Analysis of the 1990 and 1991 Namibian pelagic fishing seasons

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ABSTRACT

This paper examines some of the more important characteristics of Namibia's commercially important pelagic fish stocks exploited during the 1990 and 1991 seasons. Comparisons of landings in recent years and some broad speculations on the future state of the Namibian pelagic fish stocks are made. Species considered are pilchard *Sardinops ocellatus*, anchovy *Engraulis capensis*, horse mackerel *Trachurus capensis* and round herring *Etrumeus whiteheadi*. A total of 242 901 t pelagic fish was landed during the 1990 pelagic fishing season, while 171 094 t was landed during the 1991 season. These landings were of a similar magnitude to the mean since 1979. The landings of both seasons were largely based on a single strong cohort for all species, spawned during the austral spring and summer period of 1988/89. Indications are that recruitment of all pelagic stocks was poor during the 1989/90 breeding period.

INTRODUCTION

The marine ecosystem in the exclusive economic zone (EEZ) of the Republic of Namibia is, biologically, a highly productive system (Crawford *et al* . 1987). This region supports large populations of pelagic and demersal fish, as well as several invertebrate species, which are utilised for commercial purposes.

Owing to its economic importance to Namibia and the Walvis Bay enclave, considerable effort is placed on obtaining biological information on Namibia's pelagic fish stocks. This information is used primarily to assist the authorities in managing these stocks to provide an optimal sustainable benefit to the fishing community and to the Namibian economy. Benefit can be defined as a combination of total fish biomass landed, economic yield, and some level of socio-economic benefit (eg. number of people employed, foreign exchange earned, etc.). This directed research effort has resulted in a database of biological parameters and catch statistics on pelagic fish covering more than 25 years and represents one of the major time-series of biological information available in Namibia.

Annual reports and reviews of the multi-species pelagic fishery off Namibia can be found in the International Commission for the Southeast Atlantic Fisheries collection of scientific papers (Butterworth 1979, 1980; Butterworth & Le Clus 1979; Hewitson 1988; Hewitson *et al.* 1989a; Hewitson *et al.* 1989b; Katsuyama 1984; Le Clus 1984, 1986; Le Clus *et al.* 1987; Le Clus & Melo 1981, 1982, 1983; Le Clus & Thomas 1981, 1982; Melo 1984a, 1985; Melo & Thomas 1985; Newman & Schülein 1974; Schülein 1986; Schülein *et al.* 1978; Thomas 1981, 1983, 1984, 1986; Thomas & Boyd 1985; Wysokinski 1981) and other sources (Crawford *et al*. 1985; Moorsom 1984; Payne & Crawford 1989).

Pelagic shoaling fish are normally considered unsuitable for human consumption in an unprocessed form. Namibian pilchard is canned and thus has a higher economic value than the other species which are processed into fish meal for animal feed and fish oil for use in the chemical industry. Catches of a mixed species composition including pilchard are processed into fishmeal and oil, and such pilchard is considered as "by-catch". Fishermen are expected to limit this pilchard by-catch. The management of pelagic horse mackerel is complicated by the fact that this species, on reaching maturity, migrates offshore to form an important component of the deep-sea trawling industry.

The 1990 and 1991 pelagic seasons both commenced on 1 March and closed on 31 August. The initial 1990 pilchard canning quota was set at 40 000 t, but an additional quota of 20 000 t was granted in mid-July. By-catches were not included in the quota. In 1991 a total pilchard quota of 60 000 t, including by-catches, was allocated. Anchovy, horse mackerel and round herring catches were not subjected to quota restrictions, however landings were closely monitored to ensure that the by-catch of pilchard and especially juvenile pilchard was kept to a low level. A high bycatch of juvenile pilchard must be avoided to realize an optimum long-term yield for this species.

The 11 mm mesh-size net and the purse-seine catching technique are of such a nature that little size selectivity of fish within shoals occurs. It should be noted, however, that purse-seining is a non-random sampling procedure as shoals of larger-sized fish are usually targeted. The data presented, therefore, do not reflect the state of the entire population but merely the portion targeted by the fishing industry. These data are, however, comparable to previous years, as fishing gear and techniques and target populations have essentially remained unchanged since the late 1960's with the introduction of hydro-acoustical fish finding techniques and hydraulic power-blocks to assist net-hauling. The data can thus be used to indicate trends within the pelagic fish populations.

METHODS

A fleet of thirty-eight purse seiners was licensed to catch pelagic fish within Namibia's Exclusive Economic Zone during the two years under review. Skippers of all vessels were required to supply information on the locality and date of catches made. On off-loading at the processing factories all landings were weighed using bucket-type or band-type industrial mass meters.

Fish samples were collected by fisheries inspectors from all vessels during off-loading at intervals of approximately 20 minutes, or more frequently in the case of small landings. These samples were obtained from the chutes between the vessel and the factory and were used to determine the species composition of the total catch.

Samples for biological analyses (*viz.* measuring length, weighing, ageing, sexing and describing the reproductive state) were collected in a similar manner from a maximum of six vessels each day. Vessels sampled were selected randomly. The number of landings made and samples collected are presented in Table 1. Each sample was grouped according to species and specimens were analyzed as above.

In 1990, pilchard, anchovy and round herring were selected at random and the caudal length (L_c) recorded to the nearest 0,5 cm. Measuring continued until 50 fish of each species had been assigned to any one of the 0,5 cm length classes, resulting in a sample size of approximately 100 fish per landing. As problems determining the precise posterior position of the caudal column were experienced, total length (L_t) was measured in 1991. The difference between these two measurements, the tail flukes, appear to grow isometrically, therefore simple conversion factors could be applied to convert the 1990 caudal lengths to total length for comparison with the 1991 data. The factor calculated for each species was:

Pilchard	$L_T = 1.18\ L_C + 0.3$
Anchovy	$L_T = 1.10\ L_C + 0.7$
Round herring	$L_T = 1.1\ 1\ L_C + 1.1$

Horse mackerel were measured to total length (L_T) in both years under review.

Otoliths were used for ageing pilchard and anchovy, the methods applied being similar to those described by Melo (1984b) and Thomas (1985). In 1990 an index of the age structure of the catch was obtained from 20 fish in each length class per month. Sampling was randomised in 1991; 10 fish per sample were selected randomly.

Namibian horse mackerel were until recently not actively managed and therefore otoliths, whilst collected, have not been analyzed. Owing to the normal economic insignificance of round herring no data for ageing were collected.

RESULTS

Landings

Pelagic landings from 1964 to 1991 are summarised in Table 2.

The pilchard catch for 1990, 89 215 t, was the highest since 1977. The canning quota was exceeded by 50%. A large proportion of this excess pilchard was caught due to target misidentification, which resulted in pilchard being netted while vessels were searching for anchovy and/or horse mackerel. The 1991 pilchard catch of 68 607 t, while about 25 % less than the 1990 catch, reflected the stricter control imposed by the authorities in keeping landings within the quota, rather than the availability of pilchard.

A total of 51 506 t of anchovy was caught in 1990 and 17 537 t in 1991. Landings have thus maintained a downward trend since the peak harvest of 376 000 t in 1987 and indeed the 1991 harvest represents one of the lowest since the anchovy industry started in 1967.

Pelagic horse mackerel landings totalled 85 180 t during the 1990 season and 83 250 t in 1991. Although these landings were equal or better than most previous harvests, they were only half of the 1988 catch. With the decline in anchovy landings since 1982 and the depleted state of the pilchard stock, juvenile horse mackerel has become an important component in Namibian pelagic catches (Le Clus *et al*. 1987).

TABLE 1: Number of samples collected from purse-seine vessels during the 1990 and 1991 pelagic fishing seasons.

	Year	Pilchard	Anchovy	H.Mackerel	R.Herring
Directed landings	1990	938	462	599	26
(>50% of catch)	1991	706	173	412	
Samples collected	1990	266	89	170	39
	1991	245	19	125	2
Length measurements	1990	58 565	8 407	26 417	4 299
	1991	24 469	1 900	12 550	200
Fish aged	1990	1 478	811	0	0
	1991	2 125	174	0	0

TABLE 2: Catch statistics from 1964 to 1991 in tonnes (x 1000)

Year	Pilchard	Anchovy	H.Mackerel	Other	Total
1964	636	1			637
1965	666	1			667
1966	719	3			722
1967	926	24			950
1968	1387	161			1584
1969	1110	226			1336
1970	514	189			703
1971	325	185	140	5	655
1972	374	137	22	2	535
1973	408	296	12	4	720
1974	562	249	60	2	843
1975	561	186	14	8	769
1976	452	88	23	8	571
1977	200	133	81	1	415
1978	46	355	9	1	411
1979	34	277	28	6	245
1980	11	187	35	1	234
1981	52	187	3	2	254
1982	51	84	67	1	203
1983	44	184	107	4	339
1984	56	14	87	3	160
1985	54	51	22	3	130
1986	52	16	83	1	152
1987	66	376	34	1	476
1988	62	117	169	0	348
1989	78	79	31	0	188
1990	89	51	85	18	243
1991	68	18	83	2	171

Round herring, historically an insignificant contributor to the Namibian pelagic catch, represented 7.2% of the total pelagic catch in 1990, but returned to a more usual level of 1 700 t, 1.0% of the total catch, in 1991.

Temporal and spatial distribution of catches

The pattern for pilchard catches during 1990 was similar to previous years (Hewitson *et al.* 1989a; Hewitson *et al.* 1989b) with most of the pilchard caught early in the season (Figure 1). A further period of increased catches occurred towards the end of the season. The area between 22°00'S and 24°00'S accounted for 81.0% of the total pilchard catch taken (Figure 2). Catches in this area were high from the end of March until the end of April, contributing largely to filling the initial quota of 40 000 t. Fishing then ceased until a further quota of 20 000 t was granted in mid-July. This additional quota was taken almost entirely north of 23°00'S. Pilchard-directed fishing started later in 1991, most of the catch being taken in mid-season between 21°00'S and 23°00'S.

The overall temporal trend of anchovy catches in 1990 was similar to that of 1989 (Hewitson *et al.* 1989b), although catching started almost a month later in 1990 with maximum catches occurring from mid-March to the end of April (Figure 1). Very little anchovy was caught after this period in either year. In 1991, as in 1988 (Hewitson *et al.* 1989a), large amounts of newly recruited juvenile anchovy were caught late in the season. These recruits were not available in the intervening seasons. Seventyfour per cent of the total anchovy catch was taken between 22°00'S and 24°00'S in 1990 compared to 82% in 1991. The balance was caught further north (Figure 2).

The pelagic horse mackerel harvest was exceptionally high during March in both seasons, while the remainder of the catch was spread throughout the rest of the season in 1990, but mostly caught in April in 1991 (Figure 1). Horse mackerel was caught south of 22°00'S early in the 1990 season, while a large proportion of the remaining catch was made between 20°00'S and 22°00'S (Figure 2). In previous years most of the harvest was taken further north. In 1988, for example, the highest yields were recorded between 20°00'S and 22°00'S, while in 1987 and earlier years most of the catch was made north of 20°00'S (Hewitson 1988). The 1991 catch, which was almost entirely from north of 21°00'S, reflected a return to the more common distribution of the pelagic horse mackerel stocks.

Round herring was caught mainly in April 1990 between 22°00'S and 24°00'S, in shoals mixed with anchovy and juvenile horse mackerel. The temporal and spatial trends of catching, therefore, were very similar to those of anchovy and horse mackerel (Figures 1 & 2). Few round herring were caught in 1991.

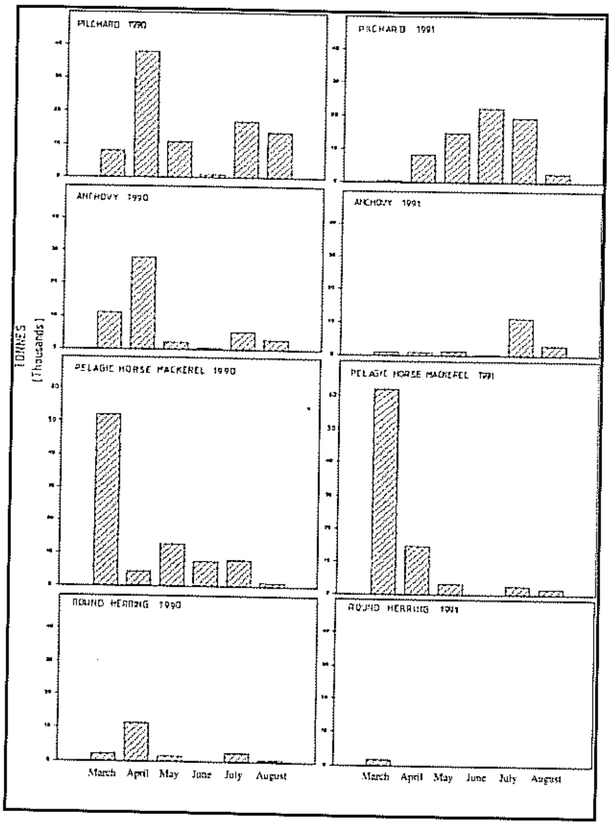

FIGURE 1: Monthly catches of a) pilchard, b) anchovy, c) pelagic horse mackerel and d) round herring in 1990 and 1991 (March to August).

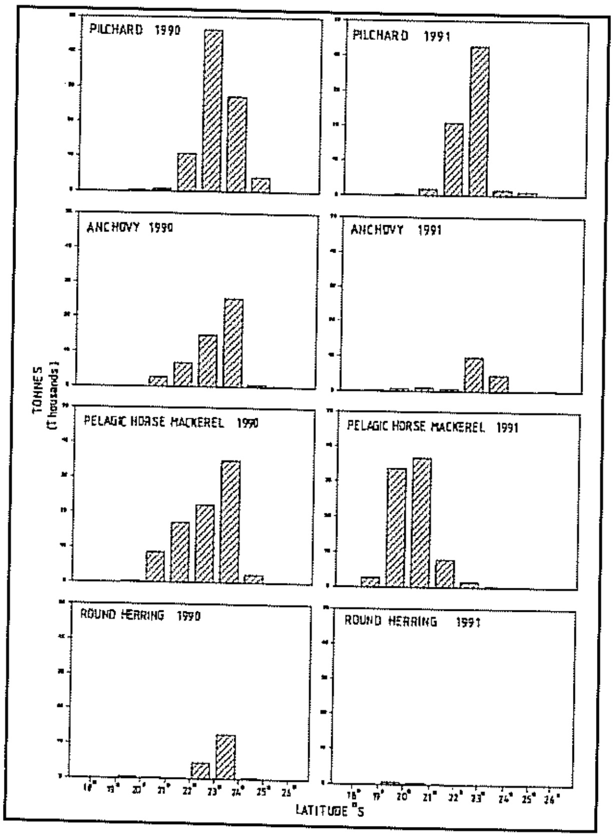

FIGURE 2: Spatial variation of a) pilchard, b) anchovy, c) pelagic horse mackerel and d) round herring catches in 1990 and 1991.

Length and age frequency

Length-frequency analysis of the pilchard landed in 1990 shows that 80% were between 20.0 cm and 24.0 cm L_t (Figure 3), while in 1991 91% were between 21.0 cm and 25.0 cm. Pilchard of less than 19.0 cm L_t, mostly 0-year olds, represented less than 19% of the total number of fish sampled in 1990 and only 5% in 1991. In the previous three years the percentage of fish smaller than 16 cm L_c (approximately 19.2 cm L_t) was considerably higher than in 1990 and 1991. Percentages of 65.9, 58.2 and 63.7 were recorded in 1989, 1988 and 1987, respectively (Hewitson 1988; Hewitson *et al.* 1989a; Hewitson *et al.* 1989b).

Age data obtained from commercial catches confirmed the paucity of 0-year old pilchard in the landings during these two years (Table 3). 0-year old fish were caught in all months except May, but accounted for only 6.4% by number of the total 1990 pilchard harvest and less than 3% in 1991. The age data, therefore, indicated that during 1990 and 1991 the pilchard population was founded on a single cohort which was spawned during the austral spring/summer period of 1988/1989. Pilchard from earlier cohorts were almost entirely absent from the landings during these two seasons.

TABLE 3: Frequency (percentage) of pilchard in each age-group caught during the 1990 and 1991 pelagic fishing seasons

		Year-Class			
Year	Month	0	1	2	3
1990	March	13.3	85.5	1.2	0.1
1990	April	8.0	88.9	2.6	0.4
1990	May	0.7	96.3	2.5	0.5
1990	June	11.8	86.5	0.6	1.0
1990	July	5.6	92.3	1.9	0.1
1990	August	3.0	93.4	3.4	0.1
1990	March-August	6.4	90.8	2.4	0.3
1991	March	-	-	-	-
1991	April	2.6	13.1	81.9	2.4
1991	May	2.6	22.5	72.5	2.4
1991	June	4.8	41.4	53.0	0.8
1991	July	0.2	33.8	65.0	1.0
1991	August	5.8	46.1	46.8	1.3
1991	March-August	2.9	28.3	67.1	1.7

The age distribution of the anchovy caught during 1990 was dominated by one-year and two-year old fish (Table 4), with a modal length (L_t) of 12.0 cm to 14.0 cm (Figure 3). This was of a similar age structure to the 1989 catch (Hewitson *et al.* 1989b). The proportion of 0-year old fish represented in the catches in these two years was the lowest ever recorded. The anchovy caught in 1991 were, in comparison, smaller with a length of 9.0 cm to 12.0 cm, of which almost half was 0-year old fish. This was similar to the catches made in 1987 and 1988 when the modal length (L_c) of fish landed was 10 cm (approximately 11.9 cm L_t) (Hewitson *et al.* 1989a; Hewitson *et al.* 1989b).

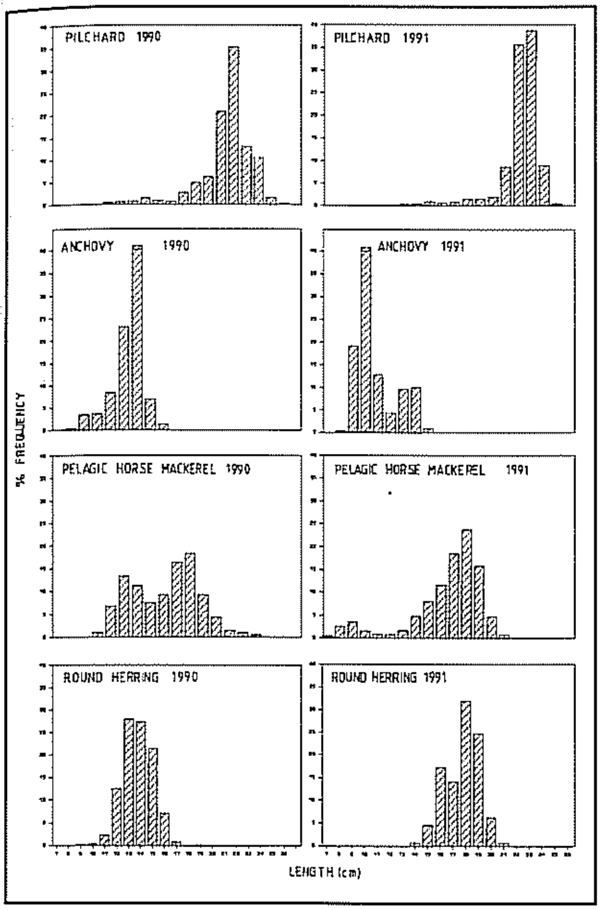

FIGURE 3: Length-frequency distribution of a) pilchard, b) anchovy, c) pelagic horse mackerel and d) round herring catches in 1990 and 1991.

TABLE 4: Frequency (percentage) of anchovy in each age-group caught during the 1990 and 1991 pelagic fishing seasons

		Year-Class			
Year	Month	0	1	2	3
1990	March	1.5	46.7	46.1	5.8
1990	April	1.0	59.7	37.6	1.7
1990	May	1.9	54.5	43.3	0.2
1990	June	23.7	42.9	29.6	3.8
1990	July	64.4	24.8	10.0	0.6
1990	August	23.0	53.4	21.9	1.5
1990	March-August	12.9	50.6	34.1	2.4
1991	March	5.3	21.0	73.7	0
1991	April	20.0	10.0	60.0	10.0
1991	May	10.7	60.7	21.4	7.2
1991	June	0	60.0	20.0	20.0
1991	July	64.8	3.7	22.2	9.3
1991	August	69.8	13.2	13.2	3.8
1991	March-August	44.8	21.3	27.0	6.9

Pelagic horse mackerel landed in 1990 had a bimodal length distribution, the larger fish being 16.0 to 18.0 cm L_t (Figure 3). This was similar to previous years, for example, the modal length (L_t) for 1986, 1987 and 1988 was 17.5 cm, 17.5 cm and 16.5 cm, respectively (Hewitson *et al.* 1989a). A modal length (L_t) of 13.0 cm was, however, recorded in 1989 (Hewitson *et al* . 1989b). Horse mackerel caught early in the season, up to mid-May, displayed a bimodal length distribution with peaks at 12.0 cm and 17.0 cm. In 1991 the modal peak was between 16.0 and 20.0 cm, representing a more normal pelagic horse mackerel catch.

Only small round herring was harvested during 1990, with a modal length (L_t) of 12.0 to 16.0 cm (Figure 3), while the few round herring caught in 1991 were about 4 cm larger. This is presumed to represent growth in the intervening period.

DISCUSSION

The total pelagic fish landings of 243 000 t for the 1990 fishing season (March to August) represents a 29% increase compared to the previous season. This catch is of a similar magnitude to the mean catch of the previous 13 years, namely 273 000 t. Most of the fish caught in 1990 were from a single strong cohort for all species, probably the result of favourable environmental conditions for egg and larval survival during the spring and summer period of 1988/89. The 1991 catch was also largely dependant on the 1988/89 cohort, but at 173 000 t, it was one of the smallest catches of the Namibian pelagic fishery since modern purse seining began. This was largely due to the strict limitation on pilchard catches, the small size of the adult anchovy stock and the subsequently failure of the anchovy recruit run.

Landings peaked in the early part of both seasons under review followed by a generally lower catch for the rest of the season (Figure 4). The fleet concentrated their efforts on horse mackerel in March of both years, but catches of pilchard and anchovy, which were relatively good in April 1990, were poor in 1991. Moderate catches of pilchard and horse mackerel were made in May 1990, but fishing was stopped entirely for much of June owing to the mixture of juvenile pilchard with adult fish. An additional pilchard quota issued in June allowed further good catches of pilchard to be made in July and August in 1991. Pilchard catches sustained the fleet through May, June and July, until the quota was filled, while a small catch of anchovy recruits in July was also made. Little fish was available in August 1991 and the industry stopped fishing voluntarily some ten days before the official end of the season.

Catches of all species shifted some 100 nm from 21°-24°S northwards to 19°-23°S (Figure 4) in the two years under review compared to the catches in the years immediately preceding this period. Few environmental data are available to indicate the causes of this shift in distribution.

The 1990 pilchard catch was composed of predominantly one-year old fish recruited from the 1988/89 cohort. These fish were of uniform size (modal L_t 20.0 - 24.0 cm) and were ideal for canning. Very few older fish were present, and data from both commercial sampling and research cruises indicated that few juveniles were present. During 1989 about 50% of the pilchard catch were 0-year old fish (Hewitson *et al.* 1989b), indicating a very successful 1988/89 spawning season. During 1990 only 6.4% (by number) 0-year old fish were present, it was therefore not surprising that the 1991 pilchard catches were again reliant on the 1988/89 cohort. A similarly strong cohort sustained the industry between 1984 and 1986 (Le Clus *et al.* 1987) indicating that this situation may not be unusual.

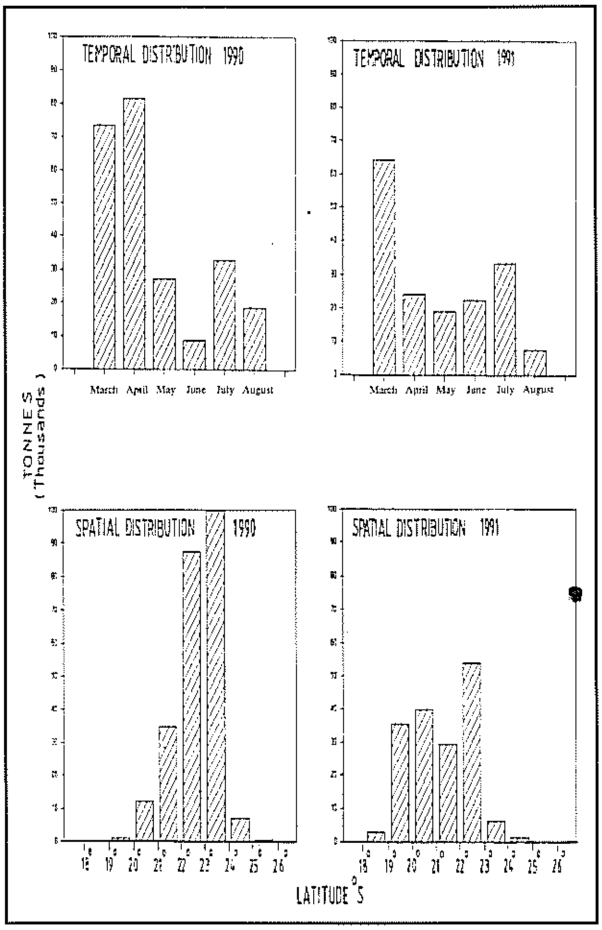

FIGURE 4: Temporal and spatial distribution of the total pelagic catch in 1990 and 1991.

The age distribution of pilchard caught over the last three decades shows considerable change from the predominantly 2-year and older fish population in the sixties (Thomas 1986), to a mixed population in the seventies (Butterworth 1980). During the eighties the population structure was dominated by 0-year old fish. Almost no 3-year or older pilchard were caught during the last decade (Le Clus *et al.* 1987) (Figure 5). There has therefore been a tendency for the development of an increasingly younger pilchard population over the last three decades. This is probably due to too high fishing mortalities during this period. Despite relatively high availability of the pilchard stock, and a reported increase in total biomass (DCB, unpub. data), the pilchard population is dominated by a single year-class and must therefore still be considered vulnerable.

Traditionally, adult anchovy are caught north of Walvis Bay early in the season, with the bulk of the anchovy catch based on the recruit run which normally peaks from July to August south of Walvis Bay. Although this trend was maintained early in the 1990 season, the recruit run failed to materialise and anchovy recruits contributed only 12% to the total number of anchovy landed. The anchovy catch consisted of predominantly 1 and 2-year old fish and for this short-lived species these relatively old fish are assumed to have suffered high natural mortality rates which resulted in a poor adult anchovy harvest early in the 1991 season. A small recruit run developed late in 1991, but still resulted in one of the lowest anchovy catches recorded since the late 1960's.

The success of the Namibian anchovy fishery is mainly determined by the strength of the recruitment run. This juvenile class normally forms the basis of the adult stock for the following year. Following the poor recruit run in 1989, the low adult harvests of 1990 and 1991 were to be expected. Conversely the correlation between the strength of recruitment and the size of the adult breeding stock has been shown to be poor for the Namibian anchovy (Le

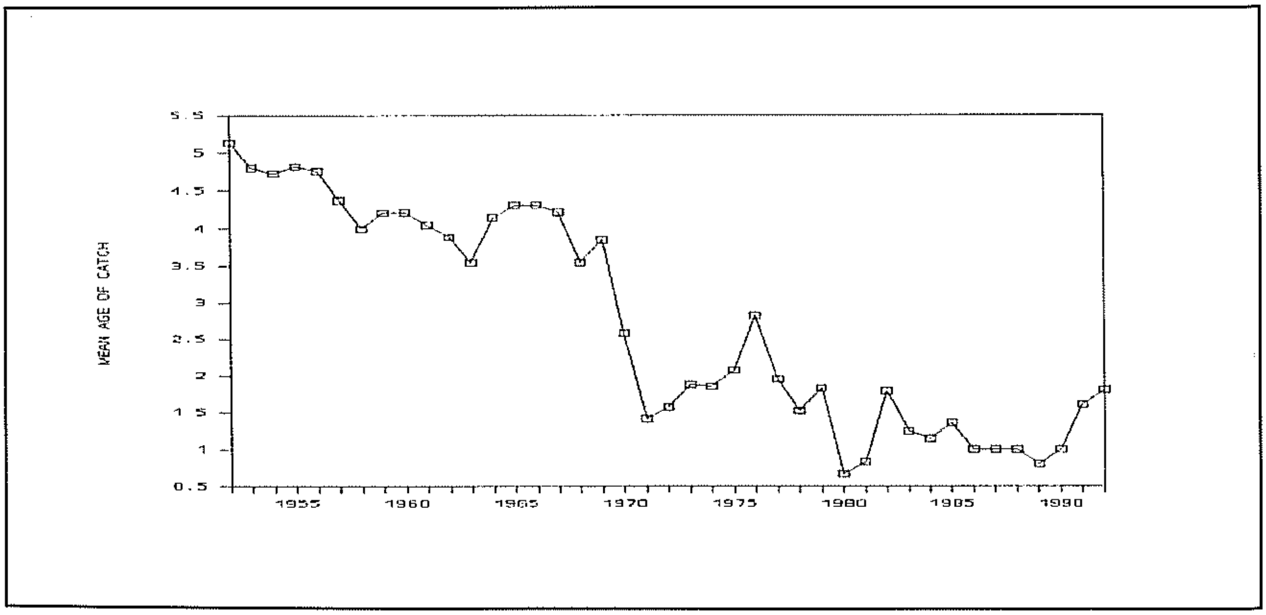

FIGURE 5: The age-distribution of pilchard catches during the last three decades.

Clus 1986), as well as for northern anchovy *(Engraulis mordax)* (Peterman *et al.* 1988). It is therefore not possible to make predictions concerning the harvest of juvenile anchovy during the latter part of the 1992 season. Further recruitment failures will, however, lead to continued reduction of the adult stock and could cause the total collapse of the anchovy fishery off the Namibian coast.

A bimodal length distribution for the Namibian pelagic horse mackerel fishery has often been recorded (Katsuyama 1984). Kenmuir and Kinloch (1985) suggested that these bimodal peaks may represent separate successful year classes. From age-length data (Katsuyama 1984), it can be deduced that the 1990 horse mackerel landings consisted of two year classes, namely 1-year old and 2-year old fish. The 1991 horse mackerel length distribution suggest that these two cohorts have converged to form one strong modal peak, but the 1990 recruit cohort was relatively weak.

Despite its relatively large contribution to the 1990 pelagic catch, catches of round herring must be considered as incidental in the Namibian pelagic fishery, due to round herring's close behavioral association with anchovy and pelagic horse mackerel.

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