CHAPTER 1 INTRODUCTION

1.1 Survey objectives

A planning meeting was held in Casablanca in July 1995 with participants from Morocco, Mauritania, Senegal, Gambia, Guinea Bissau, FAO and the Institute of Marine Research, Bergen. During this meeting, the objectives and schedules of the programme were established.

The defined general objectives were to estimate the biomass and map the distribution of small pelagic fish stocks off NW Africa (Morocco, Mauritania, Senegal, the Gambia and Guinea Bissau) by hydro-acoustic methods and describe the hydrographic conditions over a period of 60 days, in November-December 1995.

The agreed objectives were:

> To map the distribution and produce biomass estimates for the main small pelagic fish species: sardine *Sardina pilchardus*, sardinellas *Sardinella aurita*, *S. maderensis*, chub mackerel *Scomber japonicus*, horse mackerel *Trachurus trecae* and *T. trachurus*, false scad *Decapterus rhonchus*, anchovy *Engraulis encrasicolus* and other pelagic fish.
>
> To sample standard hydrographical transects for temperature, salinity and oxygen off Dakhla, Cap Bojador, Cap Juby and Cap Ghir.
>
> To sample the catches by recording length, weight and number by species.

The time allocated for this part of the survey was 26 days.

1.2 Participation

Members of the scientific team were:

CHBANI IDRISSI Mostafa, ABOUABDELLAH Lahcen, MESFIOUI Abdel-Hakim, CHFIRI Hamid and KADA Omar (from the Institut Scientifique de Pêches Maritimes, Casablanca, Morocco);

Tore STRØMME, Oddgeir ALVHEIM, Guillermo BURGOS, Martin DAHL and Bjarte KVINGE (from the Institute of Marine Research, Bergen, Norway)

1.3 Narrative

After embarking the Moroccan scientific team in Nouadhibou on 23 November, the survey started from Cape Blanc northwards. The general plan was to cover the shelf with acoustic transects 10 nm apart. Figure 1 (a-b) shows the survey tracks and the fishing and hydrographic stations. When approaching the Dakhla area the sardine was surfacing, probably due calm wind conditions. It was therefore necessary to return and sample again the near shore areas with sardine concentrations when the normal north-east wind resumed. The opportunity was taken to sample part of this track with a day and a night coverage, to assess day/ night differences under normal wind conditions. On 5 December the vessel called on Las Palmas for refuelling and loading equipment shipped from Norway. The acoustic survey track was resumed at Cape Bojador on the evening of 6 December. Between Cape Juby and Cap Dra the survey track on the outer shelf was opened to 20 nm due to poor fish recordings and to make up for the time spent on sampling the Dakhla area.

The vessel reached the planned northern limit of the survey area on 14 December and as fish concentrations were found, and as time permitted it, it was decided to extend the survey until Cap Jorf Lasfar. However, stormy weather was encountered and it was necessary to suspend work for about 24 hours off Safi.

The vessel called on Agadir on the 18 December for crew exchange, disembarkment of three Moroccan scientists and to allow a visit by the Moroccan authorities. The vessel left next day steaming to Las Palmas, while completing the cruise report. The vessel arrived at Las Palmas on the 20. December, with two Moroccan scientists and the Norwegian scientific team disembarking on the 21.

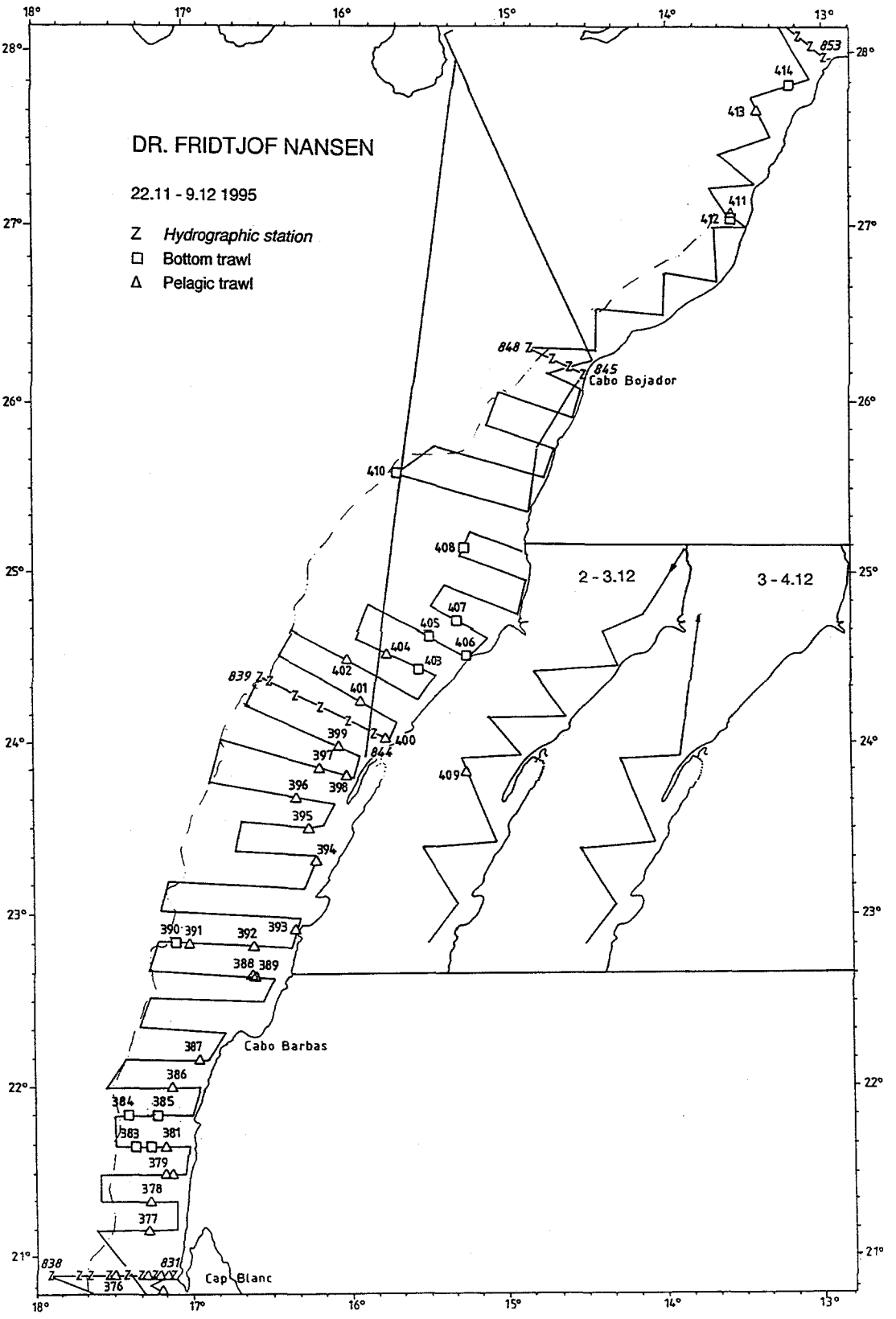


Figure 1a Course track and fishing and hydrographic stations

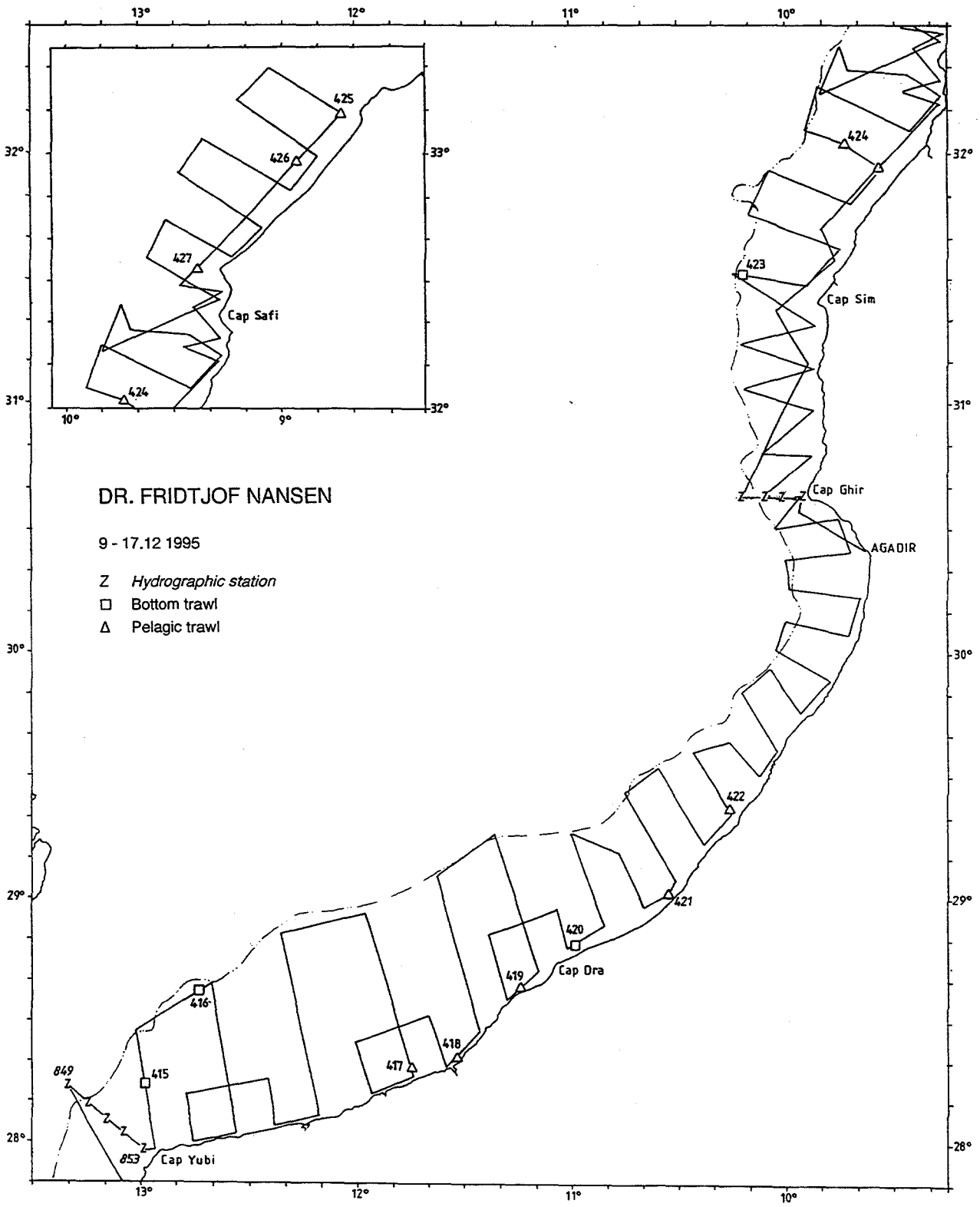


Figure 1b Course track and fishing and hydrographic stations

1.4 Methods

All catches were sampled for weight and numbers of each species. Length measurements (total length) were taken for target species. The complete records of fishing stations are shown in Annex II.

Surface and air temperature, wind speed, wind direction and solar radiation was logged automatically and recorded with position and bottom depth every nautical mile sailed.

Values for temperature, salinity and oxygen by depth were collected using a CTD sonde. These values were used to draw vertical profiles.

Simrad SA950 sonar was used for school counting and measurements of school areas by five nautical miles sailed. The sonar was set to monitor the surface waters between 25 and 300-metre distance from the starboard side of the ship. A computer program developed at IMR was used to automatically detect, count and measure fish schools.

The acoustic biomass estimates are based on the integration technique. The Bergen Integrator (BEI) was used for analysis and allocation of S_A values by species based on the composition in the trawl catches and on the characteristics of the acoustic traces. The BEI system allows better discrimination between bottom signals and dense schools close to the bottom than the previous EK500 system used during the 1992 surveys. This source of bias is thus much reduced with the present system.

The integrator values are plotted out in a working map and aggregations of fish are contoured, the mean integrator value of each aggregation is calculated and the areas are measured by a calibrated planimeter.

As for previous surveys, the North Sea herring target strength equation was used for all pelagic fish:

$$TS = 20 \log L - 72$$

The biomass density in numbers/nm^2 of a length group i is calculated from the formula:

$$\rho_i = \frac{1}{4\pi} * \bar{s}_a \frac{n_i}{\sum_{i=1}^{\max} n_i k_i} \qquad k_i = 10^{2\log l_i - 7.2}$$

The formula can be further developed into:

$$\rho_i = 1261217 * \bar{s}_a \frac{n_i}{\sum_{i=1}^{\max} n_i l_i^2}$$

where s_a = mean total integrator value from a species distribution area in m^2/nm^2

n_i = frequency count of length group i in pooled representative sample from the distribution area.

l_i = total length of fish in length group i.

These densities are then converted from numbers to weight by applying a condition factor for the species, obtained from the samples. Abundance in number and weight is obtained by multiplying the densities with the area of the aggregations.

The above equation shows that conversion from Sa-value into number of fish is much dependant on the size composition of the fish. A representative pooled length distribution to use in the above equation and the biomass estimate are obtained through the following procedure:

a. Each trawl station is given an integrator value, as a density index for the location.
b. The length distribution of each fish aggregation (area in the map) is obtained from the samples believed to be representative for that aggregation.
c. Each length sample is associated with a mean back scattering strength representative for the size distribution.
d. The selected length distributions are then pooled using the ratio between the allocated Sa value and the mean back scattering strength for the size distribution as weighting factor.
e. The pooled length distribution is used in the above formula to calculate the biomass density by length group, for each area in the map.
f. Biomass is calculated as the product of the density and the area of the aggregation.
g. The area-related biomass values from a map or a region are summed together.

The calculations in d.-e. are done automatically in NAN-SIS software after the scientist has completed steps a.-c.

The two sardinellas were treated as one species during the scrutinizing process and the mean Sa values were later separated by species (*S. aurita* and *S. maderensis*) according to the catch rates and the length distributions of the two species. The same method applies to the two horse mackerel species.

Annex III gives a description of the instruments and the fishing gear used.

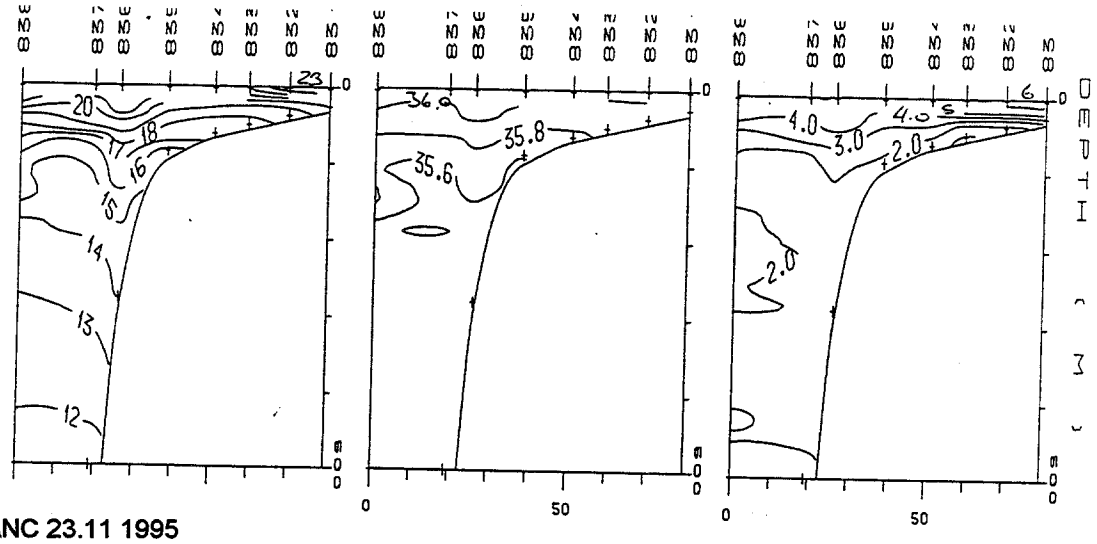
Upon completion of the survey the following data/documents were made available to the scientific team from Morocco: the present report; all data from fishing stations and length sampling (NAN-SIS format); bathymetric data of the cruise track with position and 1- nm resolution (ASCII format); working maps (A1 size) of: Sa values, bottom depths and wind conditions during the survey.

CHAPTER 2 SURVEY RESULTS

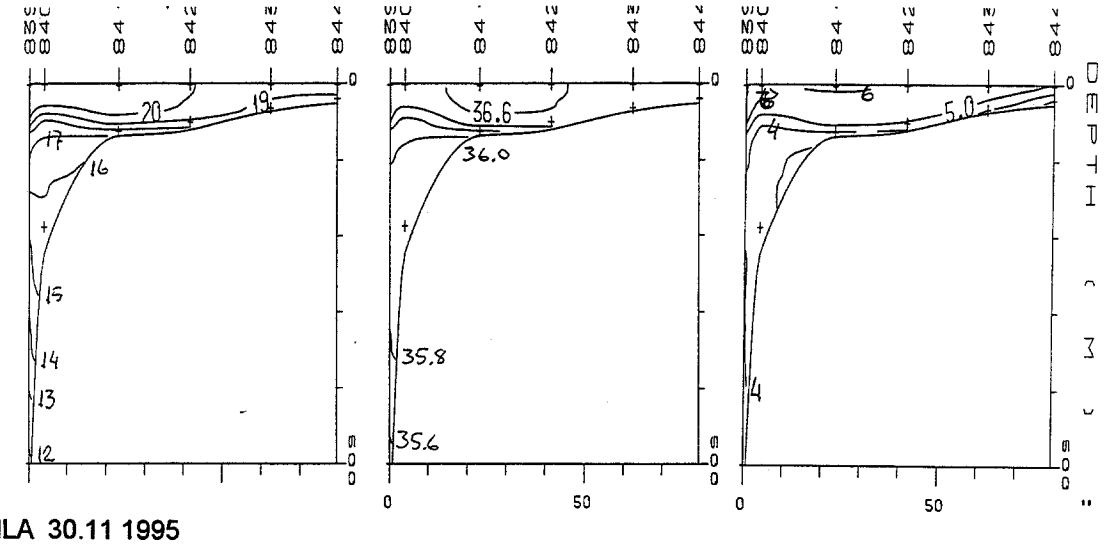
2.1 Hydrography and weather conditions

Figure 2 shows the distribution of temperature, salinity and oxygen in the five profiles and Figure 3 (a-b) the sea surface temperature at 5 m depth.

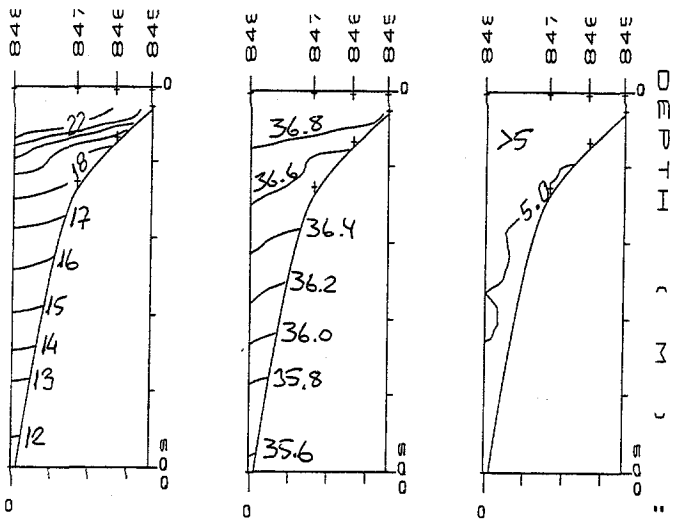
The distribution of surface temperature showed well developed coastal upwelling in the whole survey area with surface temperatures below 19°C near the coast south of Cape Bojador and decreasing to below 17°C in the north. The same pattern is pictured in the transects. There are no signs of oxygen depletion in the water over the shelf.



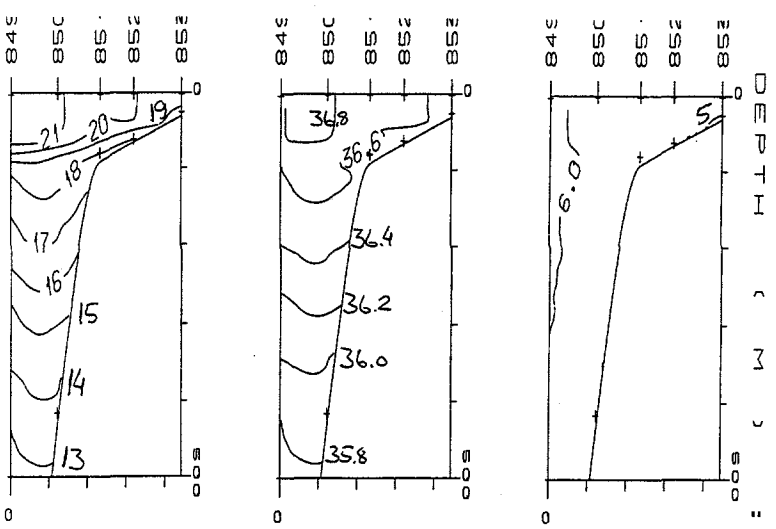
CAP BLANC 23.11 1995



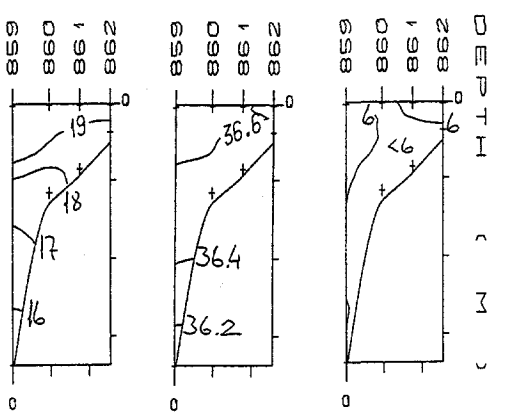
DAKHLA 30.11 1995



CAP BOJADOR 7.12 1995



CAP JUBY 9.12 1995



CAP GHIR 17.12 1995

Figure 2 Hydrographic profiles with distribution of temperature, salinity and oxygen

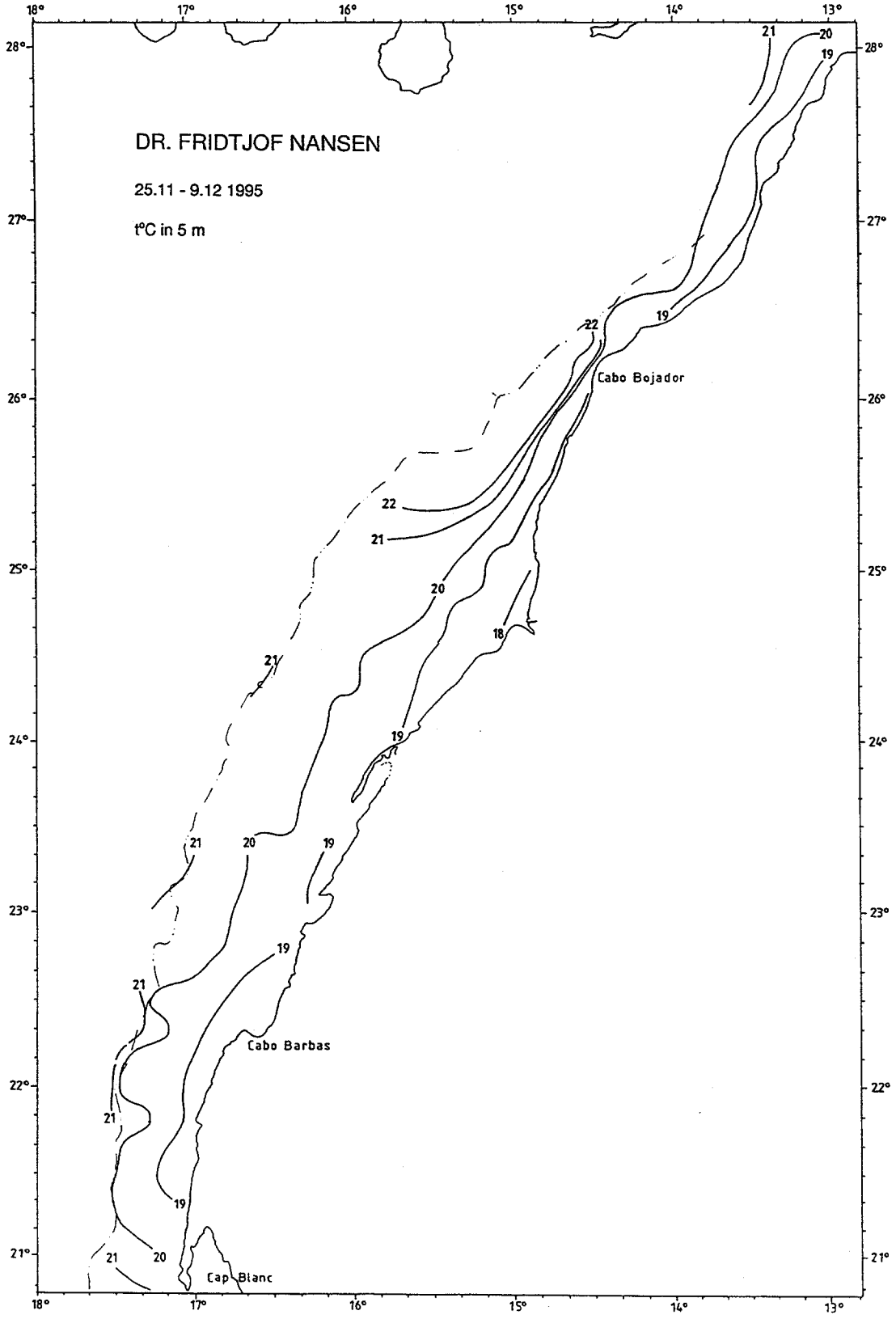


Figure 3a Sea surface temperature

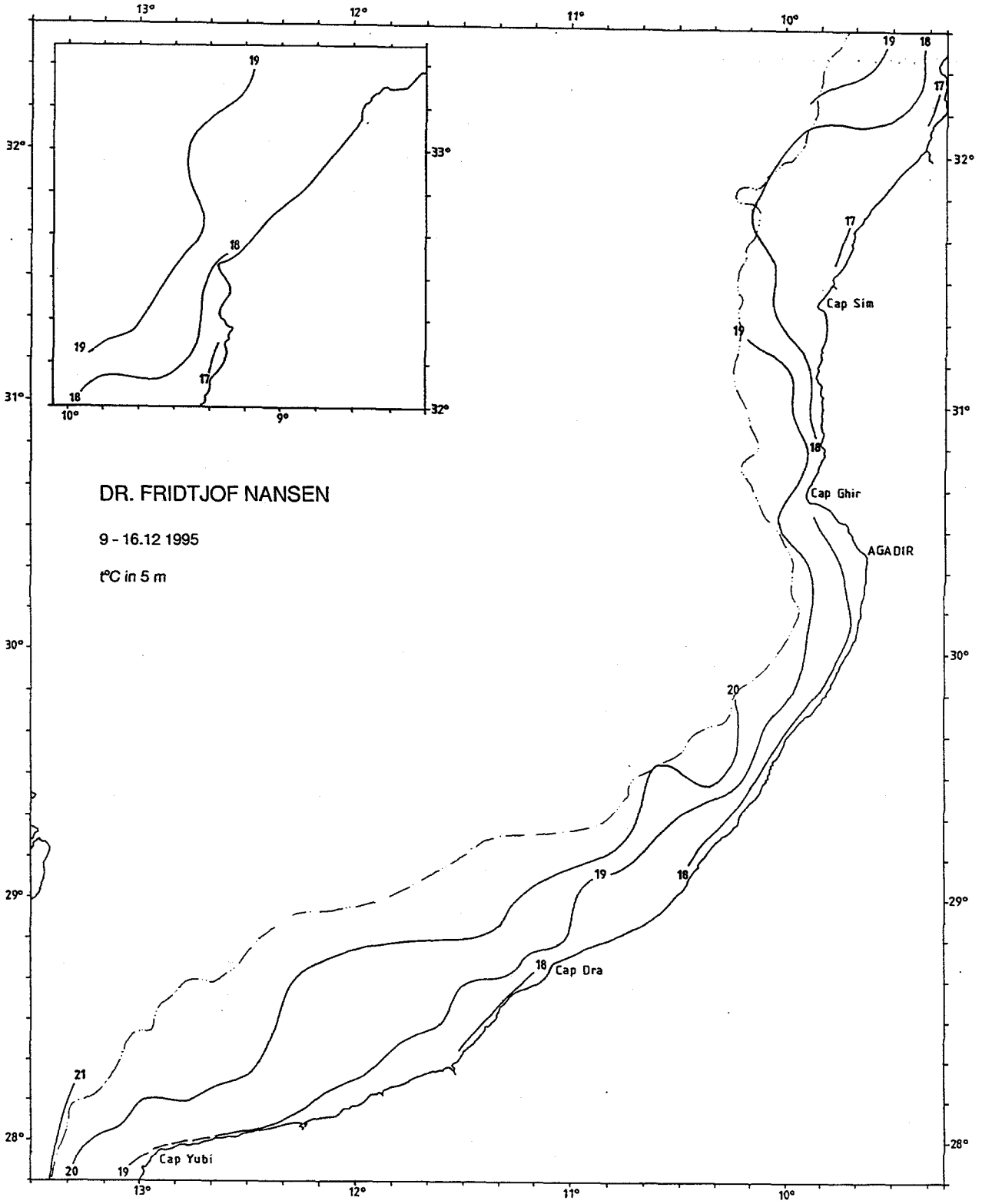


Figure 3b Sea surface temperature

The wind conditions along the survey track are shown in Figure 4 (a-b). Winds of varying strength from north-east characterised the survey between Cape Blanc and Cape Juby, interrupted by calm weather conditions for two days when operating at 23-24°N. Between Cape Juby and Safi the wind direction was more varying, and stormy weather from south-west was encountered for one day in the far north of the survey area. The weather conditions were favourable for acoustic work except during the calm weather and during the storm. The calm weather gave problems with surfacing schools.

2.2 Pelagic fish on the shelf from Cap Blanc to Cap Juby

Figures 5 to 8 show the distribution of the four main species groups of pelagic fish by contoured acoustic densities (it should be noted that the unit used is m^2/nm^2 which is 10 times that used in previous Nansen reports. The density levels used in the hatchings are consistent with previous reports).

Sardine (fig. 5) was found in a major aggregation between Cape Barbas and northwards to 25°N. As during previous surveys the highest densities were found close to the shore and the centre of the distribution is around Dakhla or 24°N. Small pockets of sardine were found further north and one small aggregation was recorded in the south at 22°N.

Sardinellas (fig. 6), were found in patches as far north as 25°N . The aggregation found from Cap Blanc and northwards is a continuation of the sardinella distribution found in Mauritania. In previous 'Dr. Fridtjof Nansen' surveys in this region (Sept. 1986, Sept. 1989, Jan.1992), sardinellas were first recorded in small amounts in 1992. The present distribution, with the sardinellas occupying and dominating the outer shelf at the centre of the sardine population has not been observed before. These concentrations represent the continuation of the population in Mauritania and Senegal, which in later years has increased several times from its level in the 80ies.

Horse mackerel (fig. 7) was found at most locations between Cap Blanc to a little north of Cap Barbas. Further north, only spurious occurrences were encountered.

Chub mackerel (fig. 8), was found in an aggregation at 25°N and a few weak spots south of Cabo Barbas.

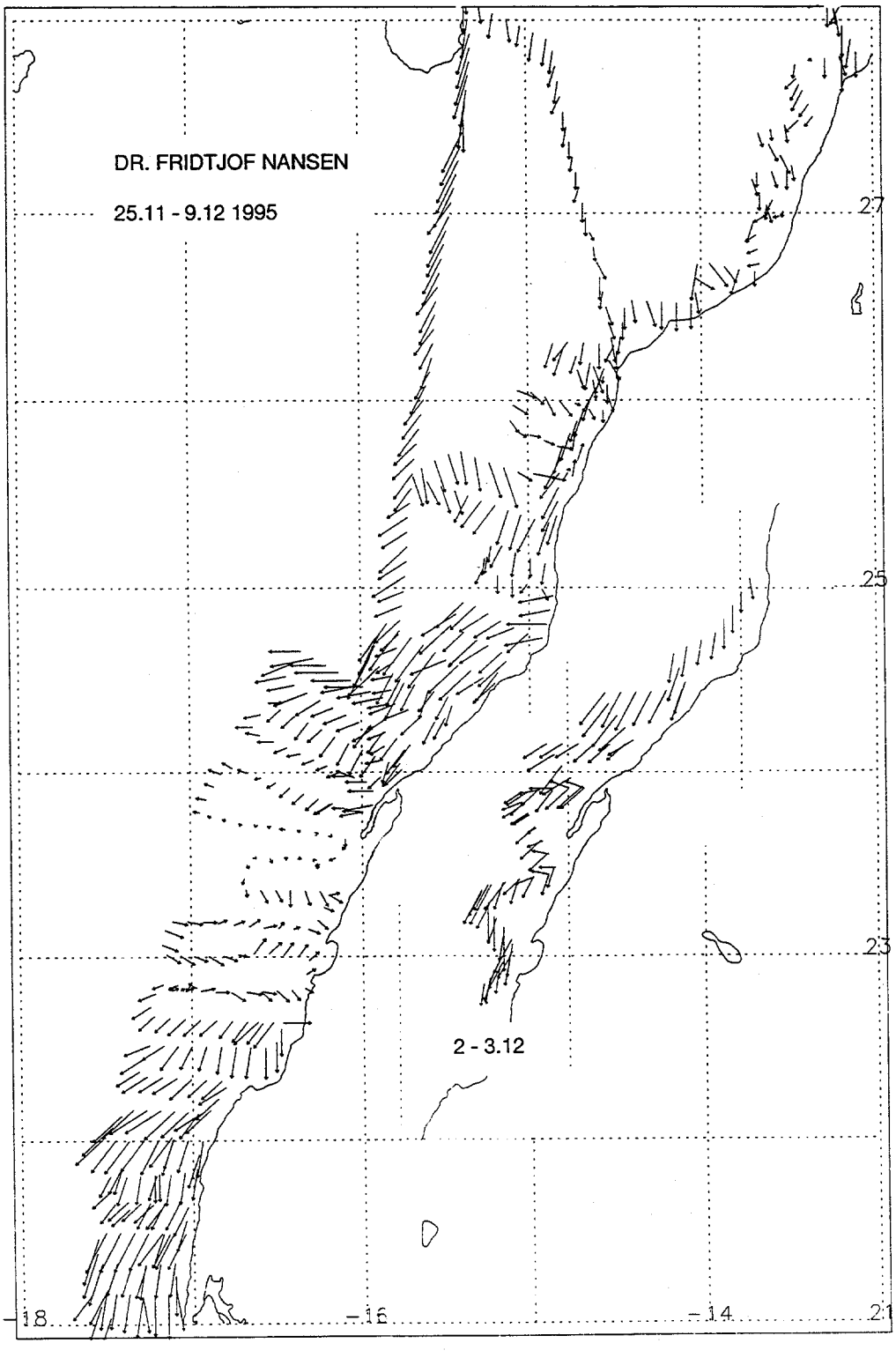


Figure 4a Wind conditions along the cruise track

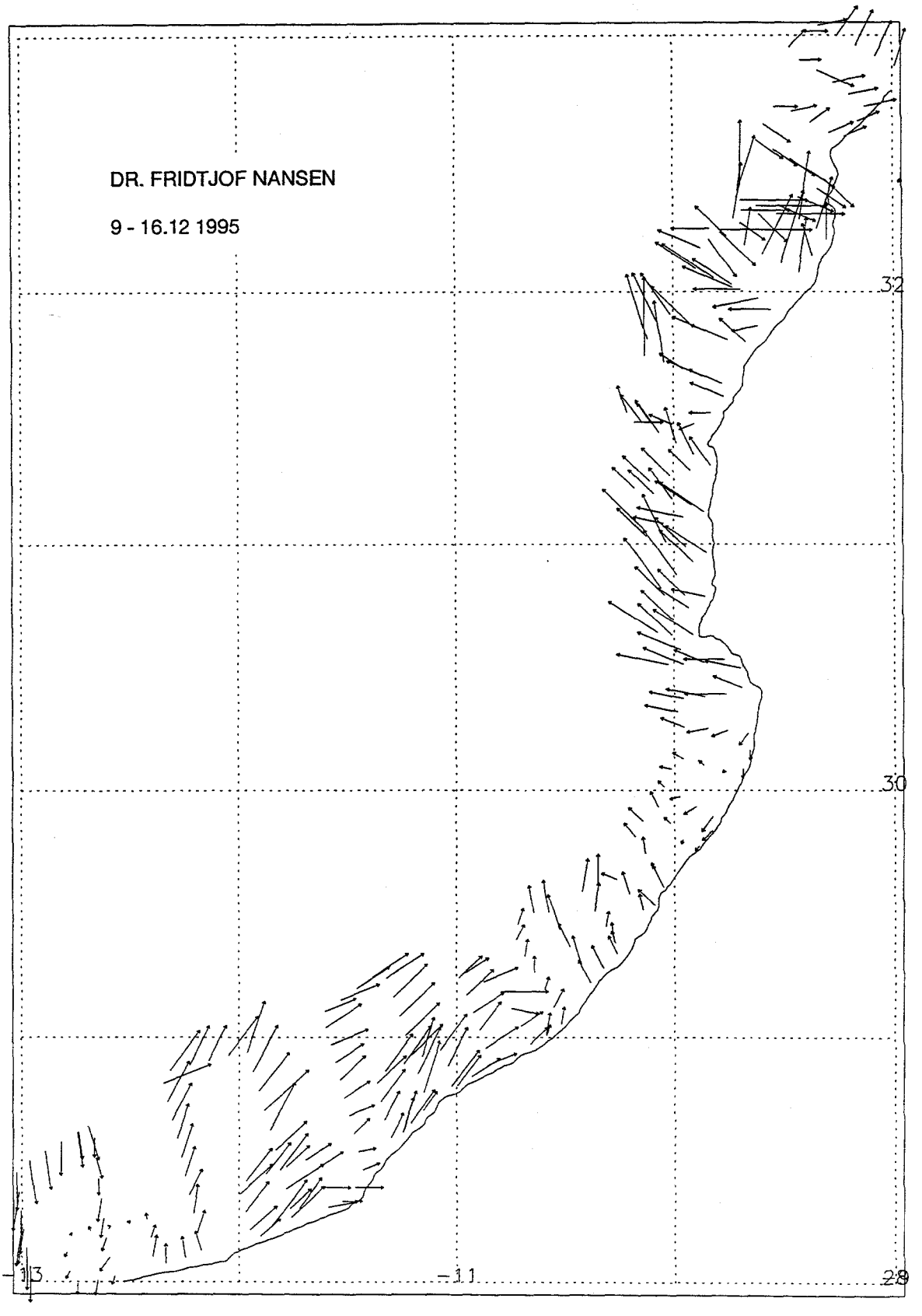


Figure 4b Wind conditions along the cruise track

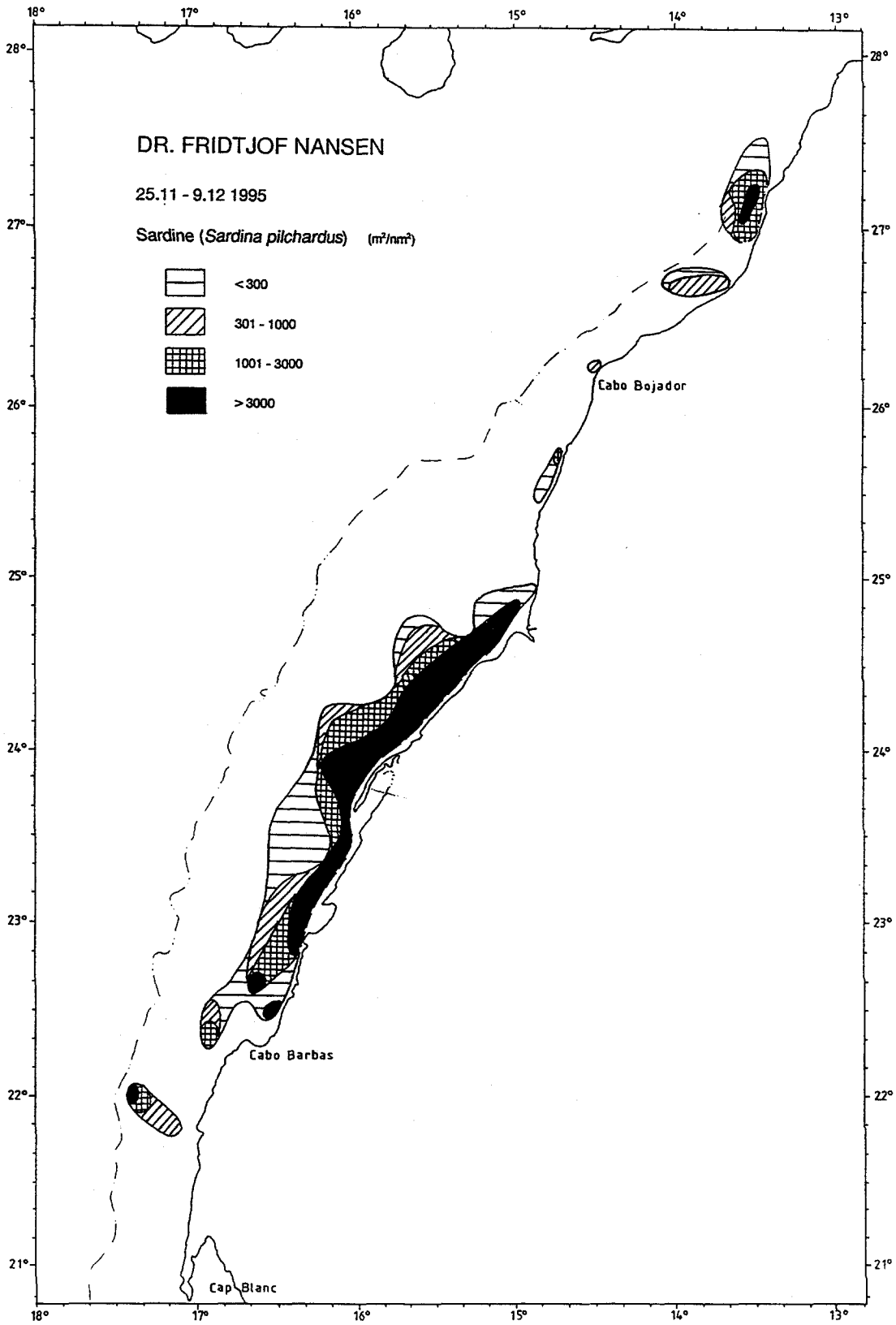


Figure 5 Distribution of sardine, Cap Blanc to Cap Juby

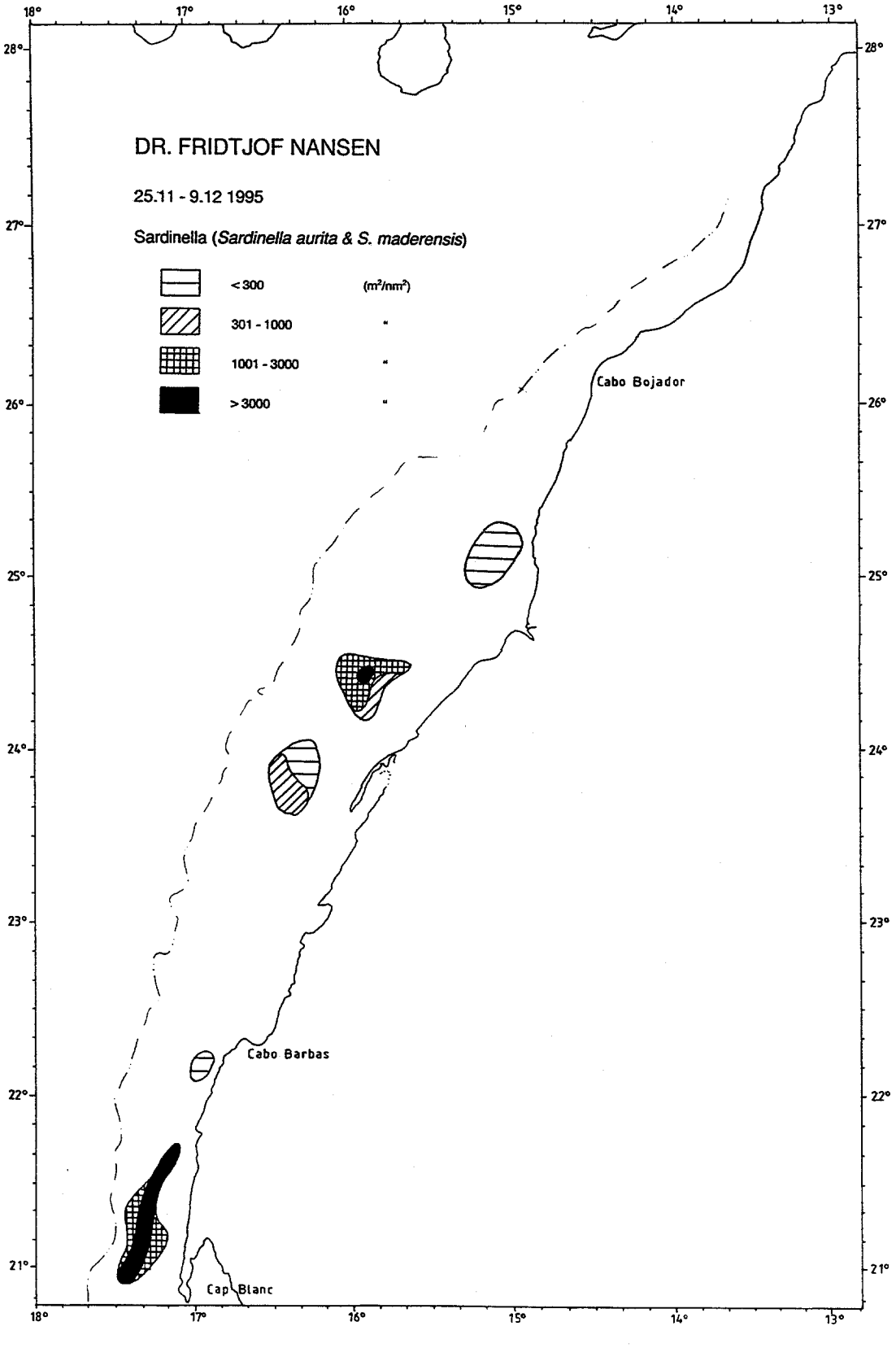


Figure 6 Distribution of sardinella, Cap Blanc to Cap Juby

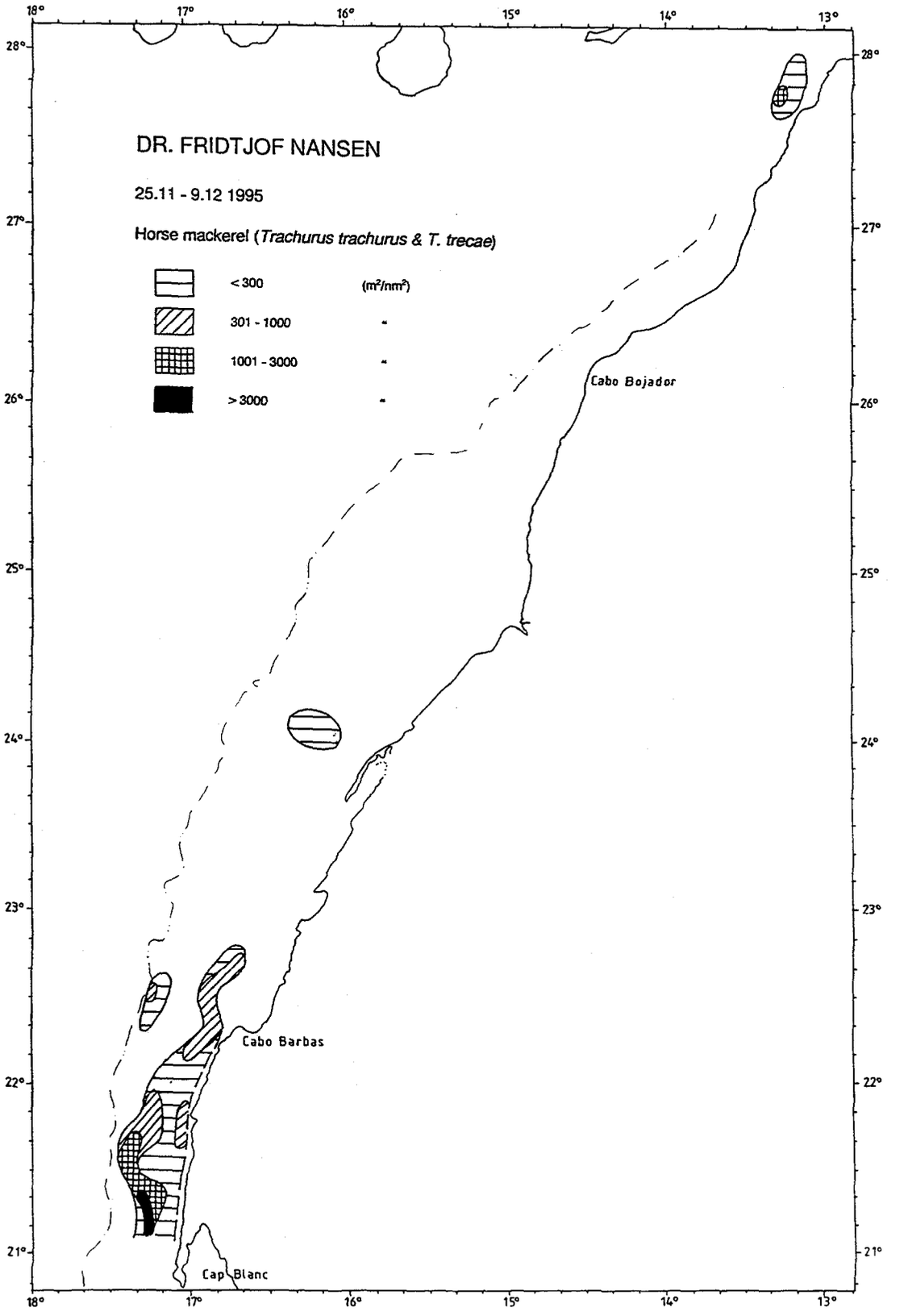


Figure 7 Distribution of horse mackerel, Cap Blanc to Cap Juby

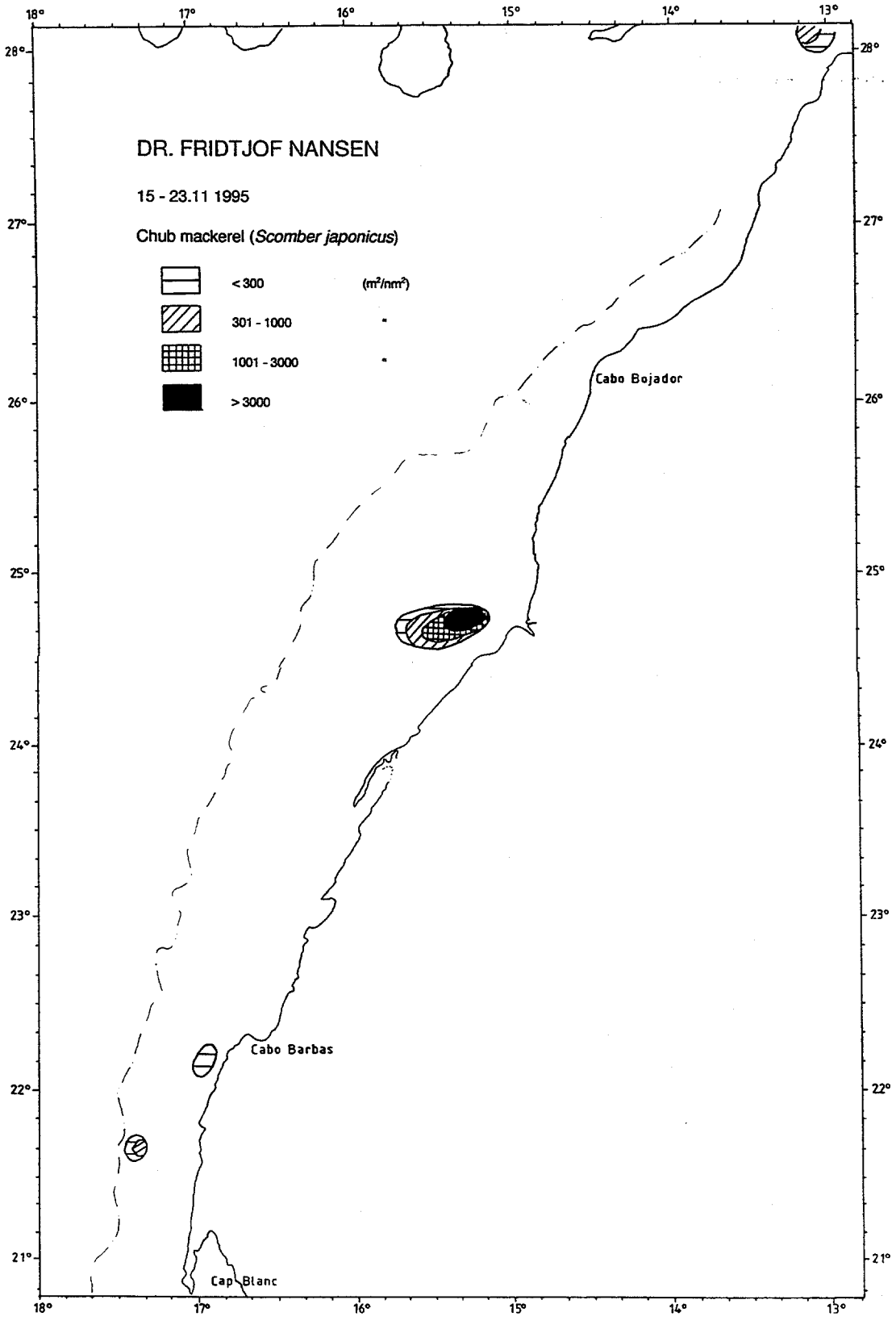


Figure 8 Distribution of chub mackerel, Cap Blanc to Cap Juby

Biomass estimates

Detailed biomass estimates in number and weight by length groups are shown in Annex I.

The sardine was estimated to 3.43 million tonnes. The length distribution is shown in Figure 9. Bhattacharya analysis gave three main cohorts in the population with modes on 12.5, 17.5 and 22.5 cm and biomasses of respectively 129, 160 and 2 970 tonnes.

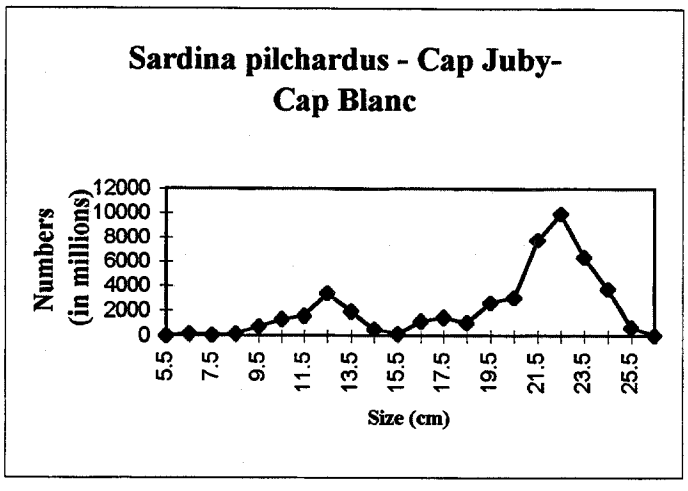


Figure 9 Length frequency distributions of sardine Cap Juby-Cap Blanc

Table 1 gives the estimates of sardinella and horse mackerel. The total estimate of sardinella is 955 thousand tonnes of which 67% is round and 33% is flat sardinella. The total estimate of horse mackerel is 340 thousand tonnes of which 74% is Atlantic and 26% is Cunene horse mackerel.

Table 1 Cap Blanc to Cap Juby. Biomass estimates of pelagic fish, 1000 tonnes

Sardines	Round sardinella	Flat sardinella	Atlantic horsem.	Cunene horsem.
3430	640	315	250	90

2.3 Pelagic fish on the shelf from Cap Juby to Cap Jorf Lasfar.

Sardine was found in most of the shallow areas in the region (fig. 11). The main concentrations with high densities were between 10° and 12°W. Outside this area mainly scattered occurrences were encountered. The estimated length frequency distribution (fig.10) shows that most of the sardine is small sized, below 18cm. From Bhattacharya analysis two modes were detected, at 13.5 and 18.3 cm, respectively.

Horse mackerel was identified by echotraces at two locations, the main part scattered (fig. 12). Chub mackerel was located in scattered patches along the coast (fig. 13), usually outside the sardine distributions.

Anchovy was only found in low densities in very few hauls and it was practically not possible to produce maps or any biomass estimates for this species.

In the surveyed area north of Safi substantial amounts of young fish of various species, but mainly sardine were recorded off the bottom, in the shallow waters. This fish was around 5-6 cm length and is not included in the maps or in any biomass estimates.

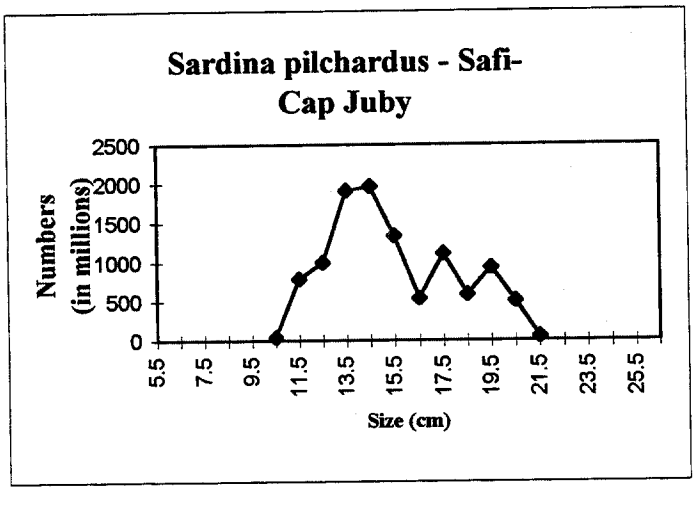


Figure 10 Length frequency distribution of sardine Cap Juby-Cap Jorf Lasfar

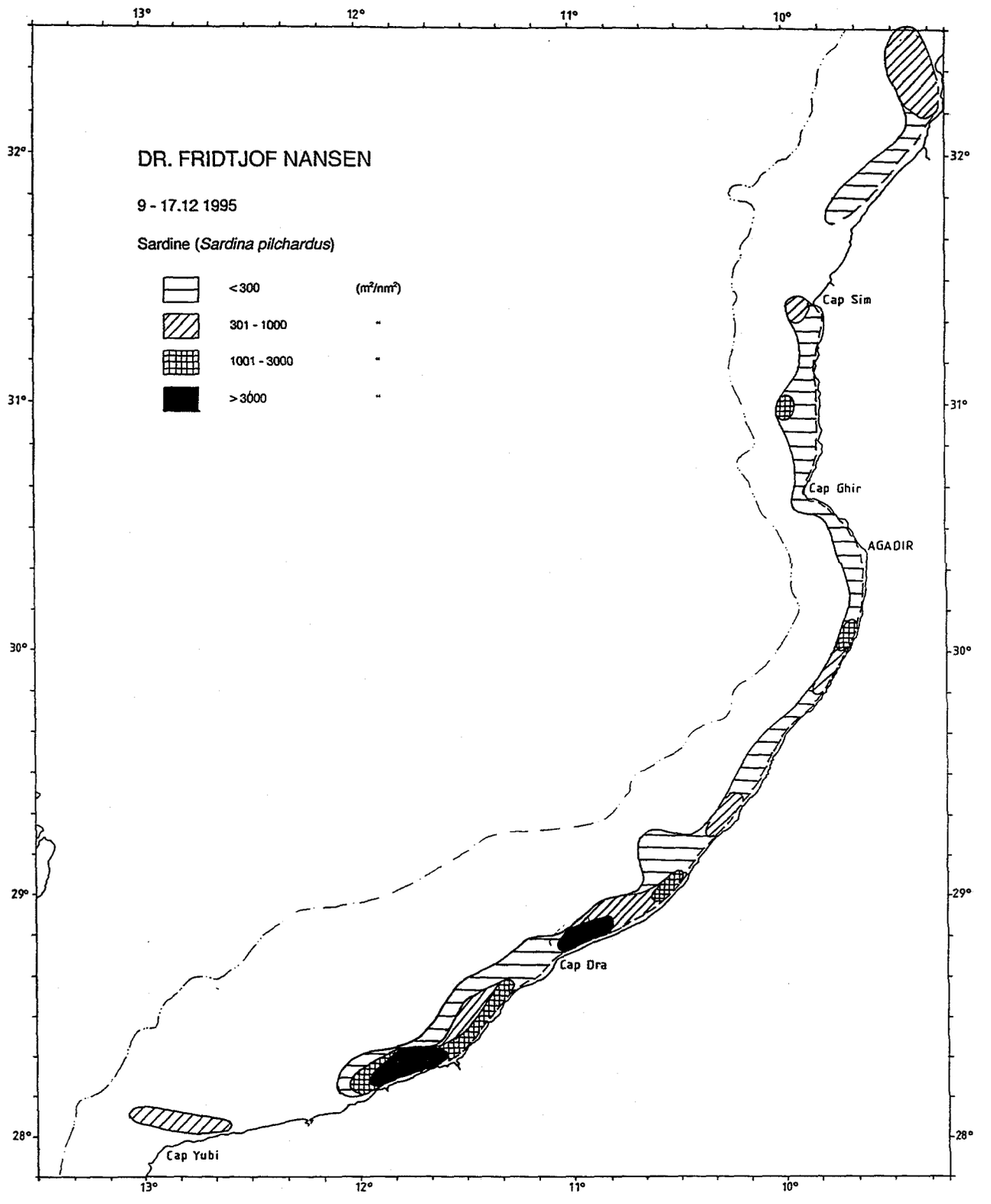


Figure 11 Distribution of sardine, Cap Juby to Cap Jorf Lasfar

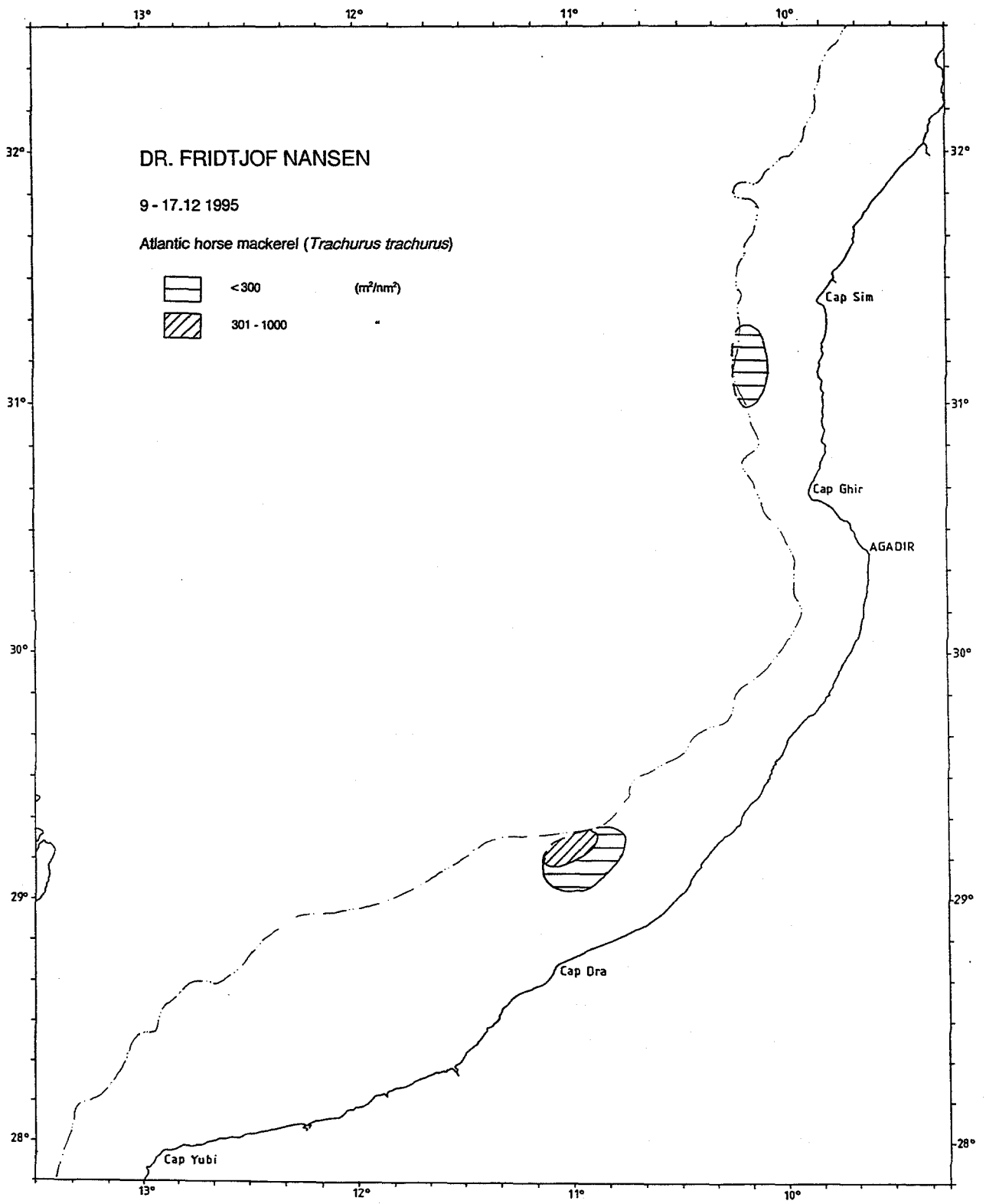


Figure 12 Distribution of horse mackerel, Cap Juby to Cap Jorf Lasfar

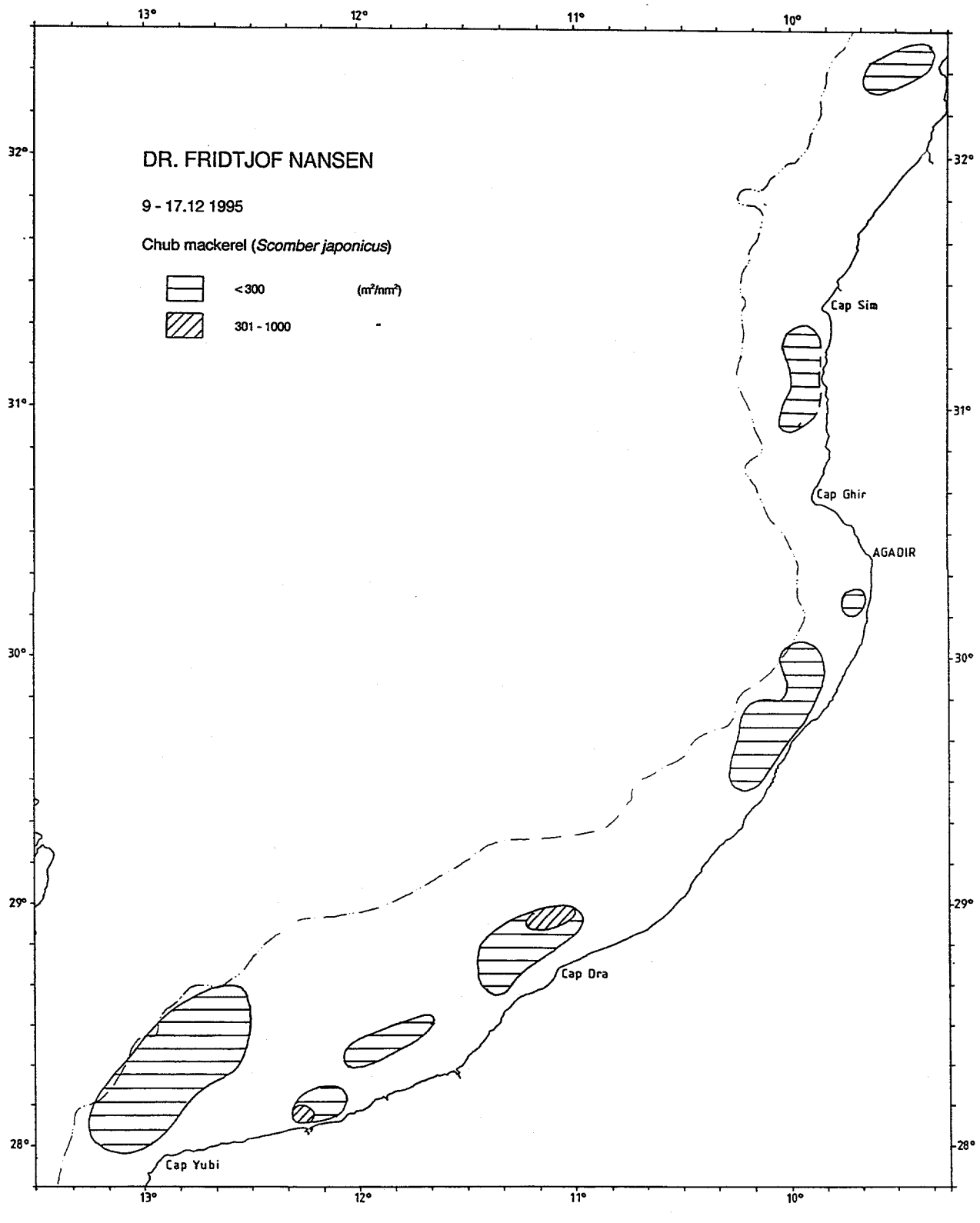


Figure 13 Distribution of chub mackerel, Cap Juby to Cap Jorf Lasfar

Biomass estimates

The sardine was estimated to 315 thousand tonnes of which 112 tonnes belong to the 13.5 cm modal length group and 172 tonnes to the 18.3 cm modal length group.

The estimate for horse mackerel in the northern area is only 8 thousand tonnes.

Chub mackerel was estimated to 32 thousand tonnes of which 30 thousand tonnes was of size less than 20cm.

CHAPTER 3 CONCLUDING REMARKS

The survey was conducted successfully in the period 24 November to 21 December with a course track of 4 800 nm and 51 fishing stations. The limits of the school areas of the targeted species are thought to have been well determined and the main areas adequately sampled.

The hydrographic data show well developed upwelling along the entire coastline, and the whole shelf holds water well enriched with oxygen. Except for the upwelling, no fronts or oceanographic barriers were observed on the shelf.

Sardine was found in high densities between CaboBarbas and 25°N, between Tan Tan and 12°W and at one location between Cap Bojador and Cap Juby. Outside these locations the species was found scattered in most of the shallow areas north of Cap Juby.

Round and flat sardinellas were found north to 25°N, in considerable abundance and density at two locations, northwest of Cap Blanc and northwest of Dakhla. The presence of sardinella in high abundance so far north, and almost coexisting with the sardine, has not been earlier reported. This might be the result of the expansion of the population in the 90ies.

Horse mackerel was found in high abundance between Cap Blanc and Cabo Barbas, a continuation of the distribution recorded in Mauritania during the previous survey. Further north, horse mackerel was recorded only in scattered aggregations.

A good concentration of chub mackerel was located at 25°N. Further north the species was common but usually in low densities that mainly consisted of small fish less than 20 cm.

The biomass estimates are summarized in Table 2.

Table 2. Summary of biomass estimates of pelagic fish. 1000 tonnes.

	C. Blanc-C. Juby	C. Juby- Safi	Total
Sardine	3435	315	3750
Sardinellas	955	0	955
Chub mackerel	160	30	190
Horse mackerel	340	8	348

Figure 14 shows the biomass estimates of sardine compared with results from previous Dr. Fridtjof Nansen surveys. The sardine in the south shows a decline from 4.05 million to 3.43 million tonnes since the previous survey, and the stock is now probably at the same level as in 1989. The central stock between Cap Juby and Safi is estimated to the same size as in 1992 and has still not recovered from its low level compared to the situation in the 80ies.

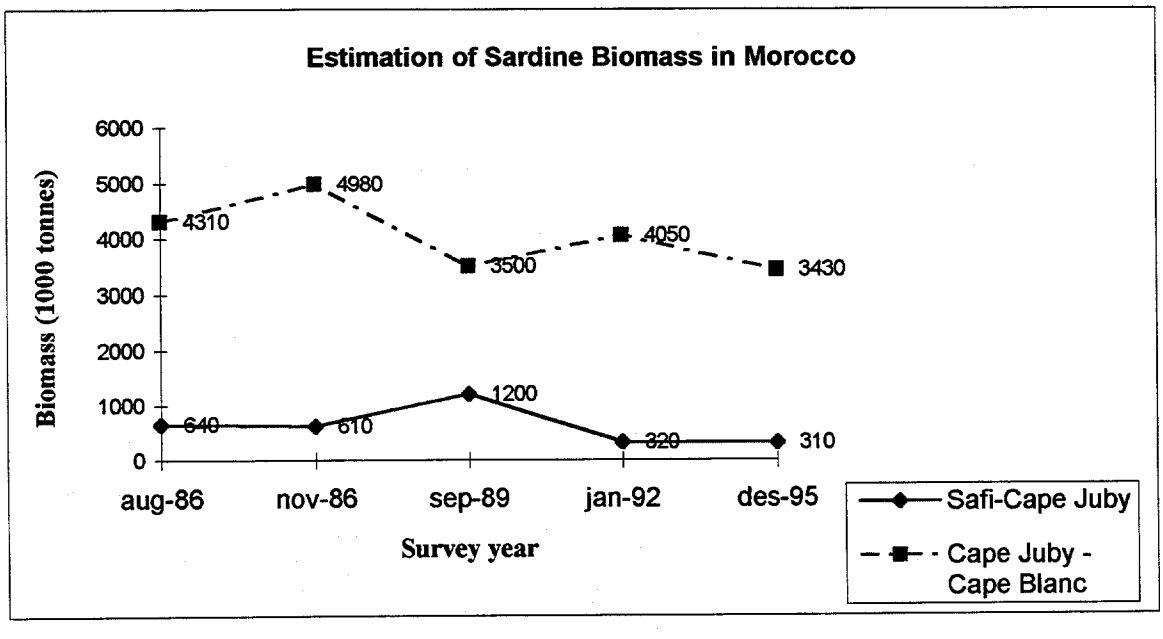


Figure 14 Biomass comparisons with previous 'Dr. Fridtjof Nansen' surveys

Sardinella was first estimated in 1992, but only to 10 thousand tonnes, and the present level close to one million tonnes is remarkable. Chub mackerel was estimated to 45 thousand tonnes in 1992 compared to the present 160 thousand tonnes. Also horse mackerel shows a strong increase from 120 thousand tonnes in 1992 to 340 thousand tonnes at present. Most of the horse mackerel is located close to Cap Blanc and the increase can be explained by seasonal migration between Mauritania and Morocco.