

PART I
Survey of the pelagic resources
2 to 17 August 1994

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION	1
1.1 Objectives	1
1.2 Participation	1
1.3 Narrative	2
1.4 Survey effort	2
CHAPTER 2 METHODS	5
2.1 Hydrographic sampling	5
2.2 Fish sampling	5
CHAPTER 3 HYDROGRAPHIC CONDITIONS	8
CHAPTER 4 DISTRIBUTION, COMPOSITION AND ABUNDANCE OF PELAGIC FISH.	11
4.1 Cabinda - Luanda	11
4.2 Luanda - Benguela	15
CHAPTER 5 BIOLOGICAL SAMPLING	19
5.1 <i>Sardinella maderensis</i>	19
5.2 <i>Trachurus trecae</i>	19
CHAPTER 6 OVERVIEW OF SURVEY RESULTS.	22
6.1 Sardinellas	22
6.2 Cunene horsemackerel	26
Annex I	Records of fishing stations
Annex II	Instruments and fishing gear used

CHAPTER 1 INTRODUCTION

1.1 Objectives

- To map the distribution and estimate the abundance of the commercially important pelagic and semipelagic fish species in Angolan waters, north of Benguela, including the two sardinella species *Sardinella aurita* and *S. maderensis*, the Cunene horse mackerel *Trachurus trecae* and other pelagic species, mainly carangids.
- To estimate the biological condition of sardinella and horse mackerel, length weight-relationships and reproductive stages.
- To study the general oceanographic conditions and carry out specific hydrographic sampling in areas of highest concentrations of sardinella.
- On-the-job training for the Angolan participants on the main survey routines would be imparted, including collection and processing of raw data, the use of the acoustic system for stock assessment purposes and general methodology in oceanographic research. This aspect is emphasized in this new phase of the 'Dr. Fridtjof Nansen' programme, which aims, besides the basic resource investigations, to increase national competence in fishery and oceanographic research.

1.2 Participation

The scientific staff consisted of:

From the Institute of Fishery Research, Angola: N'Kossi Luyeye, Chores Pinto Mpungui, Fernando Gombo and David Quissungu.

From the Institute of Marine Research, Norway: Tore Strømme, Gabriella Bianchi, Helge Ullebust, Martin Dahl and Reidar Johannesen.

1.3 Narrative

The vessel left Luanda at 18h00 on 2nd August and steamed southward to Benguela where the actual survey work started on 3 August at about midday.

The survey followed a systematic triangular transect pattern, from shore to the 200 m isobath, the endpoints of the transects being approximately 10 naut.miles apart. In areas where tight sardinella shoals were recorded, surveying was conducted both during day- and nighttime. This happened in the area between Cabeça da Baleia and Lobito and north of the Congo River estuary. As in the previous survey, a 10- nautical- mile wide zone along the coast, in the region between Ambriz and the Congo River, was not covered for security reasons. The Cabinda region was only partially covered because of oil drilling activities.

The survey work was completed on August 16 and the vessel steamed to Pointe Noire (Congo).

1.4 Survey effort

Fig. 1 (a-b) shows the cruise track with fishing stations and the hydrographic profiles.

The number of hauls per area and depth interval, can be summarized as follows:

	Pelagic hauls	Bottom hauls	Distance surveyed
Cabinda-Luanda	10	1	nm
Luanda-Beng.	14	5	nm

The total number of CTD stations were 32.

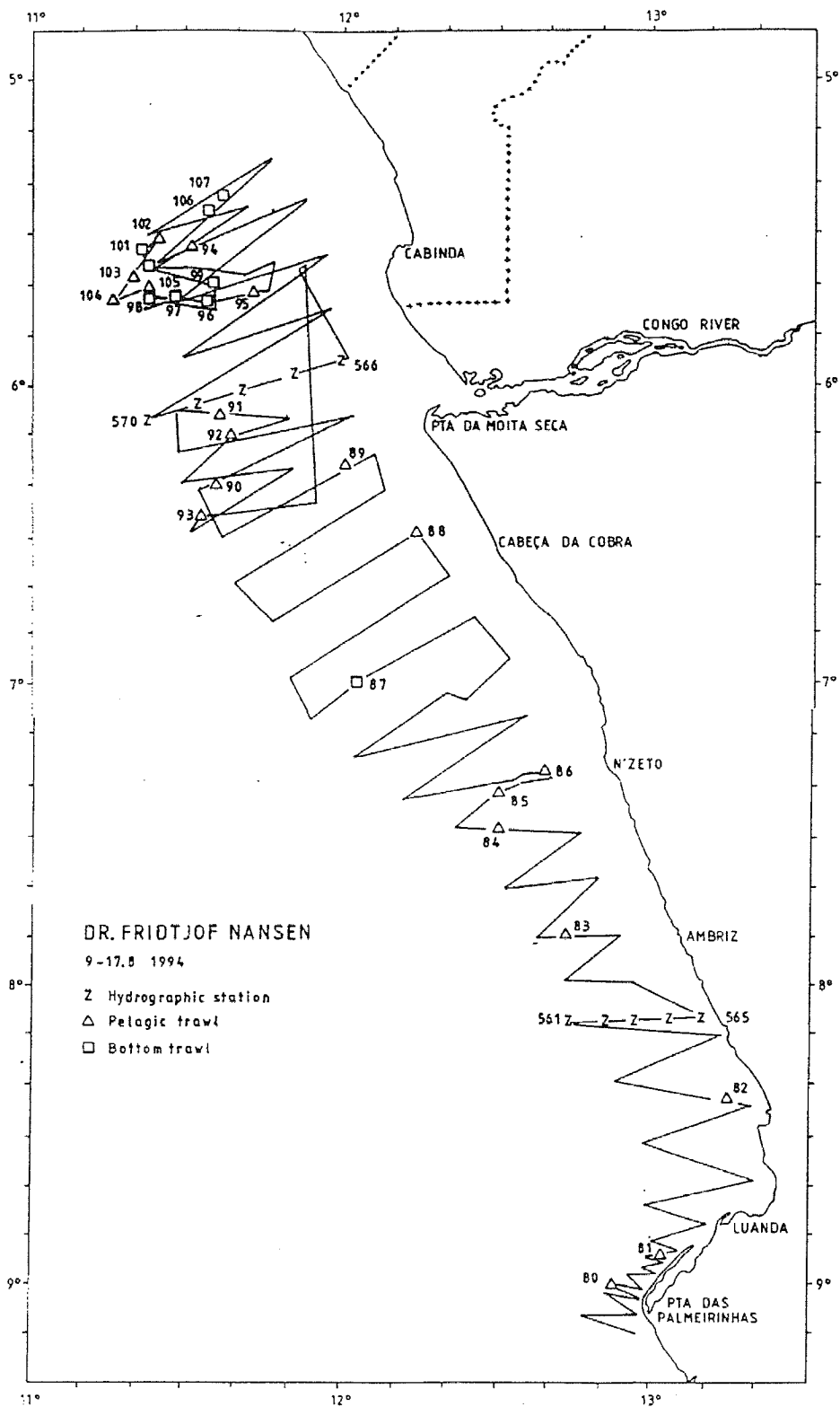


Figure 1a. Course tracks with fishing stations and hydrographic profiles, Cabinda-Luanda.

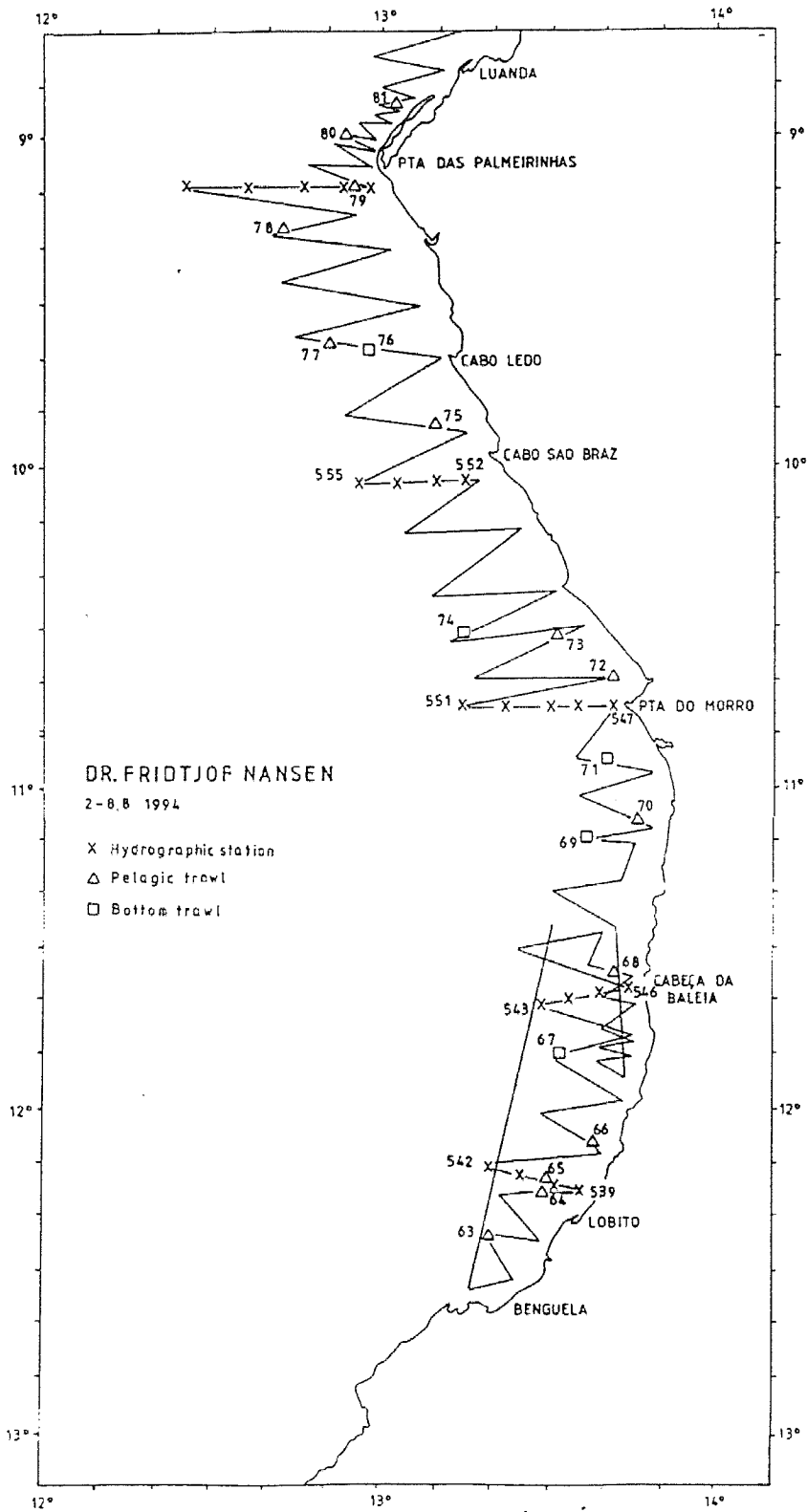


Figure 1b. Course tracks with fishing stations and hydrographic profiles, Luanda-Benguela.

CHAPTER 2 METHODS

2.1 Hydrographic sampling

Continuous profiles of temperature, salinity and oxygen were obtained with a Seabird 911 CTD Plus system. The data were logged in real time on a PC on board, using the Seabird SEASAVE software. As a routine the profiles were taken down to a few meters above the bottom. Two NISKIN bottles were triggered for water samples. These were usually taken near the bottom and near the surface (typically at 3m depth) for analysis of oxygen and salinity.

2.2 Fish sampling

Abundance determination

The catches were sampled for species composition, by weight and numbers. Biological samples, i.e. length and weight compositions were taken for the target species. Records of fishing stations are presented in Annex I.

A description of the acoustic instruments and their standard settings is given in Annex II. This also includes a description of the fishing gear used.

The following target strength (TS) function was applied to convert S_A -values (mean integrator value for a given area) to number of fish (pilchard, sardinella and Cunene horse mackerel):

$$TS = 20 \log L - 72 \text{ dB} \quad (1)$$

or in the form $C_F = 1.26 \cdot 10^6 \cdot L^{-2}$ (2)

where L is total length and C_F is the fish conversion factor. The following formula was used to calculate the number of fish in length groups (cm) for each fish concentration:

$$N_i = A \cdot S_A \cdot \frac{P_i}{\sum_{i=1}^n \frac{P_i}{C_{Fi}}} \quad (3)$$

where

N_i = number of fish in length group i

A = area (naut.miles²) of fish concentration

S_A = mean integrator value in area (A)

p_i = proportion of fish in length group i in samples from the area

C_{Fi} = fish conversion factor for length group i

The number per length group (N_i) was then summed and the total number of fish obtained:

$$N = \sum_{i=1}^n N_i \quad (4)$$

The length distribution of a given species within an area was computed by weighting the length frequencies obtained in each trawl sample within the area by the average S_A value attributed to that species in the 5 mile where the sample was taken.

In the case of cooccurrence of *Sardinella aurita* and *S. maderensis* (these species cannot be separated in the ecotraces), the respective contribution to the S_A value attributed to the 'sardinella' category was split using a factor obtained from their length frequency distributions and their CPUE in numbers. The biomass of fish per length group (B_i) was calculated by applying observed mean weights per length group (\bar{W}_i) multiplied by number of fish in the same length groups (N_i). The total biomass in each area was obtained by summing the biomass of each length group:

$$B = \sum_{i=1}^n N_i \bar{W}_i \quad (5)$$

The number and biomass per length group in each concentration were at last summed to obtain the totals for each region.

The mean integrator values in each sampling unit (S_A -values) were divided between the following categories of fish on the basis of trawl catches and characteristics of the echo traces:

- sardinella (*S. aurita* and *S. maderensis*)
- Cunene horse mackerel
- anchovies
- P2 (carangids, scombrids, barracudas and hairtails)
- *Brachydeuterus*
- other demersal fish
- plankton

Biological sampling

Total length and body weight were recorded for sardinella and horse mackerel to the nearest ½ cm or 1 g below, respectively. Sex and reproductive stages were described by macroscopic examination, scoring each individually sampled fish according to the following categories:

- | | |
|---|----------------|
| 1 | Juvenile |
| 2 | Inactive |
| 3 | Active |
| 4 | Ripe |
| 5 | Running/ Spent |

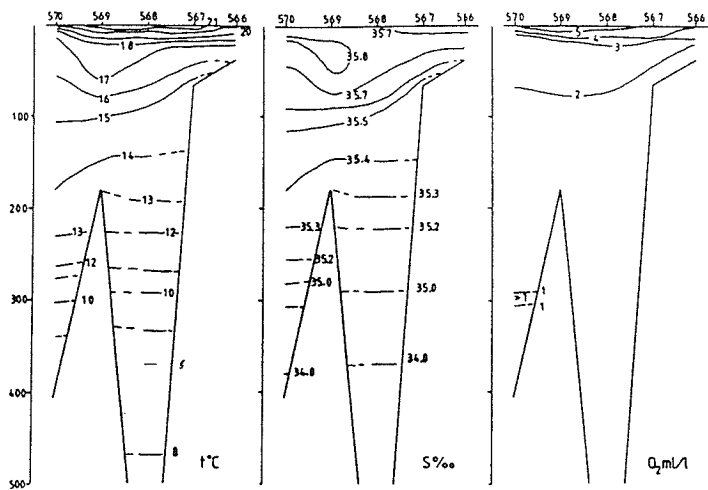
CHAPTER 3 HYDROGRAPHIC CONDITIONS

Figures 2 a and 2 b show the profiles derived from the hydrographic sampling in northern and central Angola respectively. Off the Congo River and Ambriz the thermocline appears to be very shallow and there is a clear uptilting of the isotherms and isolines of oxygen toward the coast. Off Ambriz very low oxygen waters ($O_2 < 1\text{ml/l}$) were observed over the shelf and upper slope bottom. Surface temperature was about 20-21 degrees but decreased toward the coast confirming the presence of upwelling activity. During the March survey the thermocline was deeper and more pronounced, the surface temperature was at least 5 degrees higher and relatively high oxygen levels ($O_2 > 2\text{ml/l}$) could be observed throughout the shelf.

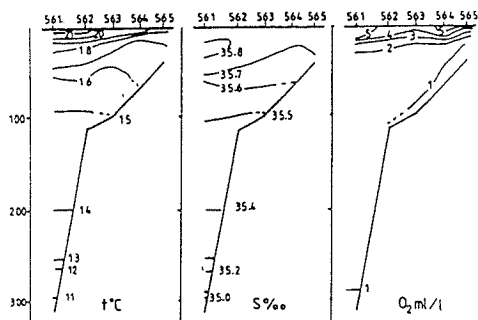
The region off Ponta das Palmeirinhas, where schools of pelagic fish usually concentrate, also showed a more pronounced dynamics, with uptilting isolines toward the coast, shallower and less pronounced thermocline and lower temperatures throughout the water column as compared to the March survey.

In the central region four sections were sampled (Fig. 2b). These showed a clear uplifting of the water column, with lower temperatures and oxygen values from the surface to about 200 to 300 m depth. Surface salinity was higher and this possibly reflects the lower total southward transport of surface water in this period of the year. This transport is strong during the summer period, when the Angola Current can easily be identified.

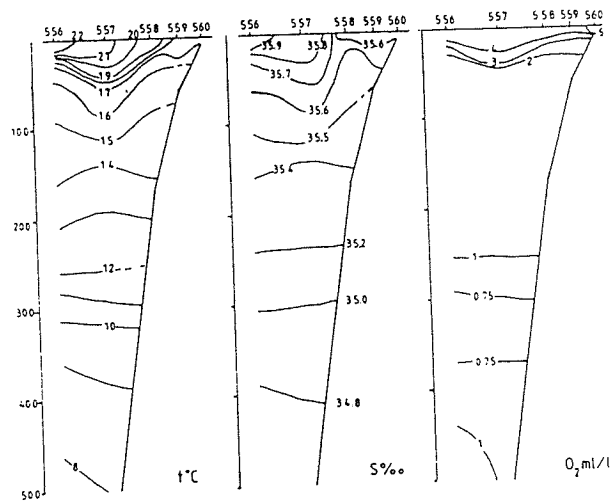
The above results show a typical winter situation in Angola, with lower temperatures and clear signs of upwelling. Another description of the hydrographic regime is available for the September survey of the demersal resources.



CONGO RIVER 14.8 1994

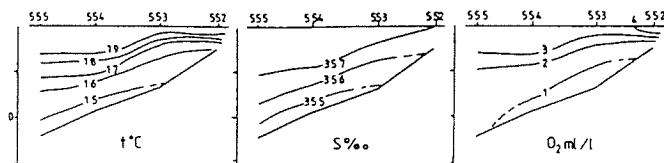


AMBRIZ 9.8 1994

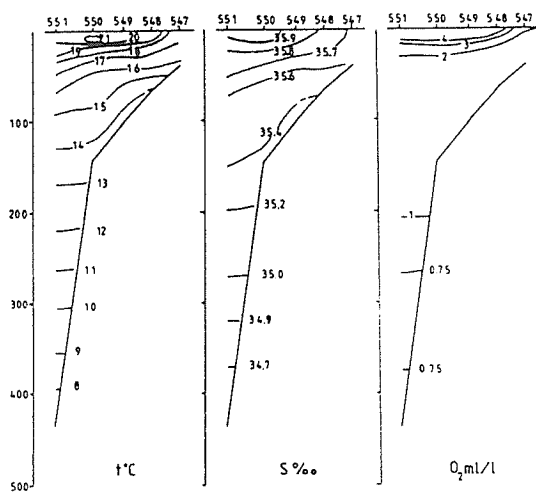


PTA DAS PALMEIRINHAS 8-9.8 1994

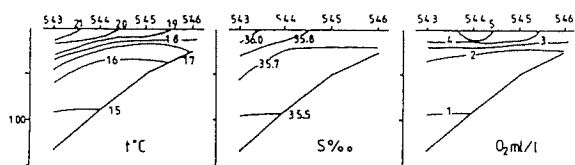
Figure 2 a. Vertical sections of temperature, salinity and oxygen, Cabinda-Ponta das Palmeirinhas



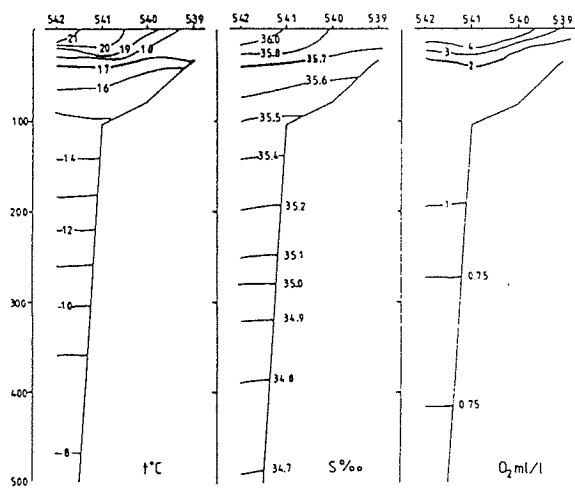
CABO SAO BRAZ 6 7.8 1994



PONTO DO MORO 5-6.8 1994



CABECA DA BALEIA 4.8 1994



LOBITO 3.8 1994

Figure 2 b. Vertical sections of temperature, salinity and oxygen, Cabo Sao Braz-Lobito

CHAPTER 4 DISTRIBUTION, COMPOSITION AND ABUNDANCE OF PELAGIC FISH

4.1 Cabinda - Luanda

A complete coverage of the shelf was unfortunately not possible because a 10-mile distance from the coast was kept north of Ambriz, for security reasons. The coverage of the shallow waters (25-40 m) off Cabinda was also somewhat limited because of oil extraction activities. As pelagic species appeared to have a more offshore distribution than usual, the coverage was extended to beyond the 200 m isobath. In the northern region, especially in the Congo River area, the survey was extended to 600 m depth because of the incidental observation of sardinella schools well offshore.

Sardinellas

Dense sardinella schools were detected only between Luanda and Ambriz. North of Ambriz schools were more dispersed but distributed over large areas. Sardinella appeared to have a spread distribution and was surprisingly found also well offshore, to depths of about 600 metres (Figure 3). Schools occurred very close to the surface and while they could easily be detected from horizontal ranging sonar images, they hardly appeared in the echo-traces obtained with the vertical echo-sounder. There was no difficulty during this survey to catch sardinella during daytime, contrary to what had happened during the March survey. This was probably because most of the sardinella were ripe or in the spawning phase (see below) and thus easier to catch.

The length distributions show that large adults dominate for both species (Figures 4 and 5). In the case of *S. maderensis* there is a mode of about 31 cm, while for *S. aurita* the mode was 35 cm. In the March '94 survey, two modes of 24 and 31 cm respectively were found for *Sardinella maderensis*.

The biomass in this area was estimated to about 290 000 t, the proportions of flat and round sardinella were about 90 and 10 % respectively.

The estimate from the previous survey in March '94 was 100 000 tonnes. This increase in the estimate of almost 300 % may be explained by a northward migration in connection with the winter period (see below).

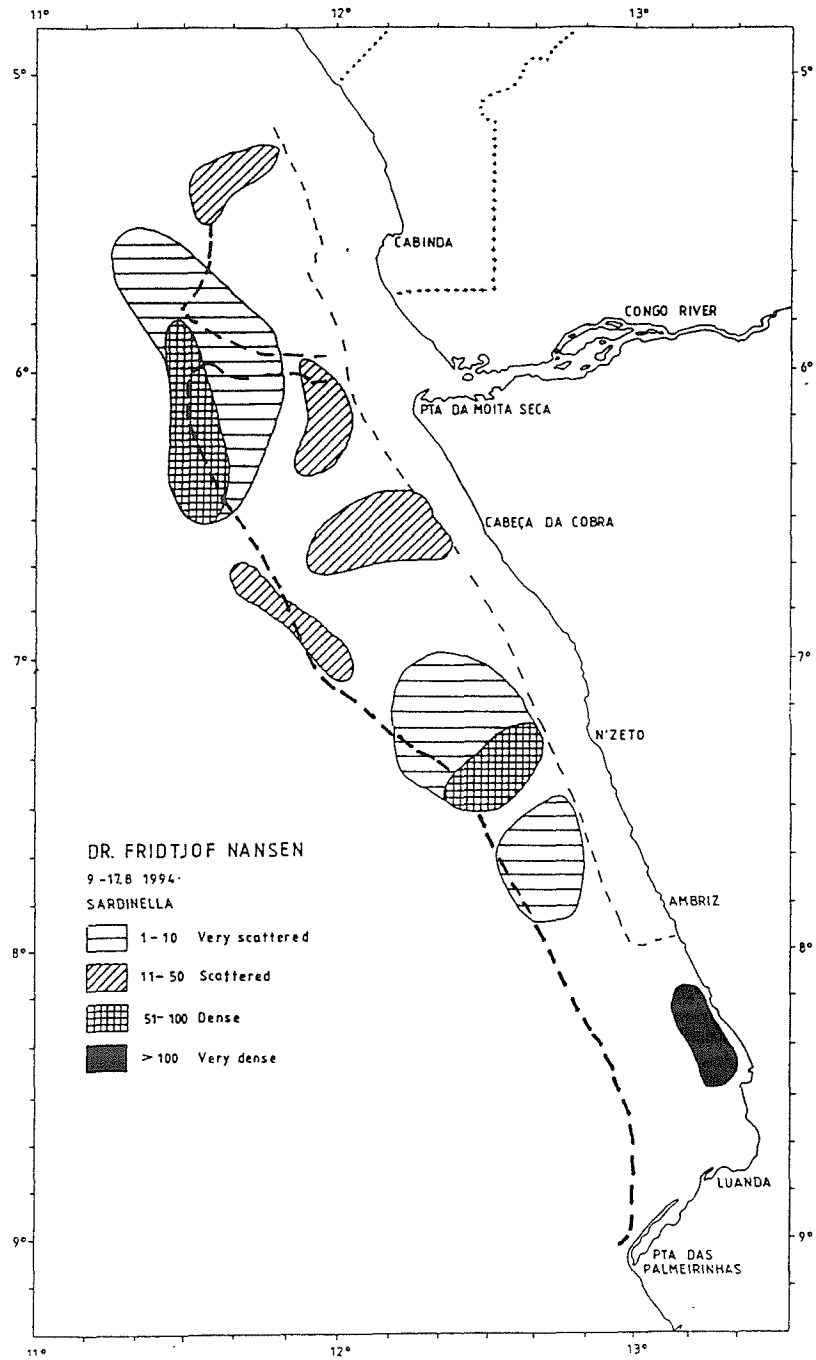


Figure 3. Distribution of sardinella, Cabinda-Luanda

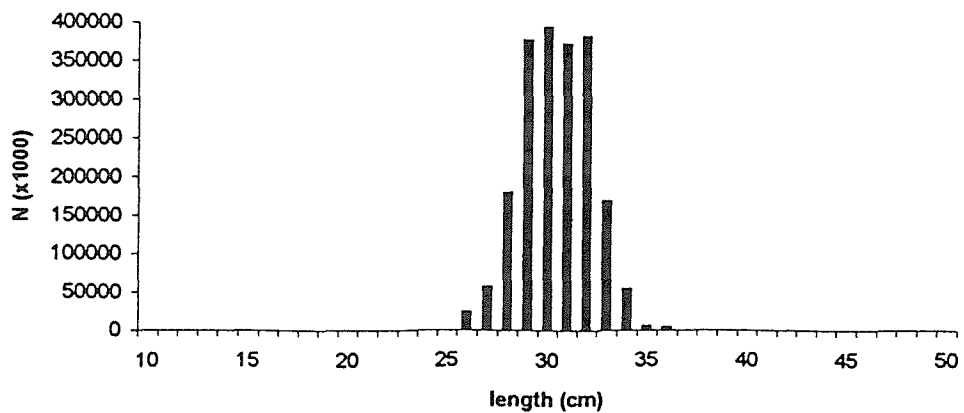


Figure 4. Total length distribution of *Sardinella maderensis*, Cabinda-Luanda

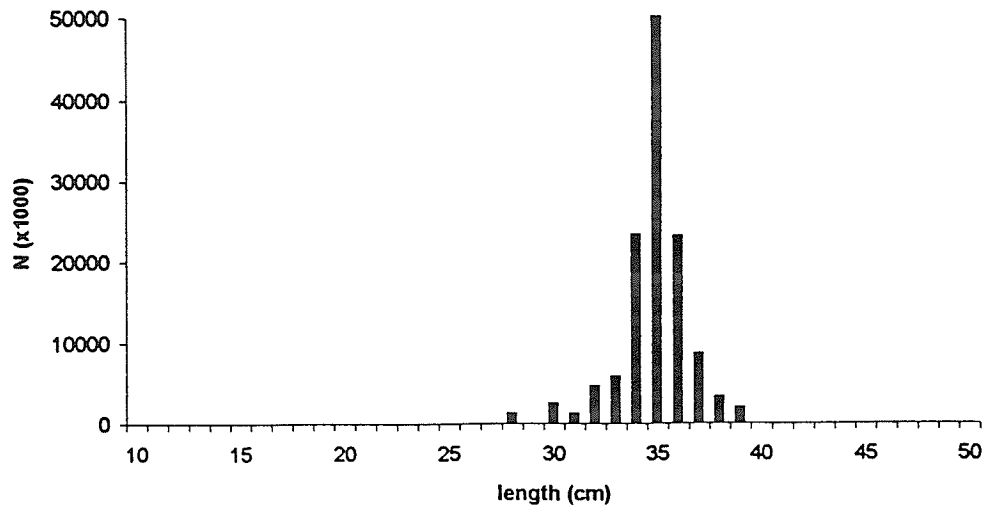


Figure 5. Total length distribution of *Sardinella aurita*, Cabinda-Luanda

Cunene horse mackerel

Figure 6 shows the distribution of the Cunene horse mackerel as detected by the echo-integration system. Although no dense concentrations were found in this region, horse mackerel was found throughout the area, mainly over the intermediate and deeper parts of the shelf and beyond the shelf edge. Schools were observed close to the bottom, especially during daytime and in midwater and surface waters at night but this pattern was not always consistent. The catches consisted mainly of large individuals (Fig. 7), the length frequency distribution having a mode of 35 cm.

The biomass was estimated to about 120 000 tonnes. This value might represent an underestimate because the offshore limit of distribution was not reached. During the March survey almost no horse mackerel was found in this region. This pattern, as it will be shown later, may be attributed to a northward migration in the winter season.

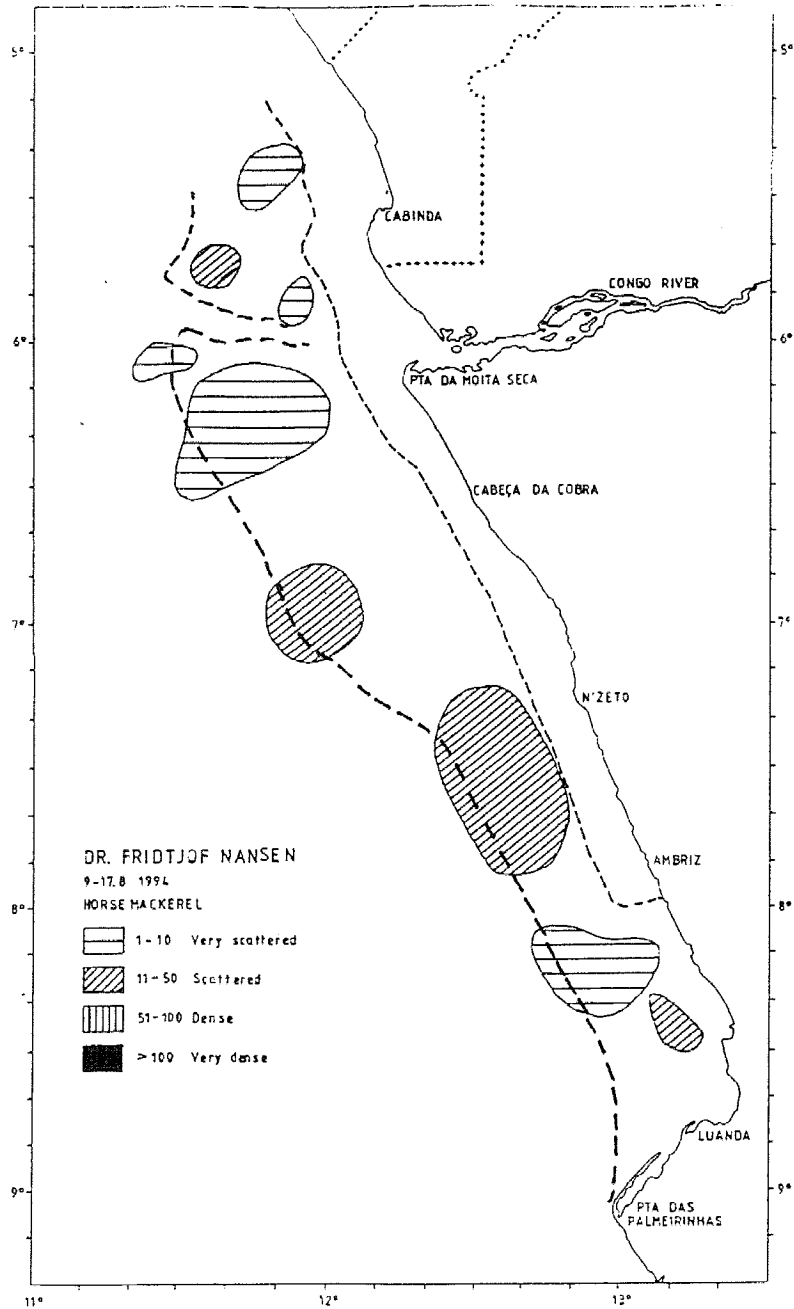


Figure 6. Distribution of *Trachurus trecae*, Cabinda-Luanda

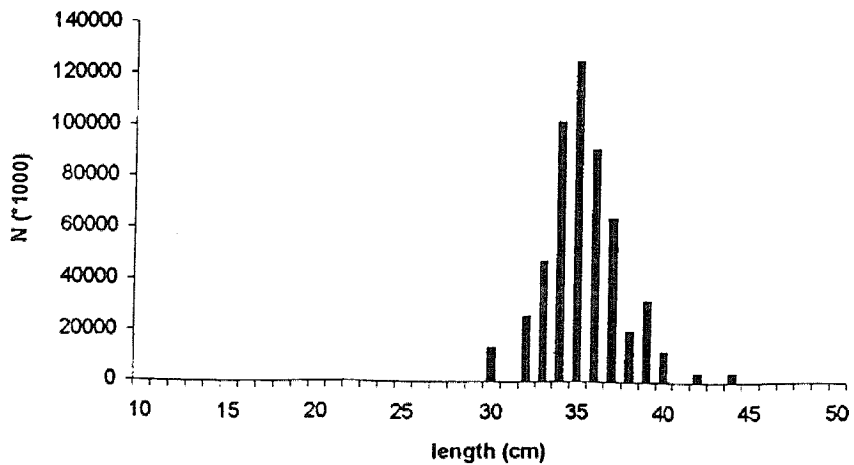


Figure 7. Total length distribution of *Trachurus trecae*, Cabinda-Luanda

Other pelagic fishes P2

Under this category several species are included, both of shallow and deeper waters. *Trichiurus lepturus* was by far the most common species, caught throughout the shelf and over slope areas. *Brachydeuterus auritus*, *Chloroscombrus chrysurus* and *Selene dorsalis* that are usually abundant in the northern region, were caught very seldom, most probably because of the limitations in the survey coverage, that did not include 10 nm from the coast north of Ambriz. Cuttlefish (mainly *Sepiella ornata* and *Sepia officinalis*) were caught in almost all pelagic trawls, especially at the edge of the shelf. Catch rates were however low (up to 14 kg/h). The echo-integrator values attributed to the P2 group were generally low and the total biomass was calculated to 21 000 tonnes, about 60% of which consisted of *Trichiurus lepturus*. However, this is probably a gross underestimate in this region, considering the incomplete coverage of the shallow waters.

4.2 Luanda - Benguela

The shelf was covered between 20 and 200 m depth, but extended to deeper waters in correspondence with the narrowest parts of the shelf.

Sardinellas

The densest concentrations were found off Lobito and Cabeça da Baleia, more dispersed in other parts of the area. The distribution appeared to be limited to shelf waters, only in few instances appeared to go beyond the 200 m isobath (south of Ponta das Palmeirinhas). (Fig.8).

Sardinella maderensis dominated the catches. Only few individuals of *Sardinella aurita* were caught and no attempt was therefore made to estimate the biomass of the two species separately. The catches were dominated by large individuals, with a mode of 33 cm (Fig. 9). The length frequency pattern was similar to the one found in March '94.

The estimated biomass for this region was 245 000 tonnes. The corresponding estimate in the March '94 survey was 410 000 tonnes. The difference between the two estimates (165 000 tonnes) is comparable with the increase noticed in the northern region in this survey, thus indicating the possibility of a northward migration in connection with the upwelling season.

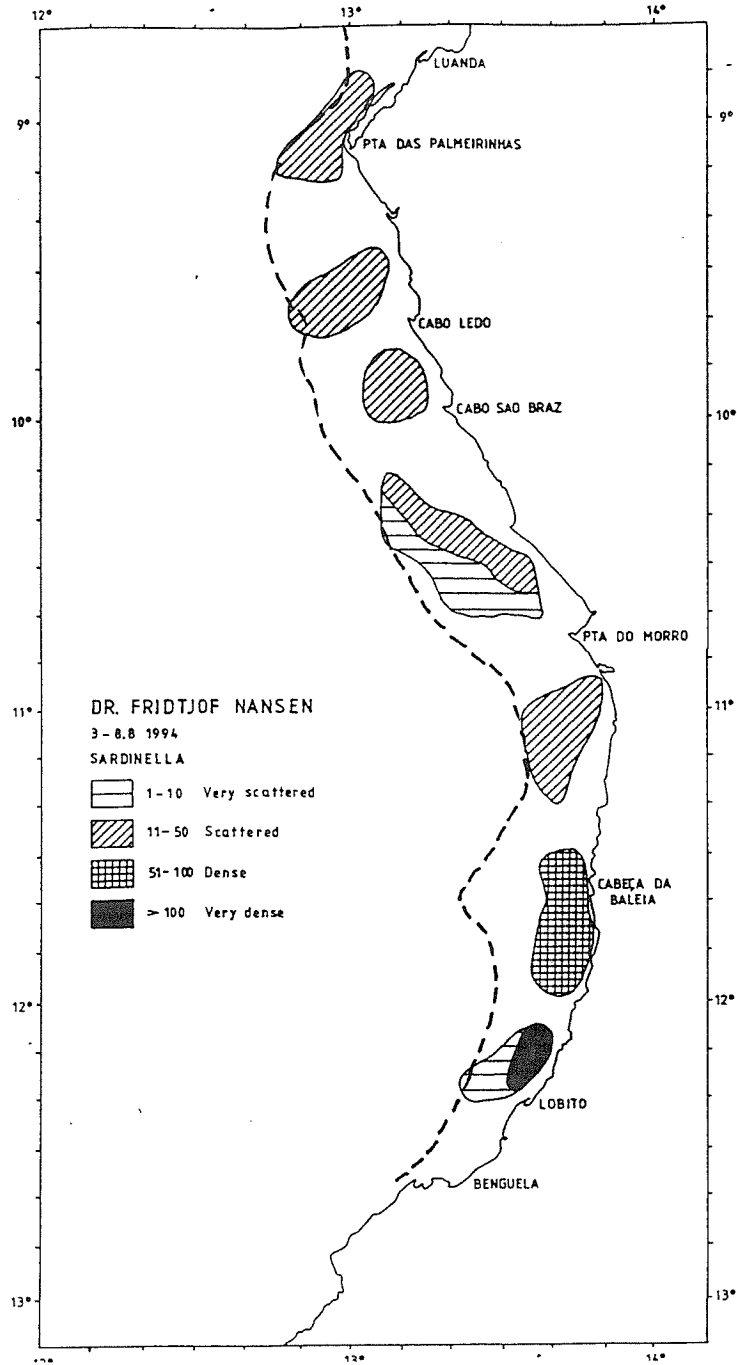


Figure 8. Distribution of sardinella, Luanda-Benguela

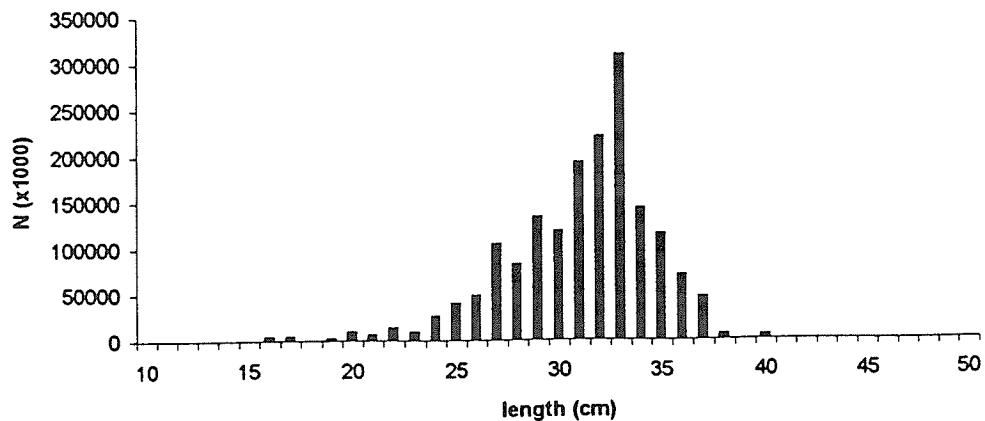


Figure 9. Total length distribution of *Sardinella maderensis*, Luanda-Benguela

Cunene horse mackerel

Also for this species the highest concentration was detected between Benguela and Cabeça da Baleia (Fig. 10). This species was present throughout the shelf and beyond the 200 m isobath. It is therefore possible that part of the stock was not covered as the survey design had initially been limited to the 200 m depth. Large individuals dominated the catches (25 to 45 cm). Figure 11 shows the length frequency distribution. Modes are difficult to detect, probably because of sampling defects.

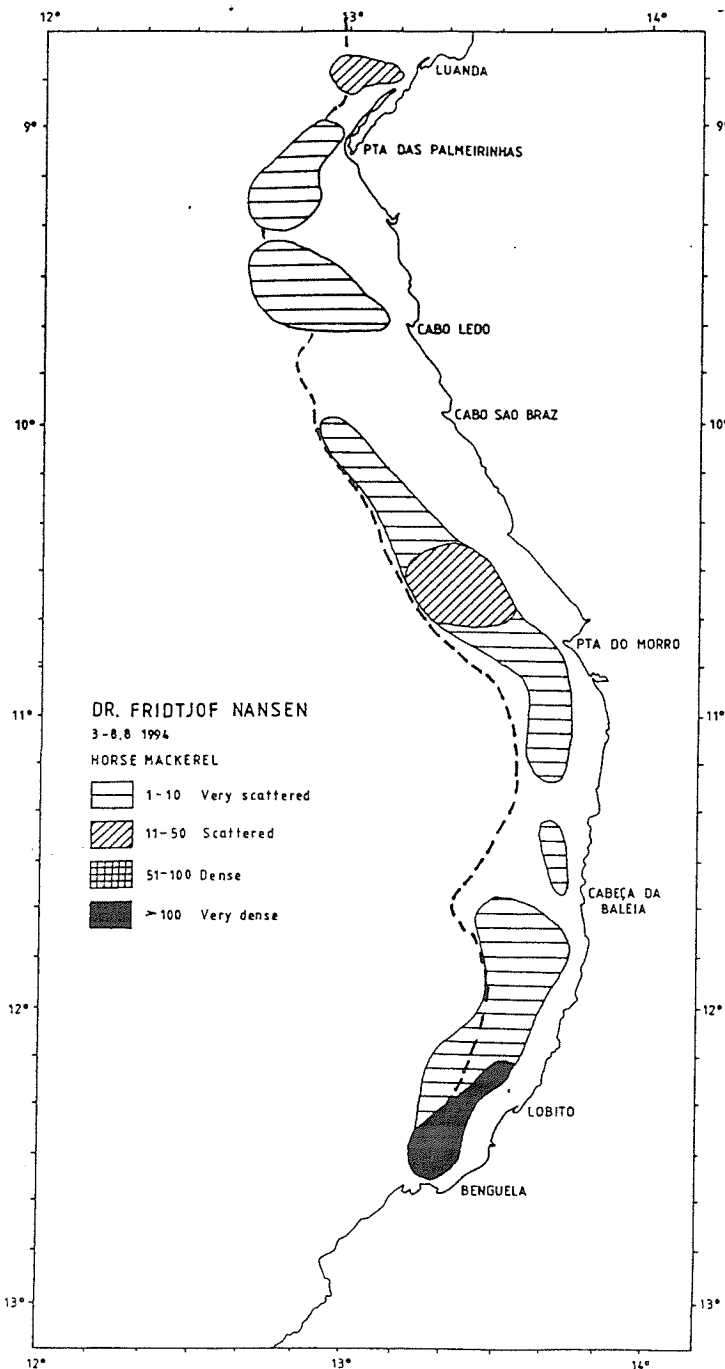


Figure 10. Distribution of *Trachurus trecae*, Luanda-Benguela

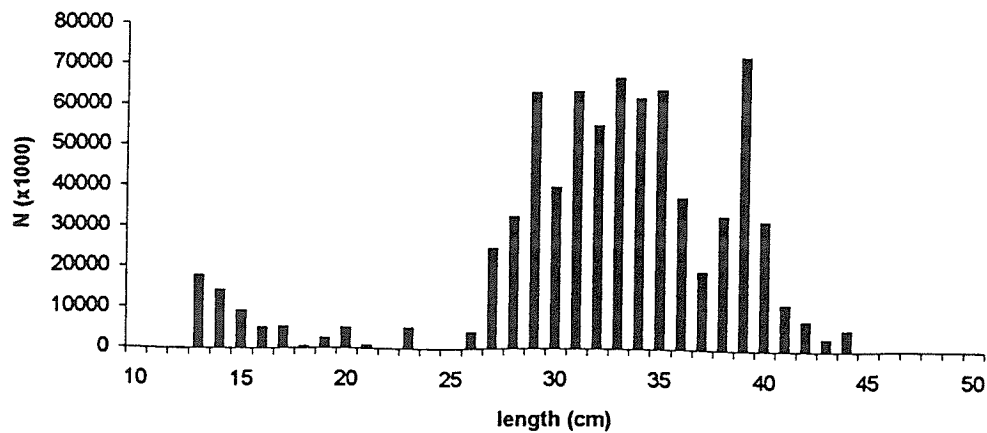


Figure 11. Total length distribution of *Trachurus trecae*, Luanda-Benguela

The total biomass in the area was estimated to 130 000 tonnes, while the estimate obtained in the March survey was about 240 000 tonnes. Also in this case, there is indication of a northward displacement in connection with the upwelling season, keeping in mind the biomass increase in the northern region of 130 000 tonnes.

Pelagic fish type 2 P2

The biomass was estimated to about 80 000 tonnes. Main components were *Trichiurus lepturus*, *Chloroscombrus chrysurus* and *Brachydeuterus auritus*.