PART II

SURVEYS OF THE PELAGIC STOCKS

28 February - 19 March 1993

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PART II

CHAPTER 1 INTRODUCTION

1.1 OBJECTIVES OF THE CRUISE

To produce a biomass estimate for pilchard *Sardinops ocellata* and map the geographical distribution of anchovy *Engraulis capensis* and round herring *Entrumeus whiteheadi*.

1.2 PARTICIPATION

The scientific staff from Namibia on the "DR. FRIDTJOF NANSEN" were:
Janet Coetzee, Dawid Gaseb, Clemens Evenson, Rudi Cloete

From Angola the following scientists participated:
Nkosi Luyeye, Teodoro Guilherme Camarada

The scientific staff from the Institute of Marine Research were:
Reidar Toresen, Magnar Mjanger, Oddgeir Alvheim and Reidar Johannesen.

CHAPTER 2 METHODS

From the general knowledge of pelagic fish distribution and from reports of commercial fishing vessels, the survey area is in general limited to the area from Dolphin Head (26°00'S) to the Cunene River (17°15'S) and from the shore to the 120 m bathometric line. The southern limit is formed by the cold and oxygen deficient upwelling region centred around Lüderitz and the northern boundary in the area off Tombua (Angola) at 16°00'S at the front of the warm Angolan current. Since the pelagic fish distribution also extends into Angolan waters, permission was obtained from Angolan authorities to extend the present survey northward to the area west of Tombua. To allow comparison with previous "DR. FRIDTJOF NANSEN" surveys, the region was divided into three areas:

1 26°00' to 21°00' Dolphin Head to Ambrose Bay
2 21°00' to 17°15' Ambrose Bay to Cunene River
3 17°15' to 16°00' Cunene River to Tombua

The "DR FRIDTJOF NANSEN" left Walvis Bay at 10h30 on 28 February and surveyed the shallow coastal water southward to Dolphin Head and returned to Walvis Bay to exchange Norwegian officers and Namibian scientific staff on 6 March. She departed at 10h30 on 7 March. and surveyed the northern region including Angolan waters north to Tombua. Here, in addition to the acoustic survey of the pelagic stocks, 19 bottom trawl stations were worked to map and estimate demersal fish species in the area to complete the sampling of the previouns bottom trawl survey. The vessel arrived in Walvis Bay on 19 March. 3700 nautical miles were steamed and 58 trawl stations worked.

The course tracks with the fishing stations from Dolphin Head to Ambrose Bay, from Ambrose Bay to Cunene River and from Cunene River to Tombua are shown in Figures 1a-c. Additional southward coverages of the shallow coastal area Cunene River to Ambrose Bay and Ambrose Bay to Sandwich Harbour are shown in Figures 1d and 1e.

All catches were sampled for composition by weight and numbers of each species and the size distribution of commercially important species, using total length, was determined. The length frequencies of these species are given in Annex I. The complete records of fishing stations are shown in Annex II.

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

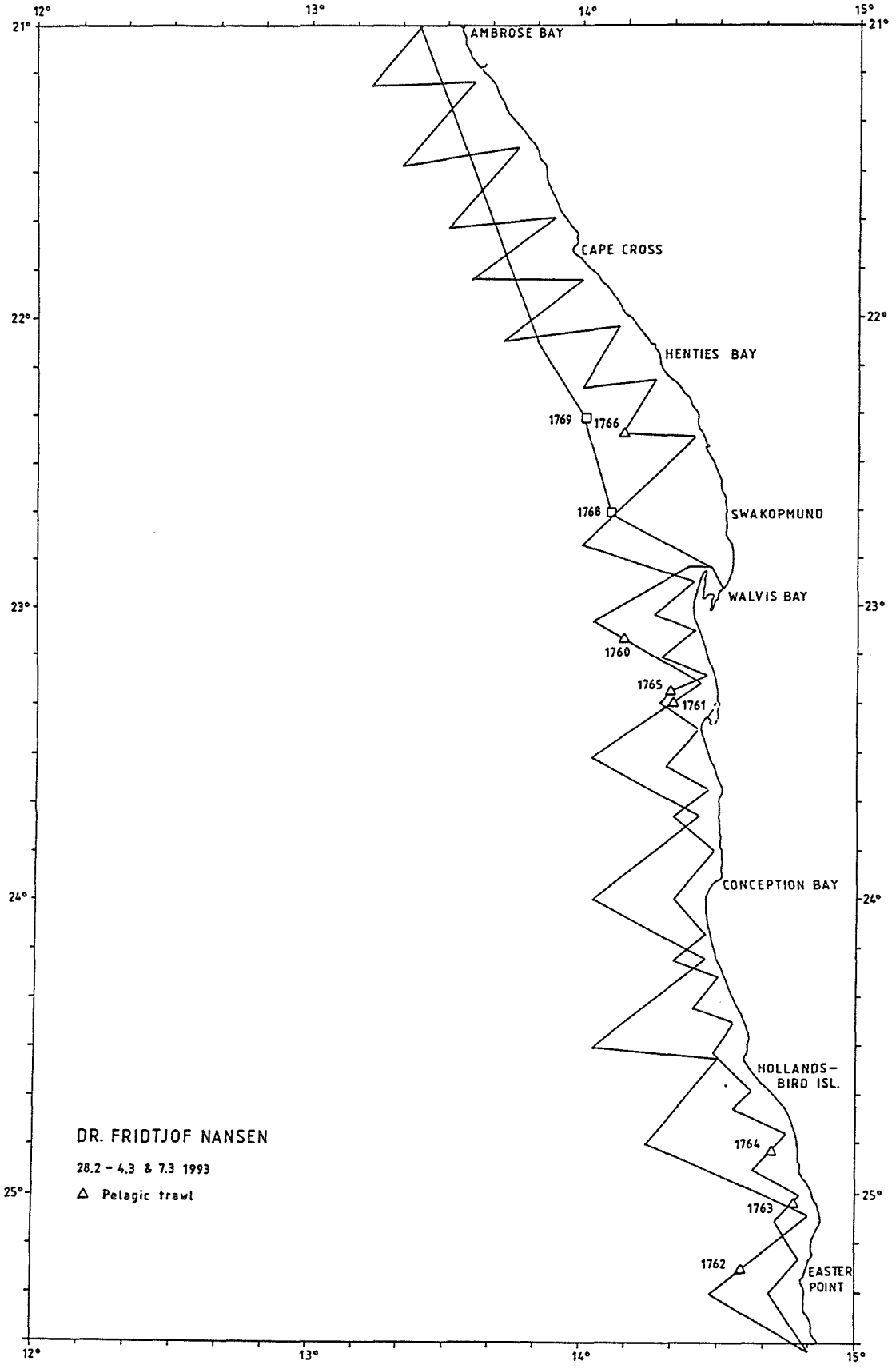

Figure 1a Course tracks and fishing stations, Dolphin Head to Ambrose Bay.

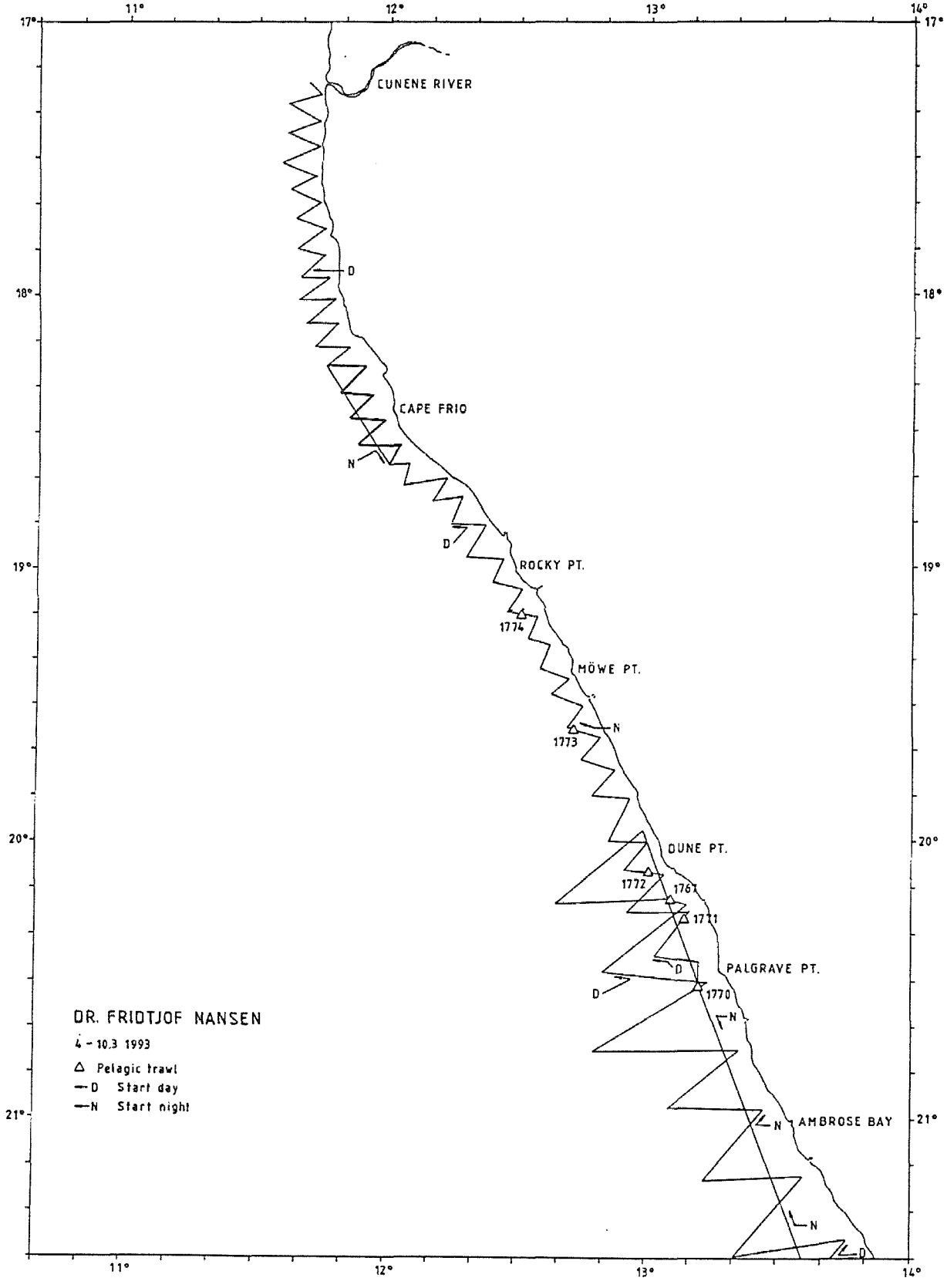

Figure 1b Course tracks and fishing stations, Ambrose Bay to Cunene River. Northward coverage.

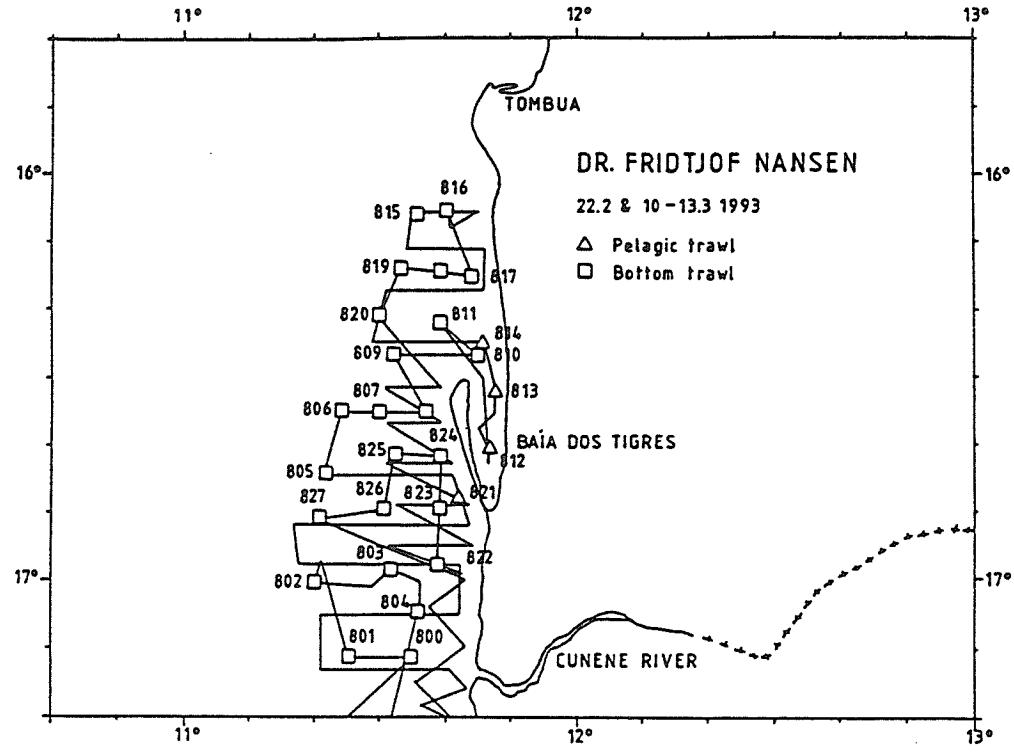

Figure 1c Course tracks and fishing stations, Cunene River to Tombua.

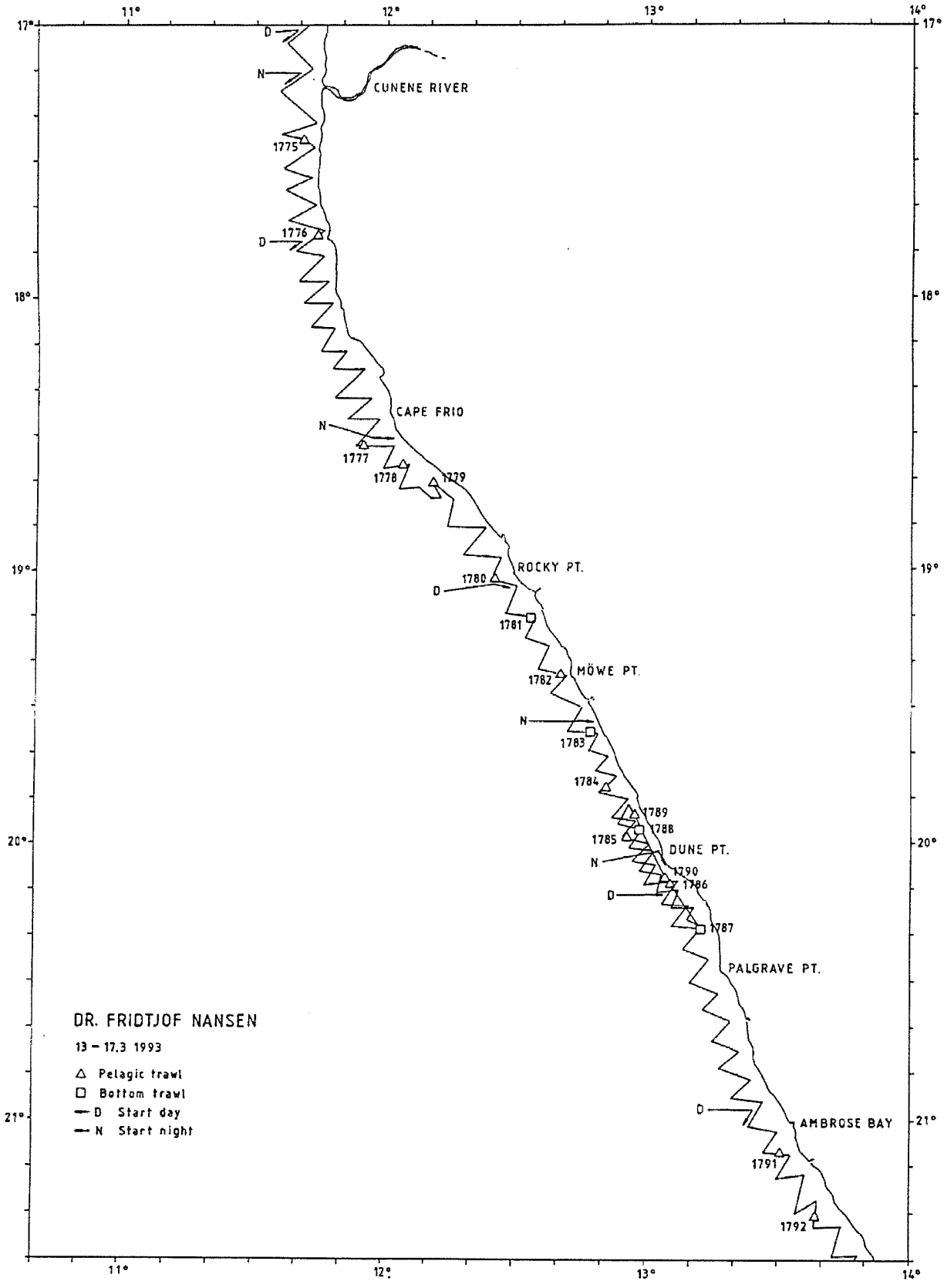

Figure 1d Course tracks and fishing stations, Ambrose Bay to Cunene River. Southward coverage.

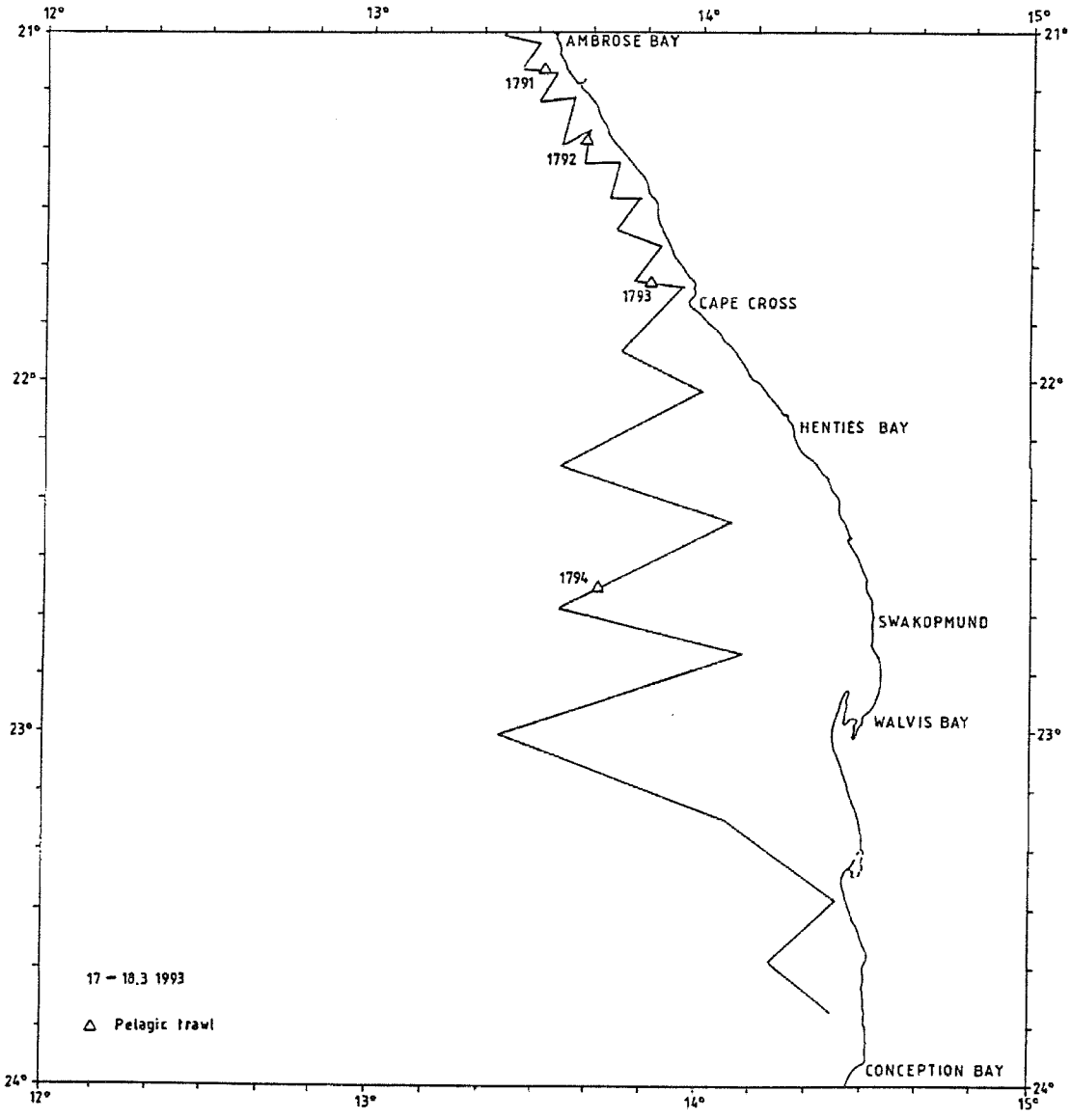

Figure 1e Course tracks and fishing stations, Sandwich Harbour to Ambrose Bay.

The following target strength (TS) function was applied to convert S_A-values to number of fish (pilchard, anchovy and round herring):

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

or on the form

$$C_F = 1.26 \cdot 10^6 \cdot L^{-2} \qquad (2)$$

where L is total length. The following formula was applied to calculate the number of fish in each length frequency group (cm) in an area:

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

where N_i = number of fish in length group i

A = area in NM^2

S_A = mean integrator value in the area

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

C_{Fi} = fish conversion factor (formulae 2) applying the length of fish in length group i

The number per length group were then summed and the total number of fish obtained. The biomass of fish was calculated applying the condition factor to get weight at length and multiplied by number of fish in each length group.

Surface temperature was measured continuously at 4 m depth by the thermograph.

The weather was favourable for an acoustic survey during the whole cruise.

CHAPTER 3 HYDROGRAPHY

The sea surface temperature inshore measured at 4 m isolines is shown in Figures 2a - c.

A comparison with the temperature in the same area measured during previous surveys at the same time of the year indicate significantly higher temperatures during this cruise. The surface temperature is 2 - 3°C higher in the whole region from Easter Point to Tombua (Angola). The extensive longshore upwelling seems to be far less profound this year than in the previous ones.

CHAPTER 4 DISTRIBUTION AND ABUNDANCE OF PELAGIC FISH

The acoustic integration system provided observations of fish densities averaged, usually over 5 nm distances, but in areas of high fish concentrations, over 1 nm. The unit of acoustic reflection was 0.1 · 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.

Pilchard *Sardinops ocellata*

Pelagic fish type 1: Clupeidae (round herring), round sardinella *Sardinella aurita* Engraulidae (anchovy)

Pelagic fish type 2: Carangidae (horse mackerel).

Plankton

The allocation of pelagic fish type 1 to species were done applying relevant trawl catches.

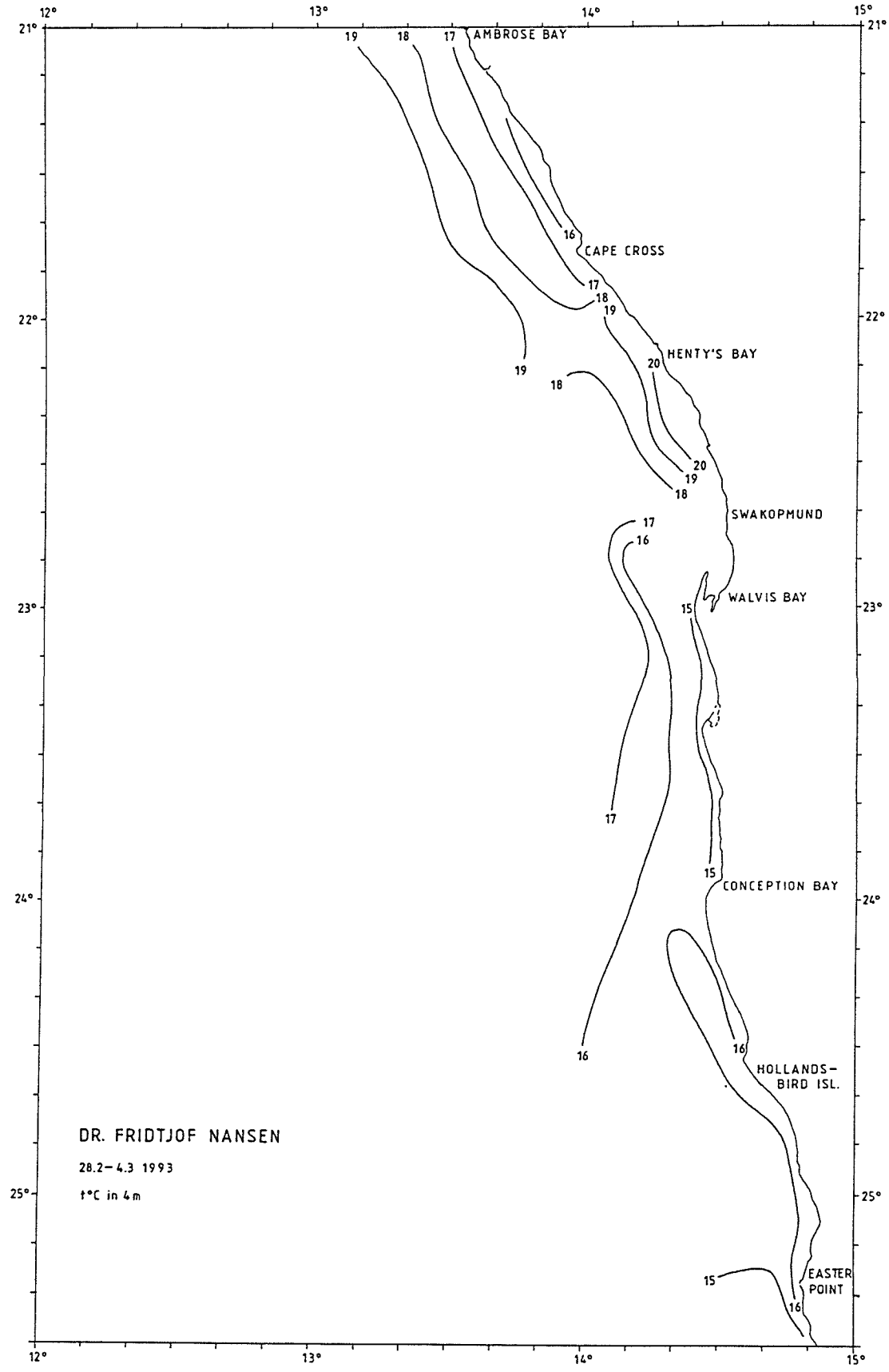

Figure 2a Distribution of sea temperature at 4 m of depth based on observations of the ships thermograph, Dolphin Head to Ambrose Bay.

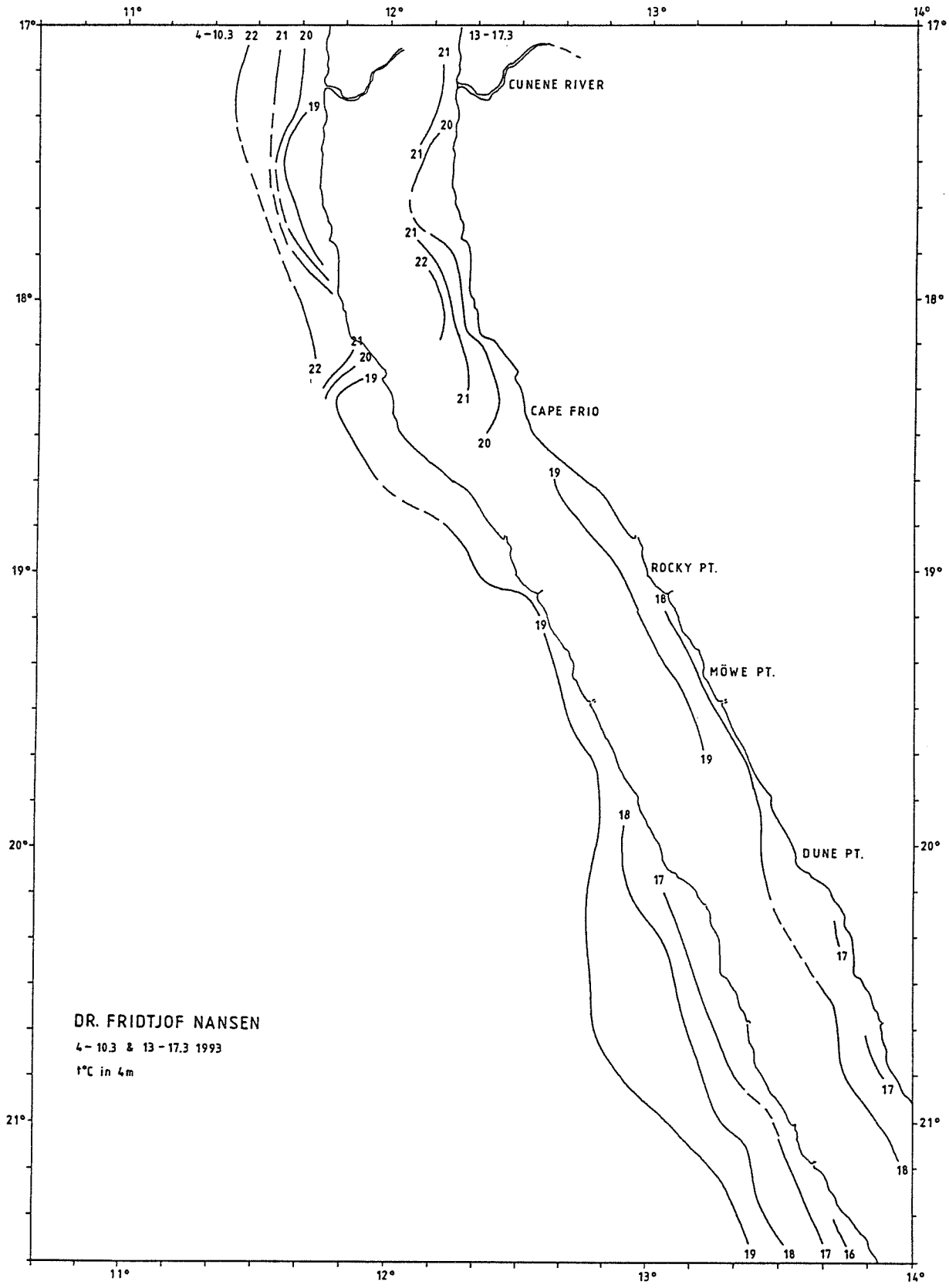

Figure 2b Distribution of sea temperature at 4 m of depth based on observations of the ships thermograph, Ambrose Bay to Cunene River.

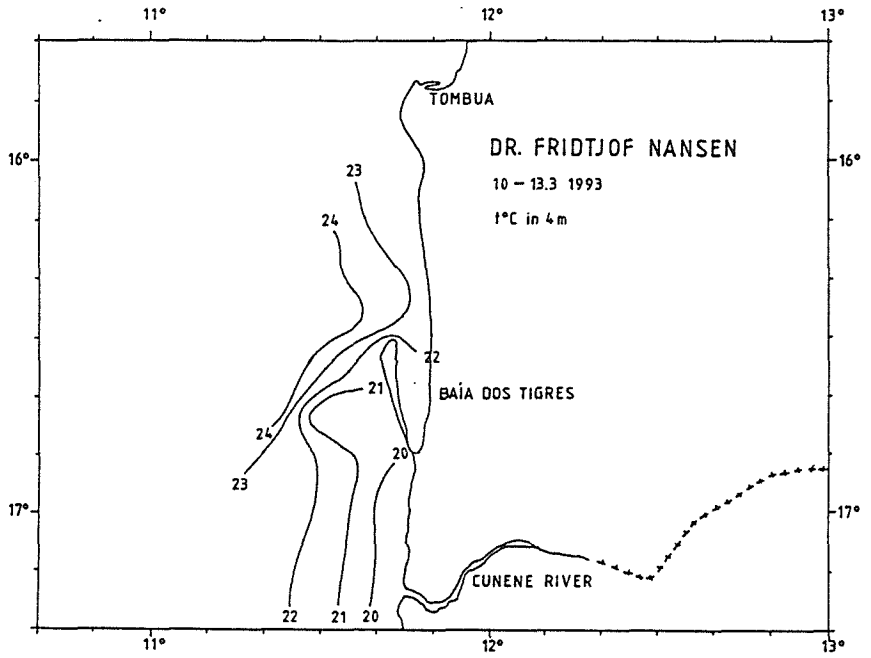

Figure 2c Distribution of sea temperature at 4 m of depth based on observations of the ships thermograph, Cunene River to Tombua.

4.1 DISTRIBUTION OF PELAGIC FISH

In summary, pilchard was only recorded in limited areas north of Walvis Bay. Anchovy and round herring were recorded in two areas south of Walvis Bay and two areas north of Walvis Bay. Horse mackerel were recorded in most of the surveyed area. Layers of recordings, consisting mainly of jellyfish, small pelagic gobies, lanternfish and other planktonic organisms were recorded in offshore waters.

Pilchard, anchovy and round herring were often recorded at the same locations making it difficult to separate the pilchard from the two other species on the basis of echo traces alone. In such cases the species composition of the nearest trawl catches were used. Sampling of fish was generally successful.

The distributions of pilchard and other clupeids (including engraulids) are shown in Figures 3a-e. An arbitrary scale was used in the distribution charts to illustrate different levels of density.

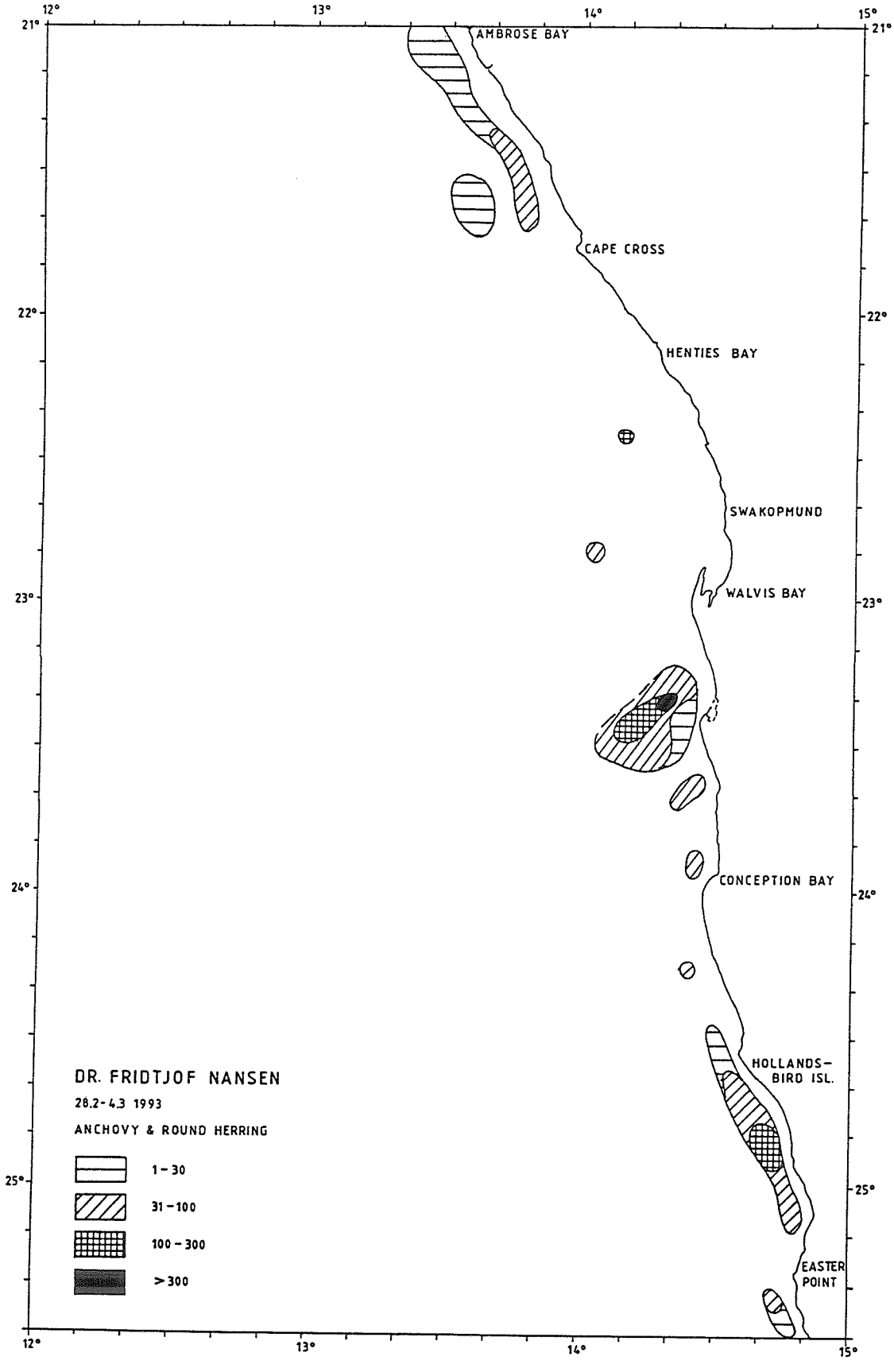

Figure 3a Distribution of anchovy and round herring, Dolphin Head to Ambrose Bay.

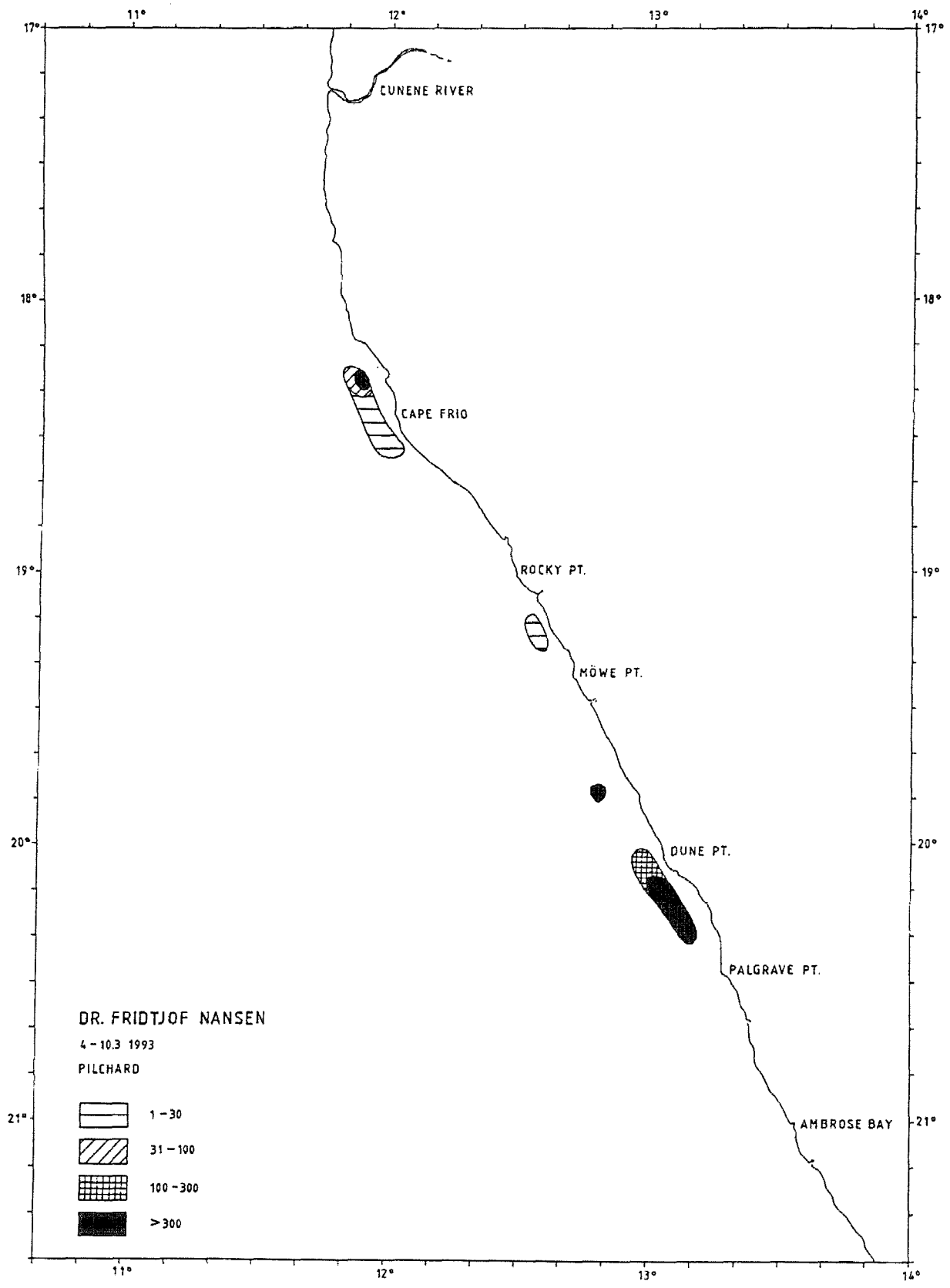

Figure 3b Distribution of pilchard, Ambrose Bay to Cunene River.

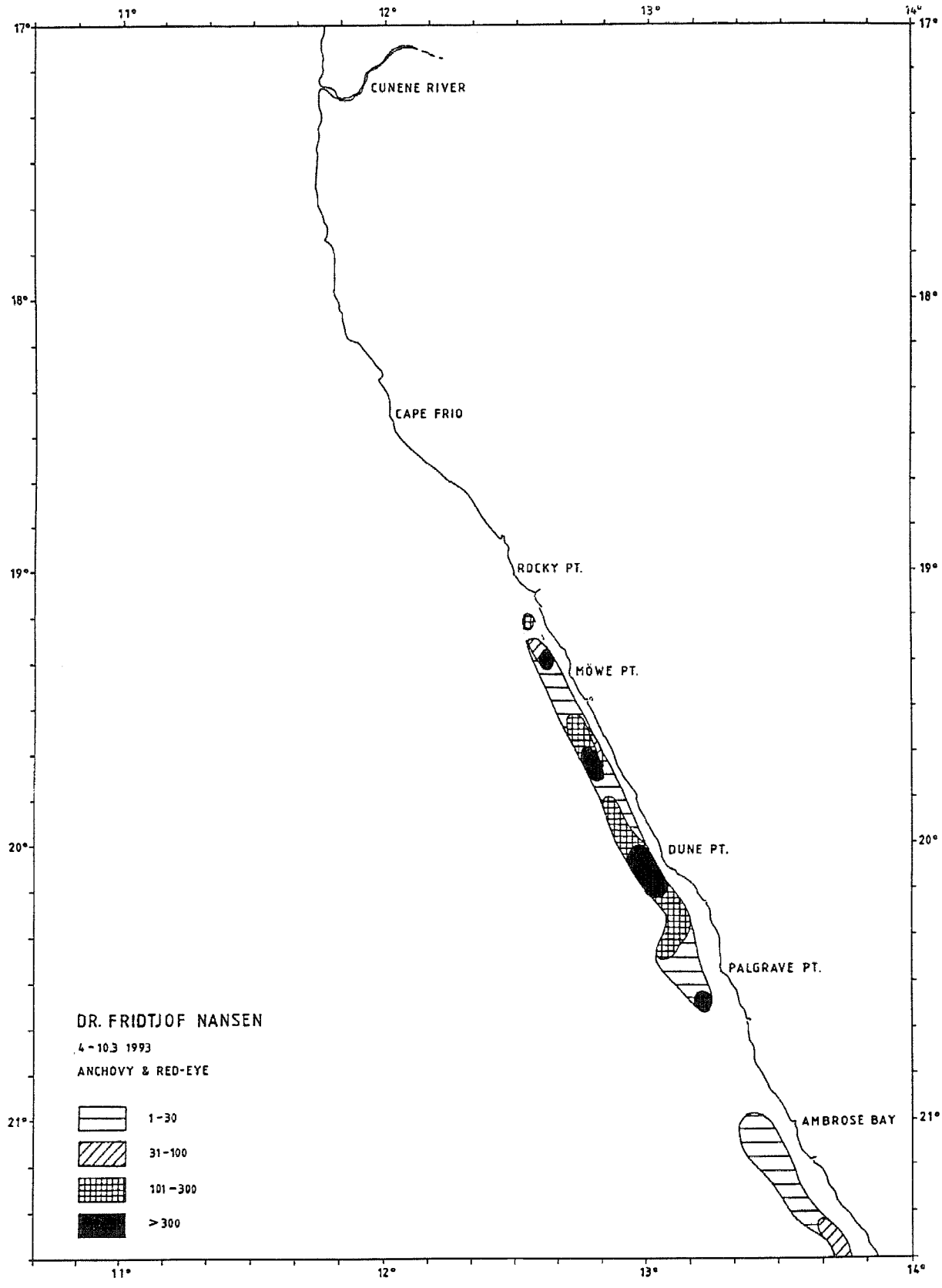

Figure 3c Distribution of anchovy and round herring, Ambrose Bay to Cunene River.

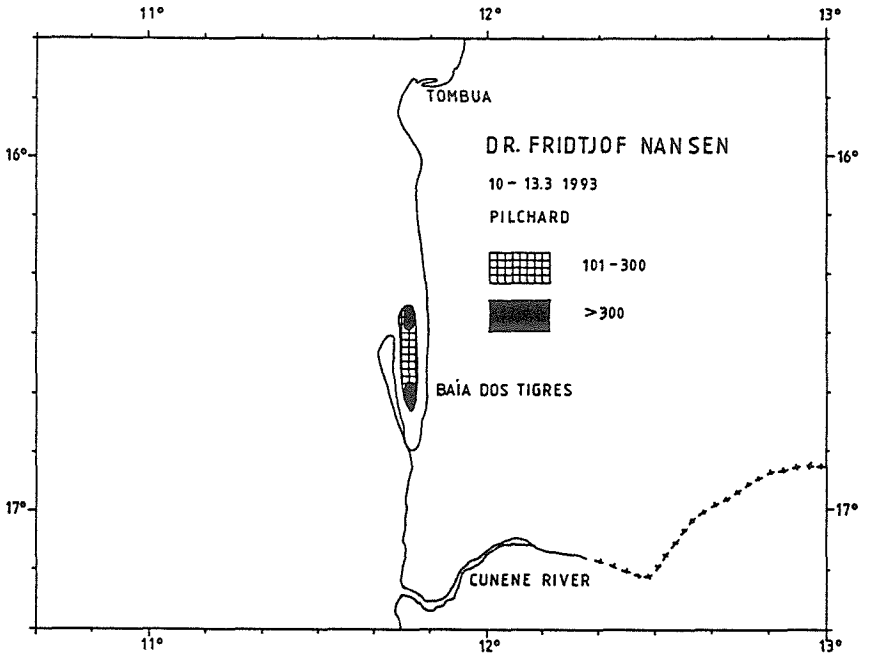

Figure 3d Distribution of pilchard, Cunene River to Tombua.

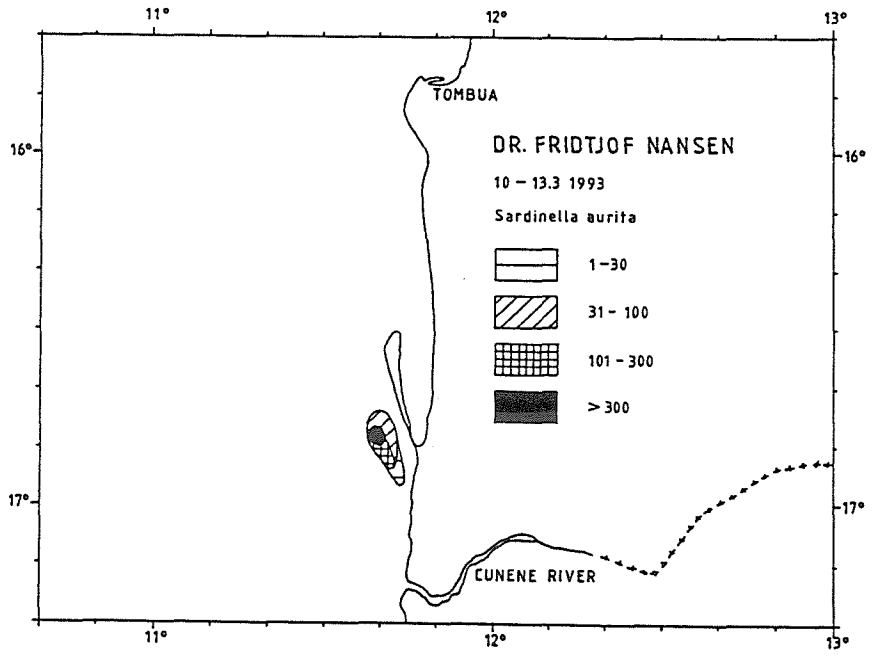

Figure 3e Distribution of round sardinella, Cunene River to Tombua.

Dolphin Head to Ambrose Bay

In this area, no pilchard was detected.

South of Walvis Bay, two main concentrations of pelagic fish type 1 was delineated, one off Hollandsbird Isl. and another off Sandwich Harbour. In addition a few smaller aggregations of pelagic fish type 1 was recorded (Figure 3a). The concentrations near Sandwich Harbour consisted mainly of anchovy with a modal length of 13 cm. However, round herring were mixed with anchovy in varying proportions. The modal length of the round herring was also 13 cm. North of Walvis Bay, anchovy and round herring were found mixed in the area between Cape Cross and Ambrose Bay. Also here these species dominated and were found in varying proportions. Few other pelagic fish of commercial value was found in this area, except for large snoek *Thyrsites atun* which were caught in a few of the hauls in this region.

Ambrose Bay to Cunene River

Three main concentrations of pilchard was recorded on the way north, one between Palgrave Pt. and Dune Pt., the second between Möwe Pt. and Rocky Pt., and the third off Cape Frio. The one at Dune Pt. was by far the most dense. Here huge shoals of pilchard concentrated close to shore fairly high up in the water column (around 20 - 30 m) in areas with bottom depth of 40 - 50m. The modal length of pilchard was 18 cm but a smaller cohort with a modal length of 11 cm was also caught. Except for the pilchard off Cape Frio, it was found very well mixed with anchovy and round herring in the other two areas and the recordings of these species were often very difficult to distinguish between.

Anchovy and round herring were found mixed in the area between Palgrave Pt. and Rocky Pt. Some shoals were very dense and often difficult to distinguish from shoals of pilchard. These species were concentrated in more or less the same depth as the pilchard and in the same distance from the shore. However, shoals of pilchard were often denser than shoals of the other two species, but this was not always the rule. Another way to distinguish shoals of pilchard from the other ones were to study their form. Pilchard shoals were often more restricted in area distribution while the other ones often formed wider aggregations. The modal length of anchovy in this area was 10 cm while the round herring had a modal length of 14 cm.

Horse mackerel was also recorded in this region, but it was not as difficult to separate recordings of this species from the recordings of the other pelagic fish. Much of the horse mackerel caught in these trawls were small with modal lengths of less than 10 cm.

On the way south, recordings of all pelagic fish were much lower. There is a possibility that it might have moved even closer to shore. The coverage southward was denser in the areas where fish were recorded on the way north.

Cunene River to Tombua

In this area pilchard was recorded in Baia dos Tigres and the recordings extended somewhat to the north of the bay (Figure 3d). During night the pilchard was recorded as a more or less dense layer mixed with horse mackerel. The pilchard had a modal length of 26 cm.

Outside the bay, to the southwest of Peninsula dos Tigres round sardinella (*Sardinella aurita*) was recorded. The modal length of this fish was 32 cm and it was mixed with horse mackerel.

No anchovy or round herring was recorded in this area.

4.2 ABUNDANCE OF PELAGIC FISH

The biomass estimates are based on the acoustic integration technique, similar to that used in previous assessments of the same stock. The target strength (TS), the factor to convert the integrator values (S_A) to fish density and the formulae by which the number by length group is calculated is shown in the section about the methods, formulae 1, 2 and 3.

The behaviour of the fish was favourable for acoustic abundance estimation, especially during daytime. At night the shoals of pilchard became less dense and were more difficult to separate from shoals of the other pelagic species.

The biomass estimates for pilchard, anchovy and round herring and round sardinella are shown in Table 1.

No attempt was made to estimate the abundance of horse mackerel.

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

Area	Pilchard	Anchovy & round herring	Sardinella	Total
Baia dos Tigres-Cunene River	45 000		40 000	95 000
Cunene River-Cape Frio	10 000			10 000
Palgrave Point-Rocky Point	315 000	150 000		465 000
Cape Cross-Ambrose Bay		25 000		25 000
Conception Bay-Walvis Bay		100 000		100 000
Easter Point-Hollandsbird Island		60 000		60 000
Total	370 000	335 000	40 000	755 000
Total Namibia	325 000	335 000		660 000

Pilchard

The estimate of pilchard in the three areas is shown in Table 2. The total estimate in terms of biomass is 370 000 tonnes. About 85 % of this was estimated to occur at Dune Pt. while 12 % was estimated at Baia dos Tigres. Only 3 % of the total was estimated at Cape Frio. The largest part of the estimated number (95 %) was estimated in the length groups 15 - 24 cm. About 4 % were estimated in the length groups 25 - 29 cm while only 1 % was estimated to the length interval 10 - 14 cm.

The estimate is based on the northward coverage only. On the southward coverage much less pelagic fish were recorded both night and day. The estimate is also solely based on the coverage of the inshore areas shallower than about 100 m. Pilchard in a migratory stage could be outside the survey area, on migration to spawning areas south of Walvis Bay. Reports from fishermen support that pilchard has migrated southwards to spawn as the fishery for large pilchard in these areas increased significantly during the last week of the survey. On the last day of the survey a few transects were sailed in the area between Walvis Bay and Conception Bay. Here dense shoals of pilchard were observed. However, due to lack of time it was impossible to work out any estimate in this area. If the migration hypothesis is correct, this could the explain the very limited recordings on the southward coverage, and could also explain why our total estimate is relatively low.

Table 2 Combined estimate of pilchard. Number in millions, weight in thousand tonnes.

	Dune Pt.	Cape Frio	B. d. Tigres	Total
L (cm)	N	N	N	N
10	1			1
11	23			23
12	4			4
13	12			12
14	2	2		4
15	12	56		68
16	22	139		161
17	548	95		643
18	1538	15		1553
19	1290	2		1292
20	828			828
21	714			714
22	439		2	441
23	110		9	119
24			47	47
25			65	65
26			84	84
27			58	58
28			39	39
29			9	9
30				
Sum N:	5533	309	313	6155
W	315	10	45	370

The estimates are affected by sources of error. The allocation of the integrator values (S_A) to species is usually difficult when investigating mixed species in dense and fast migrating shoals. Frequent sampling and most careful studies of the echo traces and their level is important to avoid severe bias of the estimates. This source of error will always be present in varying degree, but the problem has probably not had a great impact on the level of the estimate of pilchard during this survey. Another problem is the shadowing effect in the shoals. The density of fish in many of the shoals was extremly high and in such shoals strong shadowing effects occur. When large parts of the total estimate of pilchard is based on such shoals the stock will be underestimated. The problem is valid for both day and night registrations.

However, this kind of error has not been accounted for previously in Namibian waters so if the density in the shoals have not changed significantly through the last years the estimates should be comparable. This source of error could perhaps explain some of the variability detected in estimates of this stock in recent years.

Table 3 shows the estimates of the pilchard stock since 1990.

Table 3 Biomass estimates of pilchard in 1 000 tonnes, all surveys. NS = not surveyed.

Month/Year	Namibia	Angola	Total
Jan-Mar 1990	235	NS	235
May-Jun 1990	750	NS	750
Mar 1991	805	NS	805
Nov-Dec 1991	601	122	723
May-Jun 1992	530	40	570
Sep 1992	NS	210*	
Dec 1992	450	NS	450
Feb-Mar 1993	325	45	370

* From Angola survey 1992

There has been a decline in estimated biomass of this stock since March 1991. The abundance is now about half of the level estimated in 1991.

Anchovy and round herring

Separate estimates of the two stocks were not made. Separating the species from the characteristics of the echo recordings is difficult and using the composition of the trawl samples is also problematic, depending on the frequency of trawling and the catchability of the two species. A combined estimate of the two stocks were worked out resulting in a total of 335 000 tonnes. This is the largest estimate of biomass of the two stocks since these investigations started. About half of this was found south of Walvis bay, while the other half was estimated in the area between Rocky Point and Walvis Bay (Table 1).

Similar sources of error mentioned for pilchard also affect the estimate of other pelagic shoaling species. However, the shadowing effect is probably not as serious for anchovy and round herring as for the pilchard, since the shoals of these are less dense.

CHAPTER 5 CONCLUDING REMARKS

The estimates of biomass obtained during this survey are based on one coverage, considered to be the most complete of the ones carred out. Also, the estimate of pilchard is based on the observations from a very limited area as 85 % of the estimated stock was found off Dune Point. In this area a few shoals contribute largely to the total estimate. This is not the ideal distribution pattern for acoustic abundance estimation. An estimate of a stock of this size should preferably be based on more positive acoustic samples. In the survey area the sampling intensity is fairly good and of the same level as of previous surveys. However, the question remains whether there are significant quantities of fish outside the survey area. Information from the fishing fleet supports this view but it was not possible to sample and estimate the abundance of this migrating fish.

It must be concluded that the spawning season is not favourable for acoustic abundance estimation on the pilchard. The recent estimates have indicated a decreasing level of abundance of the pilchard stock, but the final conclusion should await until a later survey in a non-migratoy season could confirm this.