PART II

SURVEYS OF THE PELAGIC STOCKS
26 May - 19 June 1993

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PART II

1 INTRODUCTION

1.1 Objectives of the Cruise

To produce biomass estimates for four of the commercially important pelagic fish species; pilchard *Sardinops ocellatus*, anchovy *Engraulis capensis*, round herring *Etrumeus whiteheadi* and juvenile (inshore) Cape horse mackerel *Trachurus capensis*.

Assist the RV 'Benguela' to survey adult (offshore) Cape horse mackerel.

1.2 Participation

The scientific staff from Namibia were:

Rudolph Cloete (until 4 June), David Boyer (from 5 June), Benediktus Ushona (until 4 June), Clemens Evenson (from 5 June) and Sielfried Gowaseb.

From Angola:

Rafael Fortunato (from 5 June) and Buco Antonio (from 5 June).

From the Institute of Marine Research:

Johannes Hamre, Terje Haugland, Valantine Anthonypillai and Erling Molvær.

2 METHODS

From the general knowledge of pelagic fish distribution and from reports of commercial fishing vessels, the survey area has previously been 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 was formed by the cold and oxygen deficient upwelling region centred around Lüderitz and the northern boundary by Namibia's border with Angola. Environmental conditions between December 1992 and March 1993 resembled an El Niño-type event. One of the indicators of this phenomenum is the breakdown of the upwelling cell around Lüderitz, effectively removing the environmental barrier which separates the

southern and northern regions of the Benguela ecosystem. This has previously resulted in the transport of large quantities of pelagic fish between the two parts of the Benguela ecosystem. It was therefore decided to extend the survey to the Orange River to assess the status of the pelagic fish stocks immediately south of the upwelling cell in order to determine if any migration of fish has occurred. In addition, the South African research vessel 'Africana' was surveying the pelagic fish stocks off the western coast of South Africa, and was due to finish the survey at the border with Namibia at the end of May. This gave an opportunity to obtain a synoptic coverage of the pelagic fish stocks of the entire Benguela system. Since the pelagic fish distribution also extends into Angolan waters, permission was obtained from the Angolan authorities to extend the present survey northward to the area west of Tombua (16°00'S).

To allow comparison with the previous RV 'Dr. Fridtjof Nansen' surveys, the region was divided into four areas:

1	29°00' to 26°00'	Orange River to Dolphin Head
2	26°00' to 21°00'	Dolphin Head to Ambrose Bay
3	21°00' to 17°15'	Ambrose Bay to Cunene River
4	17°15' to 16°00'	Cunene River to Tombua

The RV 'Dr. Fridtjof Nansen' left Walvis Bay at 1000 hrs on 26th May and surveyed the shallow coastal water from Walvis Bay southward to Orange River and returned to Walvis Bay to exchange Namibian scientific staff at 1200 hrs on June 4th. On this first part she was assisted by the Namibian purse seiner 'Wildekus', which served as a scouting vessel. RV 'Dr. Fridtjof Nansen' departed Walvis Bay at 0900 hrs on June 6th and surveyed the northern region including Angolan waters north to Tombua. This part of the survey was carried out in cooperation with RV 'Benguela', which covered the distribution area of mid-water (offshore) horse mackerel, and the purse seiners 'Torsver' (to 9th June) and 'Fiskesjer' (from 10th to 14th June). The RV 'Dr. Fridtjof Nansen' arrived in Walvis Bay on 19th June at 1000 hrs; 4 800 nautical miles were steamed and 88 trawl stations worked.

The course tracks with the fishing stations for the four areas are shown in Figures 1a, 1b, 1c and 1d respectively. Additional coverages of the shallow coastal area from Orange River to Panther Head are shown as in sets.

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.

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

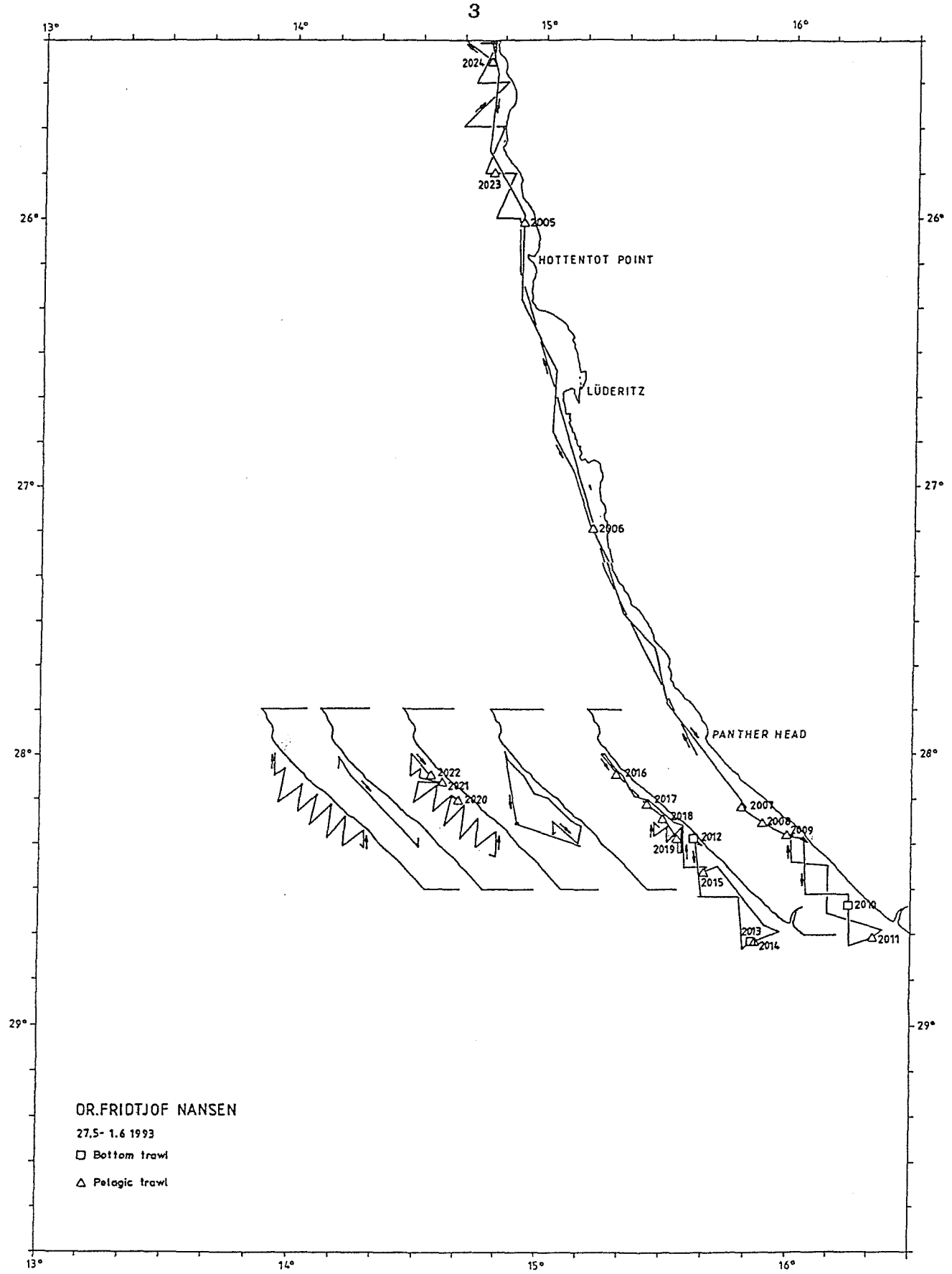

Figure 1a Course track and fishing stations, Orange River to Dolphin Head.

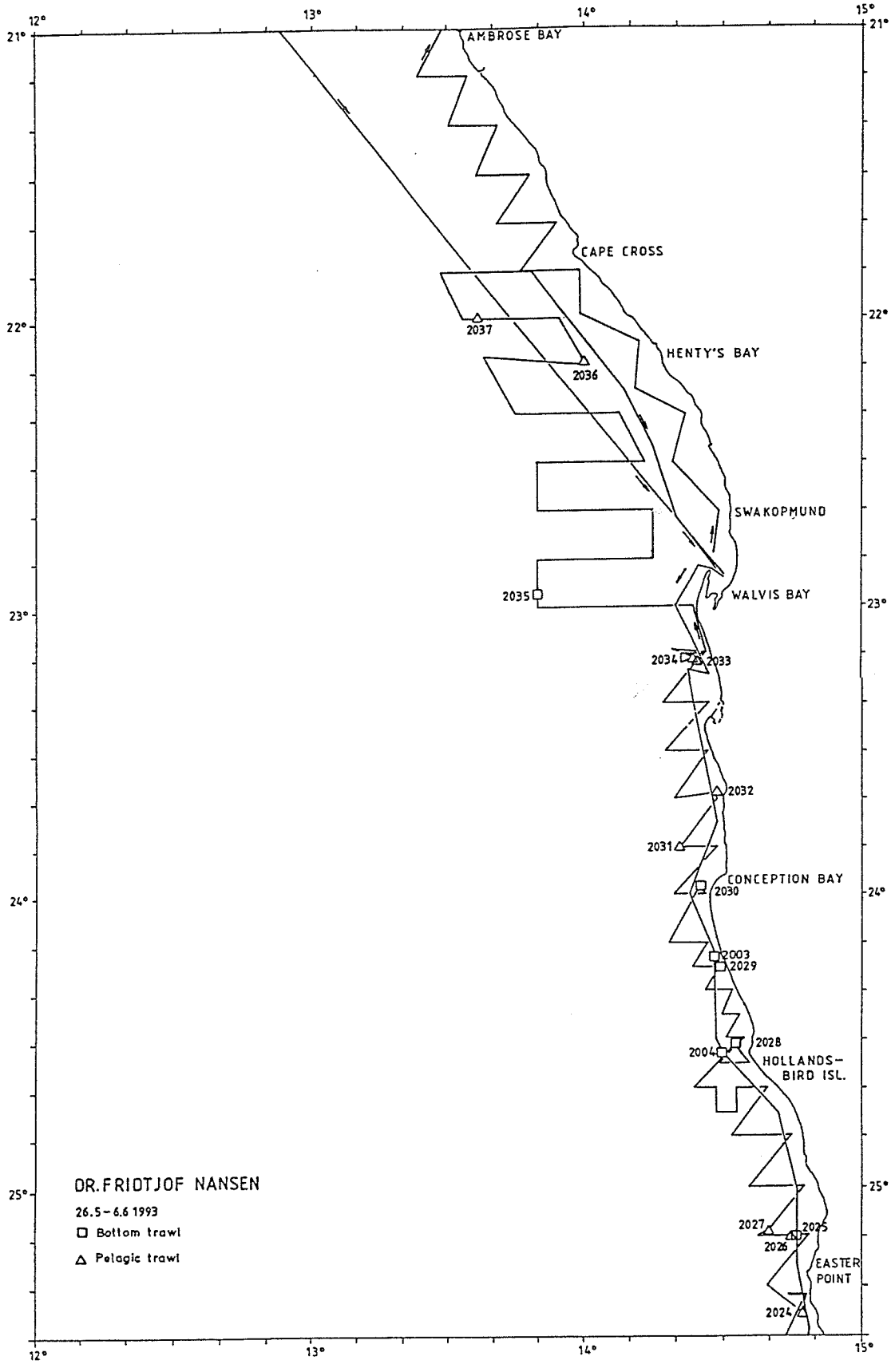

Figure 1b Course track and fishing stations, Dolphin Head to Ambrose Bay.

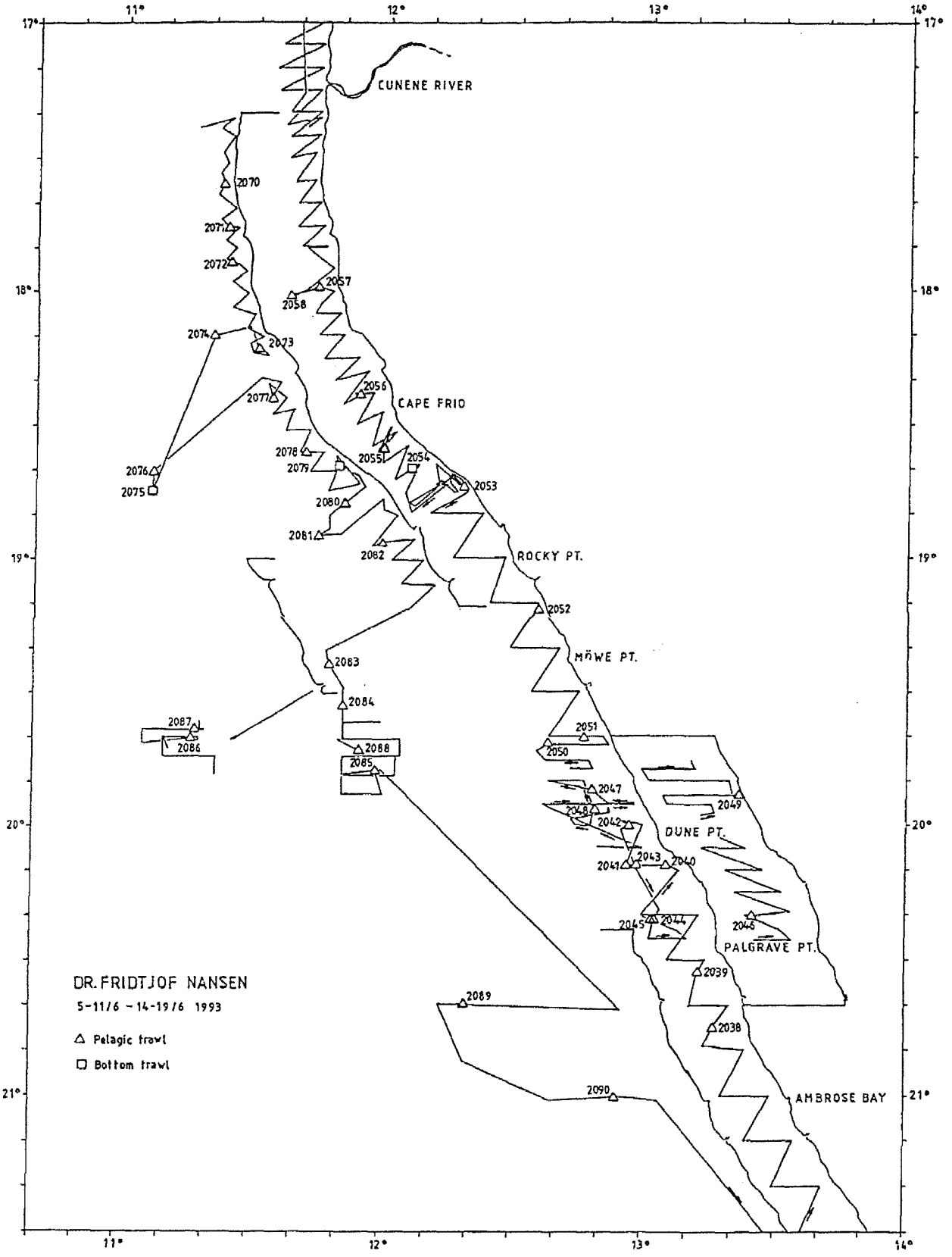

Figure 1c Course track and fishing stations, Ambrose Bay to Cunene River.

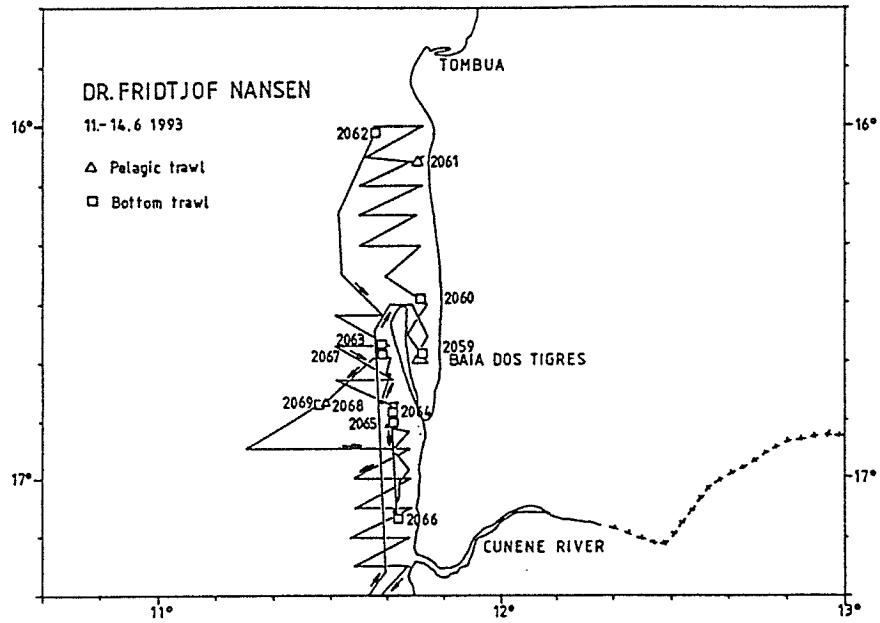

Figure 1d Course track and fishing stations, Cunene River to Tombua.

3 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 used was 0.1 x 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

Pelagic fish type-1: Clupeidae (round herring) and Engraulidae (anchovy).

Pelagic fish type-2: Carangidae (horse mackerel).

Non-commercial pelagic fish and plankton: myctophids, gobies and, primarily, jellyfish.

The allocation of pelagic type-1 fish to species was judged on the basis of the relevant trawl catches.

3.1 DISTRIBUTION

In summary, three main areas of dense pelagic fish concentrations were found. One, in the south between Orange River and Panther Head, consisted of juvenile pilchard and anchovy, while the others, in offshore waters between 19°30'S and 20°30'S and in Angolan waters, both consisting of adult pilchard. Scattered mixed shoals of round herring and anchovy occurred throughout the region from Dolphin Head to the Cunene River including, at least in the north, into deep offshore waters. A number of these shoals were mixed with juvenile pilchard and horse mackerel, with the proportion of juvenile horse mackerel increasing in the offshore waters. Determining the species composition of these mixed shoals from the echo recordings was generally not possible and trawl catches were used for identification. Sampling of fish was generally successful, and few hauls were disrupted by high concentrations of jellyfish, as has been experienced in previous surveys.

The distributions of pilchard are in Figures 2a-d, the anchovy and round herring combined in Figures 2e-h and the of carangids in Figures 2i-j. An arbitrary scale was used in the distribution charts to illustrate different levels of density.

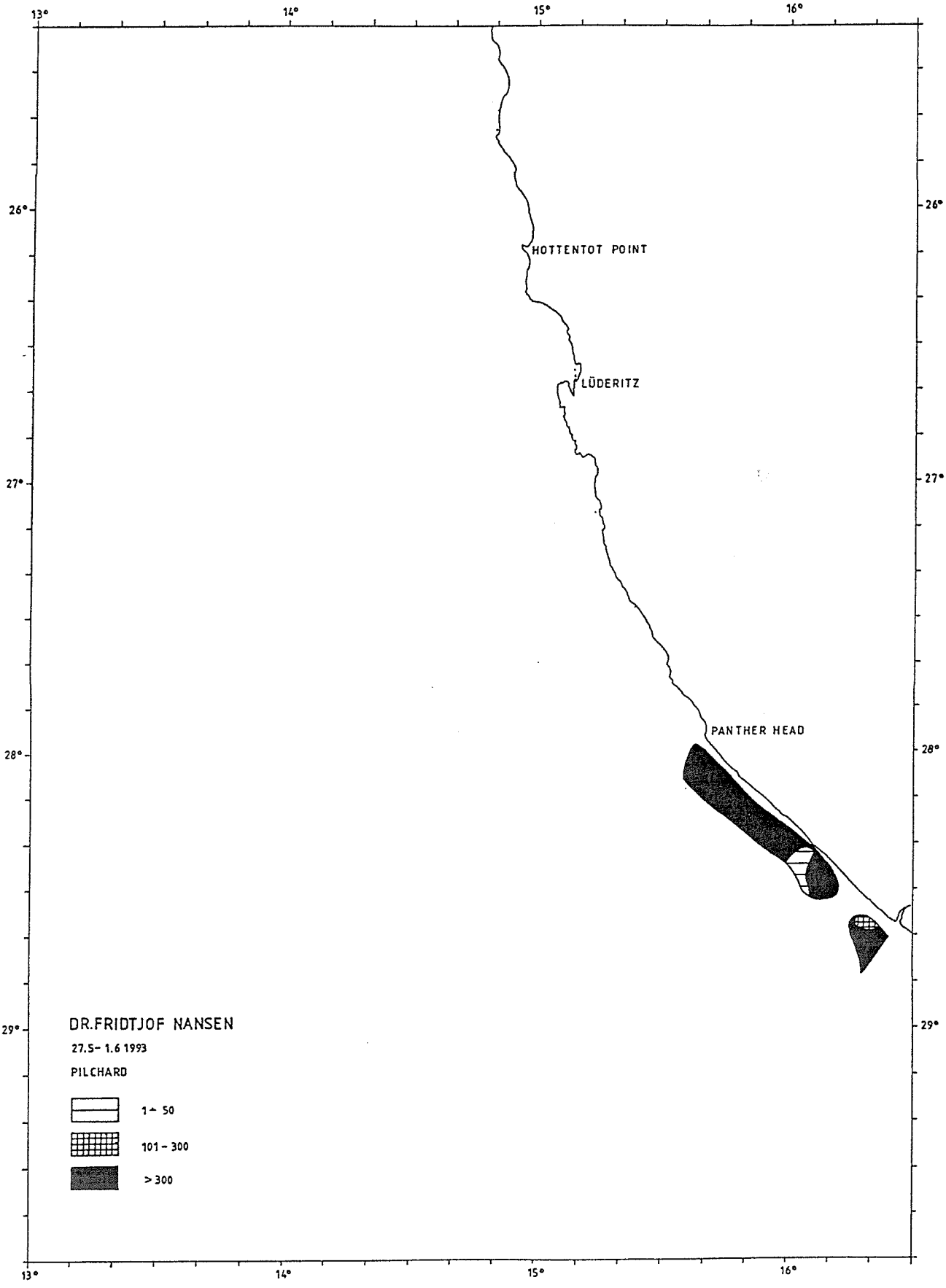

Figure 2a Distribution of pilchard, Orange River to Dolphin Head.

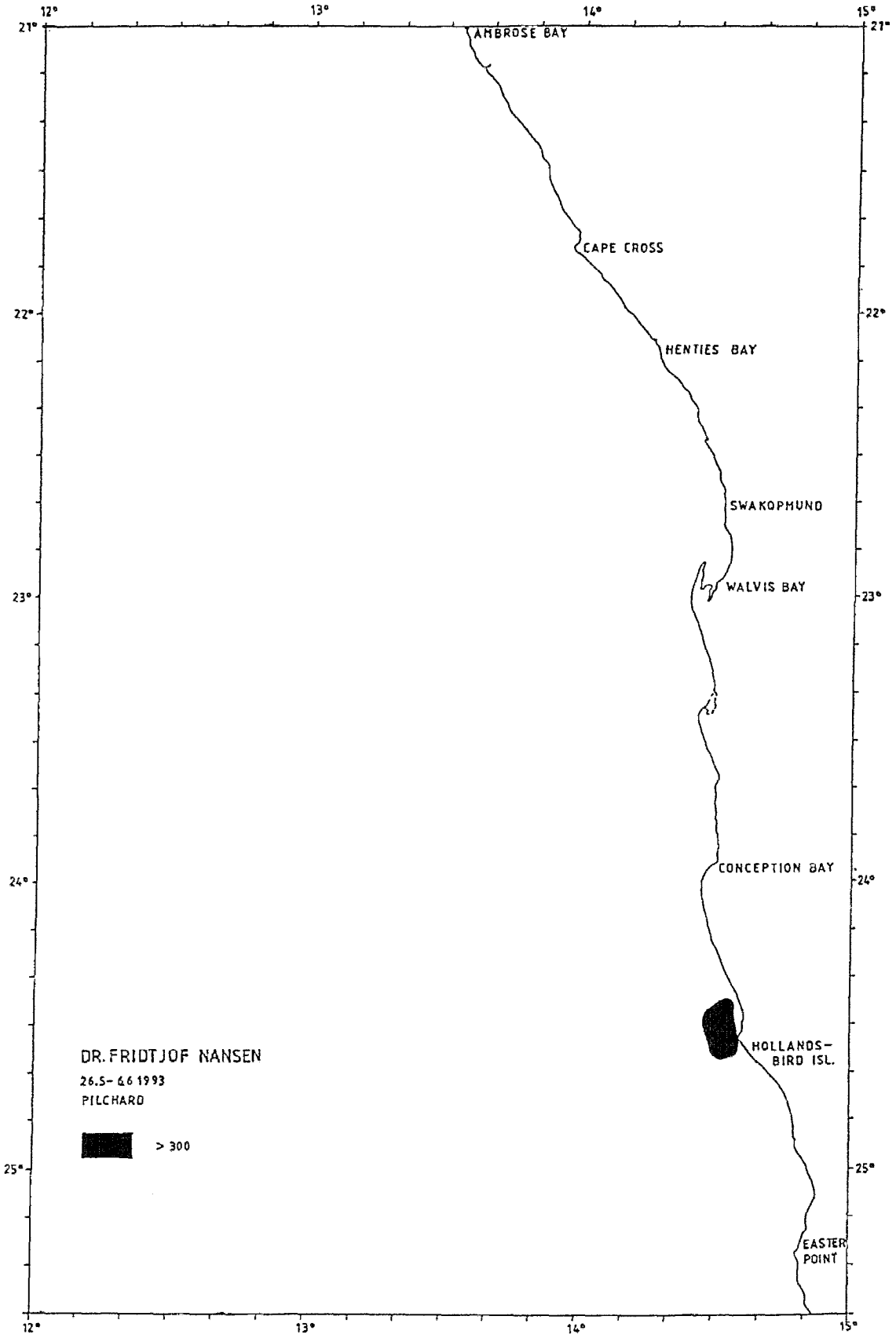

Figure 2b Distribution of pilchard, Easter Point to Ambrose Bay.

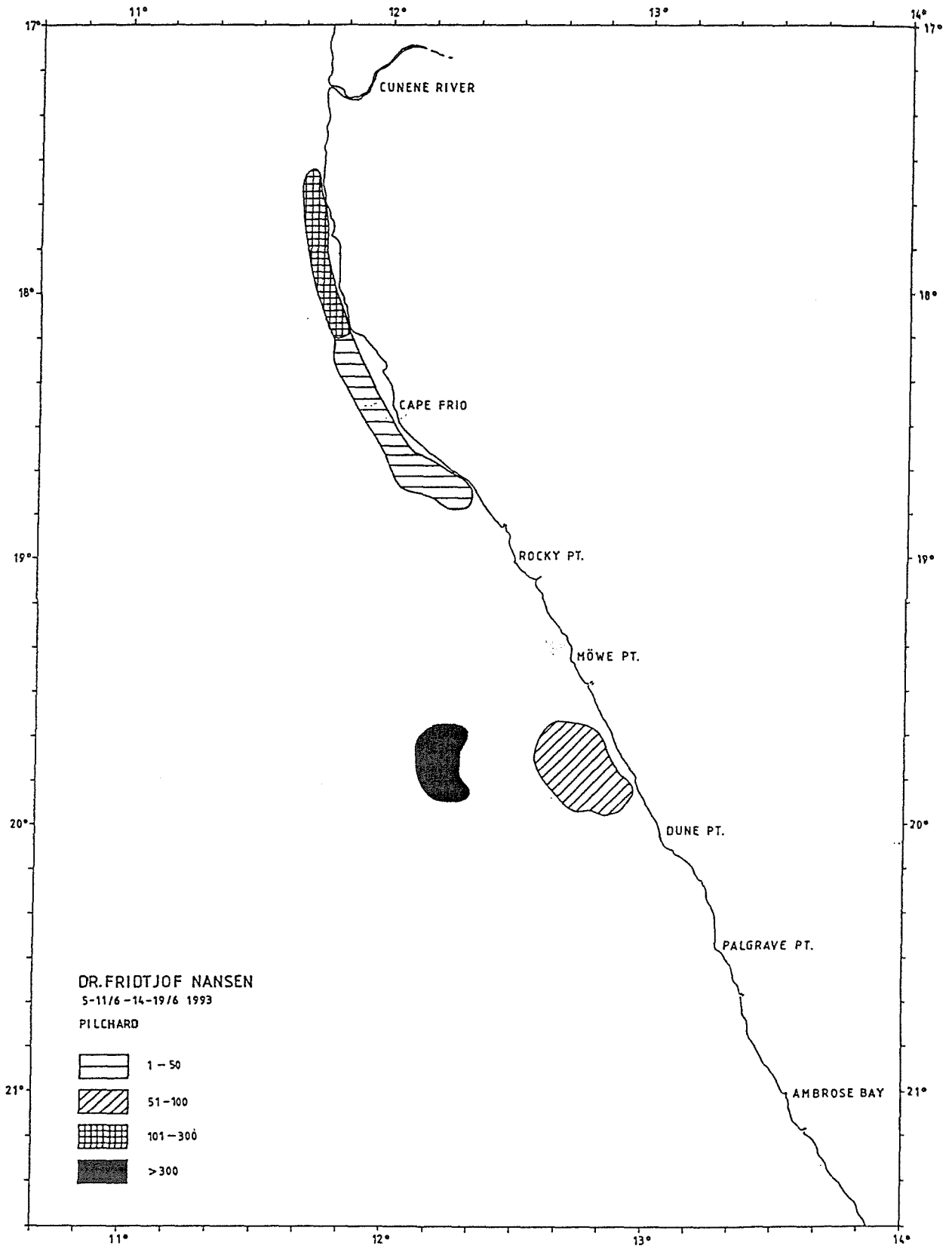

Figure 2c Distribution of pilchard, Ambrose Bay to Cunene River.

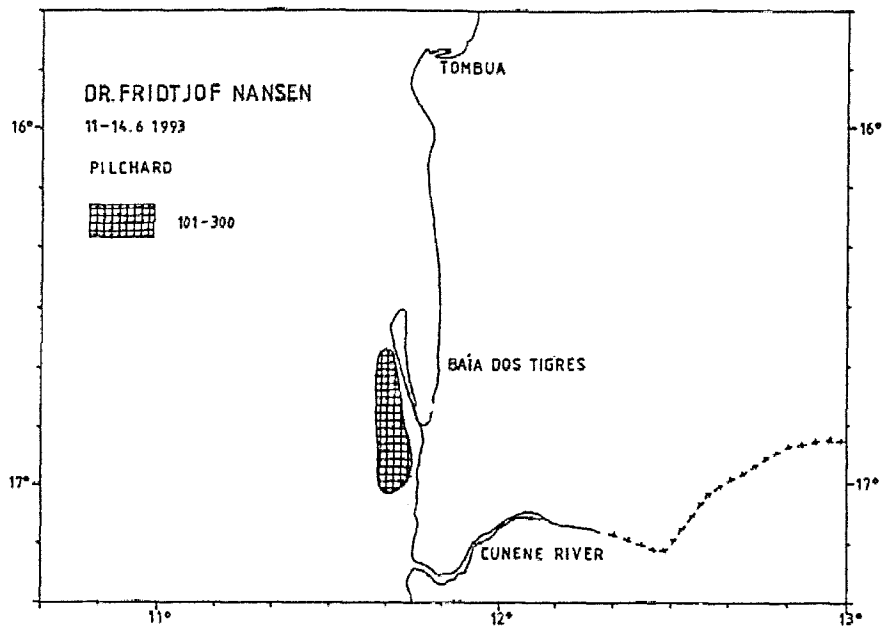

Figure 2d Distribution of pilchard, Cunene River to Tombua.

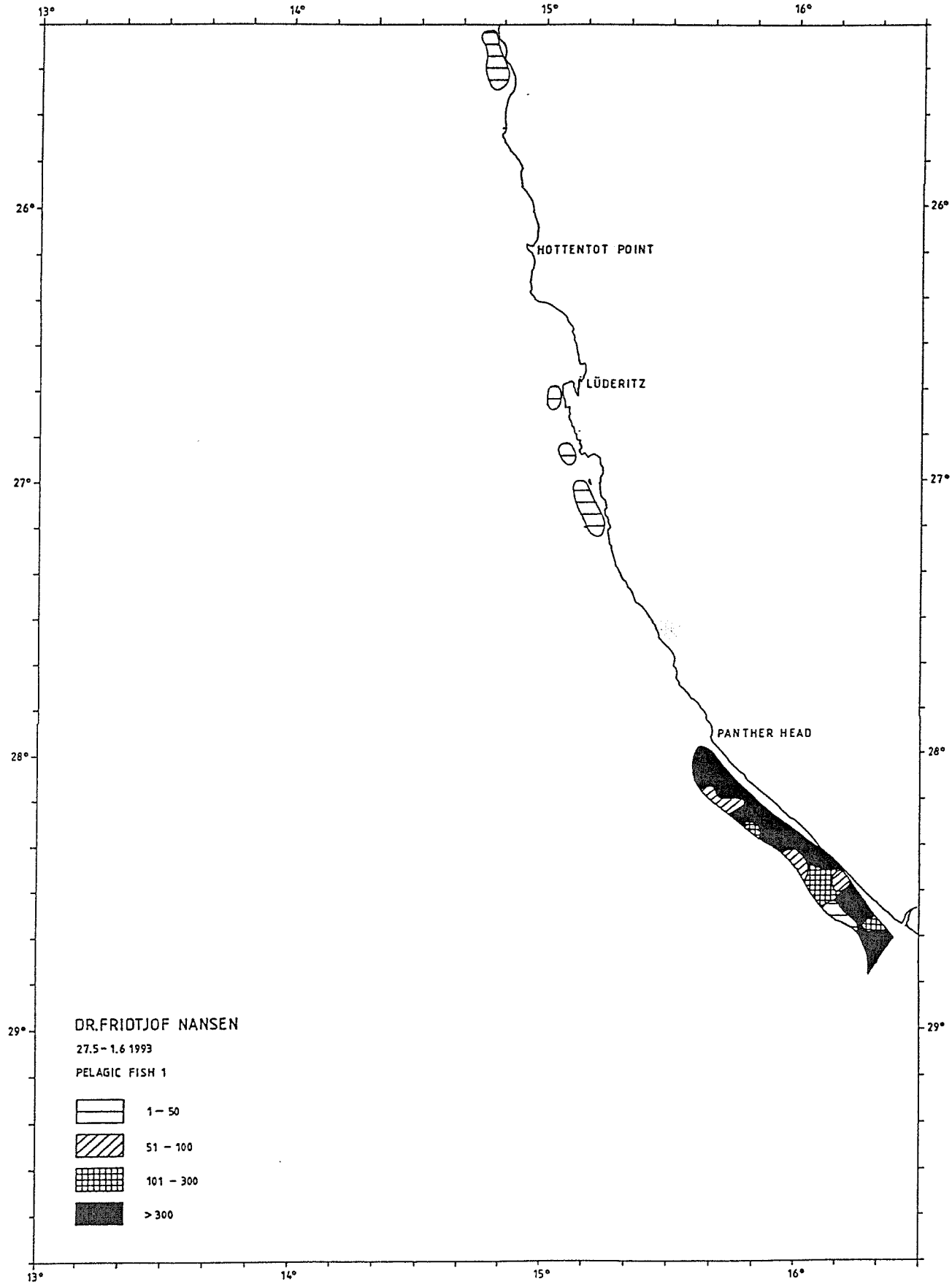

Figure 2e Distribution of pelagic fish type-1: anchovy and round herring, Orange River to Dolphin Head.

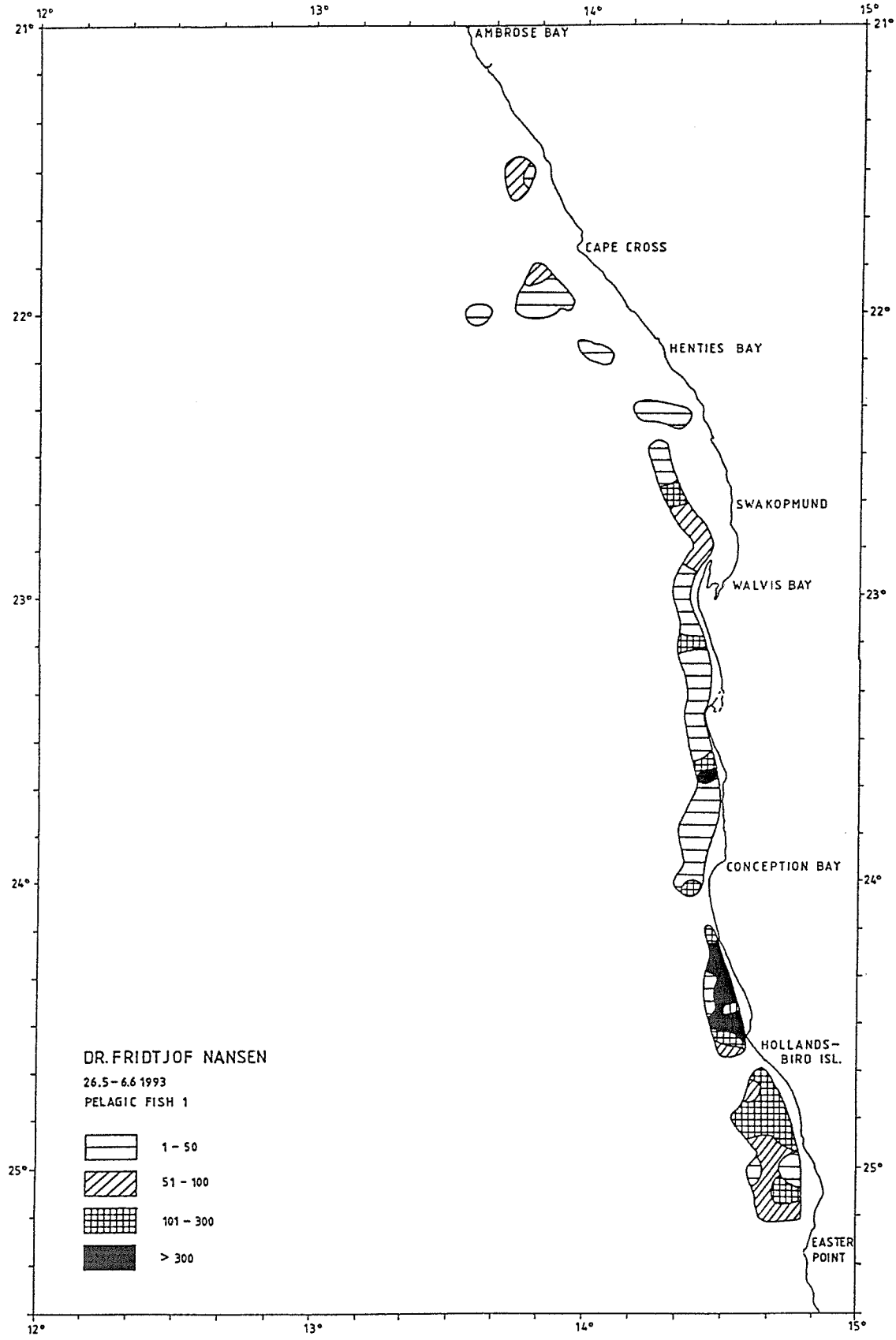

Figure 2f Distribution of pelagic fish type-1: anchovy and round herring, Easter Point to Ambrose Bay.

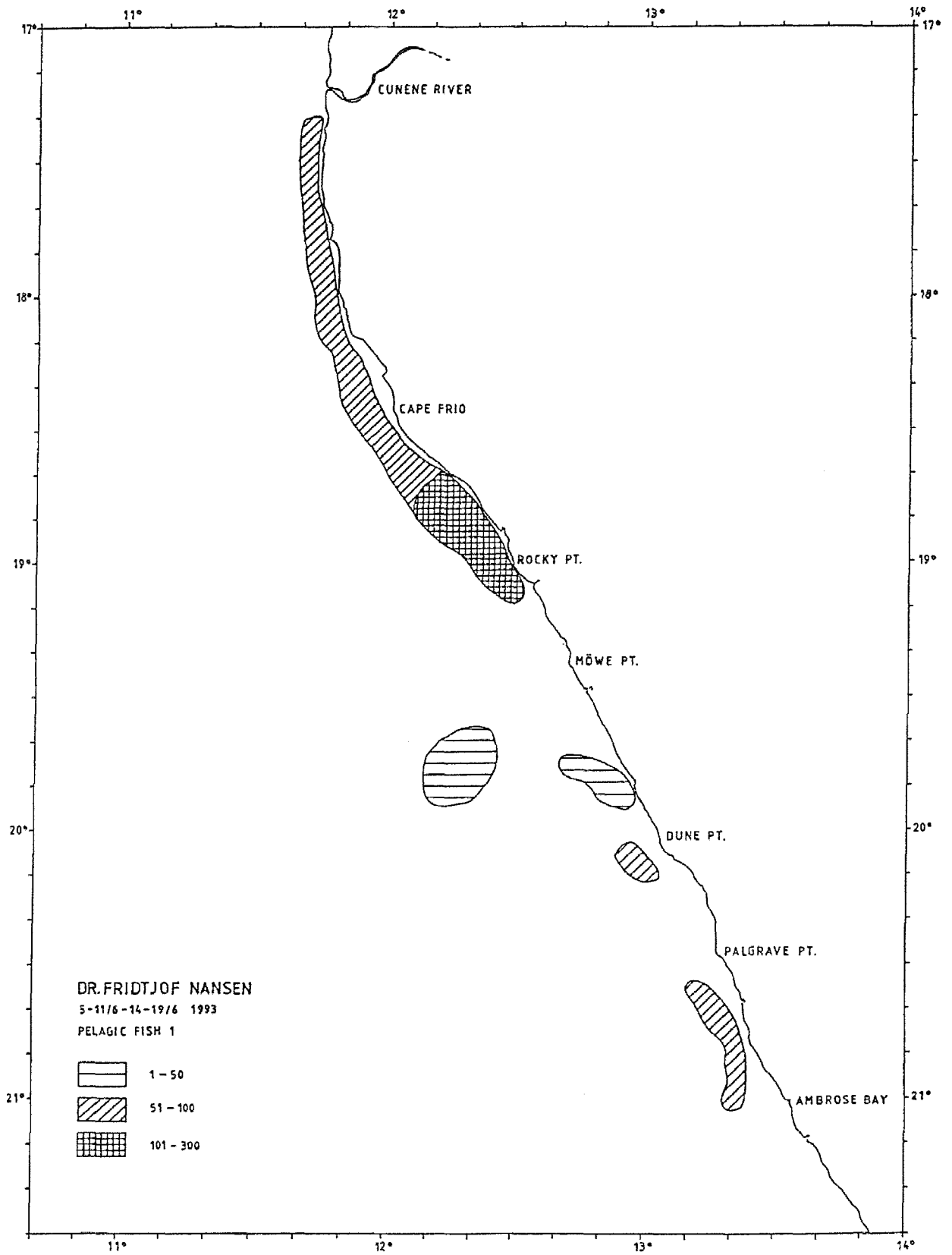

Figure 2g Distribution of pelagic fish type-1: anchovy and round herring, Ambrose Bay to Cunene River.

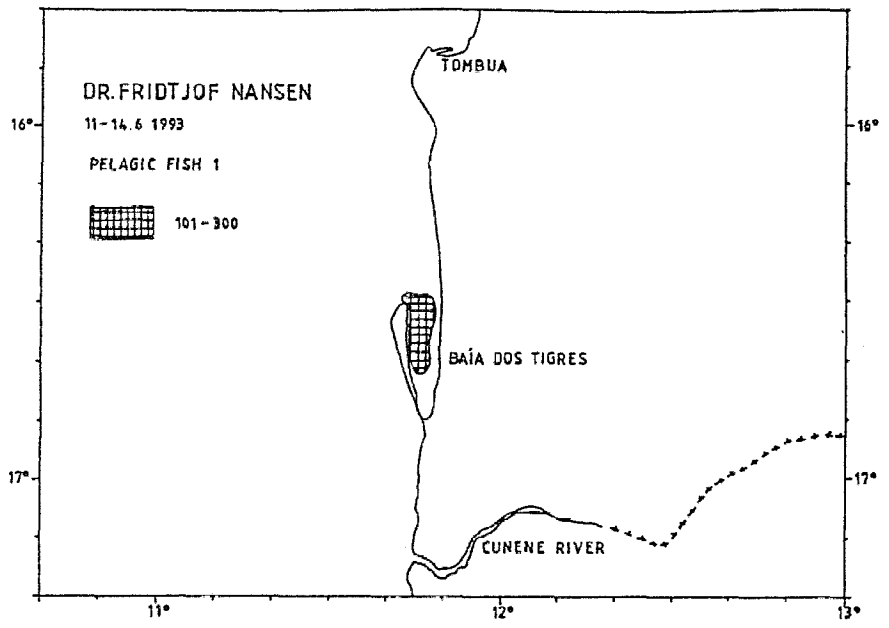

Figure 2h Distribution of pelagic fish type-1: anchovy and round herring, Cunene River to Tombua.

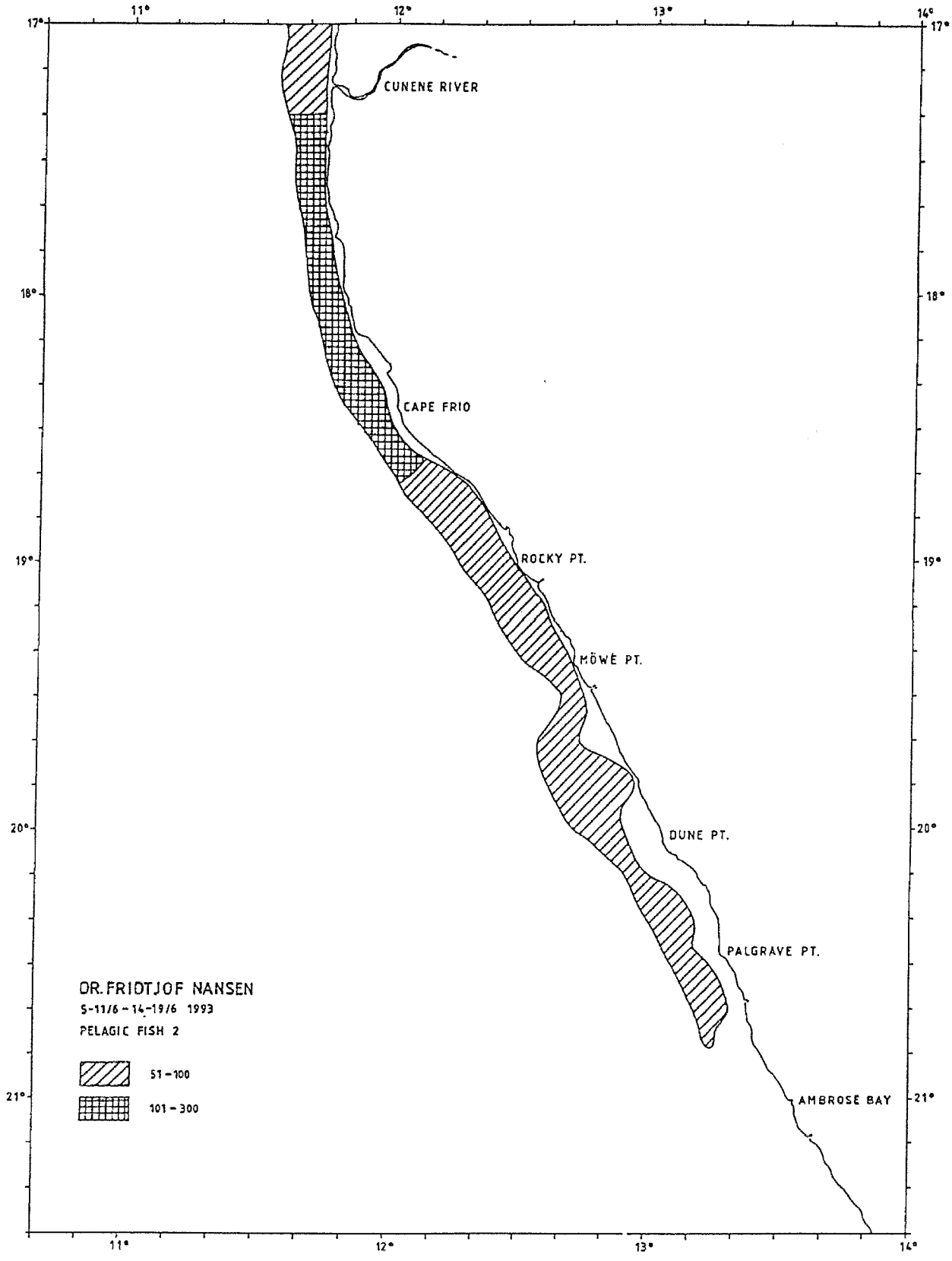

Figure 2i Distribution of horse mackerel, Ambrose Bay to Cunene River.

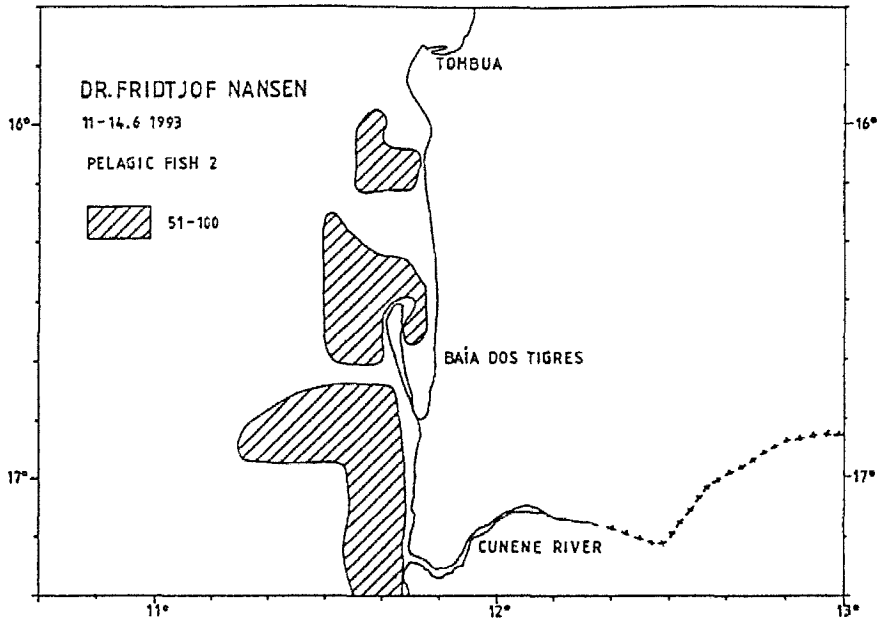

Figure 2j Distribution of horse mackerel, Cunene River to Tombua.

3.1.1 Orange River to Dolphin Head

Shoals of juvenile pilchard and anchovy were recorded from the Orange River to Panther Head, in depths between 30 m and 80 m. The shoals occurred close to the bottom during the day and were occasionally very dense. They moved some few miles out from the coast (see Figure 3) and ascended to the surface layer during night, but appeared to remain within the transducer range at all times. The shoals could be separated to species, although some of the catches were mixed, but these were assumed to consist of more then one shoal. The catches indicated that pilchard shoals were dominant in the depth zone from 50 m to 80 m, while anchovy occurred in shallower water. Some few specimens of round herring were also caught. The modal length of pilchard and anchovy were 11 cm and 8 cm respectively.

No fish was found between Panther Head and Dolphin Head.

3.1.2 Dolphin Head to Ambrose Bay

Dispersed shoals of round herring were recorded between Dolphin Head and Walvis Bay in depths between 20 m and 80 m. North of Hollands Bird Is. (24°30'-24°40'S) a small area of fish consisting of pilchard and anchovy with a modal length of 8 cm to 10 cm were found in shallow waters from 15 m to 25 m. Few pelagic fish of commercial value were found in the area from Walvis Bay to Ambrose Bay. As in previous surveys of this region, most of the reflected echo intensity was allocated to layers of plankton, gobies and lantern fish.

3.1.3 Ambrose Bay to Cunene River

On the northwards coverage one small area of dense shoals of adult pilchard was recorded north of Palgrave Point (20°30'S) at 90 m depth. The shoals were being fished by several purse seiners, which reported that the fish was moving north. Nine days later adult pilchard were found some 50 nm further to the north-west in 190 m to 250 m of water, and it is believed that this was the same fish. Anchovy and round herring were recorded in the inshore waters off Palgrave Point extending out to the area of offshore pilchard.

A small area of dense shoals of anchovy was found in shallow water (20 m - 25 m) 25 nm north of Rocky Point. Small shoals of mixed species (adult anchovy, and juvenile round herring, pilchard and horse mackerel) were recorded between Cape Frio (18°30'S) and the Cunene River in depths between 20 m and 80 m. Some dense shoals of pilchard with a modal length of 20 cm were found near Cape Frio, otherwise the mixed shoals of round herring and anchovy were dominant. The weather during the northward coverage was however not suitable for surveying the Cape Frio to Cunene River region and the area was therefore surveyed several days later on the way south.

Juvenile horse mackerel with a modal length of 9 cm occurred along the coast from north of Ambrose Bay (20°50'S) to the Cunene River (19°00'S) and extending offshore throughout all areas which were surveyed.

3.1.4 Cunene River to Tombua

Dense shoals of pilchard with a modal length of 23 cm were recorded in shallow waters (13 m - 25 m) outside of Baia dos Tigres. The shoals occurred occasionally in the surface layer both during day and night. Some few small shoals of anchovy were found in inshore waters north of Baia dos Tigres and in the outer part of the bay itself. Dispersed shoals of horse mackerel were recorded in most of the surveyed area, both inshore and in deeper waters. North of 16°40'S trawl samples indicated that the horse mackerel were entirely large *Trachurus trecae*, while to the south only juvenile *Trachurus capensis* was found.

3.2 ABUNDANCE OF PELAGIC FISH

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 by applying a condition factor to obtain weight at length. The stock assessment was carried out by the use of the computer program NAN-SIS.

A simplified version of the same formula has been used in previous assessment reports:

$$\text{Biomass} = A \cdot I \cdot 0.167 \cdot L/17$$

applying a condition factor of 0.78, normalised to a 17 cm fish,

where
- A = Area (nm^2)
- I = Integrator value
- L = Length of fish

This formula has been used in the RV 'Dr. Fridtjof Nansen surveys since December 1991, whereas the formula used before December 1991 assumed a fish condition factor = 1.0 and therefore gave approximately 25% higher biomass estimates.

The biomass estimates for the clupeids, anchovy and juvenile horse mackerel are shown in Table 1.

Table 1 Species composition and biomass estimates (in tonnes) of pelagic fish

Area	Pilchard	Anchovy	Round herring	Juvenile horse mackerel
Tombua-Cunene River	98 000	6 000	-	86 000
Cunene River-Ambrose Bay	253 000	50 000	26 000	278 000
Ambrose Bay-Dolphin Head	10 000	7 000	65 000	-
Dolphin Head-Orange River	197 000	84 000	-	-
Total Ludertiz to Cunene River	263 000	57 000	91 000	278 000
Total Luderitz to Angola	361 000	63 000	91 000	364 000
Total Orange R. to Angola	558 000	147 000	91 000	364 000

3.2.1 Pilchard, anchovy and round herring

As in previous surveys a vertical migration of type-1 pelagic fish was noted to occur at night, but judging from the echo traces most of the fish seemed to be distributed within the transducer range, especially during the first two weeks of the cruise when the moon was in 2nd and 3rd quarter. Several areas were surveyed more than once, both during night-time and during the day, and for one of these areas both the night-time and day-time data are given for comparison (Figure 3). The observations show that the surveys during night gave much lower biomass estimates even under moonlit conditions. As in previous reports, the day-time data have therefore as far as possible been used for assessment purposes.

The dense concentration of pilchard and anchovy north of the Orange River was surveyed several times, and based on the day values, almost 300 000 tonnes was estimated to occur in the area. A total of 40 000 tonnes of round herring was found between Eastern Point and Holland Bird Is. and another 23 000 tonnes north of Conception Bay, while 19 000 tonnes of mixed shoals occurred between Holland Bird and Conception Bay.

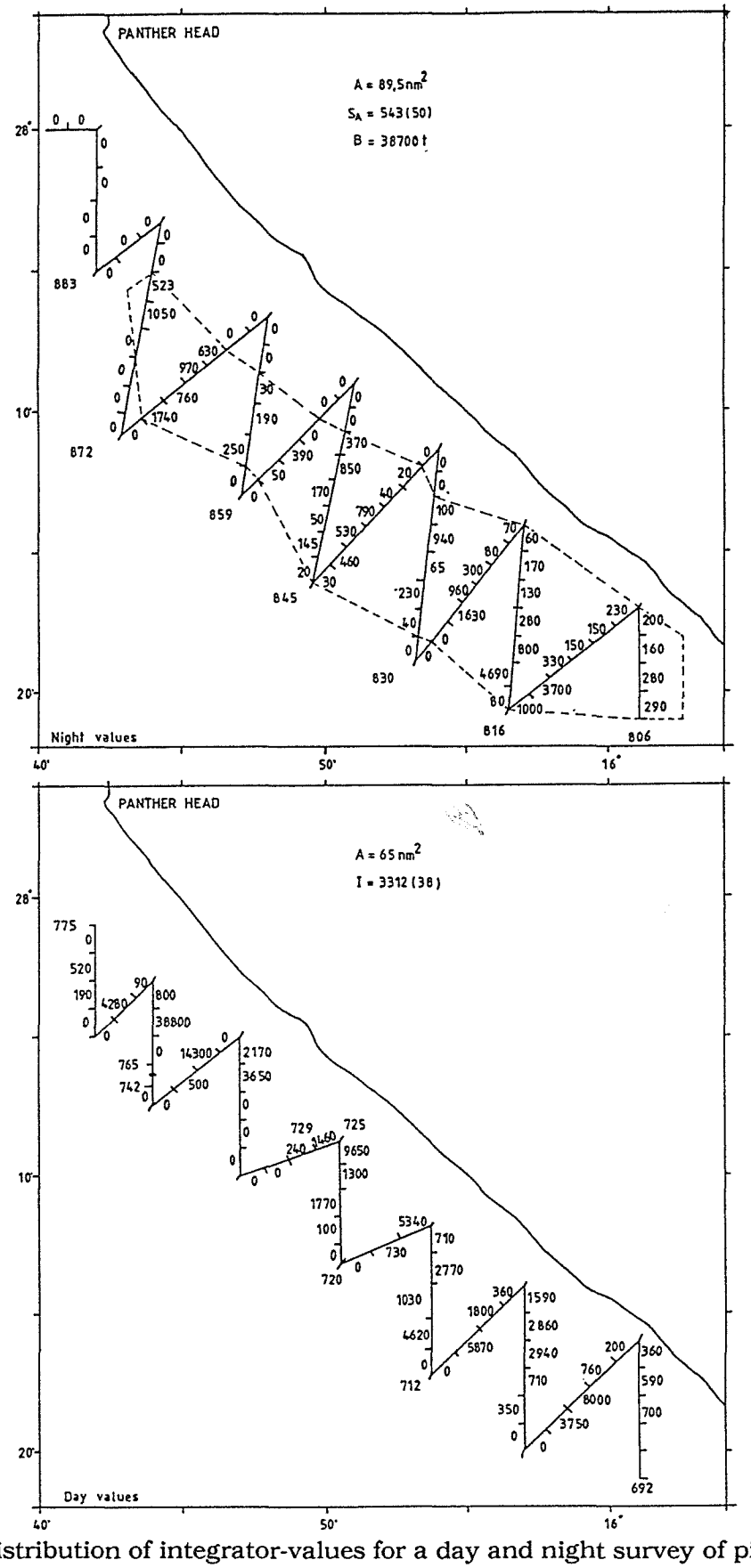

Figure 3 Distribution of integrator-values for a day and night survey of pilchard and anchovy at Panther Head.

The dense shoals of pilchard recorded offshore of Palgrave Point was originally assessed at between 250 000 tonnes and 300 000 tonnes. This value was based largely on one very dense large shoal. The region was surveyed more intensively some nine days later and an estimated 156 000 tonnes was derived. Owing to the density of the grid the western side of the distribution was still being surveyed when the fish shoals ascended to the surface and dispersed at sunset. While the second estimate is certainly more accurate than the first, it is a minimum as the entire area of distribution was not covered. The biomass of this concentration is assumed to be in the order of 200 000 tonnes. Over 6 000 tonnes of round herring was estimated to occur as dispersed shoals between the dense pilchard shoals. The extent of this distribution was not determined and therefore this estimate may also be an underestimate.

The dispersed, but mixed, concentrations of anchovy and round herring between Ambrose Bay and the Cunene River gave a total biomass of about 75 000 tonnes. From the trawl records 50 000 tonnes was assumed to be anchovy and the remainder round herring.

3.2.2 Pelagic horse mackerel

The widely dispersed pelagic horse mackerel between Ambrose Bay and the Cunene River was estimated at 250 000 tonnes, while between the Cunene River and 16°40' another 86 000 tonnes was found. North of 16°40'S 63 000 tonnes of *Trachurus trecae* was recorded.

4 CONCLUDING REMARKS

The pilchard abundance for the northern Benguela system, that is the Namibian region north of Lüderitz and southern Angola, is below 500 000 tonnes, and possibly less than 400 000 tonnes. Sampled fish have yet to be aged, but the length-frequency distribution indicates that most of the adult pilchard found during this survey were one and two-year olds. This confirms the trends documented during the previous three surveys; that the cohorts spawned between 1988 and 1990 have largely been lost. The remaining cohort, spawned in the summer of 1991/92 accounts for most of the present stock.

Large amounts of juvenile pilchard and, to a lesser extent, anchovy were found south of Lüderitz. As these fish are south of the upwelling cell which forms the environmental barrier between the southern and northern Benguela systems, these fish should be considered part of the southern Benguela system, despite being in Namibian waters. The origin of this fish

is uncertain, but as this is an important concentration it should be tracked until it enters either the South African or Namibian fishable stock.

The anchovy and round herring biomasses are similar to previous surveys, although extensive dispersed layers were found in deep offshore waters. These waters were not surveyed and therefore the reported estimate may be an underestimate.

Juvenile horse mackerel occurred extensively throughout the region north of Ambrose Bay, both in the areas surveyed and out into deeper waters. The estimate presented is also a minimum.

Almost 100 000 tonnes of pilchard were recorded outside Baia dos Tigres, as they were shoaling almost entirely in waters less than 20 m deep this concentration was almost overlooked. This highlights the difficulty of surveying this species and the importance of using purse seiners to determine the distribution of the fish.

Further underestimates probably resulted from the behaviour of the pelagic fish of migrating to surface waters at night. Low night time values indicated that much of the fish were rising above transducer level. While most of the biomass estimates were made using day values, large areas were searched during darkness and it is possible that some concentrations of fish which were dispersed at the surface may have been missed.

As noted most of the estimates were made during day coverages. Pilchard tend to shoal very densely in day-light which is far from ideal for acoustic surveys. Such distributions are often difficult to find, while obtaining a representative acoustic sample is also problematic.

The offshore region is normally surveyed during the mid-water horse mackerel and hake surveys, and no pelagic fish have been previously been reported outside of about 150 m. Dense pilchard shoals and dispersed anchovy, round herring and juvenile horse mackerel were found during this survey as far offshore as 250 m water depth. It is possible that all the major concentrations of pilchard were found, although generally the accompanying purse seiners only searched out to the 200 m bathymetric line and any other concentrations of fish would have been missed. It is not possible for two vessels to search the entire area to beyond 200 m bathymetric depth in the time available, especially when the fish occur in few very dense, but widely scattered shoals.

In recent months much of the older part of the pilchard stock has been lost, while most of a strong young hake cohort has also disappeared. Fewer mid-water horse mackerel were recorded during the survey by the RV 'Benguela', while during the same survey large areas of very low oxygen water were recorded north of Cape Frio. In addition large amounts of pilchard, anchovy, round herring and juvenile horse mackerel have been recorded in waters far beyond their normal distribution. These phenomena indicate a large-scale environmental perturbation which requires immediate investigation.