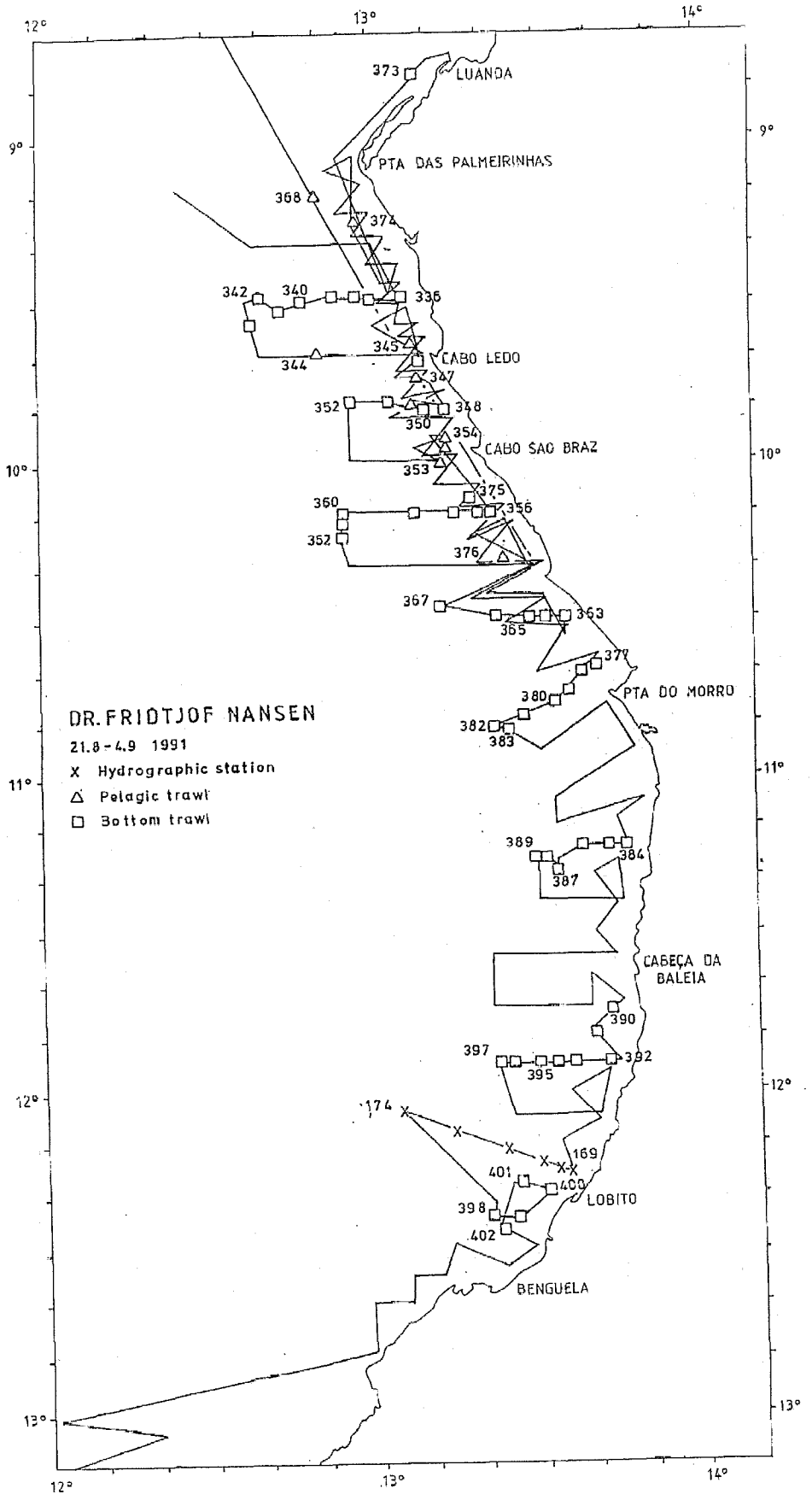


Figure 1b Course tracks with fishing stations and hydrographic profiles, Luanda - Benguela.

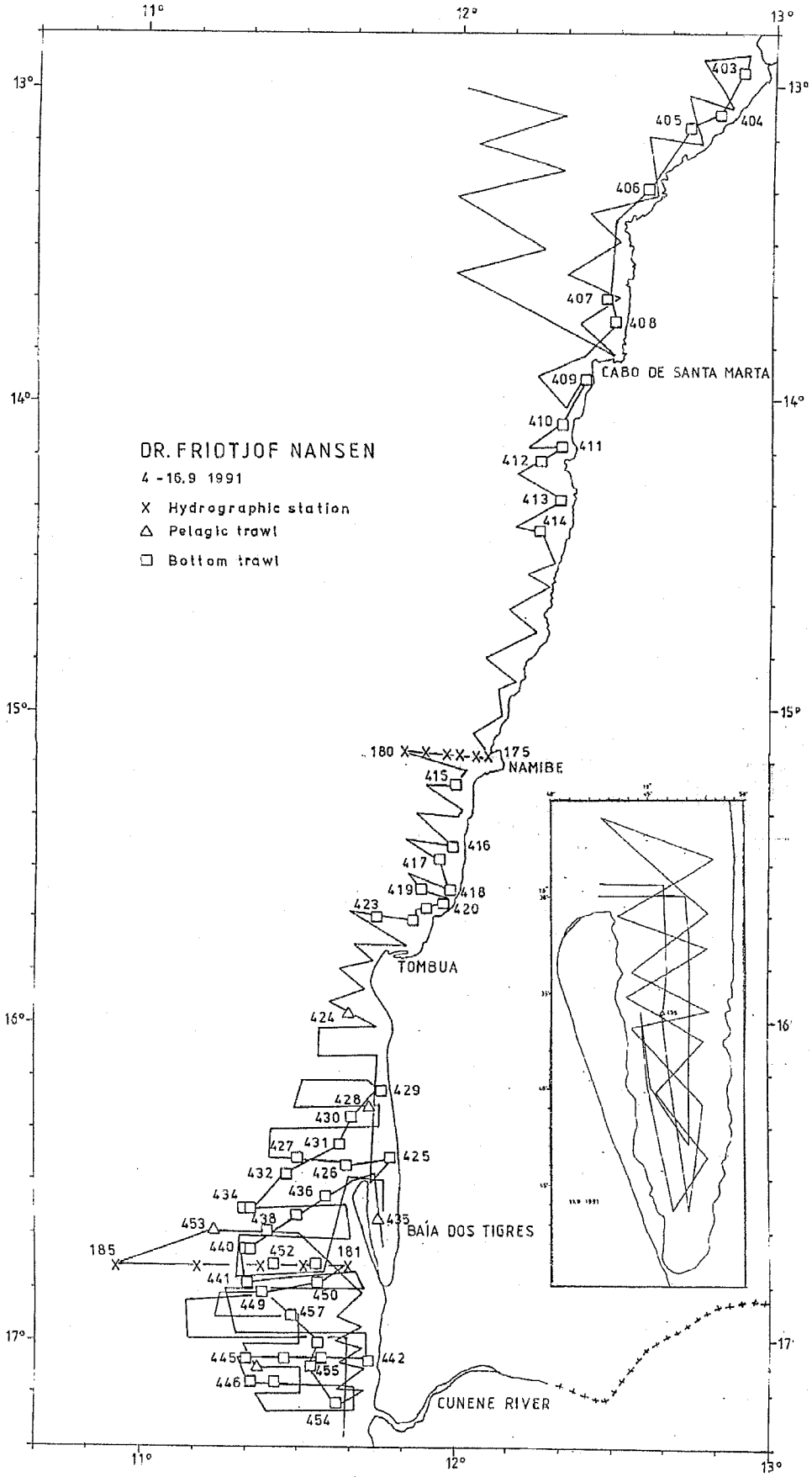


Figure 1c Course tracks with fishing stations and hydrographic profiles, Benguela - Cunene river.

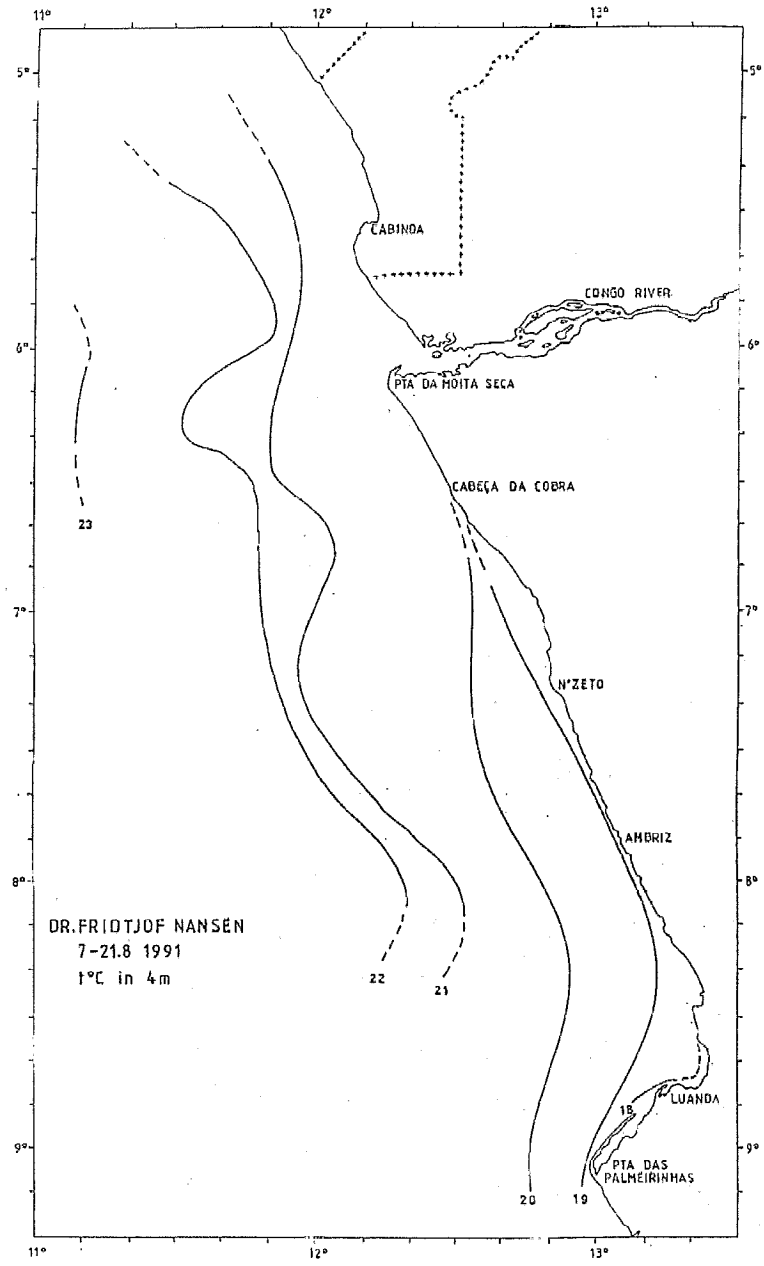


Figure 2a Temperature at sea surface, Cabinda- Luanda.

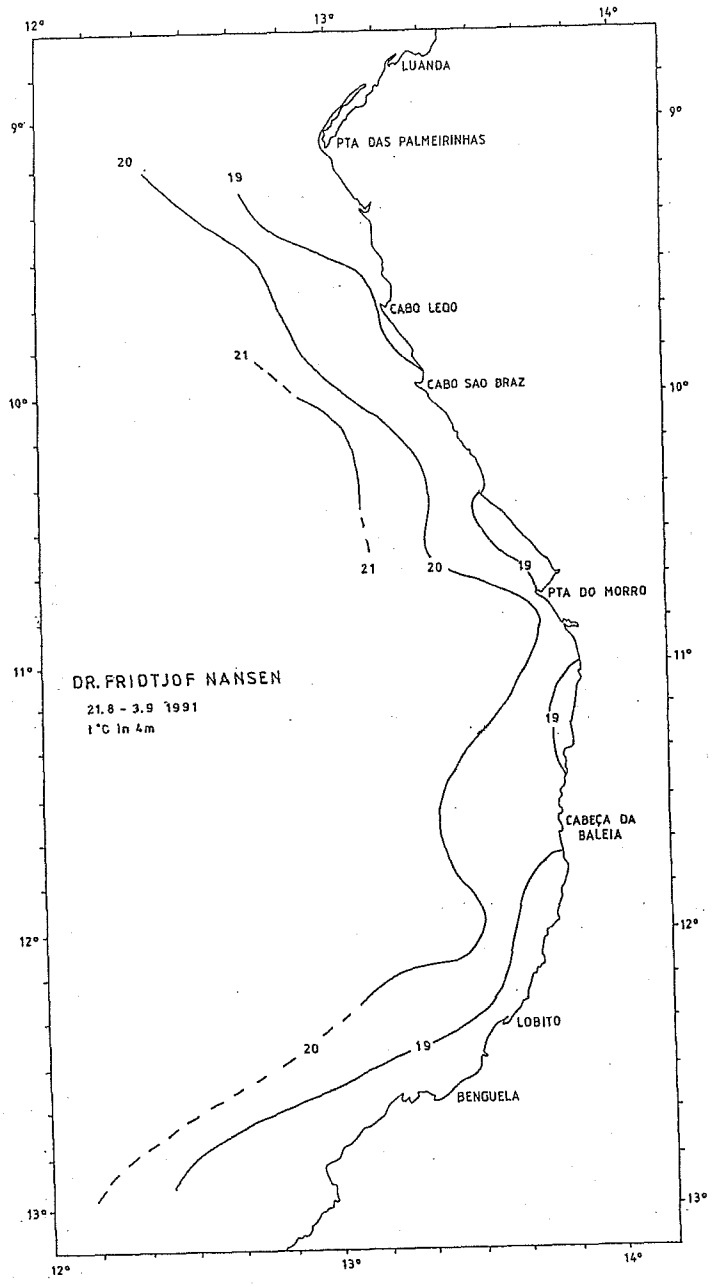


Figure 2b Temperature at sea surface, Luanda - Benguela.

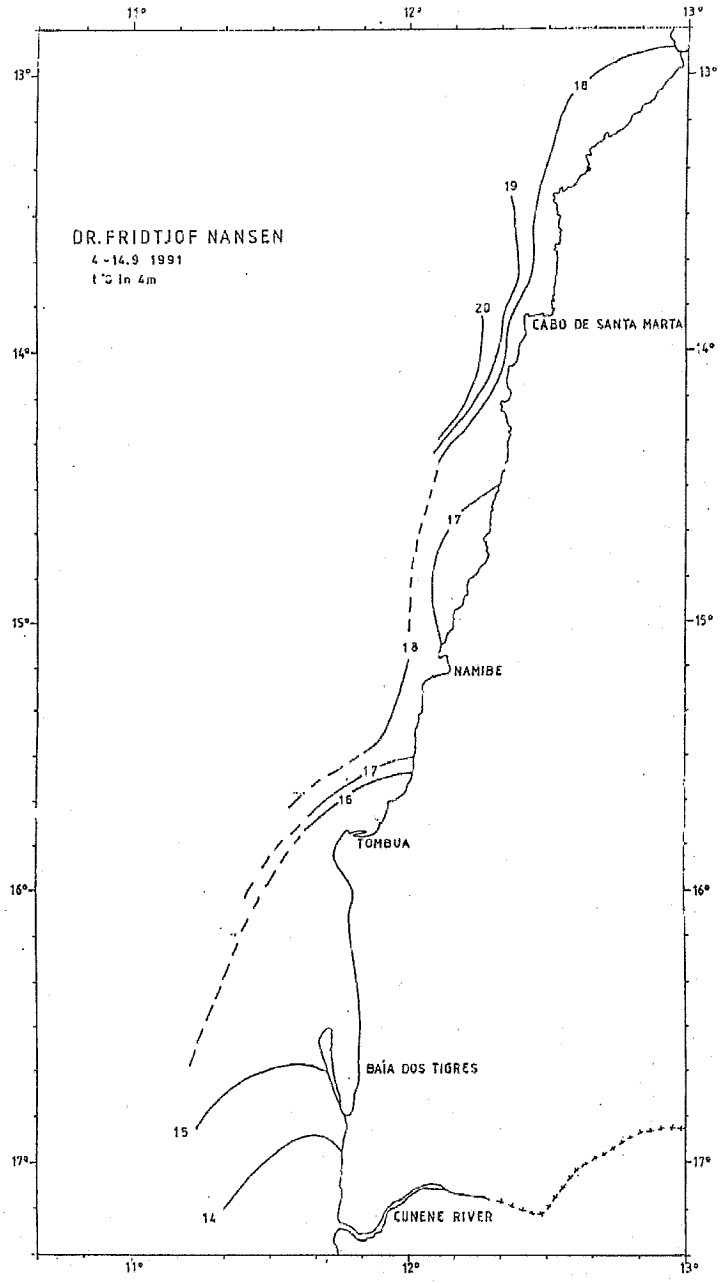
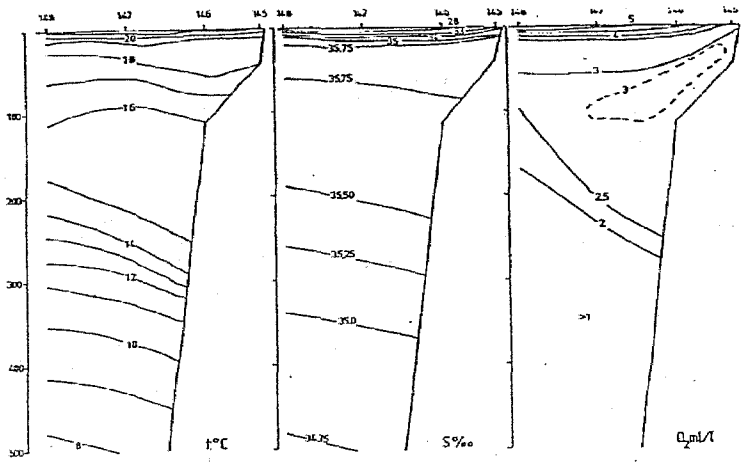
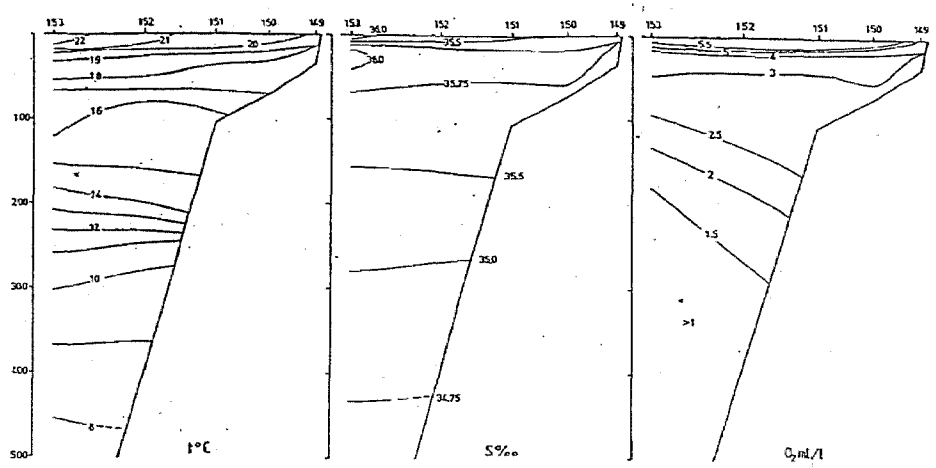


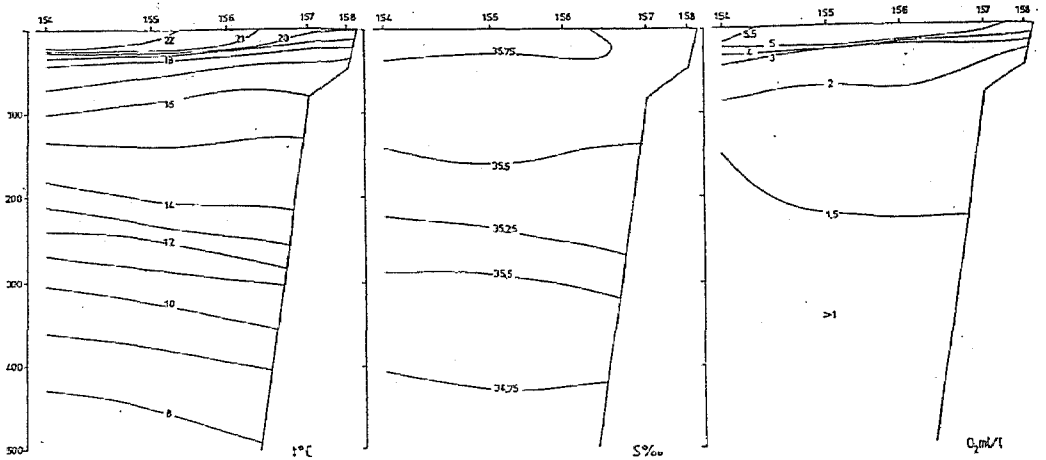
Figure 2 Temperature at sea surface, Benguela - Cunene river.



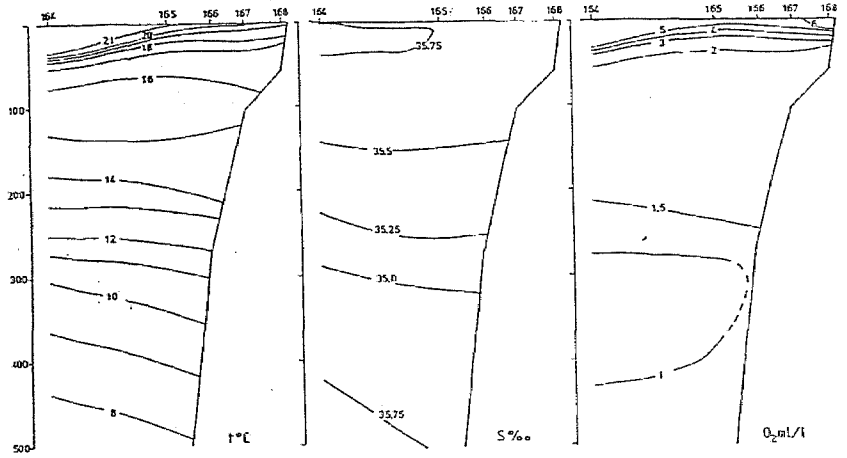
CABINDA 8/8 1991



PTA DA MOITA SECA 11/2 1991

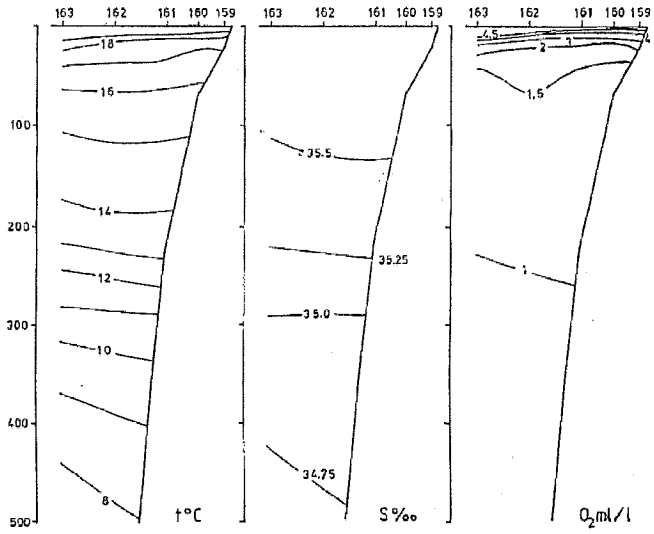


AMBRIZ 16-17/8 1991

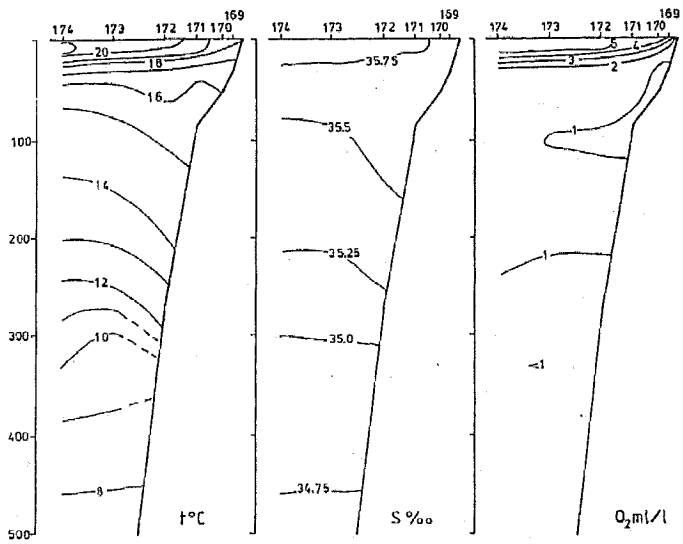


LUANDA 26.8 1991

Figure 3a Hydrographic profiles, Cabinda - Luanda.

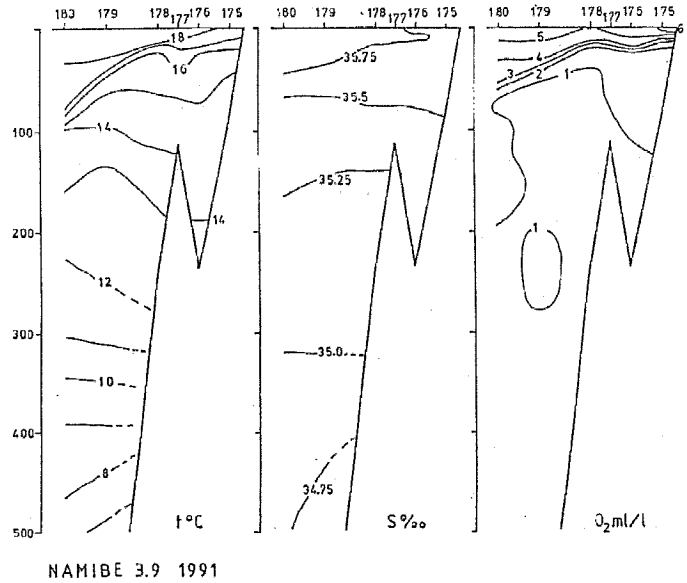


PTA DAS PALMEIRINHAS 20-21.8 1991

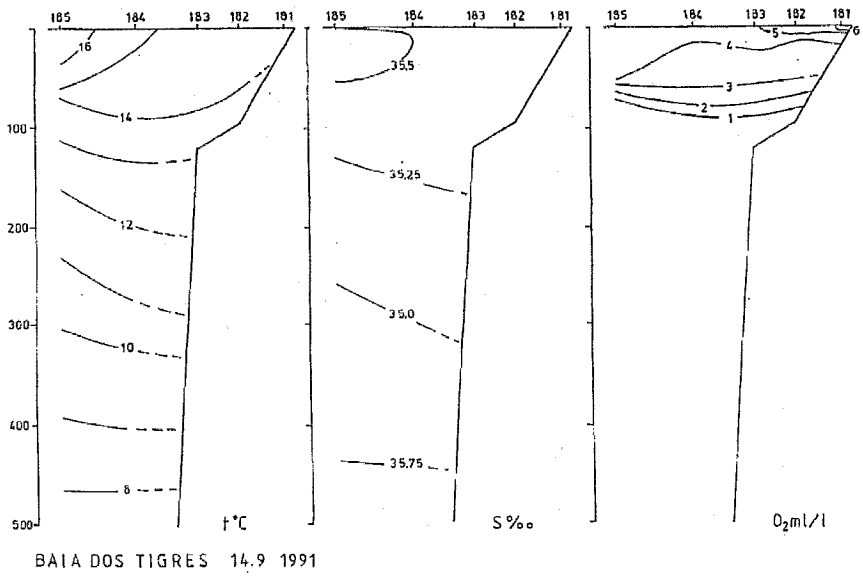


LOBITO 3.9 1991

Figure 3b. Hydrographic profiles, Luanda - Benguela.

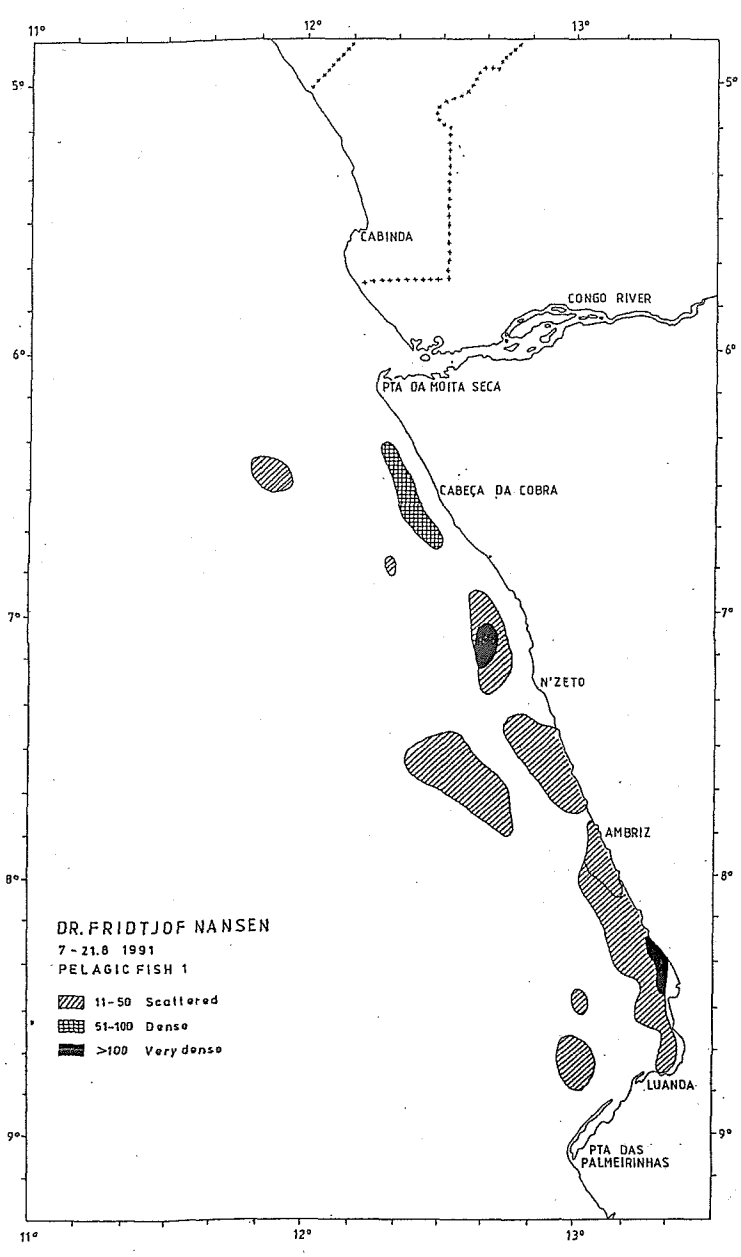


NAMIBE 3.9 1991



BAIA DOS TIGRES 14.9 1991

Figure 3c. Hydrographic profiles, Benguela - Cunene river.



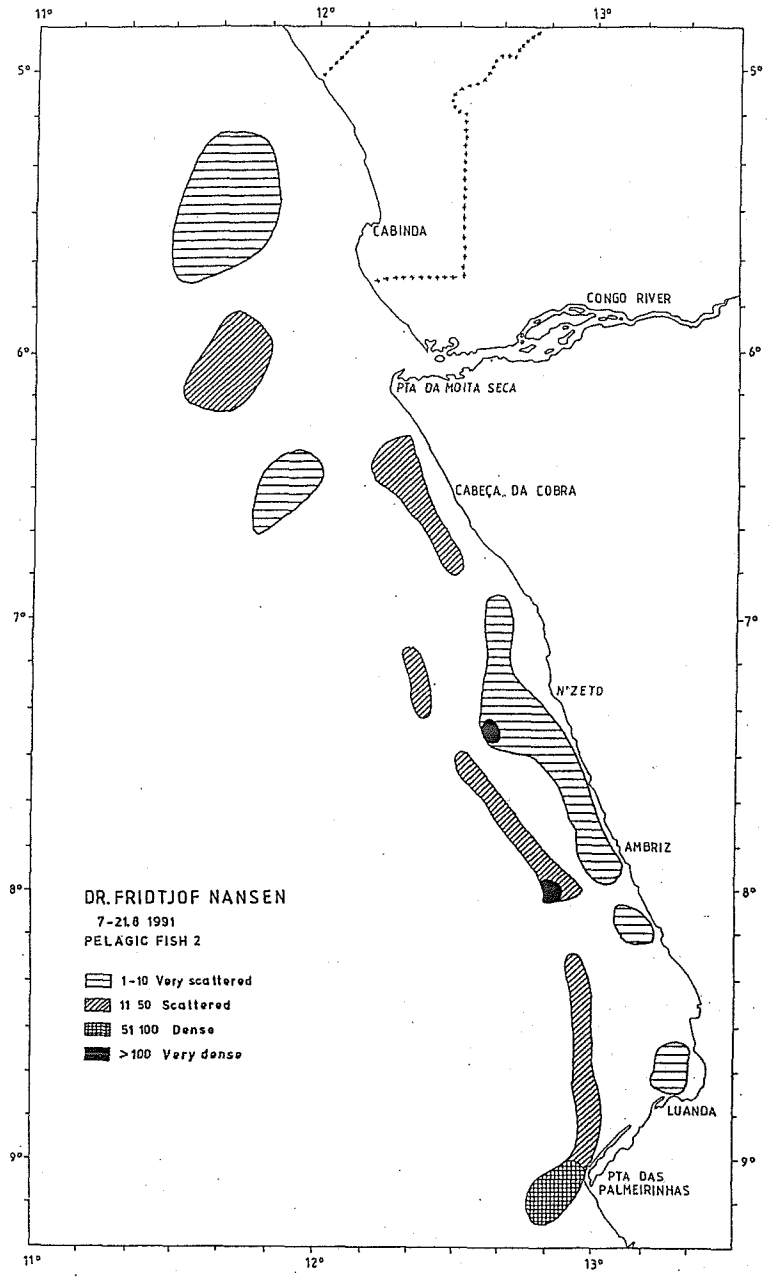
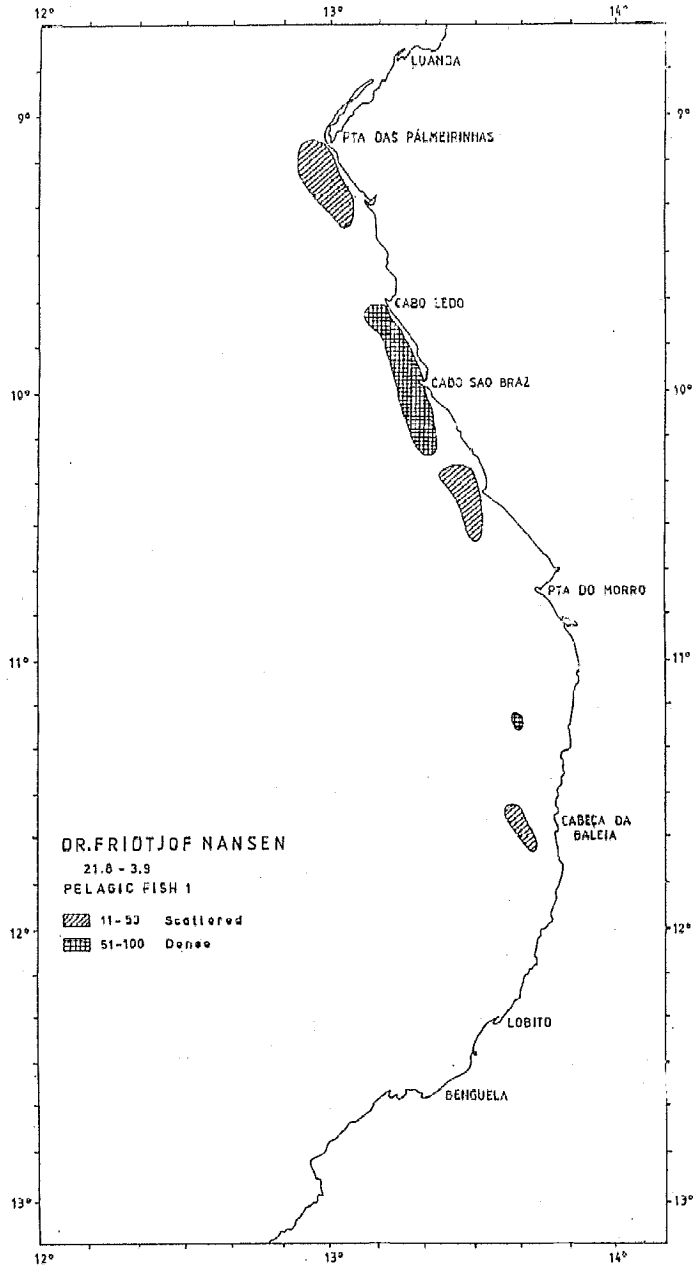


Figure 4 Cabinda - Luanda. Distribution of Pelagic fish type 1 and pelagic fish type 2.



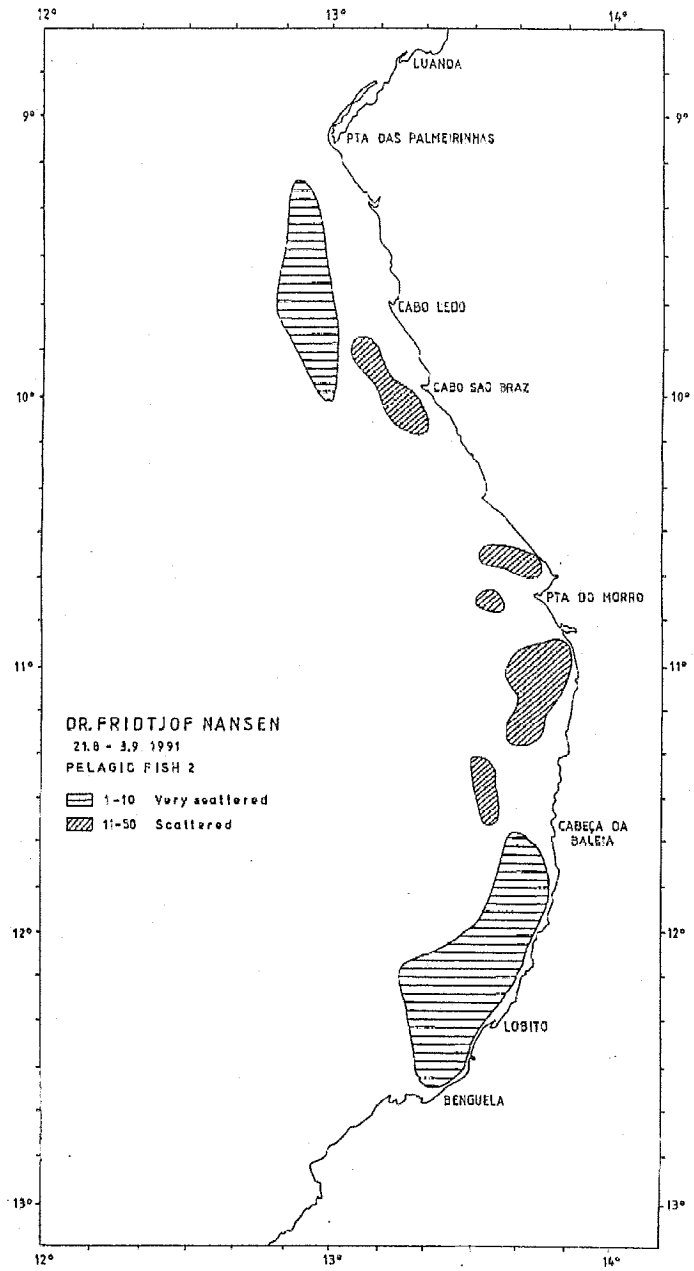


Figure 5 Luanda - Benguela. Distribution of Pelagic fish type 1 and pelagic fish type 2.

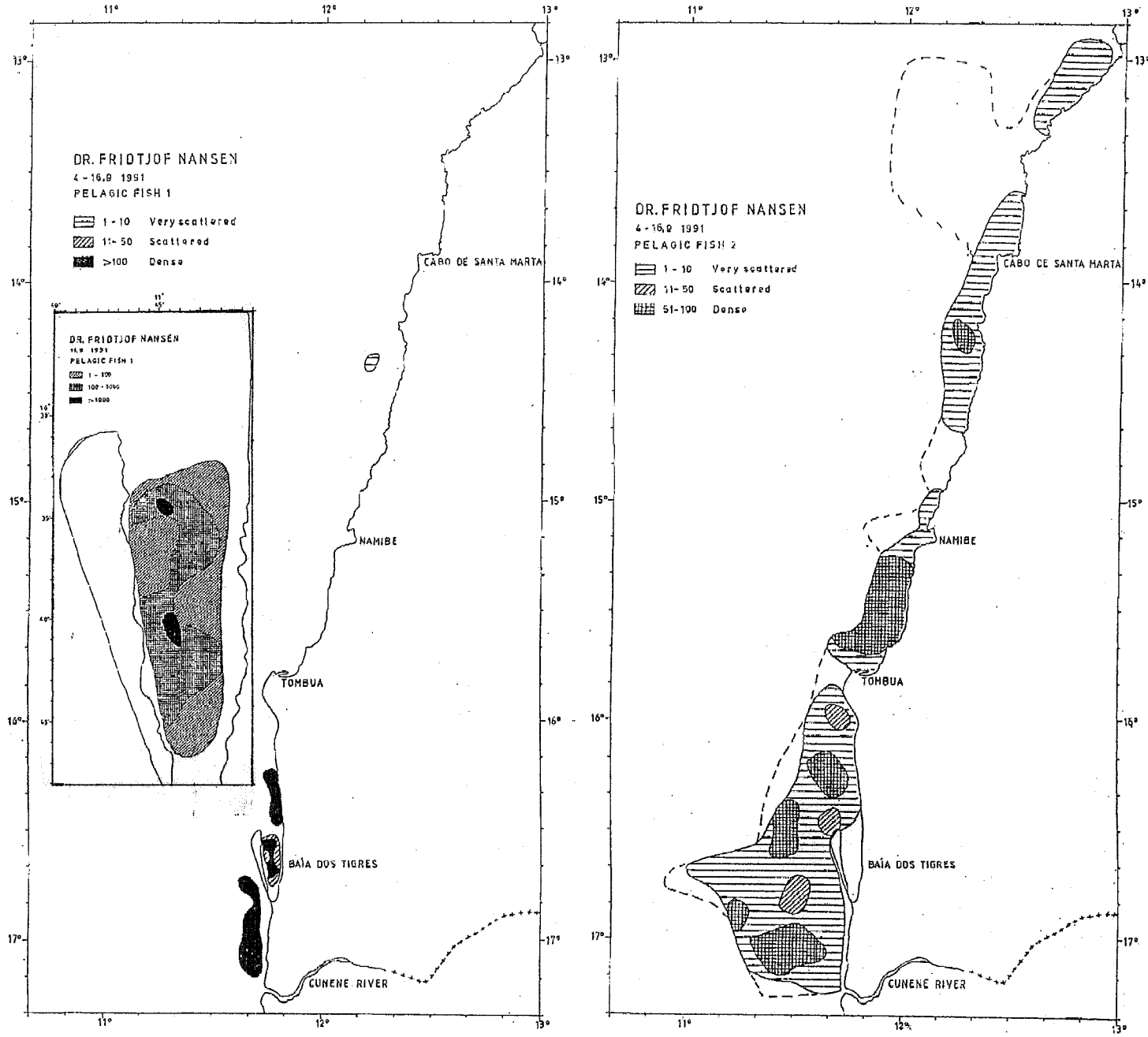


Figure 6 Benguela - Cunene river. Distribution of Pelagic fish type 1 and pelagic fish type 2.