

## CHAPTER 1 INTRODUCTION

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### 1.1 Objectives of the cruise

A planning meeting was held in Casablanca in July 1995 with participants from Morocco, Mauritania, Senegal, The 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 and map the distribution and biomass of small pelagic fish stocks off NW Africa (Morocco, Mauritania, Senegal, the The Gambia and Guinea Bissau) by hydro-acoustic methods and describe the hydrographic conditions there over a period of 60 days, in November-December 1995. For Senegal and The Gambia the agreed objectives were:

To map the distribution and produce biomass estimates for the main small pelagic fish species; sardinella *Sardinella aurita*, *S. maderensis*, horse mackerel *Trachurus trecae*, false scad *Decapterus rhonchus*, anchovy *Engraulis encrasicolus* and other pelagic fish.

To occupy standard hydrographical transects for temperature, salinity and oxygen at about 13°35' N and 14°50' N.

To carry out bottom trawl survey off The Gambia, if time available.

Catch sampling would comprise weight and number by species and length frequency distributions of the principal species.

The time allocated in the work plan for this part of the survey, off Senegal and The Gambia, was 10 days.

### 1.2 Participation

Members of the scientific teams were:

SENEGAL: Birane SAMB (2-23/11), Abdoulaye SARRE (2-23/11), Ibrahim SOW (2-23/11)  
Mor SYLLA (2-23/11)

THE GAMBIA: Asberr N. MENDY (2-13/11), Maimuna NDOW-CEESAY (2-13/11), Lamin JAWLA (2-13/11)

GUINEA BISSAU: Duarte BUCAL (2-13/11), Vittorino Assau NAHADA (2-13/11), Abel Julio SANTOS (2-13/11)

MAURITANIA ( from 12/11): Mohamed MAHFOUDH OULD TALEB SIDI, Diallo IBRA, Ball Abou CIRE

NORWAY: Gunnar SAETERSDAL, Oddgeir ALVHEIM, Guillermo BURGOS (from 13/11), Martin DAHL and Bjarte KVINGE

### **1.3 Narrative**

The course tracks with the fishing and hydrographical stations are shown in Figure 1.

After completion of the survey off Guinea Bissau on 6 November work started off Casamance on 7 November with main course tracks spaced about 10 nm apart. Since it appeared that the distribution of pelagic fish was mainly limited to the inner shelf, inside about 30 m depth, the survey intensity was increased in this shelf part. A swept area trawl survey was made off The Gambia with 17 prelocated stations spaced over the shelf at about 5 nm distance.

A school area of sardinellas with high densities was found inshore, off the estuaries of The Gambia and Saloum rivers. By extending the survey grid into 10 m depth the shoreward limits of the distribution of this school area was established. The outer limit was similarly confirmed by a grid net along 25-35 m depth. The bottom trawl with floats was used for sampling the pelagic fish in these shallow waters. Another sardinella school area was found south of Dakar on 9-10 November in slightly deeper waters and its distribution determined. The shelf northwards to Cayar was then covered before a call was made on Dakar on 13 November to disembark the participants from Guinea Bissau and The Gambia and embark participants from Mauritania.

The shelf from Cayar to St Louis was surveyed on 14 - 16 November.

The hydrographic profile off The Gambia was occupied on 9 and that off Cap Vert on 12 November.

## 1.4 Methods

All catches were sampled for composition by weight and numbers of each species. The length frequency distributions of the target species was almost always taken. Total fish length was measured. The complete records of fishing stations are shown in Annex IV.

The surface temperature was logged automatically and recorded with position and bottom depth every nautical mile sailed.

Hydrographical profiles were collected with a CTD sonde with logging of records of temperature, salinity, and depth. From these data series records were selected from standard depths and presented in figures.

The acoustic biomass estimates are based on the integration technique. The Bergen Integrator (BEI) was used for analysis and allocation of  $S_A$  values. This system does not underestimate dense schools close to the bottom as some times may have happened with the EK500 used in the 1992 surveys.

The North Sea herring target strength was used for all pelagic fish:

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

The biomass density in numbers/nm<sup>2</sup> of a length group  $i$  is calculated from the formula:

$$\rho_i = \frac{1}{4\pi} * S_a \frac{n_i}{\sum_{i=1}^{\max} n_i k_i} \quad k_i = 10^{21 \log l_i - 7.2}$$

where  $s_a$  = Mean total integrator value from a species distribution area in m<sup>2</sup>/nm<sup>2</sup>

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

$l_i$  = total length of fish in length group  $i$ .

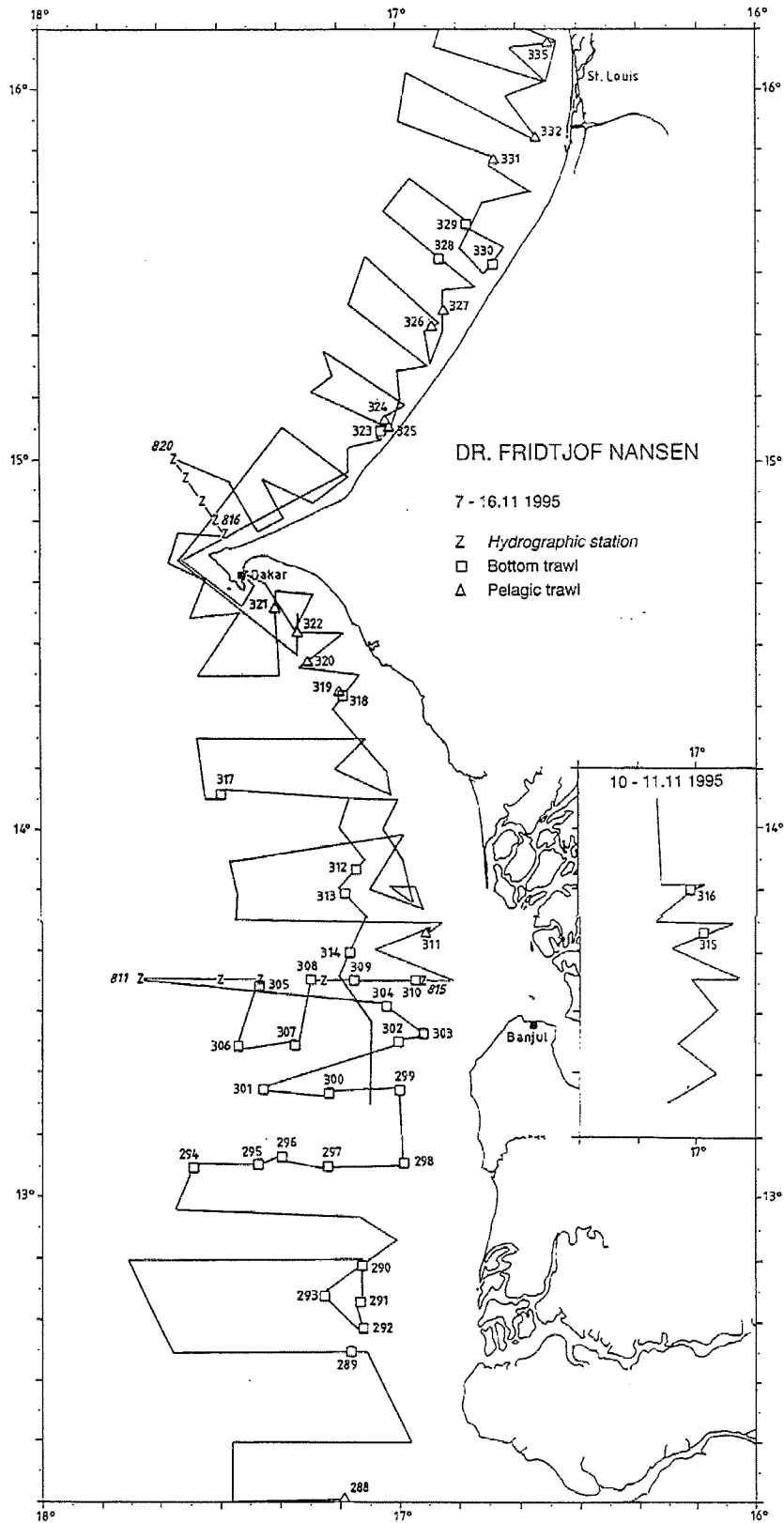


Figure 1 Course tracks with fishing and hydrographical stations

These densities are then converted from numbers to weight by applying the condition factor for the species. Absolute biomasses are obtained by multiplying the densities with the size of the distribution area, usually obtained with a digital planimeter.

The integrator outputs were split into fish groups using a combination of behaviour pattern as deduced from echo diagrams, the BEI analysis and catch composition. The following groups were used for Senegal: sardinellas, carangids and associated species which include chub mackerel, hairtails and barracudas. Catch compositions formed the basis for a further separation of biomass by species.

In the swept area trawl survey in The Gambia 30 min hauls were made at predetermined positions along the cruise track covering the various depths between about 10 m and the shelf edge at 100-200 m. For conversion of catch rates to fish densities the distance between the wings is assumed to be the width of the effective fishing area i.e.  $q$  is equal to 1. Catch rates are converted to kg per hours towing.

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

All data of fishing stations and length sampling were made available to the participants on diskettes.

## CHAPTER 2 SURVEY RESULTS

### 2.1 Hydrography

Figure 2 shows the distribution of temperature, salinity and oxygen in the two profiles and Figure 3 the sea surface temperature at 5 m of depth.

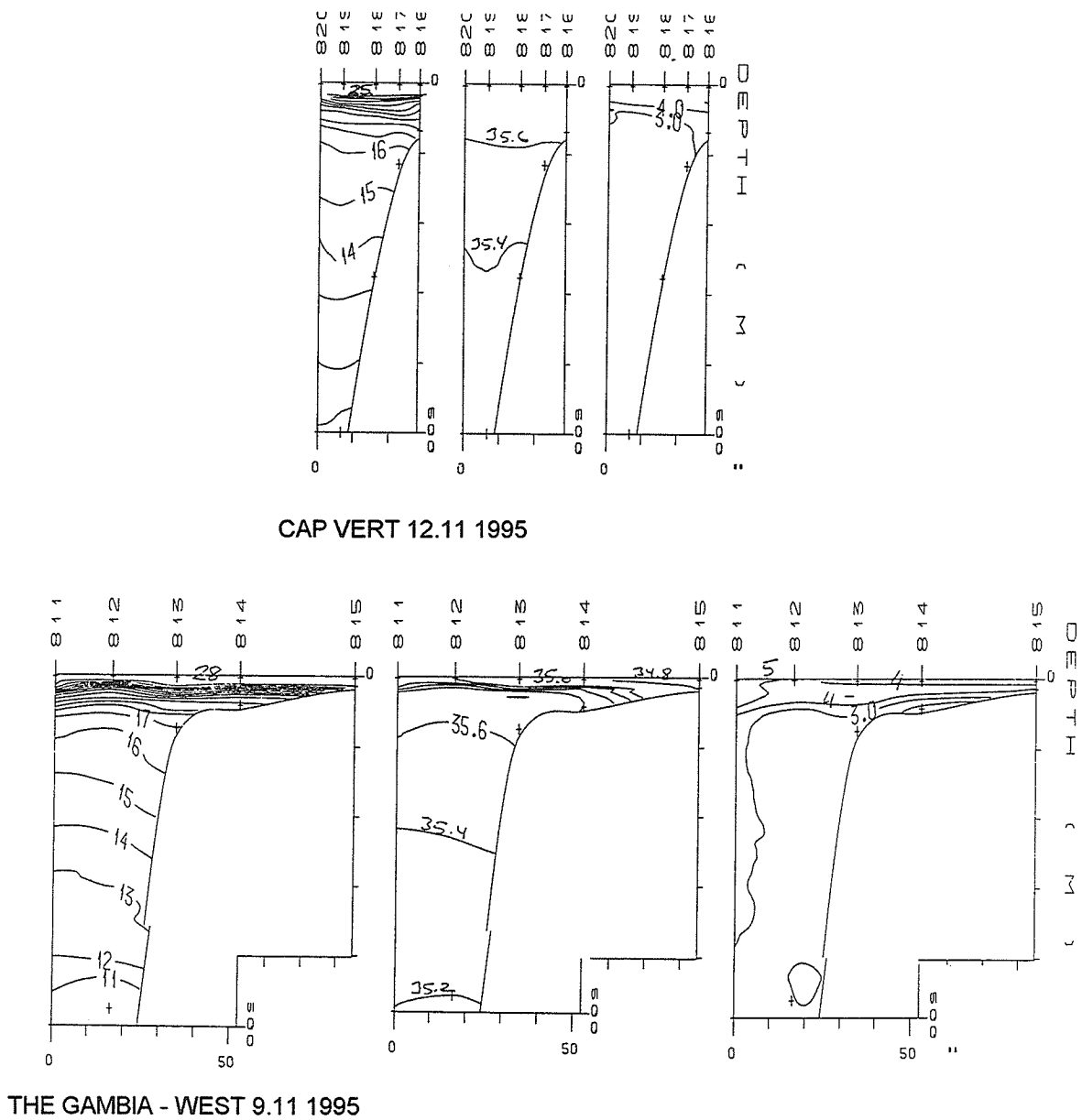


Figure 2 Hydrographic profiles with distribution of temperature, salinity and oxygen

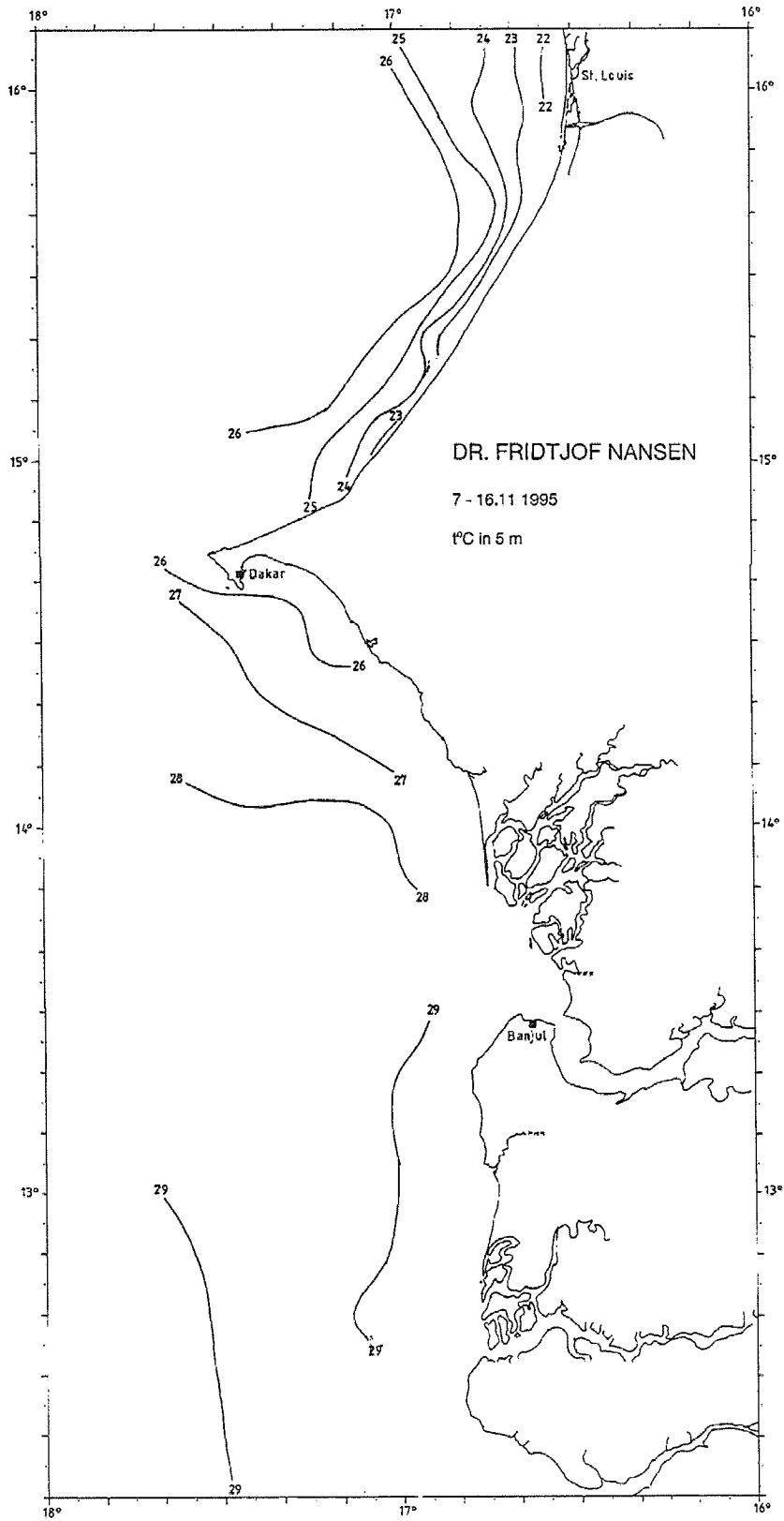


Figure 3 Sea surface temperature

The distribution of surface temperature and the profile The Gambia-West shows that there was a stable surface layer with increasing temperature, from 28°C to 29°C towards the shore over the whole shelf south of 13°50' N. Over the shelf immediately south of Dakar the surface temperature decreased towards the coast with 26°C in the surface inshore. North of Cap Vert this trend of decreasing temperature shorewards was more pronounced with a relatively sharp decline from 26°C over the outer and mid shelf to 23°C close to the shore. Near St. Louis the isolines of the cooler inshore water turned seawards indicating the approach of the front between the temperate northern waters and the tropical waters in the south. The distribution of the pelagic fish in the Dakar region and north of Cap Vert seemed in a general way to be related to the cooler inshore waters.

## 2.2 The Casamance shelf

Figures 4 and 5 show the distribution of the main groups of pelagic fish by contoured acoustic densities for the whole shelf of Senegal and The Gambia. (One should note that the unit used is  $m^2/nm^2$  which is 10 times that used in previous Nansen reports. The density levels used remain the same).

Off the Casamance coast there was a school area of sardinella of medium density in shallow water, mostly inside the 20 m depth line, see Figure 4. The samples from this distribution were only *Sardinella maderensis*. The modal size was 26 cm (total length). The size composition is shown in Annex II and the stock length compositions by numbers and weight in Annex III. The biomass was estimated at 31 000 tonnes (Table 1).

Other pelagic fish was found in low densities, but over a wider area than the sardinellas, see Figure 5. The trawl samples indicated that these consisted of bumper, lookdown, barracudas and hairtails in largely equal proportions and had an estimated total biomass of 37 000 tonnes.

Table 1 Casamance. Biomass estimates of pelagic fish, 1000 tonnes.	
Flat sardinella	Carangids etc.
31	37

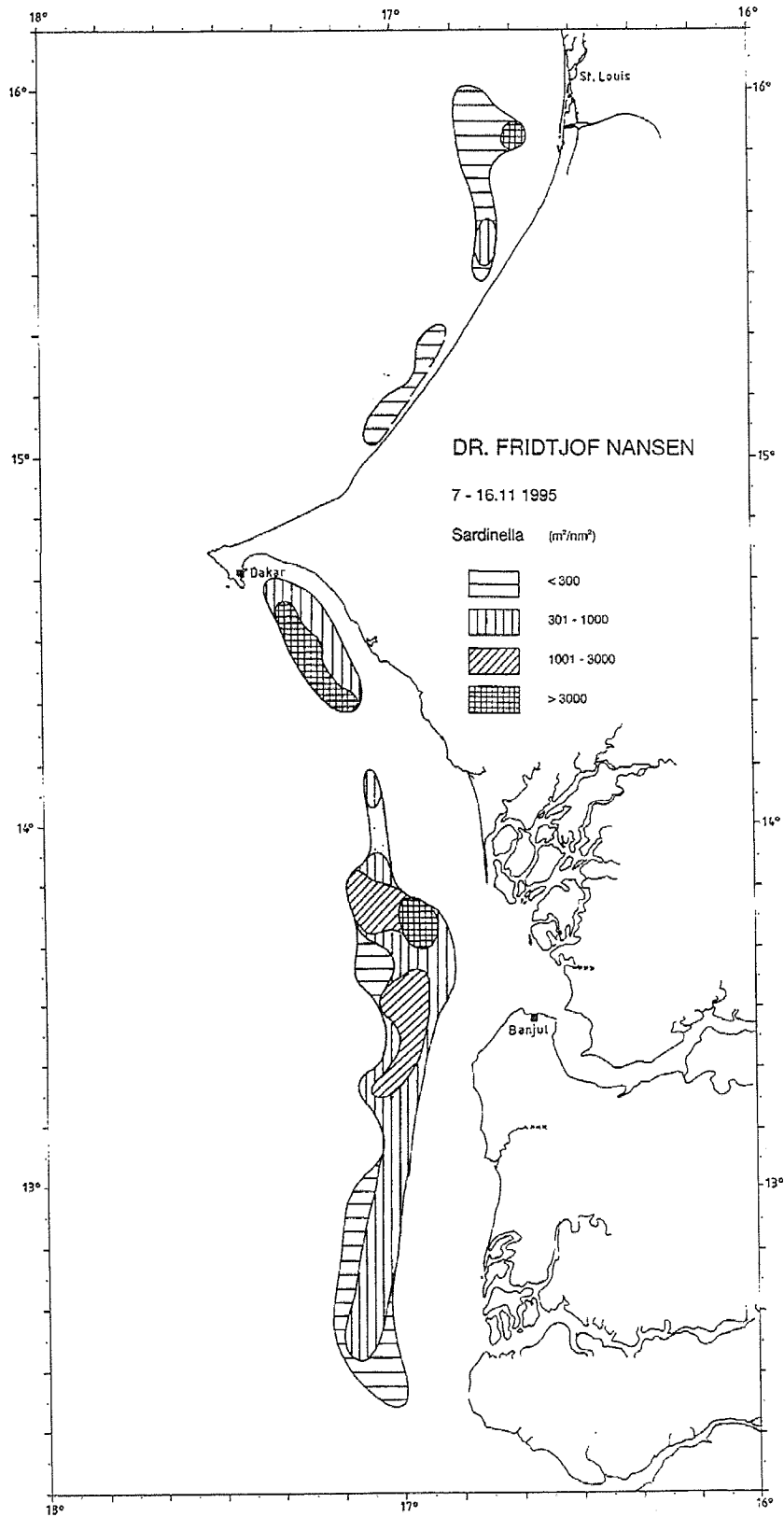


Figure 4 Distribution of sardinellas

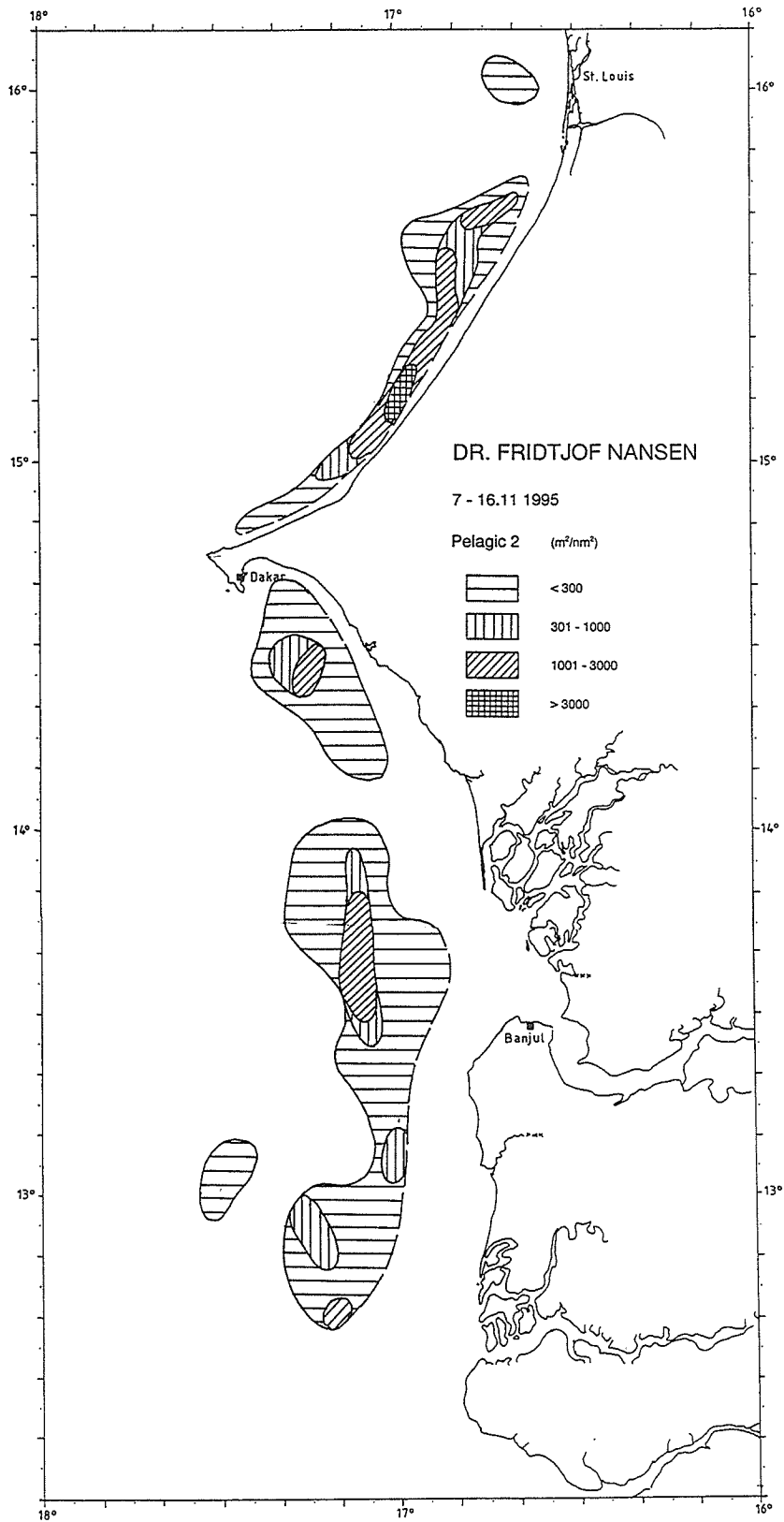


Figure 5 Distribution of carangids and associated species

## 2.3 The Gambia shelf

### Pelagic fish

The school area of sardinella found inshore off Casamance continued northwards off The Gambia with increasing density off the Gambia River estuary and with the main part inside the 20 m depth line, see Figure 4. The samples showed a dominance of flat sardinella (*Sardinella maderensis*) with a small proportion of round sardinella (*S. aurita*). The pooled length composition of the flat sardinella had a mode of 24 cm with some juveniles, see Annex II. The stock length compositions by numbers and weight (not including the juveniles) are shown in Annex III.

Table 2 shows that the biomass estimates of the pelagic fish included 116 000 tonnes of sardinellas of which 6 000 tonnes were round sardinella mostly from the offshore parts of the school area.

Carangids and associated species were found mainly outside the sardinella school area, see Figure 5.

Catches of this group consisted mainly of false scad, bumper and lookdown with small amounts of barracudas and hairtails. The biomass was estimated at 40 000 tonnes.

Table 2 The Gambia. Biomass estimates of pelagic fish, 1000 tonnes.		
Flat sardinella	Round sardinella	Carangids etc.
110	6	40

### Demersal fish

The data comprised 17 swept area hauls. Annex 1 shows the densities by species and depth ranges. Large eye grunt showed high abundance in shallow water (< 20 m). The seabreams had their highest abundance on the deeper shelf and were represented by a number of species. The squids were found over the whole shelf.

Table 3 shows the catches by main groups of commercial interest. The bogue *Boops boop* and the bigeye grunt *Brachydeuterus auritus* were common representatives

of their respective families, but are perhaps of less commercial interest than the other seabreams and grunts. Their catch rates are shown separately in Table 4.

Table 3 The Gambia Catches by main groups.

ST.NO.	DEP.	Seabreams	Grunts	Croakers	Cephalopod	Shrimp	Other
294	103	2414.0		50.0	4.6		889.6
295	55	43.8			7.8		12.2
296	49	64.2	18.6		6.6		30.2
297	36	12.3	116.1		3.2		54.5
298	17	1.3	482.7	28.4	4.7		753.8
299	17	9.0	329.8	25.9		0.7	293.2
300	40	48.5	53.2		3.4		103.5
301	66	118.8	2.8		14.0		119.9
302	20	4.8	330.3	6.2	31.7	10.6	487.4
303	18		516.8	27.2		17.5	4059.2
304	21	2.9	284.8			9.2	678.1
305	89	181.8			37.2		113.6
306	94	290.6	10.2	6.4	48.0		35.1
307	60	40.4			7.6		26.7
308	54	213.5	91.9		3.3		82.9
309	36	189.3	69.2				3012.3
310	18	1.6	377.4	5.4	10.2	0.5	115.7
MEAN		213.9	157.9	8.8	10.7	2.3	639.3

Table 4 The Gambia. Catches of Bogue and big eye grunt.

ST.NO.	DEP.	Bogue	Big eye grunt	Other
294	103	646.0		2712.2
295	55			63.9
296	49	6.2		113.4
297	36		58.9	127.1
298	17		403.7	867.1
299	17			658.6
300	40	3.4		205.2
301	66			255.5
302	20		257.6	613.4
303	18		497.6	4123.1
304	21		284.8	690.2
305	89	15.7		316.7
306	94			390.3
307	60			74.7
308	54	117.6		274.0
309	36			3270.8
310	18		377.4	133.4
MEAN		46.4	110.6	875.9

The Congo dentex *Dentex congoensis* and the red pandora *Pagellus bellottii* were the most common seabreams while the sompat grunt *Pomadasy jubelini* and the bastard grunt *Pomadasy incisus* were most abundant of this group. The cephalopods included common octopus *Octopus vulgaris* and the common cuttlefish *Sepia officinalis*. The shrimp catches most of which were from night hauls consisted of pink shrimp *Penaeus notialis* and caramote prawn *Penaeus kerathurus*.

Estimates of the standing biomass of the fish caught in the swept area hauls were as follows:

Total fish biomass	22 000 t
Of which:	
Grunts	8 700 t
Croakers	400 t
Seabreams	6 400 t
Cephalopods	400 t

Of the grunt biomass about 6 000 tonnes were bigeye grunt

A largely similar composition and amount of demersal fish was found in the 'Dr Fridtjof Nansen' survey of March 1992. A total biomass of 30 000 tonnes was then estimated, which, however, at that season included about 5 000 tonnes of *Cunene* horse mackerel.

#### 2.4 The Gambia border - Cap Vert.

Two school areas of sardinella were found on this shelf, see Figure 4. The southernmost area formed a continuation of the inshore distribution of sardinella found off Casamance and The Gambia. By far the highest densities in this school area were found off the Saloum River estuary at depths of less than 20 m. A second school area was found south of Dakar with the highest densities between 25 and 40 m depth. Table 5 shows the biomass estimates for the two areas by species. Flat sardinella dominated in the Saloum area, round sardinella south of Dakar. The sardinella biomass was 580 000 tonnes.

Pooled length compositions of samples showed that the adults parts of the flat sardinella had a modal length of 24 cm and the round sardinella 26 cm, see Annex II. Stock size compositions by numbers and weight (not including the juveniles) are shown in Annex III.

Also the carangids and associated pelagic fish appeared to have two distributional areas, that in the south mainly outside the sardinella area, but still within about 50 m depth, see Figure 5. No pelagic fish was found on the outer shelf, where this group is often found in abundance. False scad was caught in most of the trawl samples, bumper appeared with some high catch rates and barracuda was also common. It is notable that hardly any horse mackerel *Trachurus trecae* was

caught south of Dakar. The biomass of the carangids and associated pelagic fish was estimated at about 80 000 tonnes (Table 5).

Table 5 The Gambia border to Cap Vert. Biomass estimates of pelagic fish, 1 000 tonnes			
	Flat sardinella	Round sardinella	Carangids etc.
Saloum estuary	312	76	47
S. of Dakar	19	174	32
Total	331	250	79

## 2.5 Cap Vert - St. Louis

On this part of the shelf sardinellas were found in an inshore patch north of Cayar and in an area towards and outside St. Louis see Figure 4. The more offshore distribution off St. Louis coincides with the offshore turn of the 23°C surface isoline. The samples showed mainly flat sardinella with two modal groups, at about 15 and 30 cm, see Annex II. The biomass of the sardinellas was estimated at 35 000 tonnes (Table 6).

Carangids and associated pelagic fish were found on the inner part of the shelf from Cayar to St. Louis see Figure 5. The catches consisted of roughly equal parts of Cunene horse mackerel, bumper and hairtails with some barracudas and a little false scad and mackerel *Scomber japonicus*. The biomass estimate was 61 000 tonnes.

Table 6 Cap Vert to St. Louis. Biomass estimates of pelagic fish, 1 000 tonnes.		
Flat sardinella	Round sardinella	Carangids etc.
32	3	61

## CHAPTER 3 OVERVIEW AND SUMMARY OF RESULTS

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The survey was conducted successfully in the period 7 to 16 November with a course track of about 1 900 nm and 47 fishing stations of which 17 for the swept area programme off The Gambia.

The limits of the school areas found are thought to have been well determined and the areas adequately sampled.

The hydrographical data showed a stable surface layer for the whole shelf in the south, but with declining surface temperatures towards the coast from about Dakar northwards.

### **Pelagic fish**

Sardinellas were found in several school areas along the inshore shelf, see Figure 4. One area extended from Casamance northwards past The Gambia and into the shallow waters off the Saloum River estuary where by far the highest densities were found. This was mainly flat sardinella. A second sardinella area consisting mainly of round sardinella was located south of Dakar in slightly deeper waters. Two smaller areas with mainly flat sardinella were found inshore between Cayar and St. Louis.

The distribution of carangids and associated species formed a band along the coast mostly outside the sardinella areas, but still on the inner shelf, mainly inside about the 50 m depth line, see Figure 5. Hardly any pelagic fish were found on the outer shelf. South of Cap Vert the catches of this group consisted of false scad, bumper, barracudas and a little hairtails. Horse mackerel was hardly present. The catches north of Cap Vert were a mixture of horse mackerel, bumper and hairtails with some barracuda and a few false scad and mackerel..

An overview of the estimates of biomass of the main groups of pelagic fish based on the echo integration data is shown in Table 7. The total biomass of sardinellas was thus 760 000 tonnes and of carangids and associated species about 220 000 tonnes.

Table 7 Summary of biomass estimates of pelagic fish, Senegal and The Gambia. 1 000 tonnes.			
	Flat sardinella	Round sardinella	Carangids etc.
St. Louis-Cap Vert	32	3	61
Cap Vert-Gambia	331	250	79
Gambia	110	6	40
Casamance	31	0	37
Total	504	259	217

Table 8 lists biomass estimates of sardinellas and carangids and associated species from previous 'Dr Fridtjof Nansen' surveys of this shelf region. Large-scale lateral movements of pelagic fish between West Sahara and Guinea Bissau is well known and November is still within the season of northern distribution. Compared with the Sept/81 and NovDec/86 surveys the estimate of 760 000 tonnes of sardinellas from the current survey is high. The carangid estimate of 220 000 tonnes is roughly at the same level as that from NovDec/86.

Table 8 Biomass estimates from previous 'Dr Fridtjof Nansen' surveys of the Senegal-The Gambia shelf. 1 000 tonnes		
Survey:	Sardinellas	Carangids etc.
AprMay/81	210	570
Sept/81	360	*
FebMar/82	40	90
NovDec/86	330	170
FebMar/92	1 530	690

\* Not available