# CHAPTER 1 INTRODUCTION

## 1.1 GENERAL OBJECTIVES

Following an offer from NORAD extended through FAO and UNDP, an agreement was reached in Windhoek in January 1990 between the UNDP Resident Representative and Namibian authorities for the execution of a programme of surveys of the fish resources of the Namibian shelf waters during 1990 with the R/V "DR. FRIDTJOF NANSEN".

The purpose of the programme was agreed as follows:

The main objectives are descriptions of the distribution, composition and abundance of the most important resources of fish. The small pelagic fish species, horse mackerel, pilchard and anchovy, will be investigated by the acoustic integration method combined with sampling by mid-water and bottom trawls. A swept area trawl survey programme will be used for the demersal stocks. All catches will be sampled to species by weight and numbers and biological sampling will be made of the commercially important stocks. Possible taxonomic problems will be studied by sampling and examination by experts in cooperation with FAO's Fisheries Department.

Environmental studies will include recording of surface temperature on a continuous basis and a description of the water profile with a series of hydrographic stations as well as studies of bottom type by grab samples and the ROXANN bottom discrimination system.

## 1.2 SPECIFIC OBJECTIVES OF SECOND SURVEY

1. To produce a biomass estimate for the three commercially important pelagic fish species; pilchard *Sardinops ocellata*, anchovy *Engraulis capensis* and horse mackerel *Trachurus capensis*.

2. To obtain environmental data to enable correlations between fish distribution and the environment.

3. To provide training for Namibian scientific and technical staff.

## 1.3 PARTICIPATION

The scientific staff from Namibia on the "DR. FRIDTJOF NANSEN" from May 27th to June 4th were:

Bruce Tomalin, Dierdricht Bessinger, Helen Boyer, Willem Nauseb, Malakia Shimhanda and Marianna Tomalin.

From 4th to June 20th :
David Boyer, Bernatitus Birisameb, David Gaweseb, Sielfried Gowaseb and Riaan Naude.

The scientific staff from the Institute of Marine Research were:
Johannes Hamre, Oddgeir Alvheim, Terje Haugland and Erling Molvaer.

## CHAPTER 2 METHODS

From the general knowledge of pelagic fish distribution and from reports of commercial fishing vessels, the survey area was limited to the area from Dolphin Head (26°00'S) to the Cunene River (17°15'S) and from the shore to the 400 m bathymetric 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. To allow comparison with the previous "DR. FRIDTJOF NANSEN" survey, the region was divided into two areas;

1 26°00' to 21°00'S Dolphin Head to Ambrose Bay

2 21°00' to 17°00'S Ambrose Bay to Cunene River

The "DR. FRIDTJOF NANSEN" left Walvis Bay at 1800 hrs on May 27th and surveyed the area south of Walvis Bay returning to Walvis to exchange Namibian scientific staff at 0900 hrs on June 4th . She departed at 1800 hrs on the same day, surveyed the northern region and returned on June 20th at 0800 hrs. Five thousand nautical miles were steamed and 97 trawl stations worked. Nine hydrographic profiles were made.

Three purse seiners assisted with mapping the distributions of pelagic fish and carried out non-quantitative surveys of shallow waters. These were "HODDEVIK" ( May 30th to June), "ATLANTIC LEADER" (June 4-9) and "EMERALD ISLE" (June 9-12). The Namibian scientific staff on these vessels were Serubabel Kahiha, Quinton Hammond and Malakia Shimhanda

The course track with the fishing and hydrographical stations from Dolphin Head (26°00'S) to Ambrose Bay (21°00'S) are shown in Figure 1a. The northward and southward coverage from Ambrose Bay to Cunene River (17°15'S) are shown in Figures 1b and 1c respectively. As suggested in the previous cruise report, sampling intensity was increased in areas of high fish density, and special sampling efforts were made during darkness in the shallow inshore areas, when fish tend to move offshore and thus become more available for abundance estimates.

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

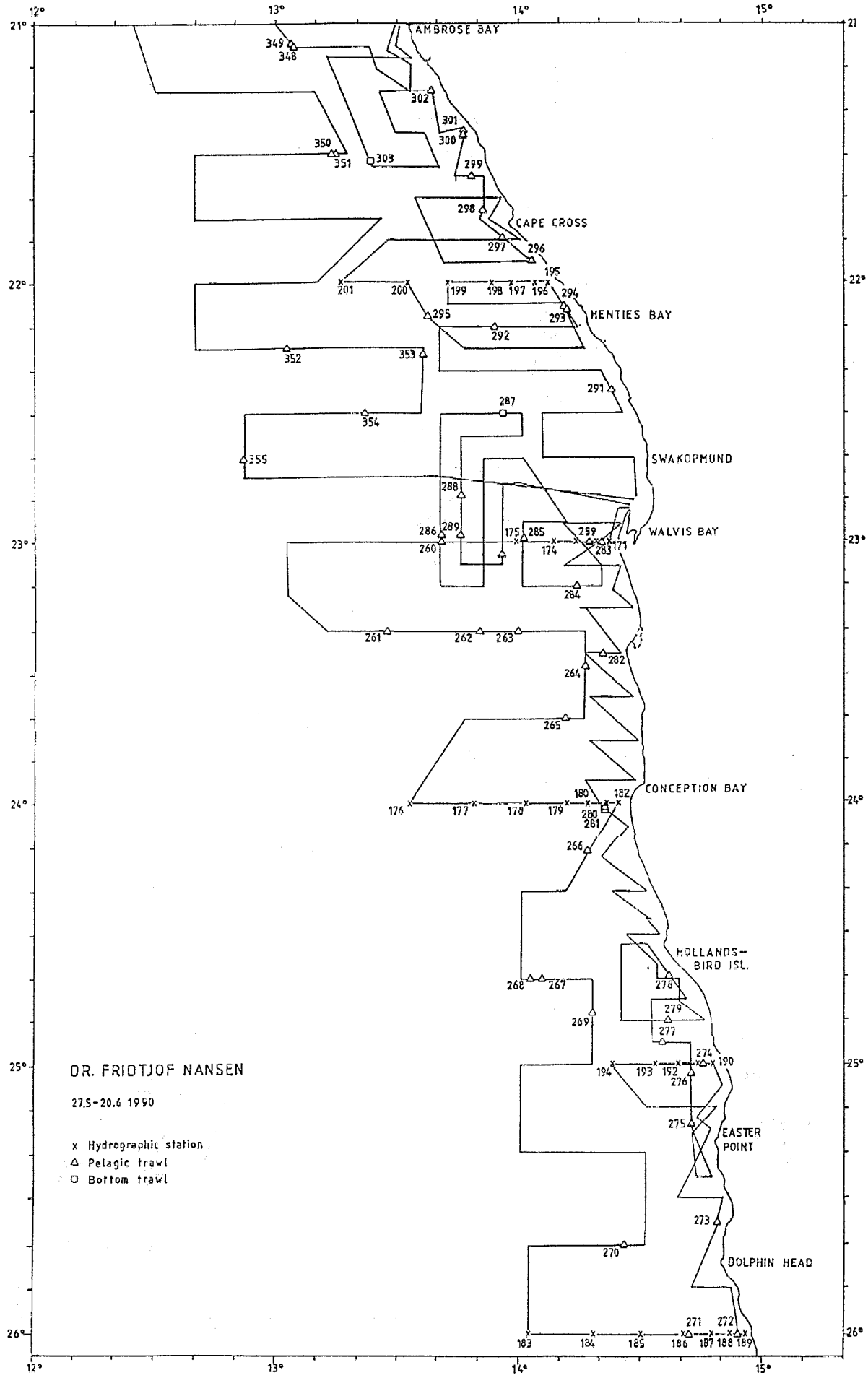


Figure1. Course track, fishing stations and hydrographic profiles,
a: Dolphin Head to Ambrose Bay

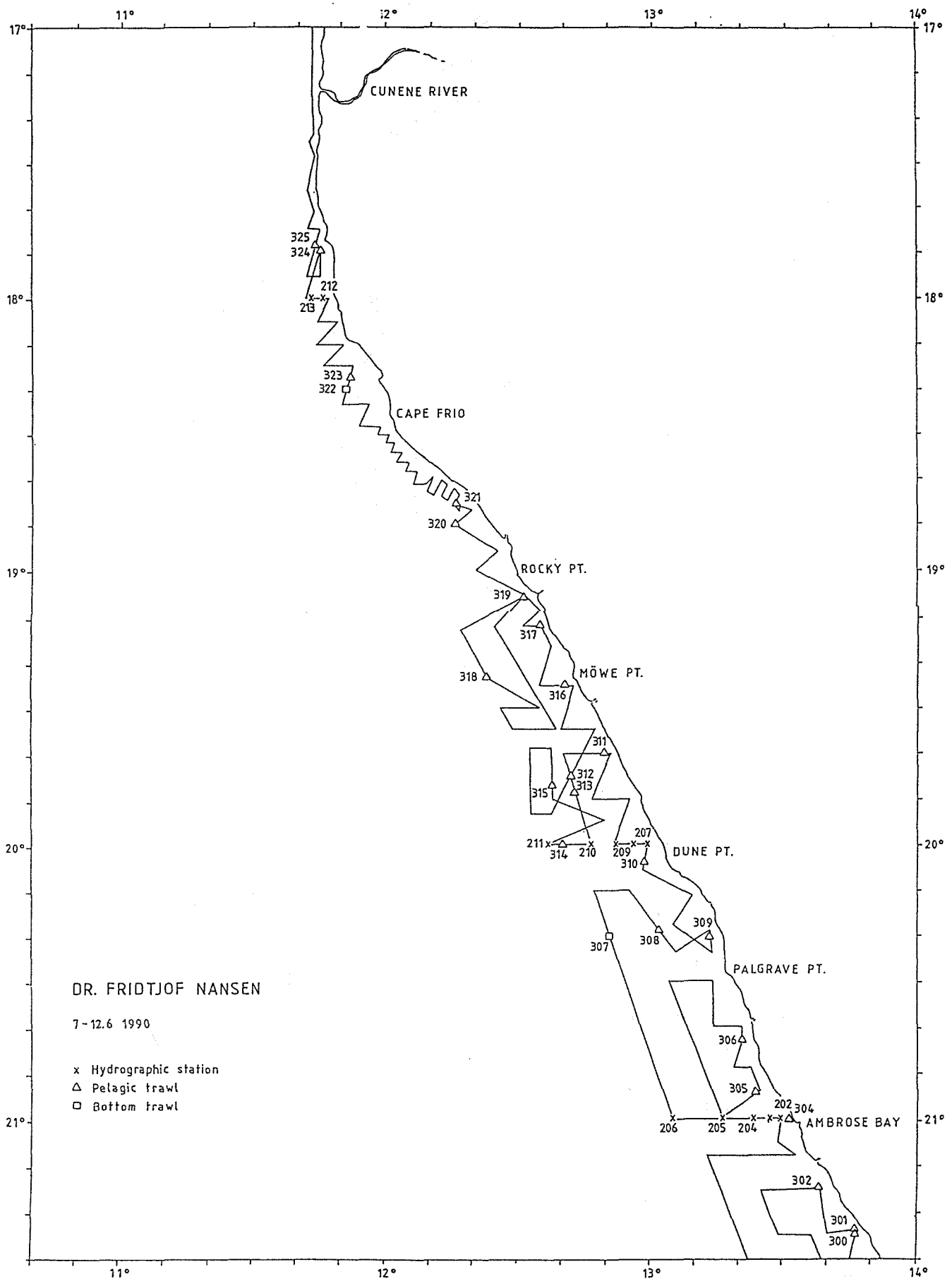


Figure 1b: Ambrose Bay to Cunene River (northwards coverage).

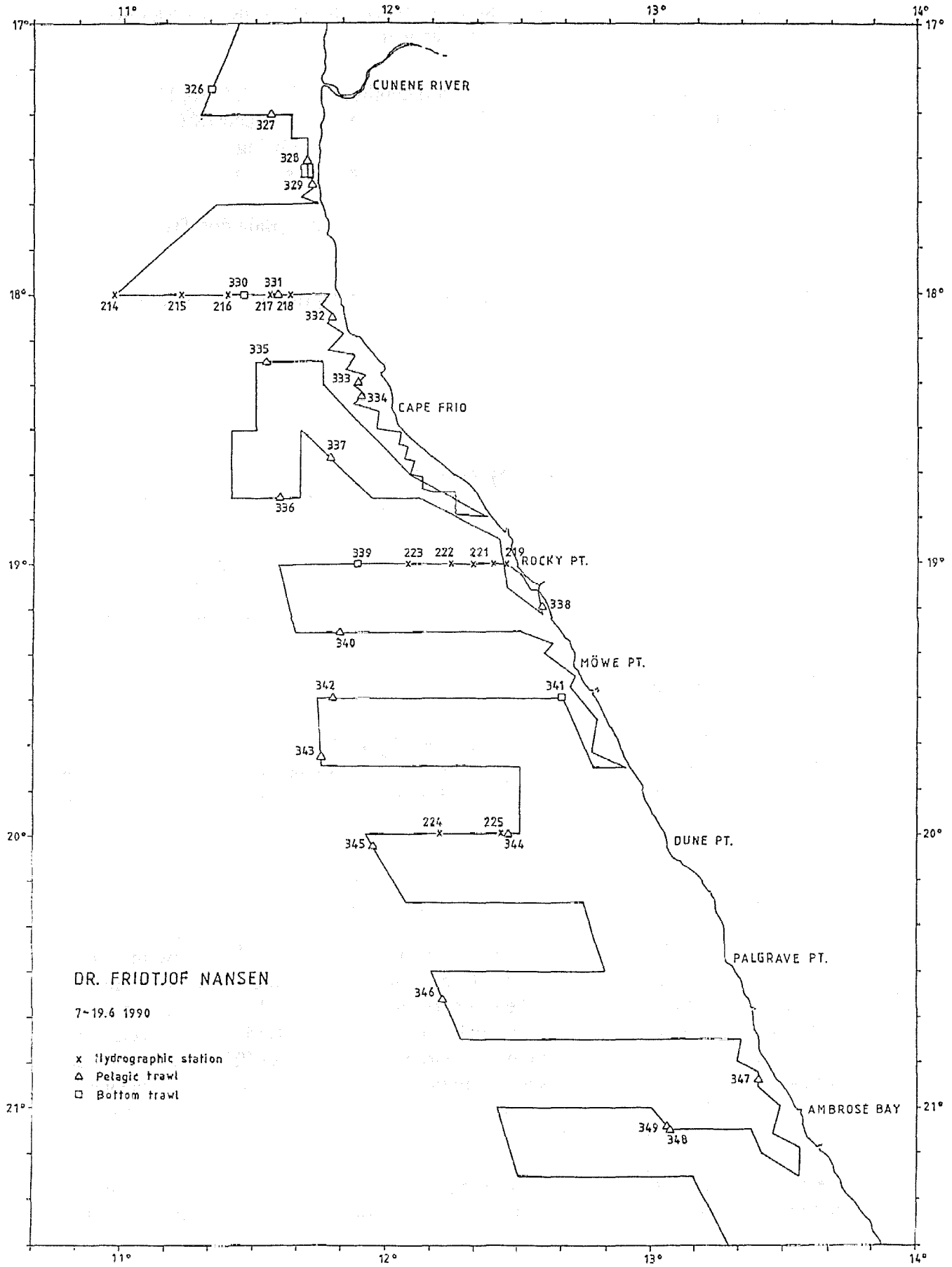


Figure 1c: Ambrose Bay to Cunene River (southwards coverage).

determined. The length frequencies of these species are given in ANNEX I. The complete records of fishing stations are shown in ANNEX II.

Hydrographical data were collected to standard depths at stations 2, 5, 10, 15 and 25 nm from the coast on all full degree lines of latitude between 26°00'S and 18°00'S. On even degree lines further stations were sampled at 35 and 50 nm. Owing to the failure of the thermograph, a continuous record of sea surface temperatures was not obtained.

The acoustic instruments were calibrated in an experiment in Baia dos Tigres, Angola on June12th .

ANNEX III gives a description of the instruments and the fishing gear used, including the results of the calibration experiment.

# CHAPTER 3 THE ENVIRONMENT

## 3.1 BATHYMETRY

A brief description of the bathymetry of the Namibian continental shelf is given in the first "DR. FRIDTJOF NANSEN" cruise report.

## 3.2 HYDROGRAPHY

Figures 2a and 2b show the temperature, salinity and oxygen profiles of the nine hydrographic transects worked. The position of the transects are shown in Figures 1a and 1b. The period of hydrographic observations cover almost a month and the data are therefore not synoptic.

The hydrography of the Namibian near-shore region of the continental shelf during this cruise was characterised by its uniformity along the entire coastline.

The sections between Dolphin Head (26°S) and Walvis Bay (23°S) show moderate upwelling from a depth of about 200 m. Temperatures were low close to the shoreline, about 13°C, while further offshore they rose to only 15 or 16°C. The water column was moderately layered, but no strong thermocline occurred. Dissolved oxygen levels were low inshore and near the ocean bed, but rose to 6 ml/l and more offshore. Low oxygen waters were apparently being transported up from 200 m, thus the entire shelf had water with a dissolved oxygen content of below 1 ml/l. Near the surface, water with an oxygen content of more than 5 ml/l extended down to a depth of 50 m.

The section at 22°S showed little indication of upwelling, surface temperatures being relatively high at 16 to 17°C, while at a depth of almost 200 m the temperature was still above 12°C.

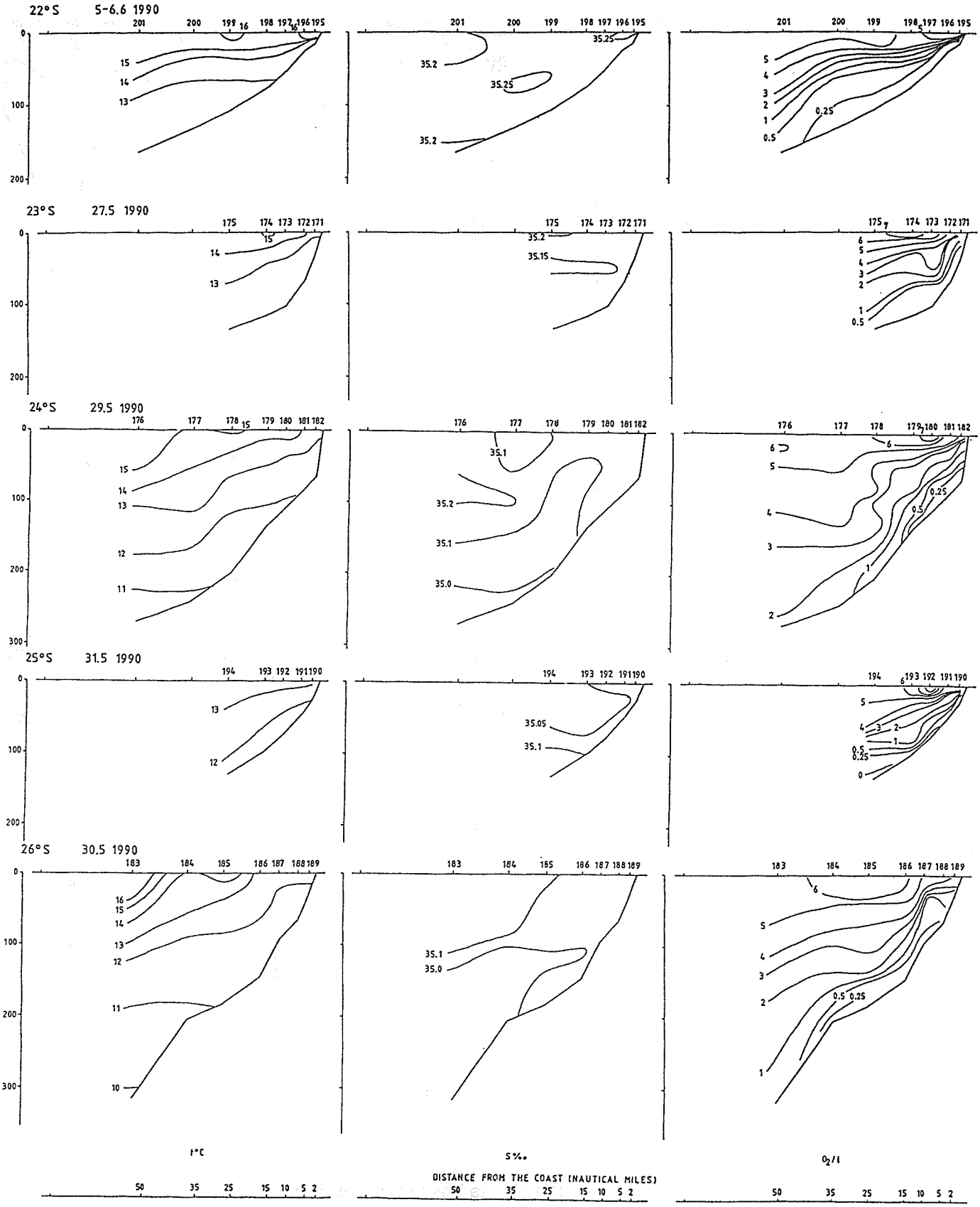


Figure 2. Hydrographic profiles. a: Dolphin Head to Henties Bay.

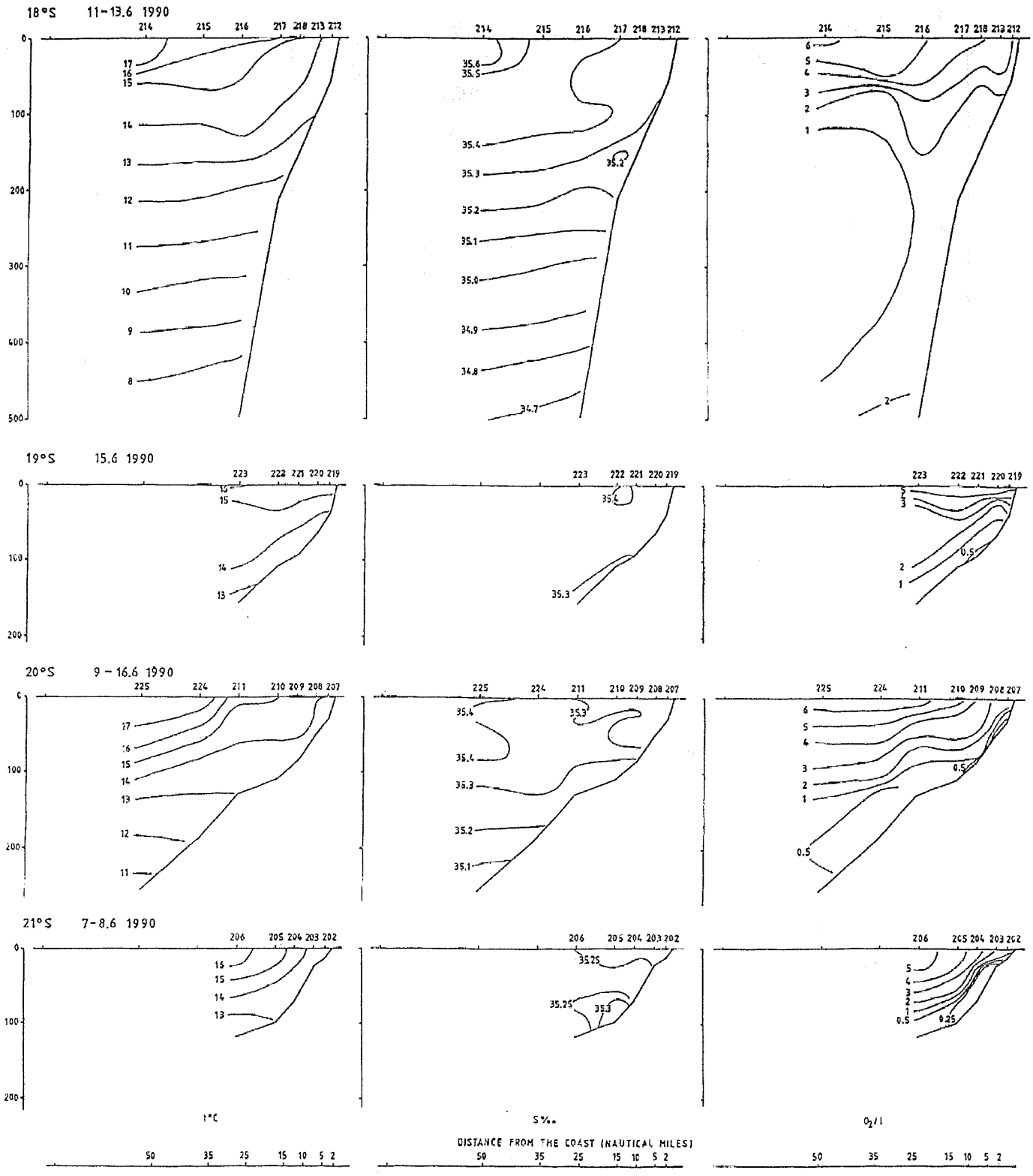


Figure 2b: Ambrose Bay to Cunene River.

The sections from 21°S to 18°S showed slight upwelling with temperatures and oxygen values being very similar to the southern sections.

Salinity levels were, in general, higher in the north rising from 35.0% in the southern sections to 35.6% at 18°. Within each section the salinity level was virtually homogeneous throughout the water column.

A comparison with the hydrography of the same area taken during the previous cruise, in the summer period, shows that upwelling is now weaker. Surface temperatures are considerably lower, although temperatures below the 100 m isoline are similar. Thus the thermocline is much less at present. Upwelling is usually stronger during the winter period as a result of strong and continuous south-westerly winds. The Namibian coastal region had strong easterly winds prior to, and during, the survey. Hence a reduction in upwelling may have occurred.

# CHAPTER 4 DISTRIBUTION AND ABUNDANCE OF PELAGIC FISH

## 4.1 DISTRIBUTION

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

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

Pelagic fish type 2: Carangidae (horse mackerel).

Non-commercial pelagic fish: myctophids and gobies.

Apart from a moderate swell causing some acoustical interference while surveying pilchard stocks near Cape Frio, the weather was favourable to hydroacoustical surveying. In general the pelagic fish were fairly dispersed, with the exception of some extremely dense shoals of pilchard. There was also some evidence of horse mackerel shoals rising to above the transducer level during night-time. According to observations made by purse seiners, concentrations of fish in waters of less than 15 m deep moved to deeper waters during night-time, thus allowing an acoustical survey to be completed. Sampling of fish was generally successful except for some hauls in the south which were disrupted by high concentrations of jellyfish, while some hauls on pilchard shoals made in daylight resulted in few specimens being caught.

The distribution of clupeids and engraulids are shown in Figure 3, and the distribution of carangids and non-commercial fish species are shown in Figures 4 and 5 respectively. An additional map of pilchard distribution is also given in Figures 6a and 6b. An arbitrary scale was used in the distribution charts to illustrate different levels of concentration.

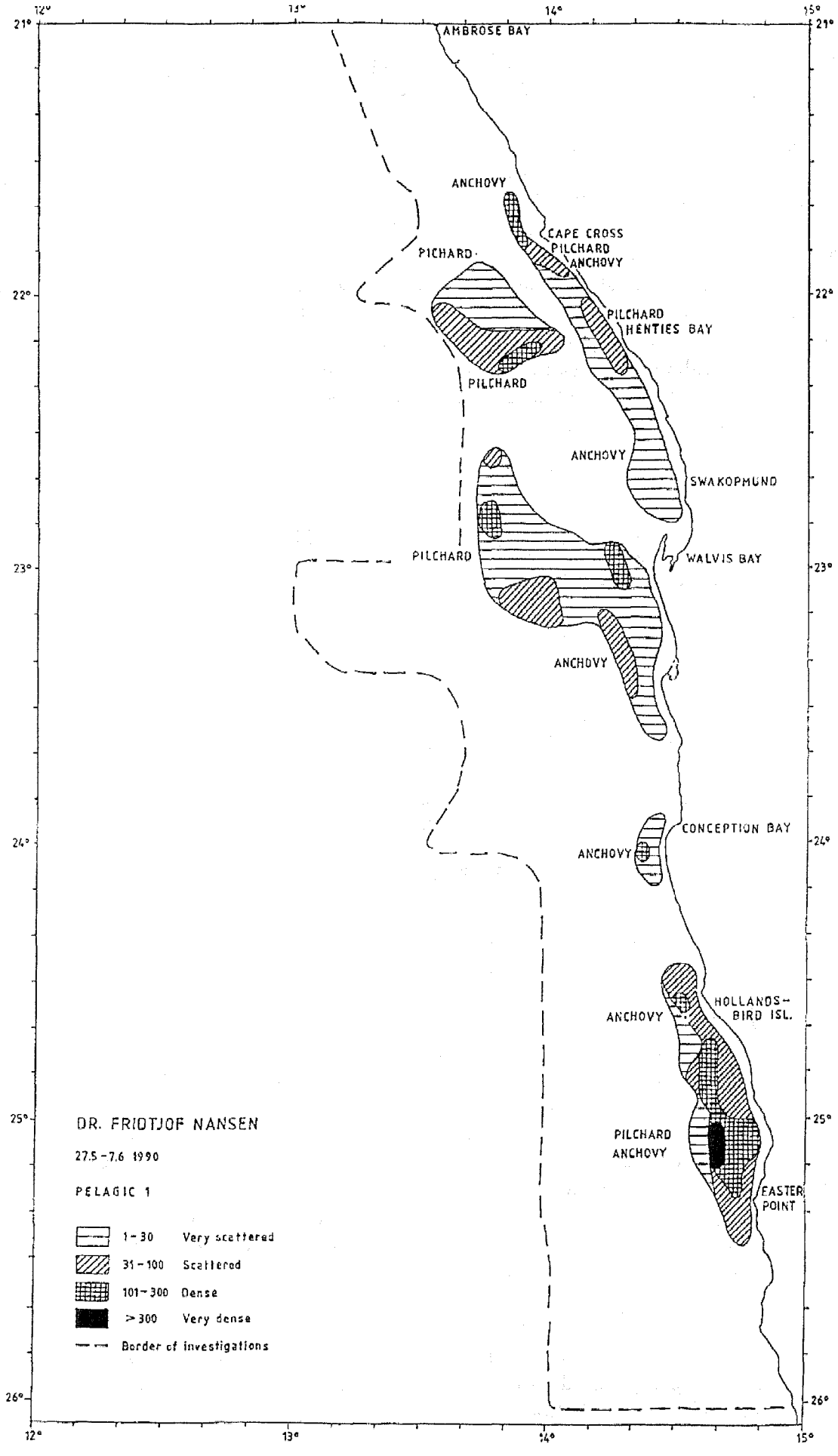


Figure 3. Distribution of pelagic fish type 1, clupeids and anchovy.
a: Dolphin Head to Ambrose Bay.

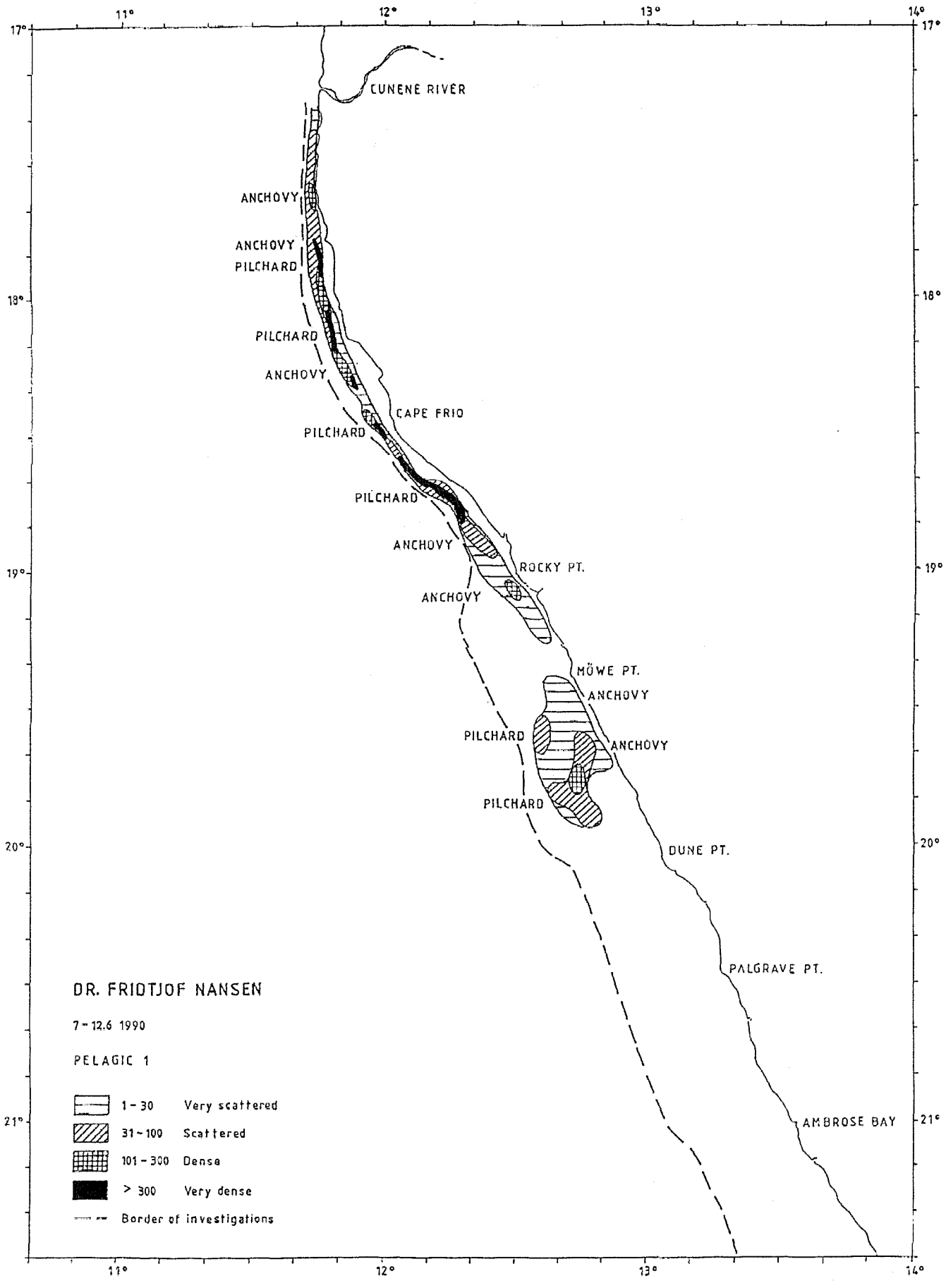


Figure 3b: Ambrose Bay to Cunene River.

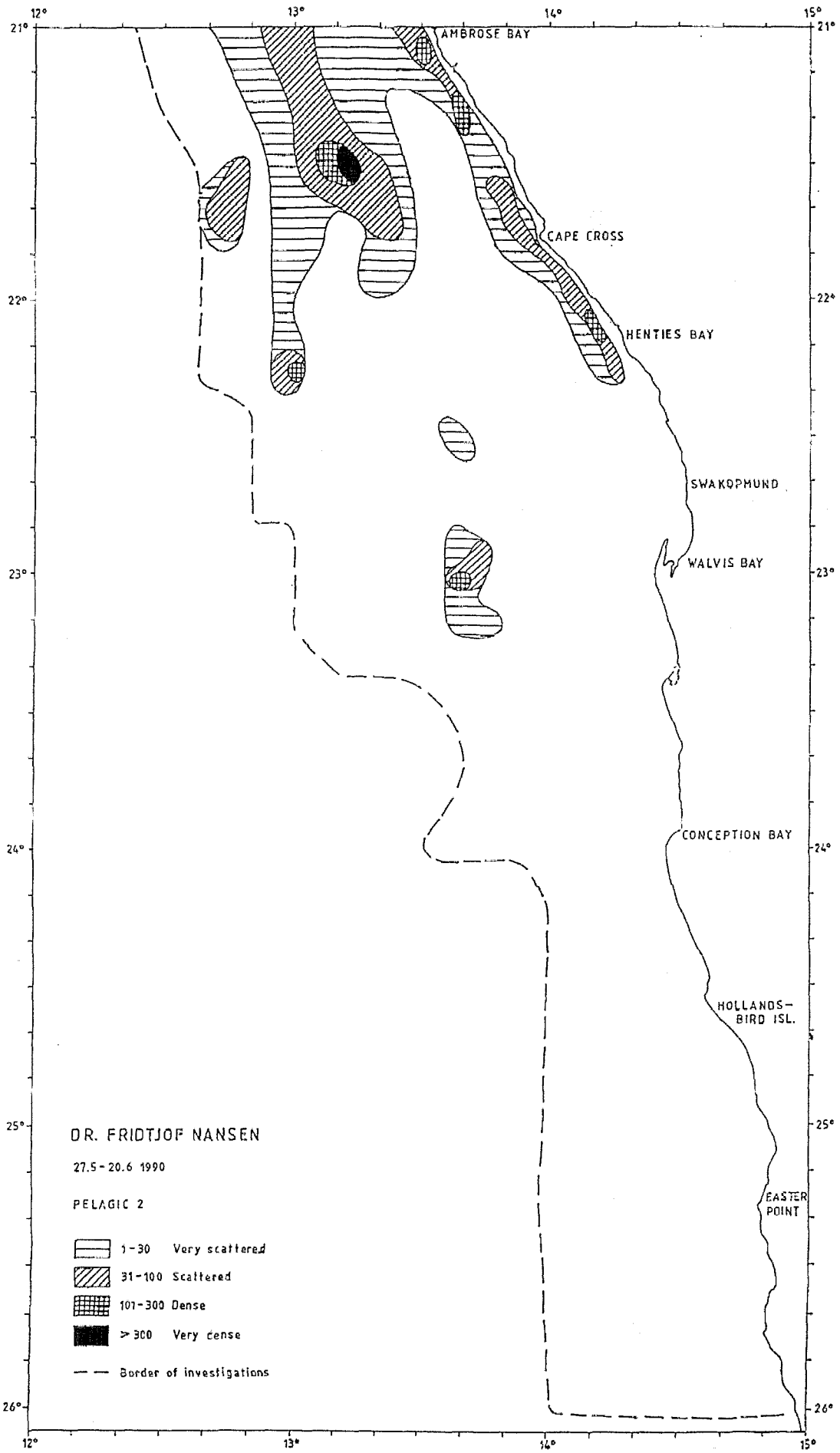


Figure 4. Distribution of pelagic fish type 2, horse mackerel.
a: Dolphin Head to Ambrose Bay

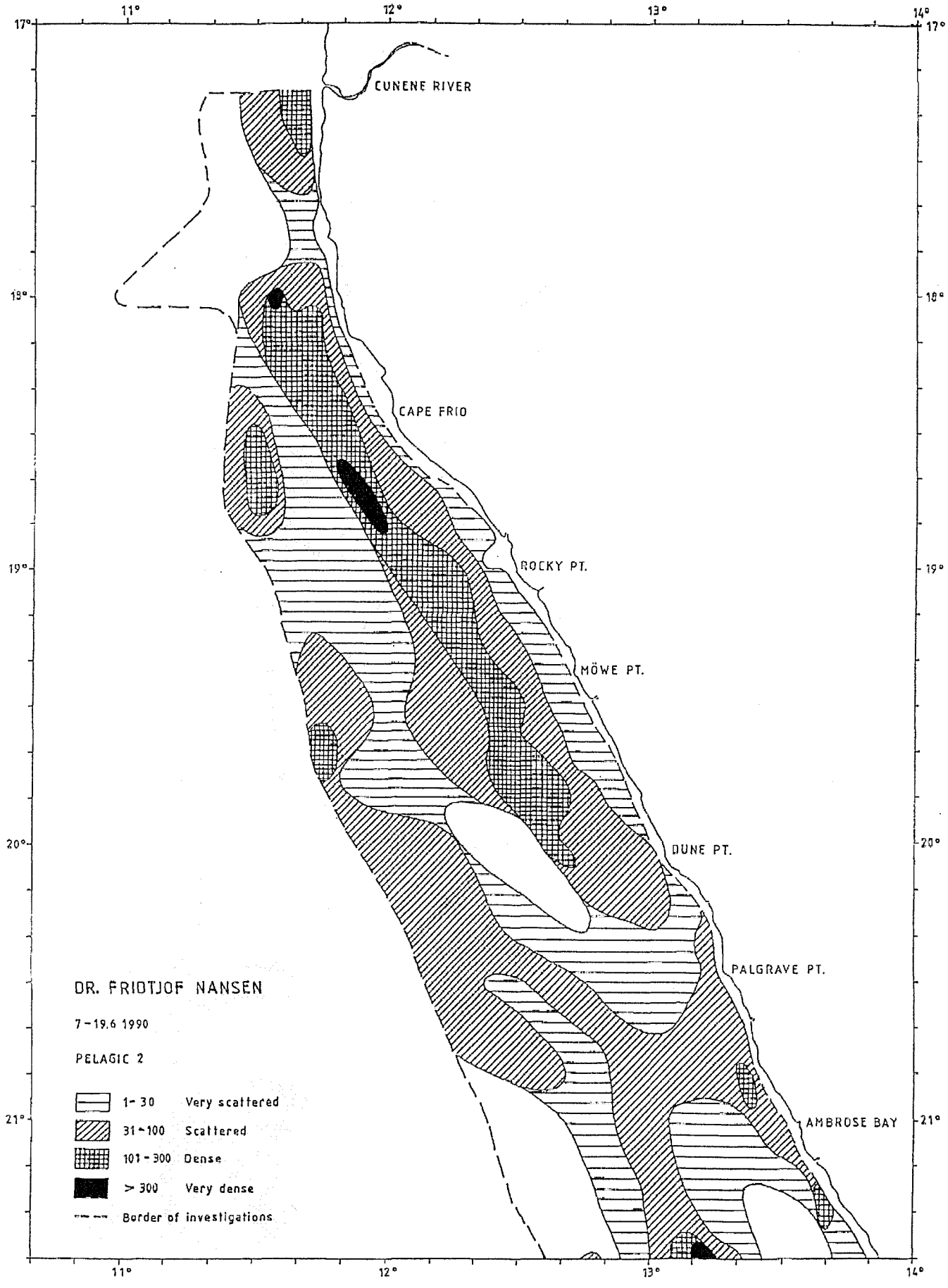


Figure 4b: Ambrose Bay to Cunene River.

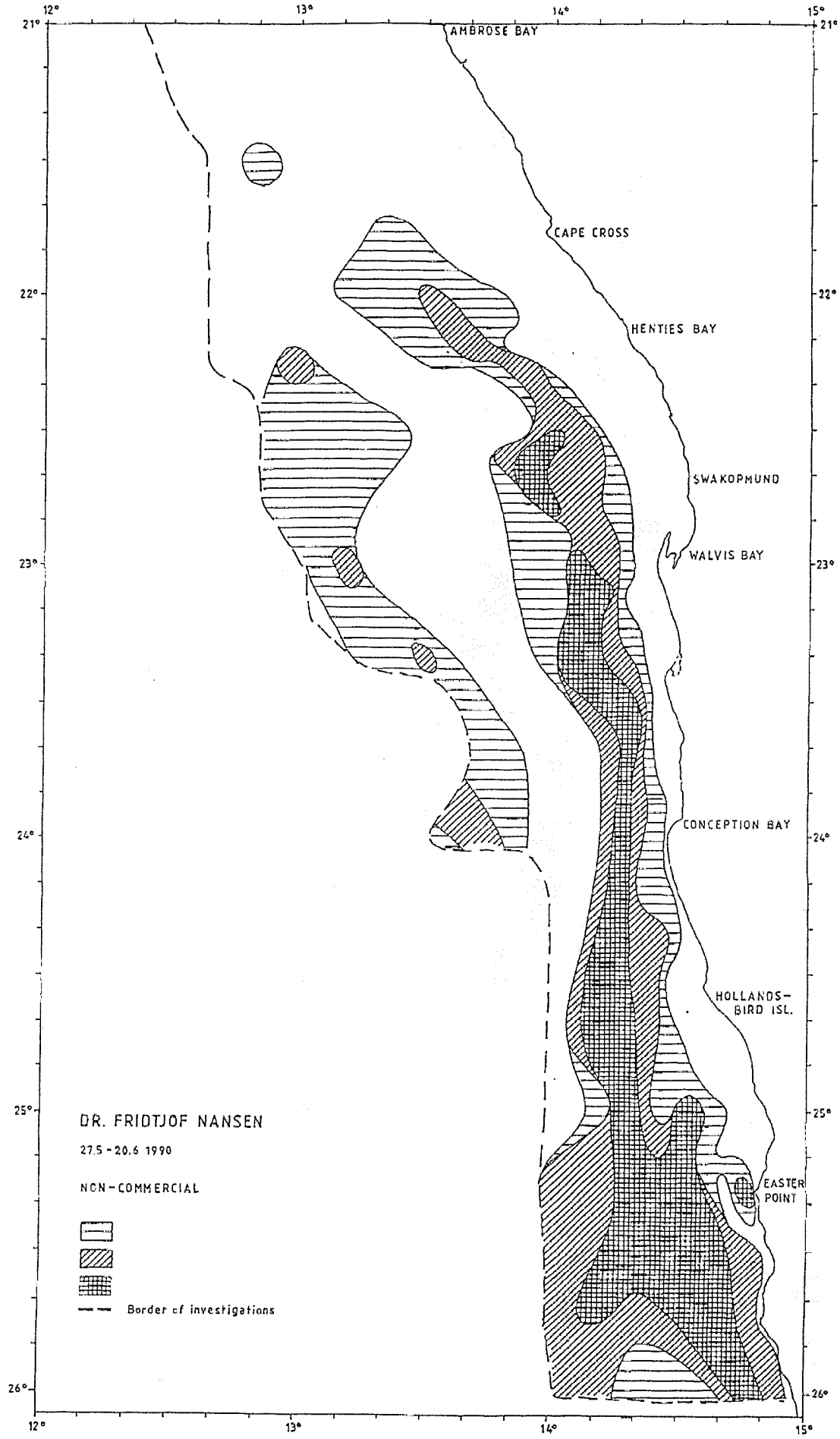


Figure 5. Distribution of non-commercial fish, myctophids and gobies.
a: Dolphin Head to Ambrose Bay.

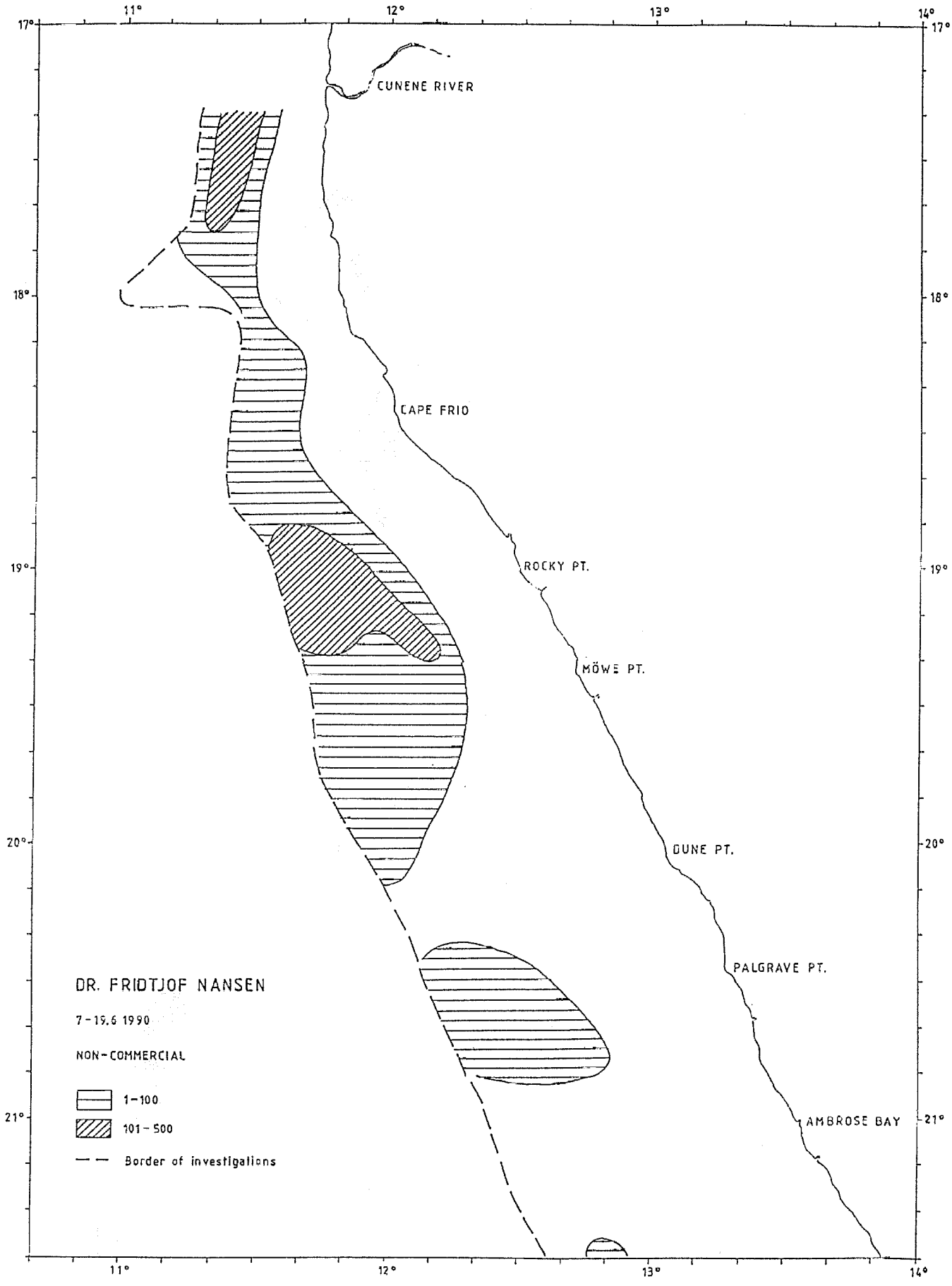


Figure 5b: Ambrose Bay to Cunene River.

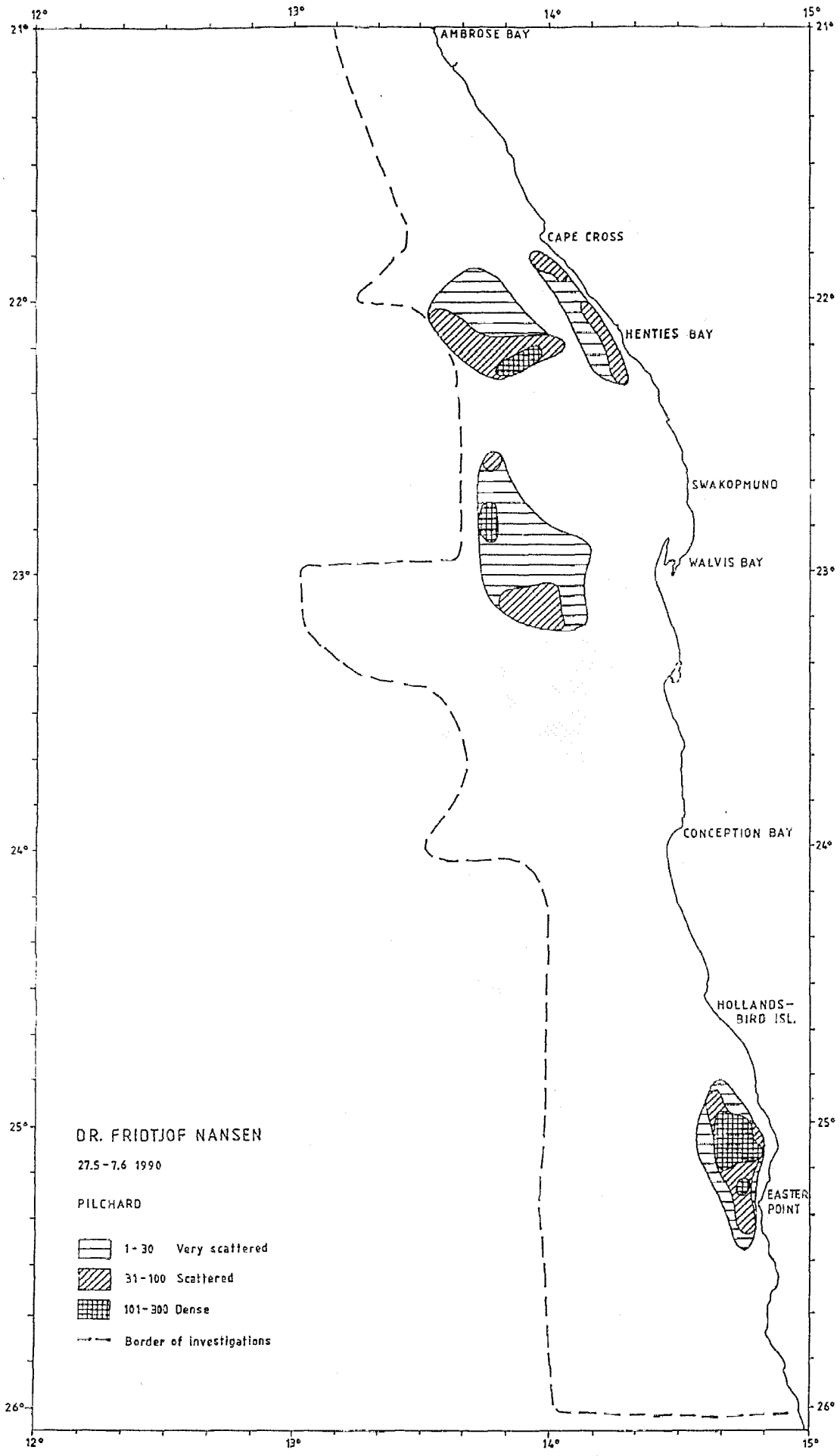


Figure 6: Distribution of pilchard. a: Dolphin Head to Ambrose Bay.

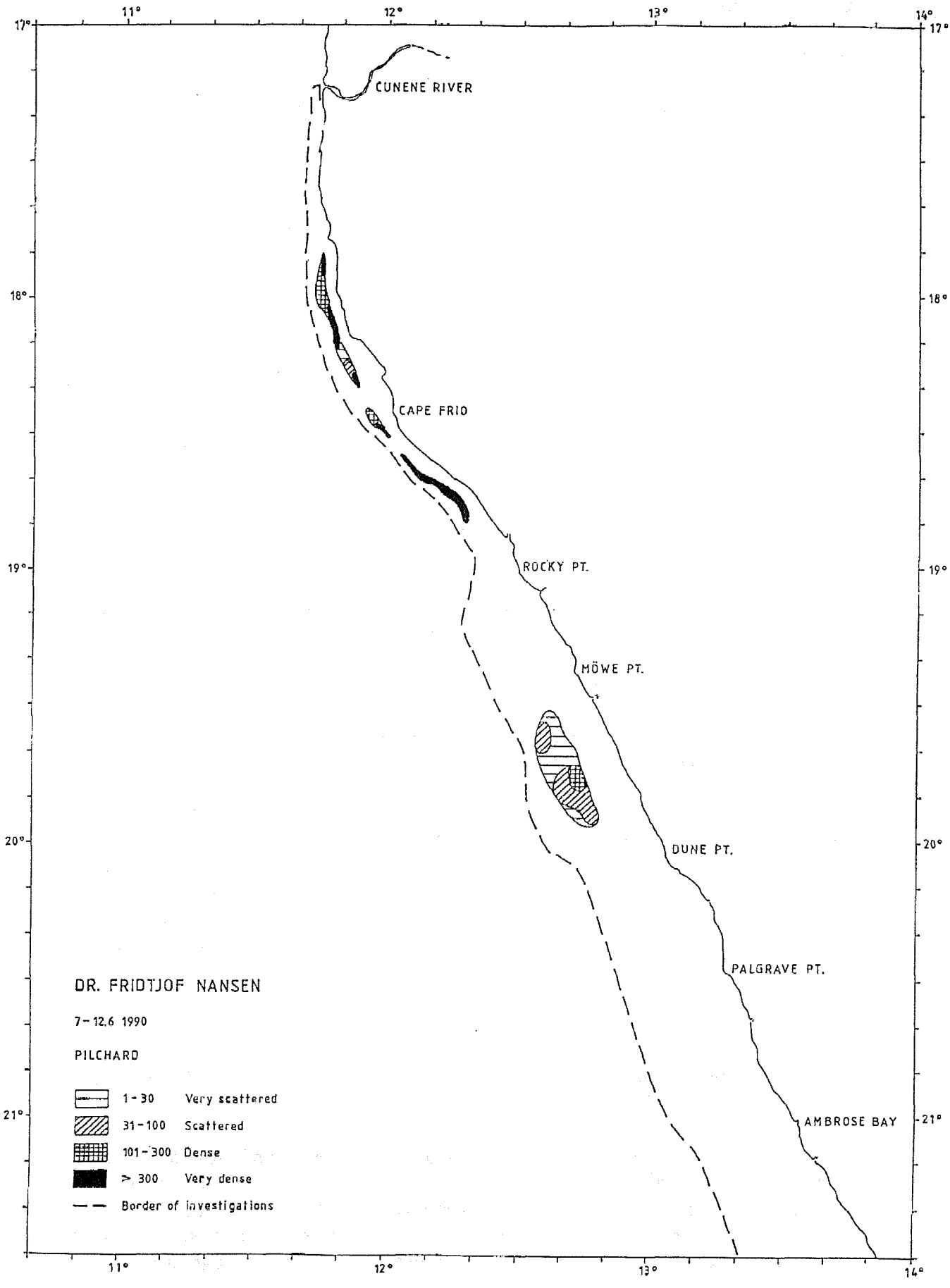


Figure 6b: Ambrose Bay to Cunene River.

### 4.1.1 Dolphin head to Ambrose Bay

*Dolphin Head to Walvis Bay*

The inshore area (100 m) was surveyed when steaming northwards, the offshore area (100 m to 400 m) on the way south.

Between 24°25'S and 25°25'S scattered, mixed shoals of pilchard, anchovy and round herring were found from the coast out to a depth of 80 m. While these shoals proved to be almost ideal for acoustic surveying, large concentrations of jellyfish, particularly south of 24°55'S, made the determination of species composition by trawling extremely difficult.

In the southern part of this area fish were, therefore, identified mainly from their acoustical appearances. About 70% of the fish, by integrator values, were in large and dense surface shoals, these were credited to pilchard. The only sample of pilchard collected in this area had a bimodal length frequency distribution, with modal peaks at 11 cm and 18 cm. Fewer jellyfish occurred north of 25°00'S and the fish in this area were identified, according to trawled samples, as round herring and anchovy.

A small concentration of fish, mainly represented by one dense shoal of anchovy, occurred off Conception Bay.

South of 23°30'S few pelagic fish were found in waters deeper than 60 m, although a very small concentration of anchovy juveniles, with a modal size 6 cm, occurred offshore of Conception Bay. Some horse mackerel were found in deep waters off Pelican Point. These were relatively large with a modal size range from 20 to 27 cm.

Mixed shoals of anchovy and round herring were found in an extensive area inshore of the 60 m bottom depth from 23°40'S to north of Walvis Bay.

Offshore of Walvis Bay and Swakopmund, in waters of 120 m to 150m deep, scattered shoals of pilchard occurred. These shoals tended to become more dispersed during the night period. The acoustic assessments made during this period, were considered more reliable than those made in the daytime and were, therefore, used for the abundance estimate. Once again, large amounts of jellyfish made sampling difficult, although not to such an extent as farther south. The length frequency distribution showed 90% of the pilchard, by number, being between 21 and 23 cm long.

*Walvis Bay to Ambrose Bay*

The inshore area was surveyed on the way north and the offshore region when returning south one week later.

Small amounts of pilchard, anchovy and round herring were found close to the shore from south of Swakopmund to north of Cape Cross, the northern part of this fish becoming quite dense. Dispersed horse mackerel were found along the entire coast north of 22°15'S to Ambrose Bay, also becoming denser in the north. These shoals moved offshore to between 20 m and 30 m during the night period, thus enabling good acoustical records to be made.

Dispersed fish and a few dense shoals were recorded between Henties Bay and Cape Cross in 60 m to 100 m depths. The dispersed fish was identified as horse mackerel, the shoals as pilchard. The pilchard had a similar length frequency distribution to those sampled in similar water depths off Walvis Bay suggesting that these two areas may have formed a continuous distribution. Owing to the scattered nature of the pilchard shoals several transects may have failed to detect any shoals giving the impression of a break in distribution between these two areas. On the return, one week later, the outer parts of this area was surveyed again and pilchard were found here. This may, however, have been fish which had moved into the area in the meantime (Figures 3a and 4a).

Large amounts of the pelagic goby was found throughout the entire area as far north as Cape Cross, mainly in water depths of 50 m to 150 m. Lantern fish were found in waters deeper than 250 m (Figure 5a).

### 4.1.2 Ambrose Bay to Cunene River

The distribution of pelagic fish in this area is shown in Figures 3b, 4b and 5b. The offshore area was surveyed while returning south, whereas the inshore area was covered continuously on the way north and partly repeated on the return.

During the northwards survey a large gap in the distribution of clupeids and anchovy occurred between 21°40'S and 20°00'S. North of Dune Point pelagic shoals were found in waters shallower than 40 m forming an almost continuous band to the Cunene River. Shoals with a mixed species composition were found close to the shore between Dune Point and Möwe Bay, while further offshore the shoals were solely pilchard. Some anchovy was found near Rocky Point. Scattered shoals of anchovy were found from 18°00' northwards, almost to the Cunene.

Very dense shoals of pilchard occurred north of Rocky Point from 18°50'S to 18°25'S in a continuous narrow belt from the 20 m water depth to about 40 m (Figure 6b). In addition to being very dense, these shoals often extended from the surface to the seabed and covered an area sometimes more than 1 nm in width.

The pilchard distribution continued along the coast, but shoals were much smaller further north, although several dense and large shoals were found near 18°00'S. The area between 18°25'S and 18°00'S was surveyed during the day, while the area 18°25'S to 18°50'S was covered during darkness. Following the calibration exercise in Angola, this region was surveyed for a second time, when the entire area was surveyed at night - (see Figure 1c). The shoals in the north were successfully surveyed, but further south no fish were found, despite searching as far south as Möwe Bay. Several days later purse seiners reported finding large amounts of pilchard inside the reef at Cape Frio, even during the night period. Therefore it is assumed that the second survey of this area was not successful due to the distribution of fish being in shallow waters and thus outside the range of the survey.

All the pilchard shoals sampled in this region had bimodal length frequency distributions, with modal peaks at 17-18 cm and 22-23 cm. The frequency of larger fish increased towards the north.

An extensive layer of horse mackerel was found west of the 60 m bottom depth (Figure 4b). These fish exhibited a marked behaviour of rising to the surface at sunset and returning to the seabed the following daybreak. The horse mackerel became particularly dense north of Dune Point to 18°00'S between bottom depths of 100 and 200 m. The size distribution of horse mackerel tended to be larger in deeper waters than inshore. In waters less than 100 m deep the horse mackerel had a bimodal size distribution with a small number of fish in the 9 to 11 cm range and most being 13 to 16 cm long. Samples collected in waters of 100 to 200 m deep had a single modal peak between 14 and 16 cm. In the offshore waters, more than 200 m deep, the horse mackerel had a bimodal length frequency. Again the 15 to 17cm range was dominant, but a second modal peak between 19 and 21cm also occurred.

Lantern fish were found in an extensive area in waters deeper than 250 m. Pelagic goby were not found in any large concentration north of Cape Cross (Figure 5b).

## 4.2 ABUNDANCE

The estimates are based on the acoustic integration technique, similar to that used in previous assessments of the same stocks. The survey coverage was assessed as being ample with increased sampling in areas of high density. The North Sea herring target strength (TS=20 log L-71.2) was used for pilchard, anchovy and round herring. The target strength used for the horse mackerel estimate is discussed below.

The biomass estimates for the clupeids and anchovy are shown in Table 1, while the estimates for horse mackerel are in Table 2. The estimate for the clupeids and anchovy are based on the northwards coverage only.

### 4.2.1 Pilchard

The "DR. FRIDTJOF NANSEN" survey undertaken earlier this year reported a pilchard biomass of 235 000 t. The present increased biomass figure of 750 000 t is thought to be due to the inclusion of the large amount of pilchard in the area around Cape Frio. This concentration has largely been absent from earlier surveys, probably due to its behaviour of shoaling very densely in shallow waters and thus avoiding detection as was the case when this area was surveyed for the second time during this cruise. The increase in the biomass estimate compared to previous estimates is, therefore, not regarded as a recovery of the stock, but merely as an improved survey coverage of pilchard distribution, especially between 18°00'S and 19°00'S where some 60% of the total pilchard stock biomass was found.

Table 1. Biomass of pilchard and mixed shoals of clupeids and anchovy (tonnes).

| | Dolphin Head-Ambrose Bay | Ambrose Bay-Cunene River | Total |
|---|---|---|---|
| Pilchard | 265 000 | 485 000 | 750 000 |
| Mixed | 115 000 | 70 000 | 185 000 |

### 4.2.2 Anchovy and round herring

Owing to the mixed shoaling behaviour of these two species it is not possible to report their biomasses separately. The anchovy stock was estimated as being 215 000 t during the first "DR. FRIDTJOF NANSEN" survey, also including some round herring. Thus the present findings of 185 000 t agrees well with this figure, lying within the limits of the accuracy of acoustic biomass estimates.

### 4.2.3 Horse mackerel

Owing to the uncertainty of the most appropriate horse mackerel target strength to be used during acoustic biomass estimation, a biomass range is presented. This range corresponds to the values of target strength for the North Sea Herring and the TS proposed by Svellingen for horse mackerel. See previous cruise report. Table 2 shows the estimates by areas.

The previous biomass estimate made by the "DR. FRIDTJOF NANSEN" indicated a total biomass of 1.40 to 2.70 million tonnes depending on which TS-value is used. The present survey estimate for the southern region (Dolphin Head to Ambrose Bay) of 0.40 - 0.75 million tonnes is slightly lower than the previous one (0.66 - 1.20 million tonnes), whereas the estimate for the northern region of 1.60 - 3.00 million tonnes is double the previous stock estimate (0.78 - 1.5 million tonnes). This increase is partly due to the coverage of a larger part of the distribution area of horse mackerel during the present survey. It may also indicate a slight increase in the stock size, particularly as small number of recruits were caught during the present survey, which were absent earlier in the year. It should be noted that neither survey has extended to the western border of the horse mackerel distribution.

Table 2. Biomass estimates of Cape horse mackerel. Range corresponds to different assumptions regarding target strength (million tonnes).

| Dolphin Head-Ambrose Bay | Ambrose Bay-Cunene River | Total |
|---|---|---|
| 0.40 - 0.75 | 1.60 - 3.00 | 2.0 - 3.75 |

## CHAPTER 5 CONCLUDING REMARKS

In general, the pelagic fish stocks in Namibian waters are suited to biomass determination by acoustic methods. Some difficulties were, however, encountered during the present survey which may have affected the results presented above.

In the southern region large concentrations of jellyfish hampered determination of species composition by trawl catches, and the allocation of the integrator values had to

be based on characteristics in shoaling behaviour. This problem may have caused errors in the determination of species composition of mixed shoals of small pilchard, anchovy and round herring. Shoals of large pilchard, however, which counted for the main biomass contribution in the southern region, have a very characteristic acoustic appearance and their identification is thus regarded as reliable.

Areas with a few, large and widely scattered shoals, such as the pilchard distribution offshore of Walvis Bay and Henties Bay, require a narrow-spaced grid in order to be properly surveyed. Because of time constraints this was not always possible, but the observations of the commercial purse seiners helped in producing the stock distribution map of these areas. In general, commercial fishing boats are ideally equipped for distribution mapping of shoaling fish.

Large concentrations of fish may occur in waters of less than 15 m depth. Purse seiners, with a shallower draught than the "DR. FRIDTJOF NANSEN", were used to map the fish distribution in these shallow waters, thus enabling the "DR. FRIDTJOF NANSEN" to survey the inshore area when the fish had moved to deeper waters. The advantage of an assisting fishing boat under such circumstances became particularly evident during the second survey of pilchard at Cape Frio when a large fraction of the stock was not found. From later reports of purse seiners, it became evident that these fish were in shallow waters on the shore side of a reef.

It is recommended that further pelagic surveys in this region should make full use of the local fishing vessels for distributional mapping and surveying shallow waters.

In general, the horse mackerel were well dispersed and ideally suited to biomass determination by acoustic methods. The identification of shoals of horse mackerel mixed with myctophids was occasionally difficult, thus some error may have been incurred. Also some horse mackerel were seen rising through the water column at sunset only to disappear shortly after. Horse mackerel were, moreover, recorded at the outer end of many of the survey lines in the north. Thus the biomass figures reported for pelagic horse mackerel should be considered as the lower limit.

Pilchard stocks were found in discrete areas. Shoals were very dense and, within these areas, were occasionally widely scattered.

The biomass estimate of 750 000 t is considerably higher than those reported from acoustic surveys in later years by the Sea Fisheries Institute of Cape Town, the highest of which was 200-250 000 t in June-July 1988. It is uncertain to which extent the higher level of the present estimate is caused by the special efforts made during this survey to cover inshore shallow water areas of pilchard distribution with the assistance of auxiliary vessels. It seems very likely that this is the main reason for the difference between the "DR. FRIDTJOF NANSEN" estimates of March and June this year.

Anyway the higher present biomass estimate implies that the current catch levels bears a reasonable relationship to the stock biomass.

Size sampling of the pilchard catches showed that adult fish of the age group 2+, the 1987/88 yearclass (and perhaps higher groups) dominated the present stock. The 1+ group could be identified especially between Ambrose Bay and Cunene, but this

yearclass (1988/89) is far less abundant. The relatively high abundance of the 1987/88 yearclass observed in this survey conforms with the experience of an unusual predominance of middle sized fish during the 1989 fishing season.

Juvenile 0-group fish was virtually absent from the samples of the present survey. This is a matter for concern, unless this seasons recruitment is delayed due to late spawning. The observations indicate that the1988/89 yearclass is poor. The outlook for further growth of the stock in the next coming years is thus not good unless an abundant group is recruited later this season. It is therefore recommended that major policy changes regarding the management of the stock should not be taken until additional information on the state of the stock has been obtained.

Anchovy stocks were dispersed throughout the inshore region and were nowhere abundant. Few juvenile anchovy were found. In this situation it is recommended that fishing on anchovy should be limited as far as possible in order to preserve the spawning component of the stock.

Pelagic horse mackerel stocks were, compared to pilchard and anchovy, very large. These stocks were widely distributed north of Walvis. Almost all the horse mackerel surveyed were of a single year-class (immature). No juvenile or mature adults were found. The state of this stock would allow substantial catches to be taken.

Large stocks of gobies were found from Cape Cross southwards, mainly inshore of 150 m deep. Lantern fish were found in waters deeper than 250 m, particularly north of Dune Point.