1 INTRODUCTION

1.1 Objectives of the Cruise

A planning meeting was held in Rabat 13-14 January with participants from Morocco, Mauritania, Senegal, Gambia, Guinea Bissau, FAO and Institute of Marine Research, Bergen. During this meeting the schedule and the objectives of the various parts of the survey was established.

Objectives for the survey in Morocco as agreed on this meeting were:

By hydroacoustic methods to map the distribution and produce a biomass estimate for the main four small pelagic fish species; sardine *Sardina pilchardus*, anchovy *Engraulis encrasicolus*, Chub mackerel *Scomber japonicus* and the Atlantic horse mackerel *Trachurus trachurus*. The sardine has the highest priority.

If feasible the biomass estimates shall also be presented by length groups.

Survey area will be from Safi to Cape Blanc.

For the target species intensive sampling will be carried out. The biological parameters will be: length frequency distributions, length/weight relationships, sex and maturity index. Otoliths will be taken from the full size range of the species in order to establish length/age relationships. (The additional parameters sex, maturity, age studies are collected to support the VPA analysis carried out by ISPM and they will not be further covered by this report).

The hydrographic work will comprise logging of surface temperature and bathymetric data. Four to five hydrographical sections will be carried out with a CTD sonde.

Where conditions permit special studies on target strength measurements and fish behaviour will be performed in order to improve the accuracy of the acoustic estimates.

1.2 Participation

Members of the scientific team from Morocco were:

From ISPM Casablanca: Salah Bencherifi, Mostafa Chbani, Abouabdellah Lahcen, Abdallah Kinani.

From Ministry of Fisheries, Rabat: Mohamed El Aroussi.

Members of the scientific staff from the Institute of Marine Research were:

Tore Strømme, Ingvald Svellingen, Kjell Strømsnes, Erling Molvær and Endre Aas.

1.3 Narrative

The "DR. FRIDTJOF NANSEN" left Agadir on morning 17 January, heading north to start the work from Safi southwards. A mixture of anchovy and small sized sardine was recorded in the shallow waters, which was sampled with a dense grid. The outer shelf were sampled more openly.

In the shallow waters between Cape Draa and Cape Juby the sardine registrations were considerably less than expected and sampling intensity was increased to ensure that major concentrations were not concealed between the transects. The outer shelf between Agadir and Cape Juby was sampled with transects 20 nm apart.

Between Cape Juby and Cape Bojador the shelf is narrow and was sampled with one zig-zag net. In this period the hydraulic winch of the net sonde broke down, making targeted pelagic trawling complicated. It was therefore decided to go to Las Palmas to obtain spare parts that were shipped from Norway. While at Las Palmas the vessel was refuelled and a calibration of the acoustic system was done at anchorage in Las Palmas harbour.

Southwards from Cape Bojador the shelf gradually widens, and a sampling pattern giving 10 nm between the transects in the shallow waters and 20 mile more offshore was adopted, see Figure 1b. At latitude N 25°10' (Cape Garnet) and southwards very dense patches of concentrations of sardine were recorded in the shallow waters. In order to map these distributions properly the transect distance were narrowed to about 5 nm. It was also observed that the sardine partially escaped echosounder detection during some of the night hours, probably surfacing, and this area had to be resurveyed during daytime. This was not a systematic pattern though, and during most of the survey there was a close correlation between echosounder and sonar recordings both during night and day. Generally surfacing schools did not seem to constitute a major problem. The unexpected call at Las Palmas and the intensive surveying in the shallow waters put some time constraints on the schedule. Due to this the outer shelf north of Dakhla was not surveyed with the intensity as planned, perhaps leaving some horse mackerel undetected. For the same reason the course track from about latitude 21°25' and southwards to Cape Blanc had to be modified into a zig-zag pattern.

During work west of Dakhla pure and scattered registrations of sardine were recorded. Some hours were spent in this area to collect target strength measurements on the species. These data will be analyzed in Bergen and will be published in a separate report.

The weather was favourable for an acoustic survey throughout the cruise. The moon was full on 19 January at the beginning of the survey and new moon was on 3 February when surveying the major sardine concentrations north of Dakhla.

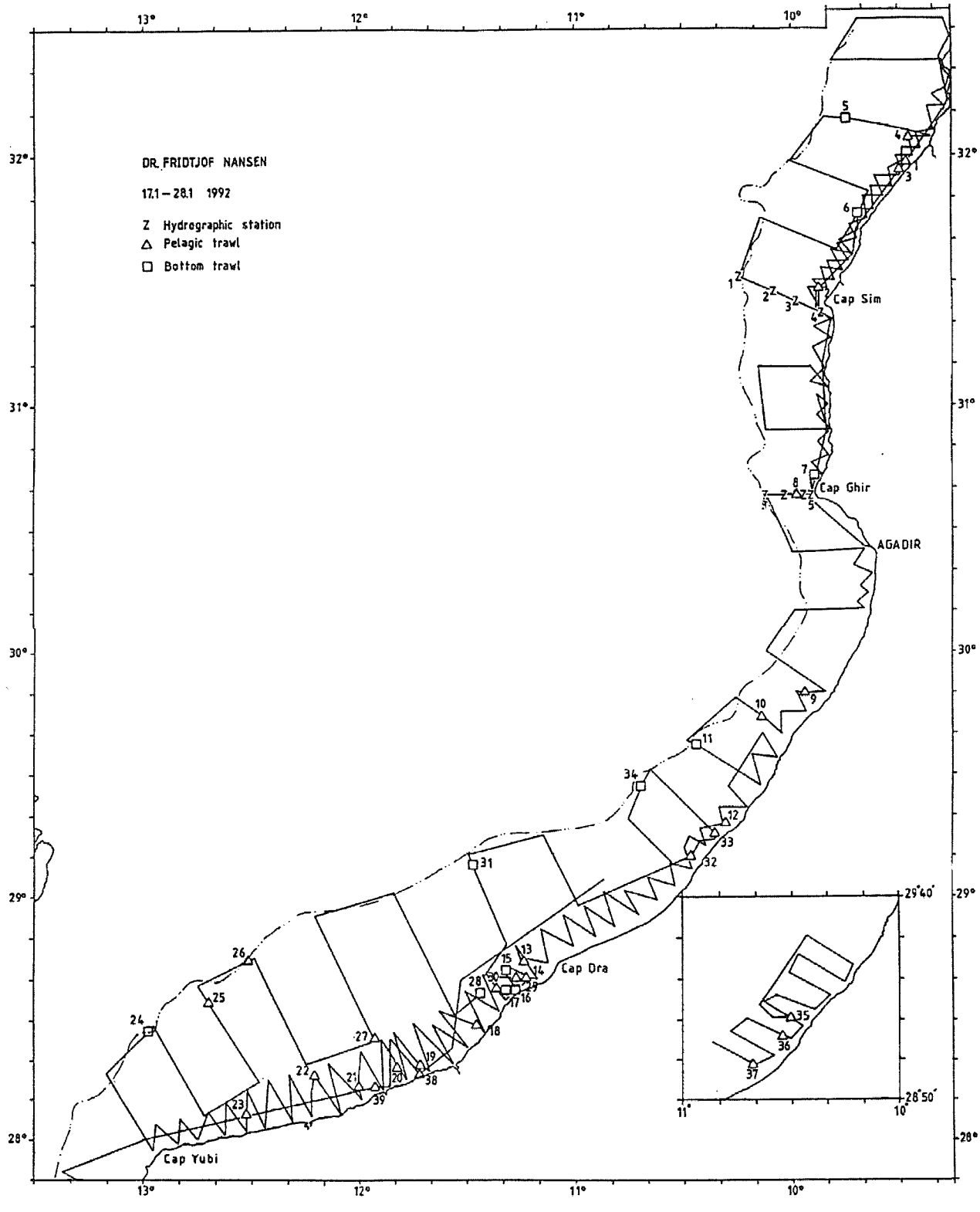

Figure 1a. Course track and fishing stations. Safi to Cape Juby.

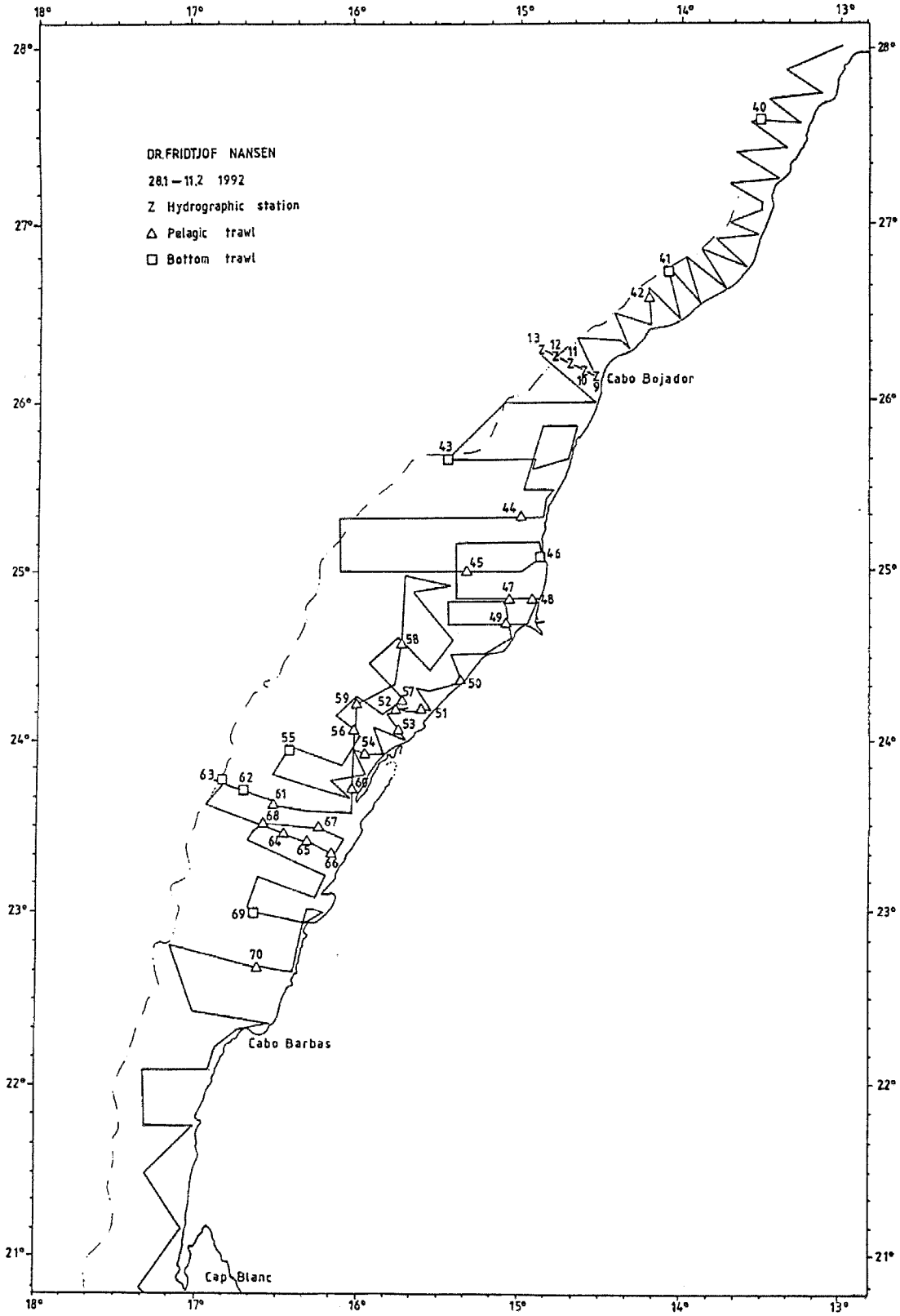

Figure 1b. Course track, fishing stations Cape Juby to Cape Blanc.

1.4 Effort

Distance sailed	:	4821 nautical miles
Days at sea	:	23 days
Sampling	:	70 trawl stations
		19 hydrographic stations
		117 length frequency samples
		550 pairs of otoliths collected.

2 METHODS

From the general knowledge on the sardine the species in Morocco is known to be separated in three stocks: The northern stock from Tanger to Safi, the central stock from Safi to Cape Bojador and the southern stock from Cape Bojador and into the northern parts of Mauritania. The southern stock is by far the biggest, while the central stock has the highest economic importance for the local based semi-industrialized fisheries. Due to the time constraints on the survey, 21 days, it was decided to concentrate the effort on the central and the southern stocks, i.e. the survey area was from Safi to Cape Blanc.

The sardine, anchovy and young chub mackerel are known to be located mainly in bottom depths less than 50 meters, while the horse mackerel and adult chub mackerel also have a more offshore distribution. In line with the priorities of the survey the shallow waters were sampled more intense with acoustic transects approximately 10 nm apart, compared to the offshore waters with a transect distance up to 20 nm. Where denser concentrations were found the sampling intensity could be increased to 5 nm between the transects, or by resurveying the area with the concentrations.

The course tracks with the fishing and hydrographical stations from Safi to Cape Juby and from Cape Juby to Cape Blanc are shown in Figures 1a and 1b respectively.

All catches were sampled for composition by weight and numbers of each species. The length frequency distributions of the target species were almost always taken. Following the CECAF recommendations the sardine and anchovy were measured by total length while horse mackerel, chub mackerel and sardinella were measured by fork lengths. The collected length frequencies are given in ANNEX I, and pooled frequency distributions by target species and regions are shown in ANNEX III. The complete records of fishing stations are shown in ANNEX III.

In selected samples individual specimens were measured for length, weight, sex and maturity, and otolith samples were taken. These were collected for special studies by ISPM and will be analyzed separately.

Surface temperature was logged automaticly and recorded with position (Figure 2a-2b) and bottom depth every nautical mile sailed.

Hydrographical profiles were collected with a portable mini CTD sonde with internal logging of records of temperature, salinity, and depth 30 times per minute. From the data series records were selected from standard depths and presented in Figure 3.

The biomass estimates are based on the acoustic integration technique, similar to that used in previous assessments of the same stocks. The North Sea herring target strength was used for all pelagic fish:

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

The biomass density in numbers/nm² of a length group i is calculated from the formula:

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

where s_a = Mean total integrator value from a species distribution area in m²/nm²

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.

These densities are then converted from numbers to weight 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.

A more direct and simpler method for biomass estimation, not giving biomass per length classes are:

Using a fish constant for 17 cm fish and normalizing the fish length to 17 cm the biomass (in tonnes) is calculated by the formula:

$$\text{Biomass} = A * I * 2.14 * C * L/17$$

where A = Size of distribution area (nm²)

I = Average integrator value from distribution area in m²/nm²

L = Total mean length of fish

C = Condition factor

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

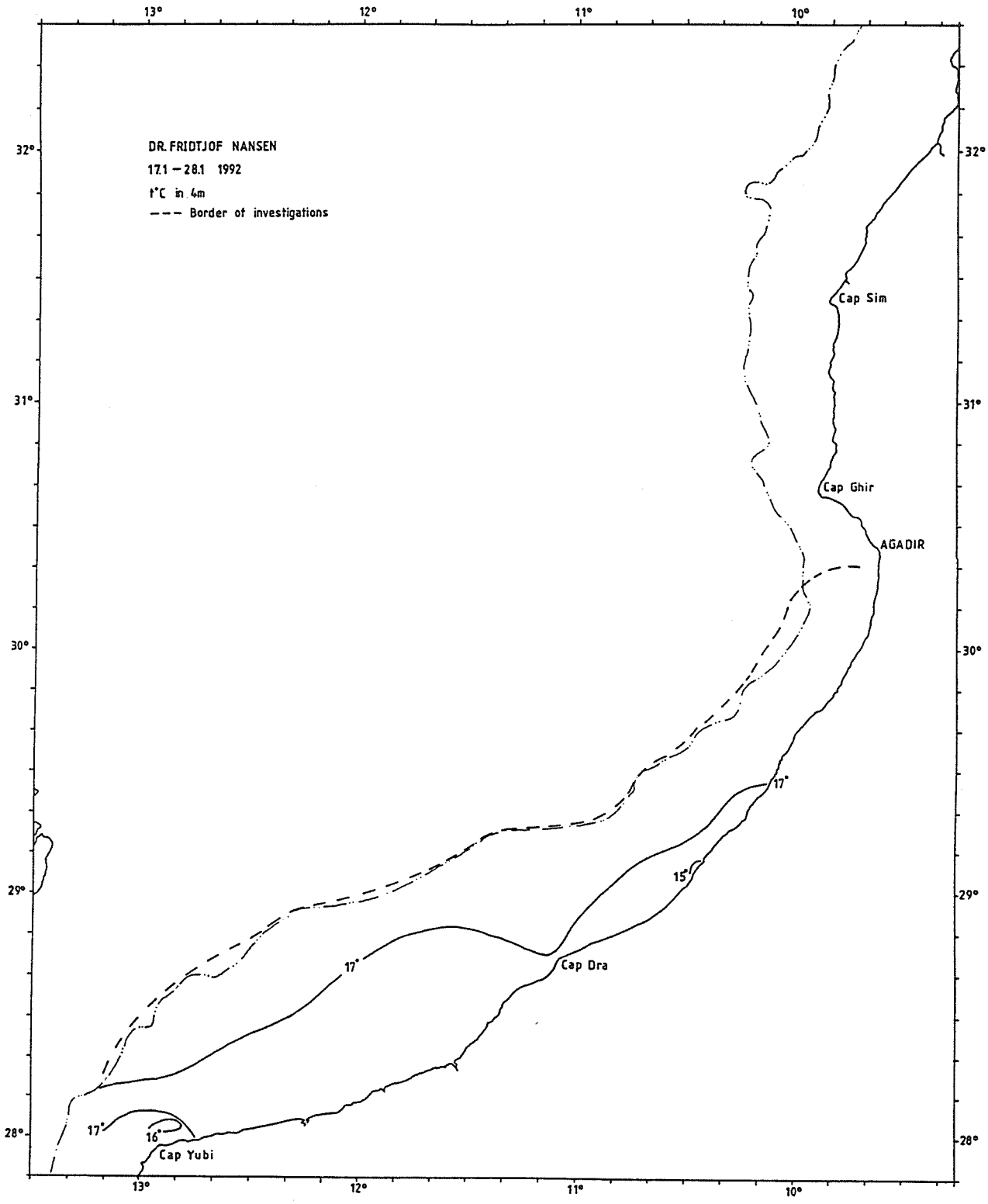

Figure 2a. Sea surface temperatures. Safi to Cape Juby.

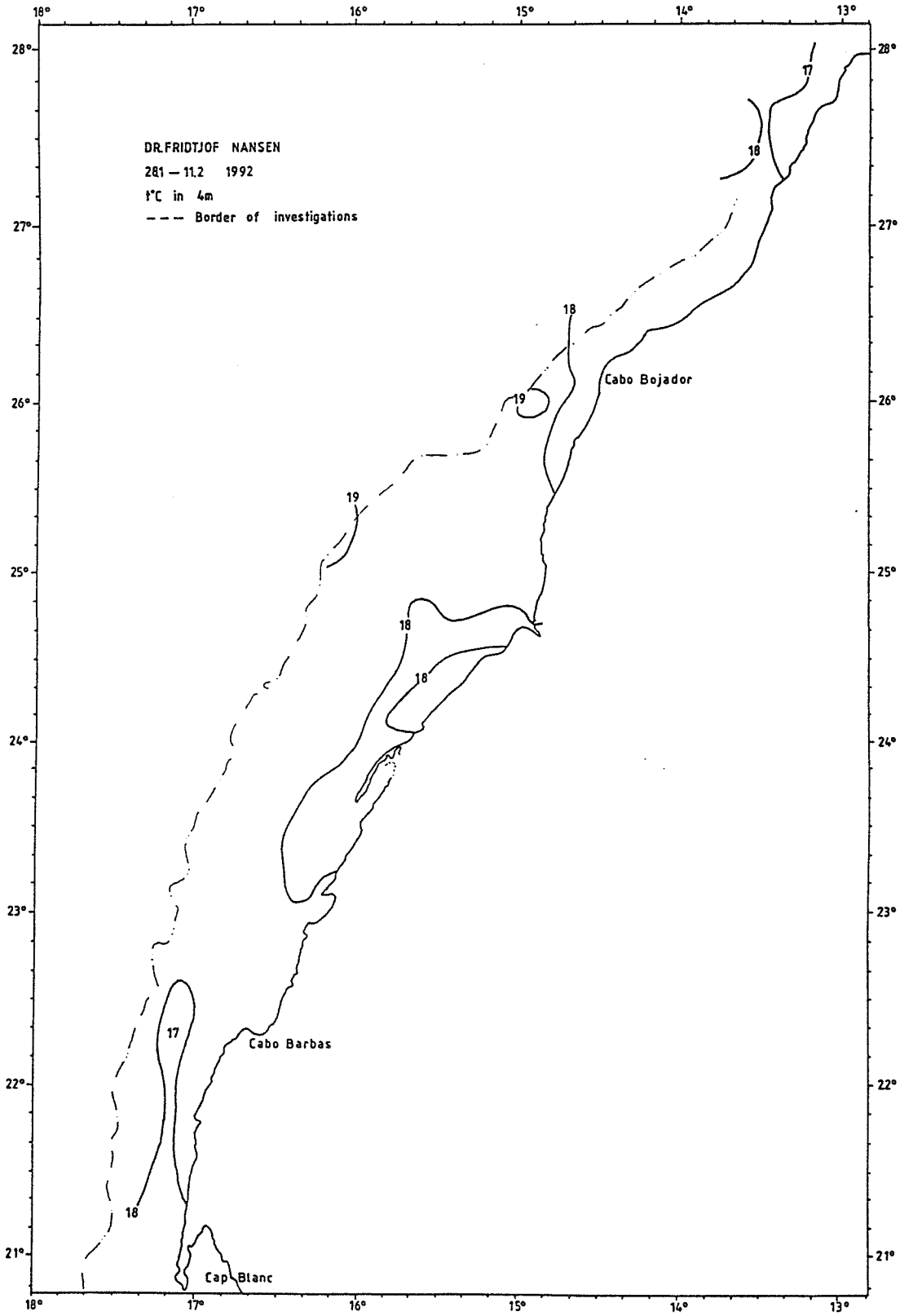

Figure 2b. Sea surface temperatures. Cape Juby to Cape Blanc.

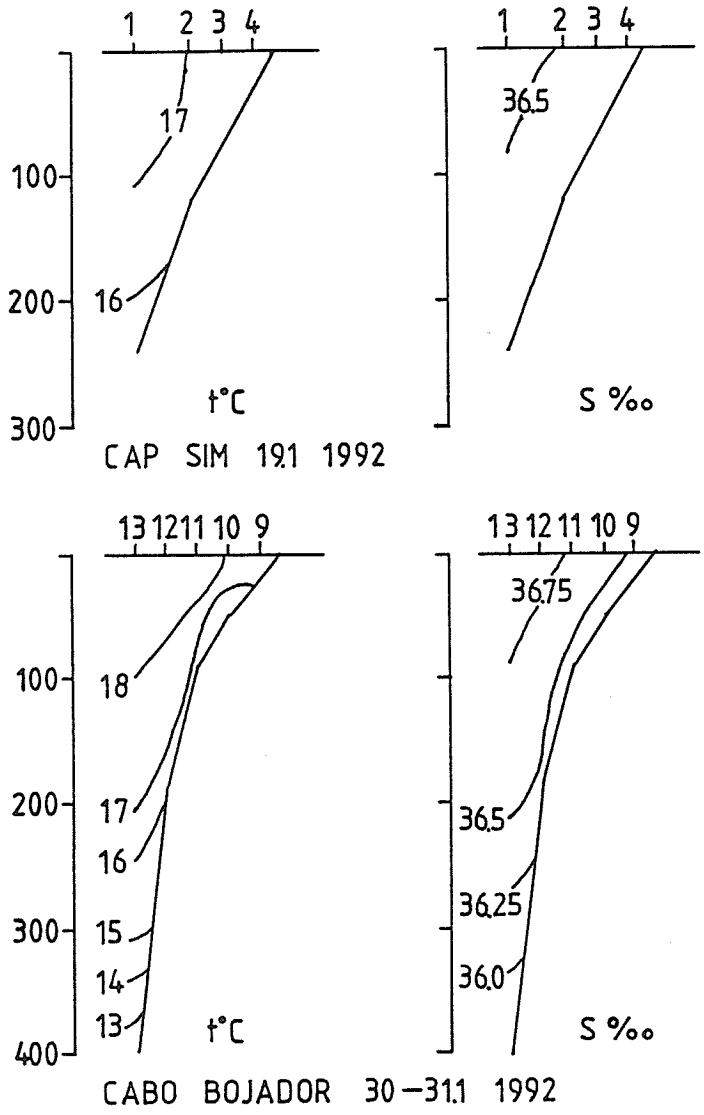

Figure 3. Hydrographic profiles.

3 DISTRIBUTION AND ABUNDANCE OF PELAGIC FISH

The acoustic integration system provided observations of fish densities averaged over 5 nm distances. The unit of acoustic reflection used was m^2/nm^2 reflecting surface. The integrator values from fish targets were allocated to the following groups on the basis of trawl sampling and characteristic behaviour recognised from the echo recordings:

Sardine (*Sardina pilchardus*)
Round sardinella (*Sardinella aurita*)
Anchovy (*Engraulis encrasicolus*)
Chub mackerel (*Scomber japonicus*)
Atlantic horse mackerel (*Trachurus trachurus*)
Other fish, mainly demersal
Plankton, including 0-group fish and myctophids.

3.1 Distribution

In brief, the main areas of pelagic fish were between Cape Draa and Cape Juby and from Cape Garnet and southwards to Cape Blanc. In addition some minor concentrations of juvenile sardine and anchovies were located south of Safi. In the area between Safi and Cape Juby the dominant species was the sardine, but there frequently associated with anchovies and chub mackerel. The acoustic integrator values in this area were split mainly on basis of the trawl catches and the share of each species in the estimates can not be considered as exact. In the south, from Cape Garnet and southwards, the above all dominating species was the sardine, with minor components of round sardinella. Offshore, between Cape Draa and Cape Bojador the outer shelf was occupied with trumpet fish *Macroramphosus* sp. with no commercial value.

The distributions of sardine, sardinella, anchovies chub mackerel and horse mackerel are shown in figures 4ab-8ab. An arbitrary semi-log scale was used in the distribution charts to illustrate different levels of density. The units on the maps are the integrator units (m^2/nm^2) divided by 10 to make them comparable with the maps from the previous surveys.

Pooled length frequency distributions by main species and regions are given in ANNEX II.

3.1.1 Safi to Agadir

A mixture of small sized sardine (modal length around 11 cm) and anchovy was registrated in the shallow waters between Safi and Cape Sim. Horse mackerel was recorded at several locations but only in scattered distributions.

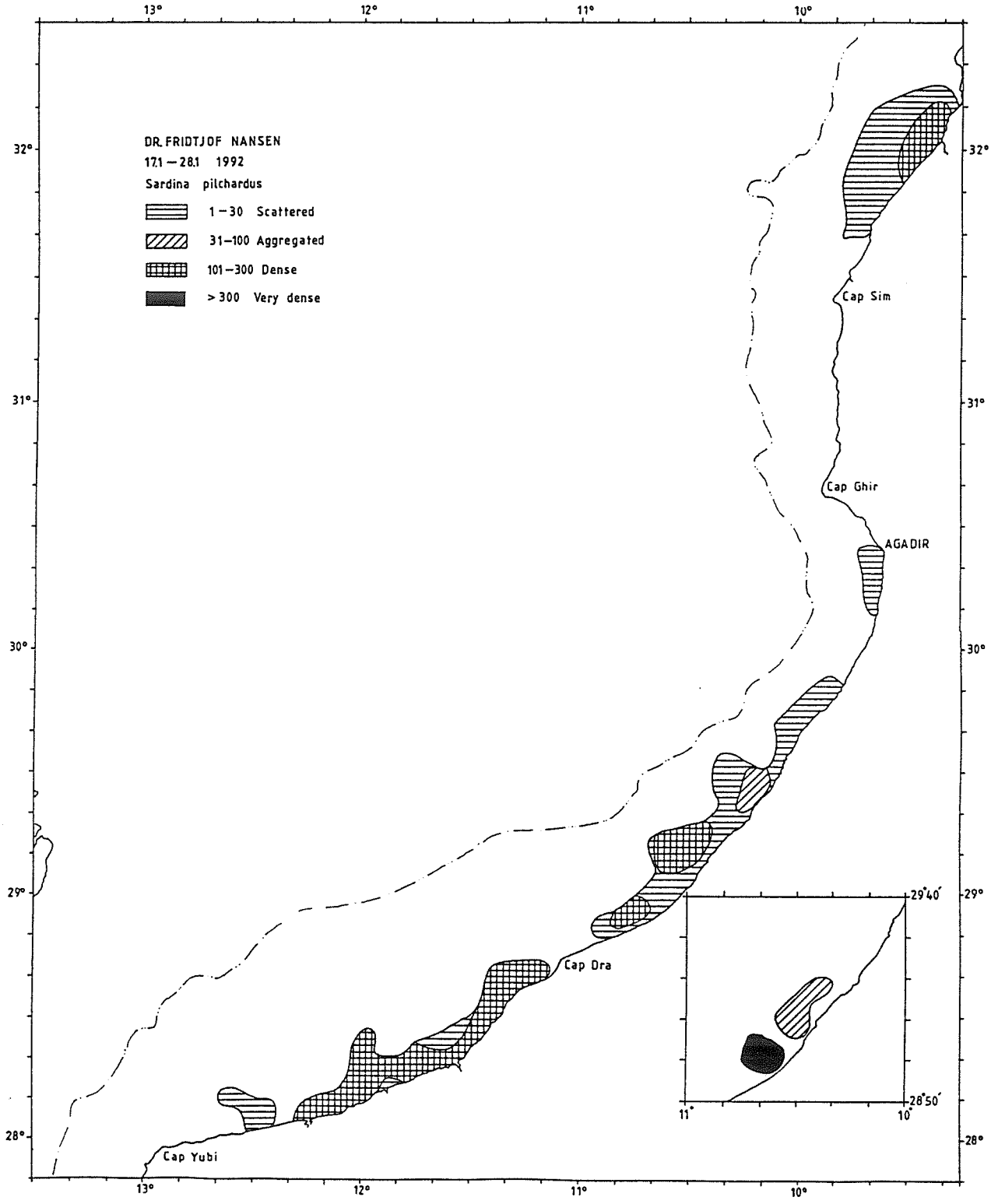

Figure 4a. Distribution of sardine from Safi to Cape Juby.

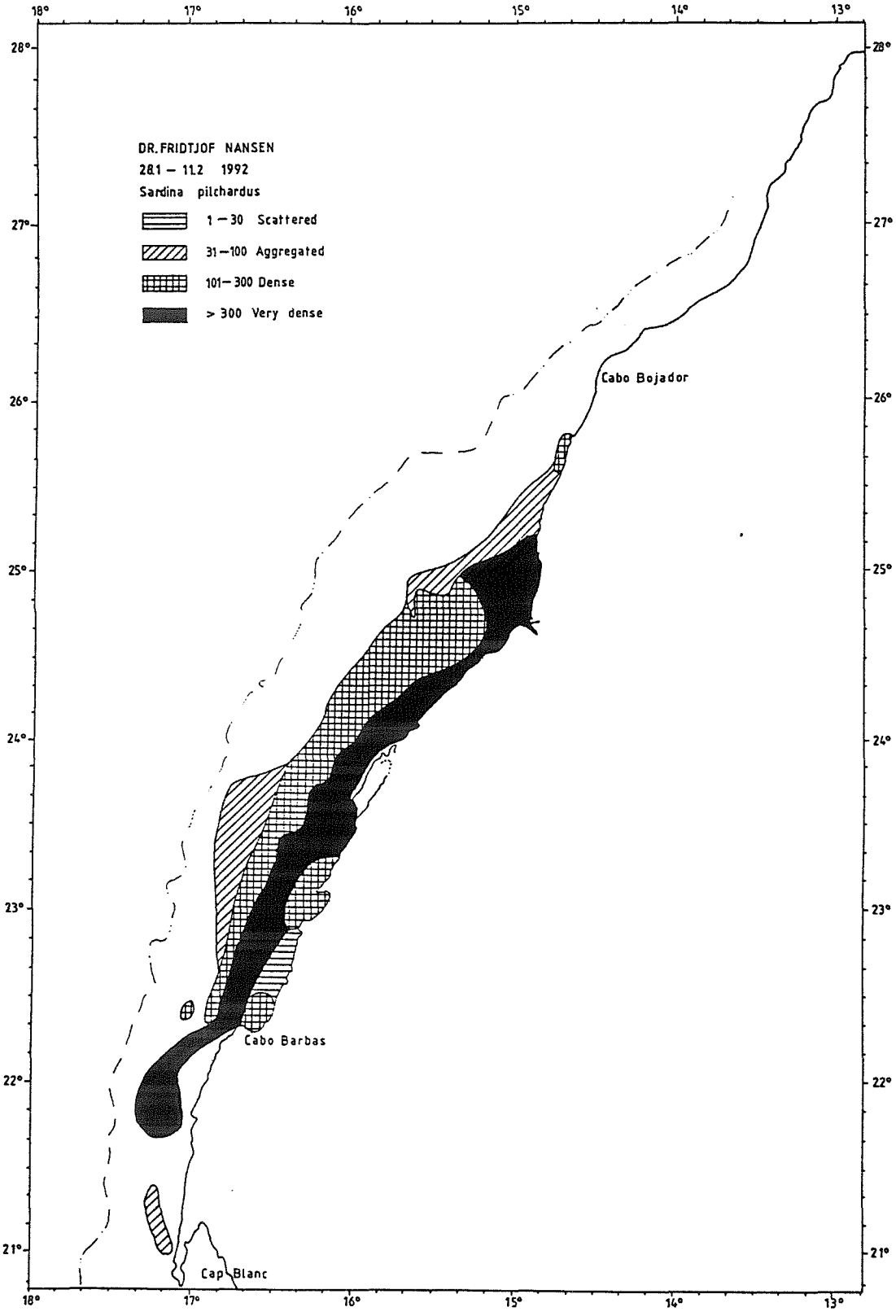

Figure 4b. Distribution of sardine from Cape Juby to Cape Blanc.

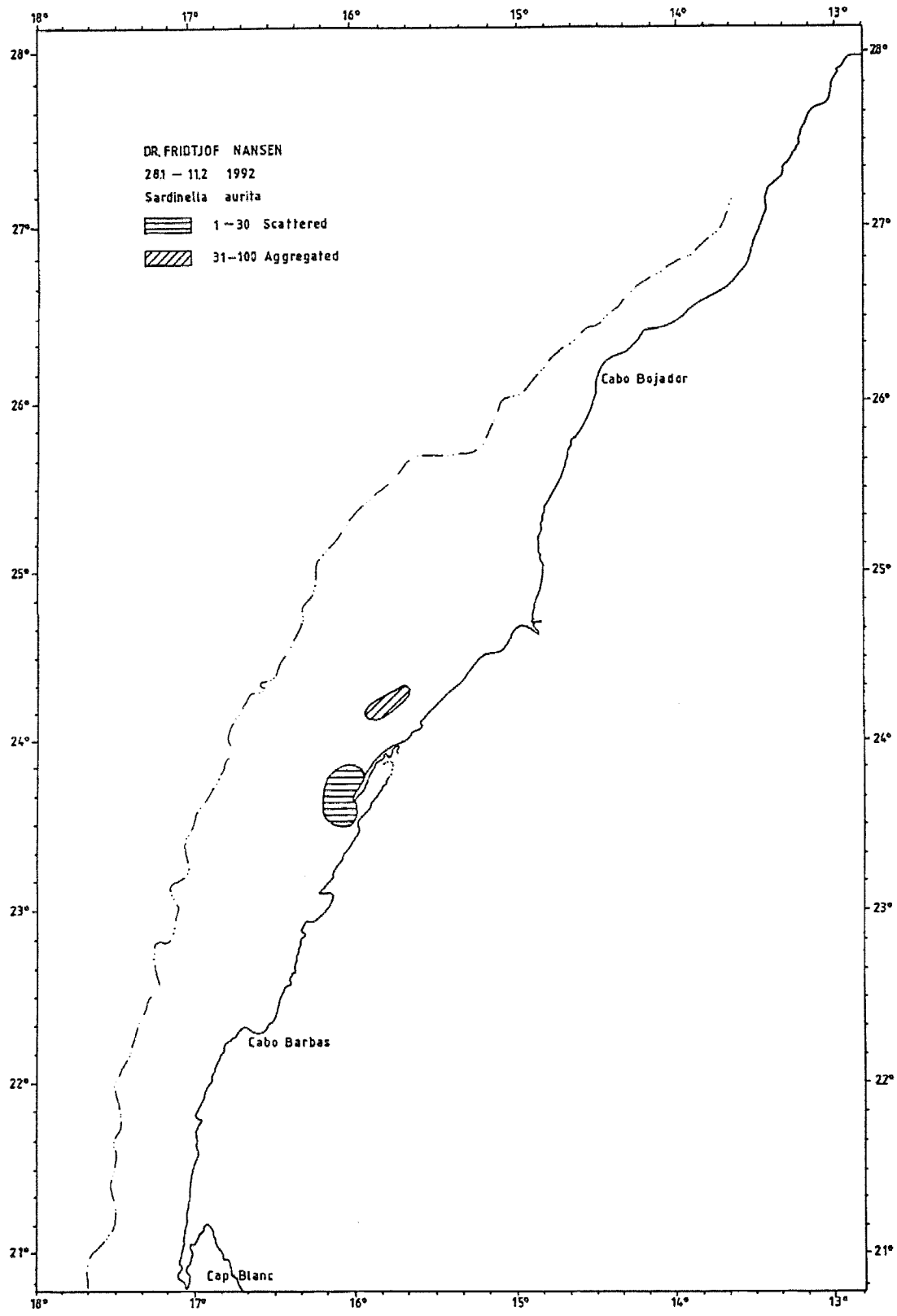

Figure 5. Distribution of sardinella from Cape Juby to Cape Blanc.

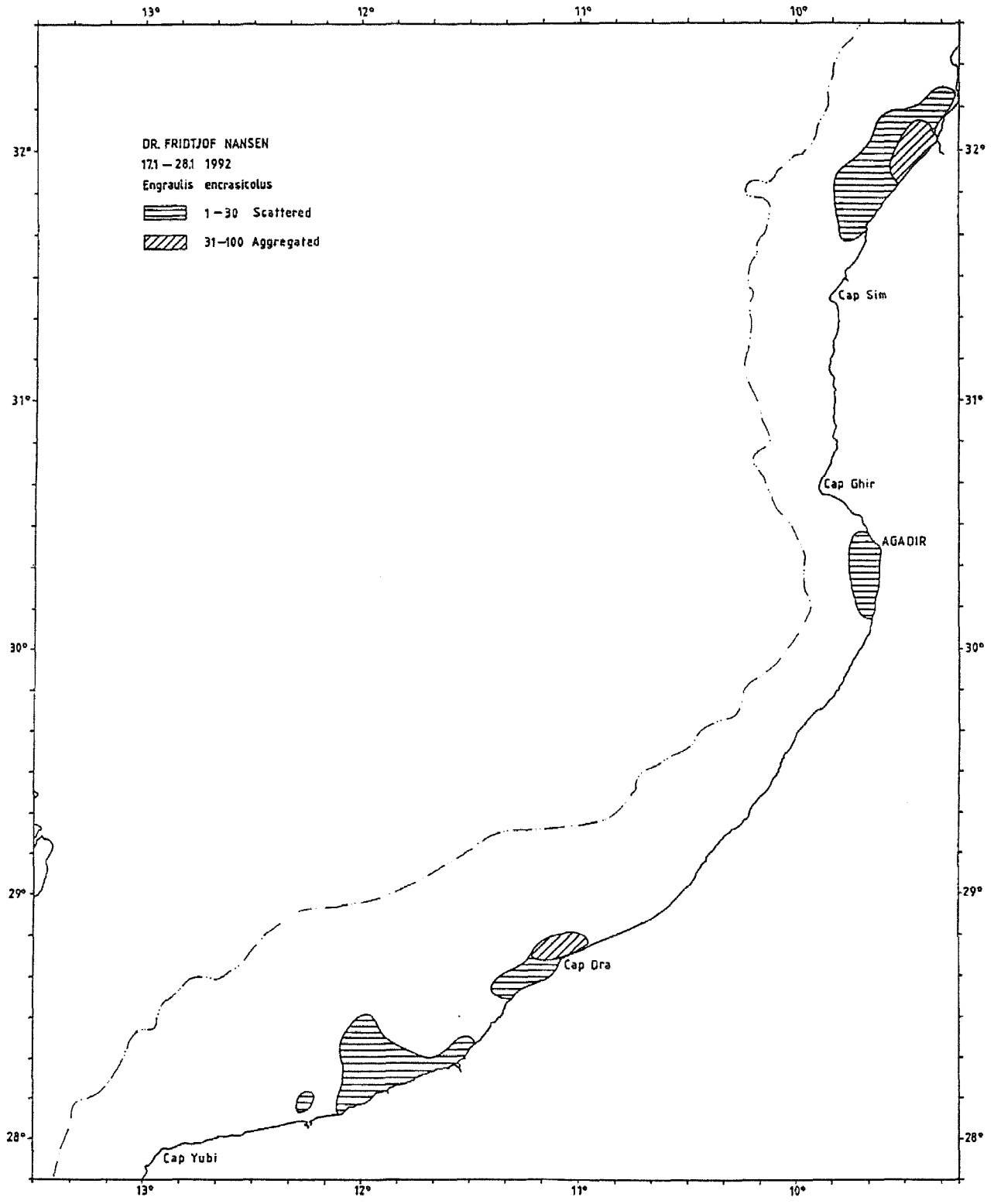

Figure 6a. Distribution of anchovy from Safi to Cape Juby.

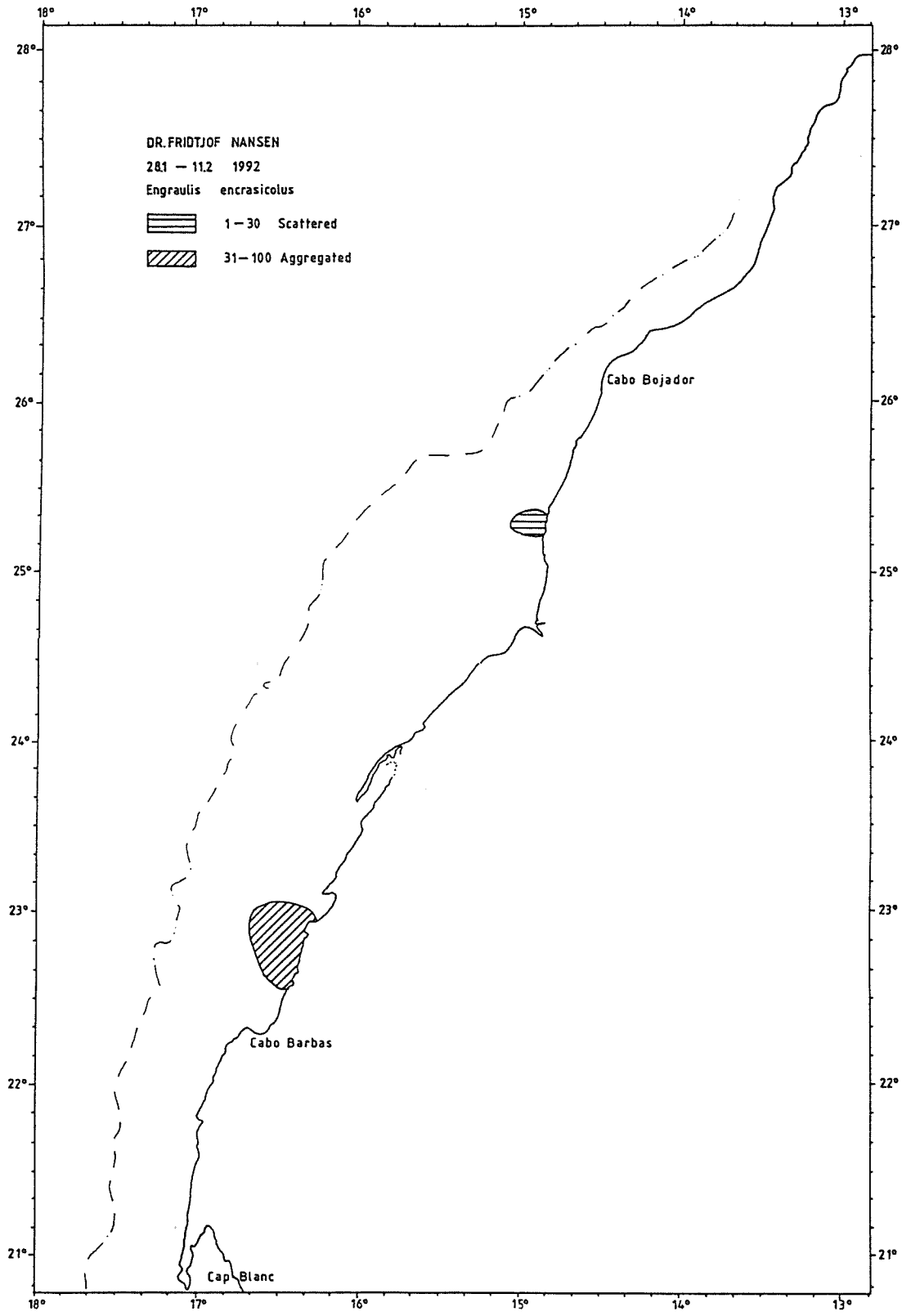

Figure 6b. Distribution of anchovy from Cape Juby to Cape Blanc.

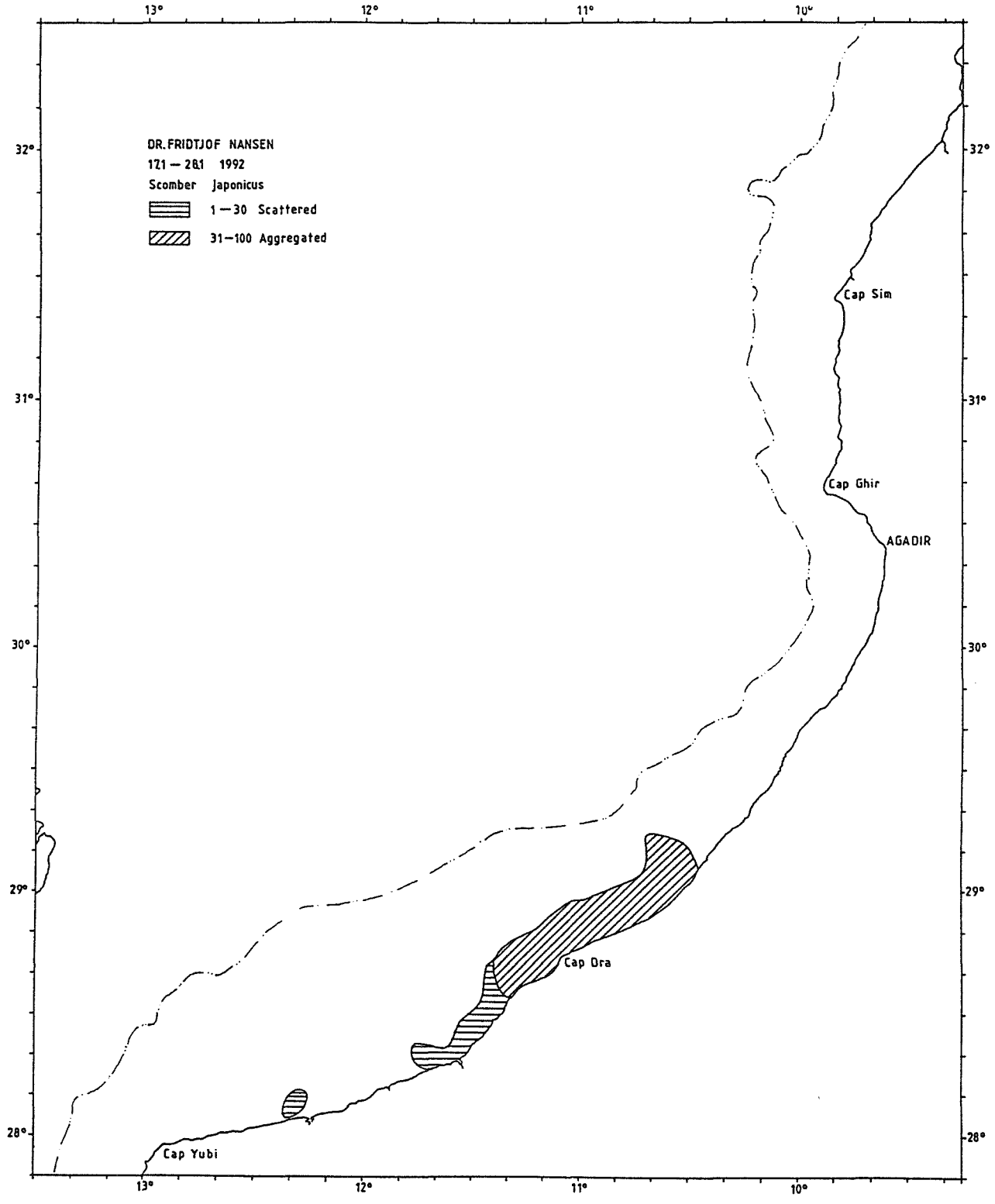

Figure 7. Distribution of chub mackerel from Safi to Cape Juby.

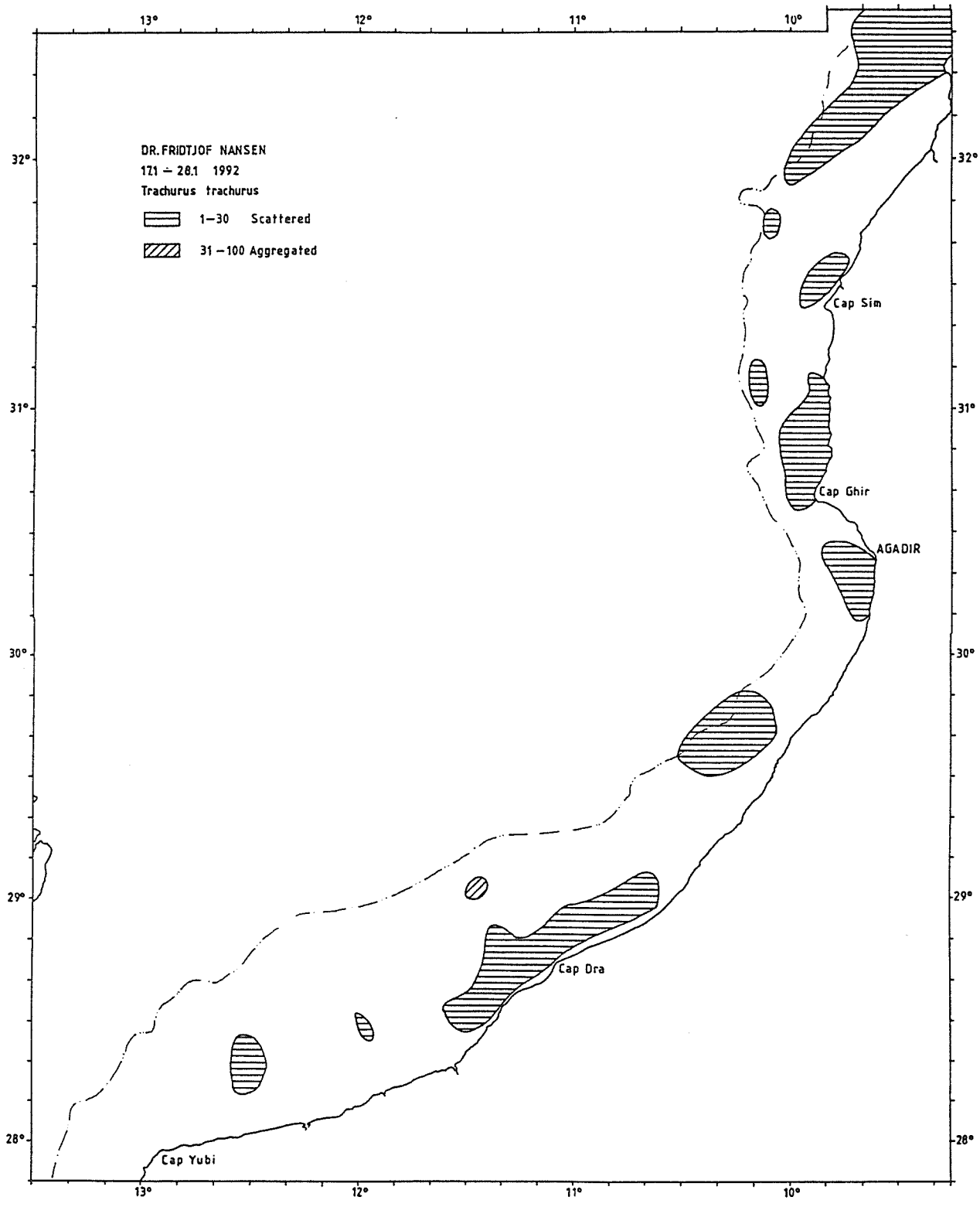

Figure 8a. Distribution of horse mackerel from Safi to Cape Juby.

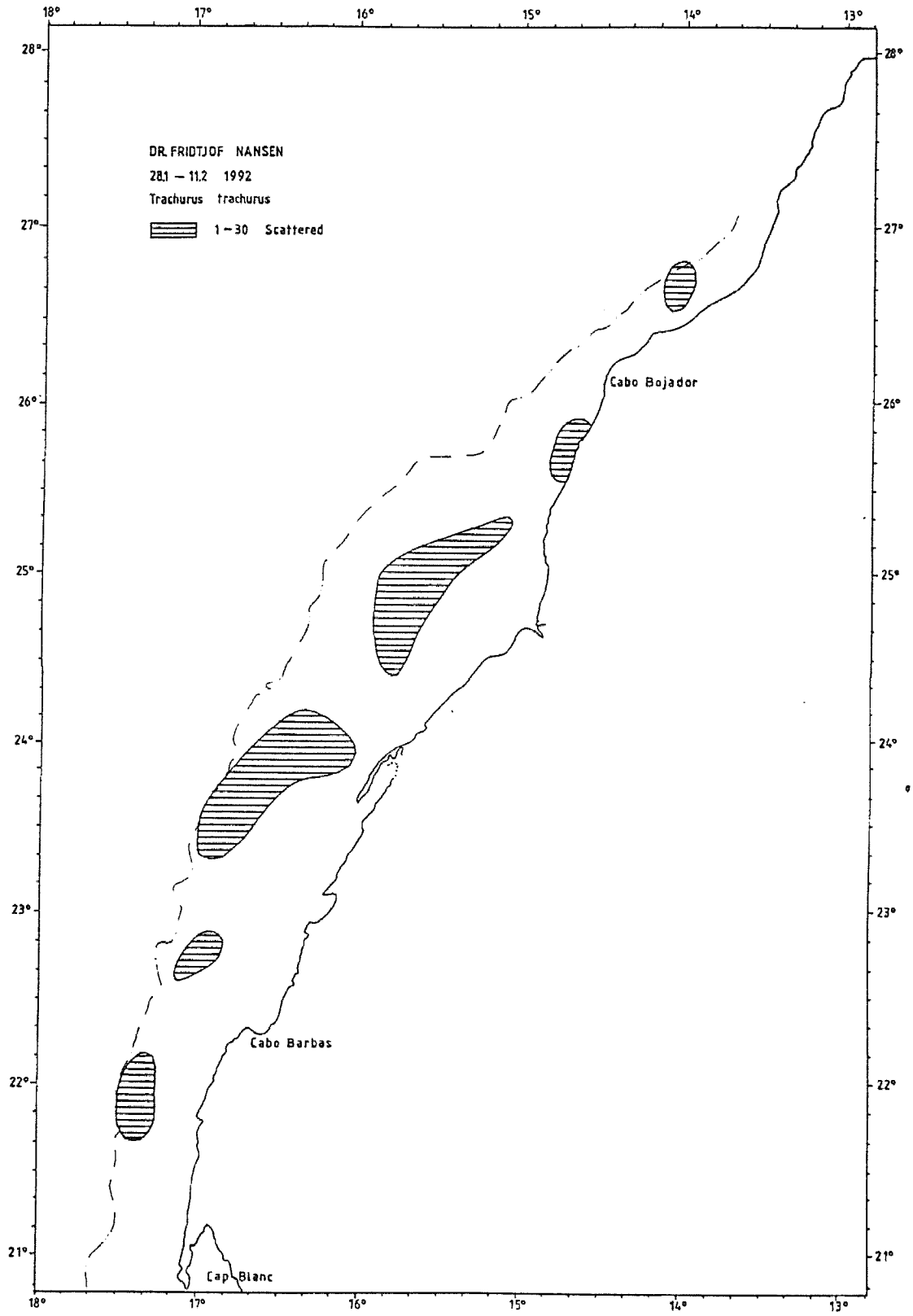

Figure 8b. Distribution of horse mackerel from Cape Juby to Cape Blanc.

3.1.2 Agadir to Cape Juby

Sardine was found in most of the shallow waters. The main concentration was between Cape Draa and Cape Juby but dense, however, small concentrations were found also about 20 nm and 40 nm northeast of Cape Draa. Between Agadir and Cape Draa the size range of the sardine was from 14 to 21 cm with a mean around 15.4 cm. Between Cape Draa and Cape Juby the range was from 10 to 23 with a mean around 15.9. The registrations of sardine was on a clearly lower level compared to the surveys in 1986 and in 1989.

In most of the sardine catches, anchovy was also present. 92% of the sardine catch was taken with anchovy, while 61% of the anchovy catch was taken with sardine. While the sardine was restricted to bottom depths less than 40 m, and most abundant in bottom depths less than 20 m, the anchovy could also be found more offshore, up to 100 m bottom depths. As the sardine and anchovy also had its highest densities in the shallow waters. Chub mackerel was common in the catches in shallow water from about 40 nm northeast of Cape Draa and southwards, but never abundant.

3.1.3 Cape Juby to Cape Bojador

This region was surveyed in two days, and except from some trumpet fish (*Macroramphosus* sp. and *Capros aper*) close to the shelf edge, the shelf waters was in practice empty from fish. In autumn 1989, 0.6 million tonnes of sardine were recorded on this shelf.

3.1.4 Cape Bojador to Cape Blanc

Sardine was registrated from about latitude N 25°40' and southwards to N 21°40'. The densest registrations were close to the coast, where integrator readings exceeding 3000 units were not uncommon. The sardine co-occurred with round sardinella and anchovies at several stations but the two latter were usually only a small fraction of the total catch. The horse mackerel was relatively common, but not abundant in the catches.

3.2 Abundance of pelagic fish

The following condition factors were applied in the abundance estimates: sardine 0.75, anchovy 0.62, chub mackerel 0.62, and horse mackerel 0.73. These condition factors were derived from the length frequency samples and reflect the best fit for these samples assuming an isometric growth.

Applying the above condition factors, the biomass estimates will be reduced by some 25% compared to the biomass estimates from the previous Nansen surveys in Morocco, when a condition factor of 1.0 was applied.

The total biomass estimates for sardine, sardinella and anchovy are shown in Table 1, and chub mackerel and horse mackerel in Table 4.

Estimates are also presented by one cm length groups with number of specimens and tonnes of biomass in each length class. The basis for distributing the total biomass by length classes are the pooled regional length frequency distributions in ANNEX II. Tables 2, 3, 5 and 6 give these estimates for sardine, anchovy, chub mackerel and horse mackerel respectively.

3.2.1 Pelagic fish type 1 (Clupeoids and anchovies)

Table 1 Species composition and biomass estimates (in thousand tonnes) of pelagic type-1 fish by regions.

Area	Sardine	Anchovy	Sardinella	Total
Safi - Cap Ghir	32	14	0	46
Cap Ghir - Cap Juby	291	12	0	303
Cap Juby - Cap Bojador	0	0	0	0
Cap Bojador - Cap Blanc	4 020	18	10	4048
Total	4 343	44	10	4 397

The main part of the anchovy distribution in the Cape Ghir-Cape Bojador region occurred heavily mixed with sardine and its exact share of the biomass was difficult to estimate. The acoustic indices are split into anchovy and sardine usually on basis of the characteristics of the traces on the echograms. This procedure gives in this case an estimate of anchovy of only 4% of the total (anchovy and sardine). In the catches from the area the catches of anchovy constitutes 35% of the catches of sardine and anchovy combined. Even when taking into account a higher catchability of anchovy compared to sardine the relative high share of anchovy in the catches could indicate that it is somewhat underestimated in the procedure for the acoustic estimate.

As shown in Table 1 the Cape Bojador-Cape Blanc region holds 92% of the total biomass of sardine in the surveyed area.

Table 2 Biomass of sardine by lengthgroups.

Length cm	Safi-C. Juby tonnes	Safi-C. Juby n*10E6	C. Juby - C. Barbas tonnes	C. Juby - C. Barbas n*10E6	Total tonnes	Total n*10E6
6	17	10			17	10
7	53	19			53	19
8	0	0			0	0
9	399	73			399	73
10	5697	758			5697	758
11	15584	1539	1014	102	16598	1641
12	16421	1231	7896	609	24317	1840
13	16496	986	46849	2843	63345	3829
14	32512	1551	175540	8530	208052	10081
15	39458	1514	539767	21324	579225	22838
16	30336	952	664436	21629	694772	22581
17	36547	959	639818	17364	676365	18323
18	44555	980	430827	9850	475382	10830
19	25679	479	120144	2336	145823	2815
20	18799	301	36556	609	55355	910
21	16906	228	232748	3351	249654	3579
22	19024	223	470338	5890	489362	6113
23	4725	49	463305	5077	468030	5126
24			178977	1726	178977	1726
25			11900	101	11900	101
Sum	323213	1185	4020114	101340	4343327	102525

Table 3 Biomass of anchovy by lengthgroups.

Length cm	Safi-C. Juby tonnes	Safi-C. Juby n*10E6	C. Juby - C. Blanc tonnes	C. Juby - C. Blanc n*10E6	Total tonnes	Total n*10E6
5	4	5			4	5
6	77	58			77	58
7	105	49			105	49
8	187	58	74	24	261	82
9	701	155	2704	598	3405	753
10	961	155	2724	44	3685	199
11	2087	253	1214	15	3301	268
12	7231	675	1114	10	8345	685
13	6817	500	3713	27	10530	527
14	4444	261	6040	36	10484	297
15	2556	122	492	2	3048	124
16	448	18			448	18
17	35	1			35	1
SUM	25655	2311	18077	196	43732	2507

3.2.2 Pelagic fish type 2 (mackerel and horse mackerel)

Table 4 Species composition and biomass estimates (in thousand tonnes) of pelagic type-2 fish by area.

Area	Chub mackerel	Horse mackerel	Total
Safi - Cap Ghir	0	24	24
Cap Ghir - Cap Juby	45	28	73
Cap Juby - Cap Bojador	0	0	0
Cap Bojador - Cap Blanc	0	68	68
Total	45	120	165

Table 5 Chub mackerel. Biomass in weight and numbers by lengthgroups.

Length cm	Safi-Cape Juby tonnes	n*10E6
13		
14	167	10
15	564	27
16	3396	133
17	7214	237
18	15396	425
19	11376	267
20	4199	85
21	1479	26
22	243	37
23	0	0
24	841	10
25	0	0
26	0	0
27	0	0
28	0	0
29	185	1
Sum	45064	1226

Table 6 Horsemackerel. Biomass in weight and numbers by lengthgroups.

Length cm	Safi-C. Juby tonnes	Safi-C. Juby n*10E6	C. Juby - C. Blanc tonnes	C. Juby - C. Blanc n*10E6	Total tonnes	Total n*10E6
4	6	13			6	13
5	26	28	6	5	32	33
6	555	352	0	0	555	352
7	263	105	0	0	263	105
8	182	48	22	6	204	54
9	807	151	143	27	950	178
10	1182	16	120	16	1302	32
11	3771	39	101	10	3872	49
12	3534	28	132	10	3666	38
13	1567	10	0	0	1567	10
14	1493	7	1166	58	2659	65
15	4497	18	4340	176	8837	194
16	5610	18	8169	273	13779	291
17	7651	21	10548	294	18199	315
18	3392	8	6165	144	9557	152
19	1287	3	4260	85	5547	88
20	1200	2	2180	37	3380	39
21	347	1	2221	32	2568	33
22	1998	3	9515	122	11513	125
23	3881	4	9547	107	13428	111
24	5706	6	5875	58	11581	64
25	1466	1	1873	16	3339	17
26	659	1	766	6	1425	7
27	1108	1	858	6	1966	7
28						
29						
Sum	52195	884	68010	1494	120205	2378

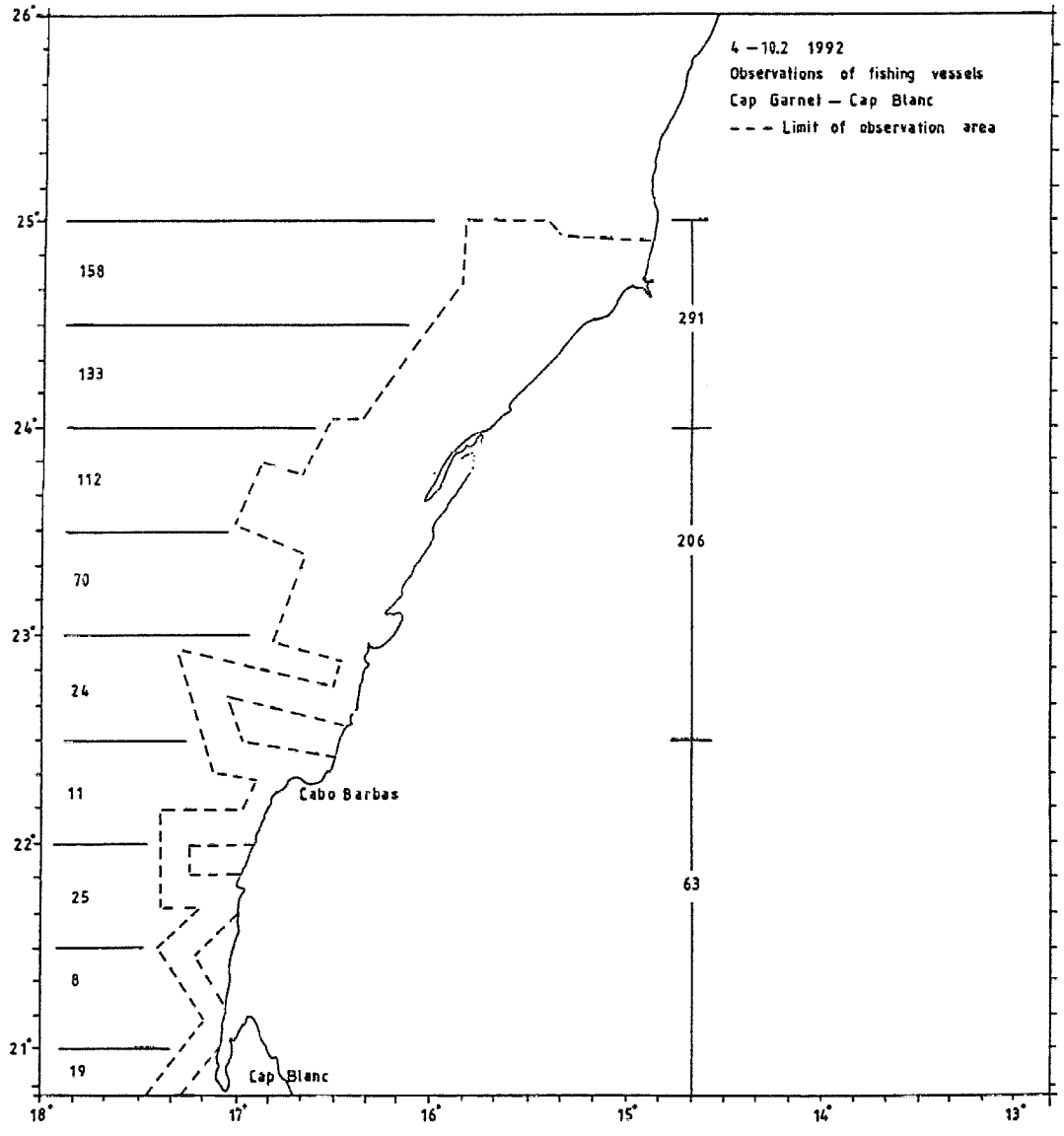

Figure 9. Observations of fishing vessels within 5 nm off the course track.

4 CONCLUDING REMARKS

Due to a repair of the damaged net sonde winch and due the very dense sardine schools in the shallow waters requiring a dense sampling grid, some time constraints were put on the survey and parts of the outer shelf had to be left unsurveyed. This might have left some horse mackerel undetected. However, horse mackerel were never encountered in high densities, and it is not likely that this constitutes a major loss in the estimates.

For the same reason the area between Cape Barbas and Cape Blanc had to be surveyed with a more open grid than planned, lowering the precision of the 350 000 tonnes estimated from this sector. For the rest of the area of sardine distribution the coverage is considered to be satisfactory.

The sardine was found occasionally with anchovy, chub mackerel (in the central area) and with young sardinella (in the southern stock). The acoustic estimates of these less abundant species are to a large extent based on their share in the samples, and should be considered more indicative than accurate.

The estimates by length groups are based on the pooled length distributions in Annex II, and are not corrected for any selectivity.

Comparing the present estimates with previous estimates by R/V "DR.FRIDTJOF NANSEN" it is necessary to take into account the condition factors. Based on the length distributions collected during the 1986 and 1989 surveys a condition factor of 0.85 gives the closest fit between sample weights and length distributions. Table 7 shows the recalculated biomass estimates from the previous surveys joined with the recent estimates, and Figure 10 is a graphical presentation of the same estimates.

Table 7 Sardine. Biomass comparisons with previous "DR. FRIDTJOF NANSEN" surveys. 1 000 tonnes.

	Safi- Cape Juby	Cape Juby- Cape Bojador	Cape Bojador- Cape Blanc	Total
Aug 1986	640*	n.s	4 310	4 950
Nov 1986	610*	660	4 320	5 590
Sep 1989	1 200	450	3 050	4 700
Jan 1992	320	0	4 050	4 370

n.s. = no survey
* Safi- Agadir not surveyed

The southern stock is estimated to rounded 4.1 mill tonnes while the corrected figures for 1986 and 1989 will be 4.3 and 3.1 mill. tonnes respectively. It is also worth noting that the present biomass to a large extent is represented by a young cohort with modal length around

15 cm and with a strong growth potential, while in 1989 the biomass was mainly represented by old fish with modal length around 22 cm.

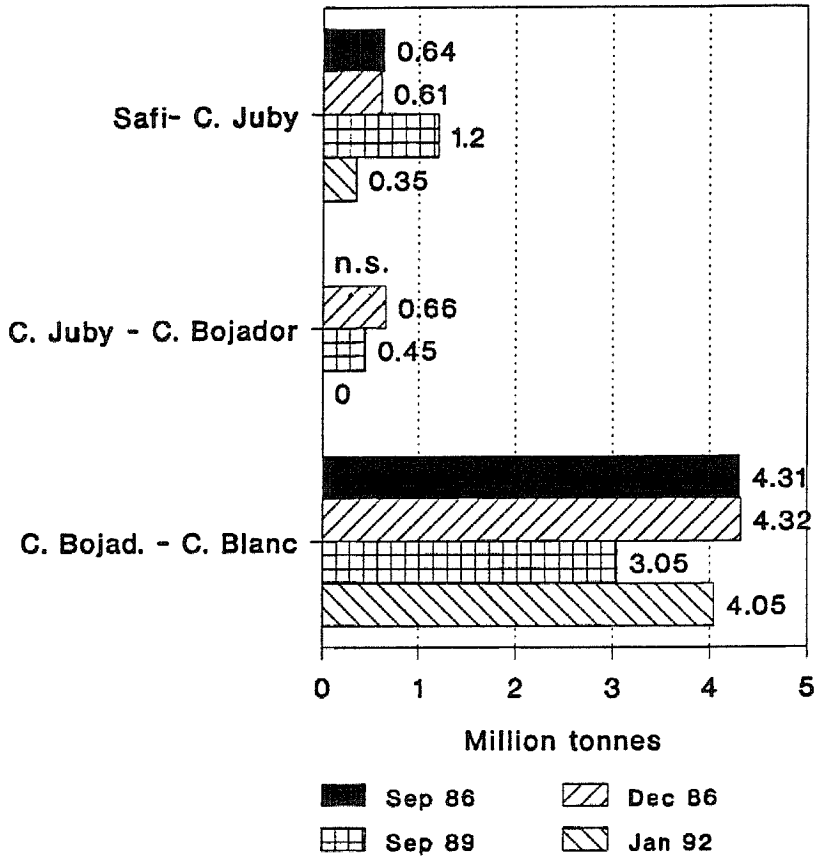

Figure 10. Sardine. Biomass estimates 1986-92.

The southern stock has mainly been fished on by the former USSR during the later years. Table 8 shows the catch of sardine by USSR from fishing area 34 as given in FAO Year-book of Fishery Statistics.

Table 8 Catch of sardine by USSR in fishing area 34 by years. 1 000 tonnes.				
Year	1986	1987	1988	1989
Catch	169	339	425	610

The sharp increase in the catch still seems to be within safe limits of what the southern stock can sustain and the strong component of juveniles in the 1992 estimate points to a successful recruitment to this stock.

The central sardine stock seems to have declined drastically since 1989. The present estimate of 323 000 tonnes compared to the corrected estimate of 1 200 000 tonnes for 1989,

points to a stock reduced to perhaps one fourth of its previous size. If the estimates from the area between Cape Juby and Cape Bojador is included as part of the stock the reduction is even more striking. As mentioned previously in the report there are some indications that the amount of anchovy in the central area could be underestimated during the last survey, in which case the sardine estimate should be still more reduced. Some prospects for recruitment into the adult stock are, however, indicated. In the Safi area the estimate on sardine was 32 000 tonnes, but only of young fish with a modal length of 11 cm. This is probably an underestimate due to the juveniles' very shallow distribution. Between Agadir and Cape Juby most of the fish was in the range 14 to 20 cm. Older fish was not common.

Table 9 shows the Moroccan sardine catch from fishing area 34. In 1986-87 the level was around 250 000 tonnes, increasing to around 300 000 tonnes in 1988-89. This catch level is close to the estimated present stock size and a relatively high level of effort maintained under the present biological condition is considered risky, and will likely lead to a further drastic reduction in the stock size.

Table 9 Catch of sardine by Morocco in fishing area 34 by years. 1 000 tonnes.

Year	1986	1987	1988	1989
Catch	258	247	291	312

In general the coverage of the main distribution areas was considered to be adequate and the survey conditions were favourable in all areas of high fish concentration.

Several series of good target strength measurements on sardine have been collected during the cruise. These measurements will be analyzed at IMR, Bergen in the nearest future, and the above biomass estimates may be subject to some revision later. The trends in the estimates when comparing with previous results will not be affected by this.