CHAPTER 3 RESULTS

3.1 HYDROGRAPHY

Annex II shows sections of temperature, salinity and oxygen obtained during the cruise.

The surface temperature is relatively low, about 13°C to 15°C, typical for the season, resulting in weakly stratified water masses. In the upper 200m the temperature varies less than 2 degrees in the southern part, increasing to slightly above 2 degrees in the northern part where the surface layer is somewhat warmer.

The salinity is also extremely homogeneous in the upper 200 m, especially in the southern part.

The surface oxygen censentration is above 4 ml/l in the southern part, decreasing to less than 3 ml/l in the northernmost section at Cunene. The bottom values are less than 1 ml/l.

The water characteristica indicate upwelling at some of the sections. This is most clearly seen in the oxygen distribution by the upward tilt of the isolines approaching the coast, but it is also indicated by the temperature and salinity distributions. The most typical upwelling situation is seen in the section taken at Walvis Bay, where the surface oxygen consentration is less than 2 ml/l close to the shore. Strong upwelling also seems to have occurred at the Rocky Point section. There is evidence for upwelling also at the other sections, except the northernmost one at Cunene.

3.2 DISTRIBUTION

3.2.1 Dolphin Head to Ambrose Bay

No adult pelagic fish were found in this region. Scattered shoals of juvenile fish occurred close inshore from Walvis Bay to Conception Bay. North of Sandwich Harbour this concentration was fairly dense, but elsewhere the values were low. The species composition was mixed and owing to high densities of jellyfish disrupting the trawls, difficult to determine with any accuracy. Horse mackerel appeared to be the dominant species.

Some mixed shoals of juvenile pelagic fish occurred in the northern part of this region, extending northwards of Ambrose Bay. At the end of the survey a number of shoals of surface schooling juvenile fish were also found in 100 to 130 m waters off Cape Cross. Two trawls were made, one shoal was identified as juvenile hake and juvenile Cape horse mackerel, while another consisted of mainly anchovy and round herring, with smaller proportions of pilchard, horse mackerel and hake. The Lt. of all species was 6.5 to 8.5 cm. While steaming back to Walvis Bay from this region large areas of dispersed juvenile fish were observed near the surface. As it was full moon, it is likely that these fish had occurred above the transducer level during earlier coverages of this region and had not been observed. Owing to lack of time further investigations of this region were not possible. Both the RV 'Dr. Fridtjof Nansen' and RV 'Welwitschia' had surveyed this region acoustically during the previous week and had not found any pelagic fish. It was therefore assumed that the total biomass of juvenile fish occurring in this offshore region was not large.

Very little adult pelagic fish was found north of Walvis Bay.

Despite reports of commercial catches of mid-water horse mackerel being made south of 22°S and the RV 'Dr. Fridtjof Nansen' recording substantial catches at 24°S in particular during the trawl survey in May, mid-water horse mackerel was not recorded south of Walvis Bay. Some few individuals were caught in day-time bottom trawls targeted at demersal hake.

3.2.2 Ambrose Bay to Cunene River

The main concentration of pelagic fish in this region was a dense area of pilchard schools north of 17°25'S, continuing northwards into Angolan waters. These schools migrated from very shallow waters during daylight out to between the 40 and 60m isobaths at night. Some few very small schools of pilchard were also recorded near Cape Frio Point and south of Cape Frio reef.

Some dispersed pelagic fish occurred in waters less than 50m deep in the northern part of this region. These fish were often scattered between the dense pilchard schools. These layers were mixed species, usually dominated by anchovy, but also containing round herring, horse mackerel, pilchard and various predatory species such as snoek *Thyrsites atun*, sharks and kob *Argyrosomus hololepidotus*.

Dispersed juvenile fish occurred between Möwe Bay and Ambrose Bay near the surface between the 20 m and 80 m isobaths, the density being fairly high near Ambrose Bay. Pilchard, anchovy, horse mackerel and round herring occurred in this layer, but concentrations of jellyfish hindered

the determination of species proportions. Inshore all four target species seemed to be well represented, while further offshore round herring formed the dominant species.

Further offshore juvenile horse mackerel occurred throughout the region in sometimes fairly dense layers close to the seabed in depths of 80 to 150m. Adult horse mackerel formed a band of fish between the 200 m and 350m isobaths in the north. Trawling in this region was disrupted by dense layers of jellyfish.

3.2.3 Cunene River to Tombua

This region was dominated by dense schools of pilchard occurring from south of the Cunene to Baía dos Tigres, including inside the bay. As with the pilchard south of the Cunene, these schools migrated inshore into very shallow waters during the day and into depths of 20 to 40m water at night, in some areas this represented a daily migration of at least 5nm in each direction.

Some less dense shoals consisting mainly of anchovy occurred just north of the Cunene, while round herring occurred throughout the region, often in fairly dense shoals near the seabed around the 80m isobath.

Horse mackerel occurred throughout the inshore part of the region. Transects to assess the mid-water stocks were not conducted north of 17°S, but as relatively high densities were recorded on the northern-most transect it is likely that some mid-water horse mackerel also occurred north of this line. Trawl samples north of 16°40'S consisted almost entirely Cunene horse mackerel *Trachurus trecae*, while further south Cape horse mackerel *T. capensis* was caught.

3.3 ABUNDANCE

A strong lateral migration of pilchard into shallow waters was noted in the north, such that during the day all fish were in waters less than 15 m depth and hence outside of the range of the RV 'Dr. Fridtjof Nansen'. All areas where pilchard were found were therefore surveyed at night, and in most areas zero-values were recorded on the inshore part of each transect indicating that all fish had moved into deep waters..

Previous surveys have shown that lower densities are recorded at night compared to the day-time values in the same area. In these instances the daytime values were used for the biomass estimate

based on the assumption that at night considerable amounts of fish occurred above the transducer level. As in previous surveys a vertical migration of pilchard was noted to occur at night, but judging from the recordings, and the SA950 sonar records, most of the fish seemed to be distributed within the transducer range.

The total biomass of pilchard found in Namibia and southern Angola (Table 1) was estimated to be about 260 000 tonnes.

Owing to the inherent problems of assessing a small stock of schooling fish in shallow water using vertical echo sounders, the precision of the estimated biomass of pilchard may be rather low. However, supportive data from the sonar, not yet quantified for biomass estimation, also indicate that the present stock is small.

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

Area	Pilchard	Anchovy	Round herring	Horse mackerel
Tombua-Cunene River	240 000	6 000	2 000	60 000
Cunene River-Ambrose Bay	20 000	30 000	50 000	1 330 000
Ambrose Bay-Dolphin Head	1 000	15 000	18 000	110 000
Total Angola	240 000	6 000	2 000	60 000
Total Namibia	20 000	45 000	70 000	1 440 000
Total northern Benguela	260 000	51 000	72 000	1 500 000

Some few pre-recruit pilchard schools were registered near Ambrose Bay and south of Walvis Bay, but the abundance was very low. While these fish may still be dispersed in the surface water layers, or possibly in deep waters outside of the survey area, and hence are not yet be fully available to acoustic surveys of this type, the indications are that recruitment of pilchard in 1994 will be weak.

Most anchovy were found in the Ambrose Bay to Möwe Bay region, but at an estimated biomass of some 51 000 tonnes, this stock is also extremely small. More anchovy pre-recruits were recorded than pilchard, but the total number remains very few.

The biomass of round herring was estimated to 72 000 tonnes. The round herring biomass was larger than anchovy, but as much of the stock formed small dispersed schools close to the bottom in waters of 50 m deep or more, this species is unlikely to be targeted by the purse seine fleet and therefore will remain economically unimportant.

Horse mackerel was widely dispersed between Ambrose Bay and 16°40'S, and the total biomass was estimated at about 1 500 000 tonnes.

3.4 BIOLOGICAL ANALYSIS OF FISH

3.4.1 Length-frequency

Annex VI shows the length-frequency of each species in each of the 2° areas. Samples for ageing were collected and these data will become available later.

Adult pilchard and anchovy were found north of 19°S, while pre-recruits occurred at Ambrose Bay and south of Walvis Bay. Few adult round herring were sampled. Pre-recruit round herring (Lt. = 15-18 cm) were found north of 21°S, usually in deeper waters than the other pelagic species. Juvenile round herring occurred in shoals mixed with similarly sized horse mackerel or anchovy, the main concentrations being north of Ambrose Bay and just south of Walvis Bay.

3.4.2 Length - Weight

Length-weight curves and regression equations for each of the four species in the whole region and for each latitude interval per species may be found in Annex VII.

3.4.3 Reproductive Status

Results were tabulated for both anchovy and pilchard per latitude interval (see Annex VIII). It was difficult to draw any conclusions from these results given the low number of samples per 1 cm length class and apparent inconsistencies between workers in evaluating maturity stage. Nevertheless the following were noted.

1 The sex ratio of anchovy and pilchard appeared to be inversely related to length in all the latitude intervals for which there were data.

2 Low spawning activity was suggested by low mean gonad weights. This is to be expected given that the main spawning activity of both species in the northern Benguela usually occurs in late summer and autumn.

3.4.4 Condition

Mean condition factor, and related parameters, are presented per area for pilchard and anchovy in Annex IX. For both species mean condition was found to be significantly higher in 16°-17°S than for the more southerly latitude intervals. The null hypothesis for both species was that there was no difference in condition between the areas.

For pilchard the results of the two tailed F-test and Students t-test on the difference between two means was F_s= 1,20 (P≤0,05) and T_s=6,71 (P≤0,001). The results of the ANOVA test on anchovy condition are presented in Annex VI. Condition factor variances were found to be significantly greater among latitude intervals than within latitude intervals (F_s=8,81, P≤0,01). Although no significant difference in condition was found between intervals 18° - 19°S and 20° - 21°S (F_s=0,74, P≤0.05), anchovy had significantly lower condition factors in both these intervals than in 16° - 17°S (F_s=16,00, P≤0,01 and F_s=6,97, P≤0,05 respectively).

These differences in fish condition between the northern and central parts of the region suggest that feeding conditions were better in the north, at least during the duration of the survey. It is recommended that this be investigated further by examining the results of the plankton and environmental samples.

CHAPTER 4 CONCLUDING REMARKS

Conditions were, in general, favourable for surveying pelagic fish acoustically. Weather conditions were acceptable, while the fish distributions were usually within the range of the equipment. Some problems were encountered, including surface shoaling and diurnal migration into shallow waters occurred, but were compensated for by adjusting the survey strategy accordingly. Dense concentrations of jellyfish occurred, particularly in the central and southern region. These hampered trawling and probably masked fish echoes. The impact of such concentrations on the functioning of the ecosystem are likely to be large, whether through predation on fish eggs and

larvae, or through the removal of large amounts of energy and nutrients from the system. Determining the role of jellyfish in the northern Benguela urgently requires attention.

The survey commenced in the north and proceeded southwards, the first time that the region has been surveyed in this direction. Apart from the discomfort of sailing into the prevailing winds and seas, the major part of the fish stocks were surveyed during the early part of the survey, while large areas with low densities were covered at the end. It was therefore difficult to allocate survey time according to fish density. It is recommended that future surveys should be conducted from south to north thereby finishing with the highest concentrations and any remaining time can be allocated to improving the accuracy of the estimate of these high densities.

For the first time in several years the mid-water horse mackerel stocks were assessed during a pelagic survey. This necessitated spending a considerable amount of time on long transects offshore, when the time might have been better spent working more intensively inshore. It is suggested that the offshore stocks of horse mackerel would be better surveyed during the hake swept-area trawl surveys.

The pilchard abundance for the northern Benguela system, that is the Namibian region north of Luderitz and southern Angola, was estimated at below 300 000 tonnes. This confirms the trends documented during the previous six surveys, that the stock size is declining rapidly and is now at such a small size that despite relatively conservative quotas, over-fishing is likely to exasperate the situation. The anchovy and round herring stocks are similarly very small, while the horse mackerel estimate is also lower than most previous estimates.

Experiments conducted during this and previous surveys and, in particular, on similar species elsewhere, indicate that the target strength used to calculate these estimates may be too low and that the actual biomass is somewhat less than the values reported. This means that Namibian pelagic stocks may be considerably smaller than the following tables suggest.

These data are supported by the poor catches of the purse seine fleet during the past 6 months. The catch of non-quota species, anchovy, round herring and juvenile horse mackerel, is some 70% below the catches during the same period in 1993, which was itself only an average season. The total amount of pilchard caught in 1994 has been similar to 1993, but while in most seasons almost all catches have been made close to Walvis Bay, between 24°S and 21°S, only 23% have come from this region in 1994 and indeed less than 40 tonnes have been caught within 60 nm of Walvis so far this year.

In addition, the condition factor of the fish caught during this survey was significantly poorer in the central region, 22°S to 19°S, than farther north. Assuming that the condition factor reflects the quality of the fishes' environment this suggests that feeding conditions, and other related environmental parameters, were not conducive to the maintenance of high pelagic biomasses in this region. Furthermore these poor environmental conditions are likely to have been further shunted up the food chain given the high seal moralities, reportedly due to starvation, in the region.

Table 2 Biomass estimates of pilchard, 1990 to 1994

Survey	Vessel	Namibian waters	Angolan waters	Total
March 1990	Nansen	160 000	-	-
June 1990	Nansen	515 000	-	-
March 1991	Nansen	495 000	-	-
August 1991	Benguela	565 000	-	-
November 1991	Nansen/Benguela	625 000	155 000	780 000
June 1992	Nansen/Benguela	610 000	45 000	655 000
August 1992	Benguela	410 000	-	-
November 1992	Benguela	515 000	-	-
March 1993	Nansen	385 000	50 000	435 000
June 1993	Nansen	300 000	105 000	405 000
August 1993	Benguela	445 000	-	-
November 1993	Benguela	320 000	-	-
February 1994	Nansen/Benguela	0	250 000	250 000
June 1994	Nansen	20 000	240 000	260 000

Table 3 Biomass estimates of anchovy and round herring combined and horse mackerel, 1990 to 1994, in the northern Benguela system.

Survey	Vessel	Anchovy/ Round herring	Horse mackerel
March 1990	Nansen	170 000	1 200 000
June 1990	Nansen	140 000	1 700 000
March 1991	Nansen	180 000	1 300 000
August 1991	Benguela	345 000	-
November 1991	Nansen/Benguela	325 000	1 400 000
June 1992	Nansen/Benguela	175 000	2 100 000
August 1992	Benguela	250 000	-
November 1992	Benguela	17 000	-
March 1993	Nansen	335 000	-
June 1993	Nansen	230 000	-
August 1993	Benguela	220 000	-
November 1993	Benguela	?	-
June 1994	Nansen	120 000	1 500 000