CHAPTER 3 RESULTS OF THE ACOUSTIC AND TRAWL SURVEY

3.1 DISCUSSION OF METHODS

In the trawl survey programme all catches were sampled for composition in weight and numbers by species. The bottom trawl has a headline of 31m (float line), footrope 47 m, estimated headline height 5m and distance between wings during towing about 18m. Observations on the geometry of this type of trawl were made during Survey 2/90 and are described in the corresponding report. For conversion of catch rates to fish densities the area between the wings is assumed to be the effective fishing area i.e. q is equal to 1.

The problem of mid-water occurrence of hake and the effect on the swept area assessments were discussed in the report of Survey 1/91. Fish occurring above the headline of the trawl, more than 5m from the bottom must be assumed to cause an under-estimate. The extent of this behaviour seems to have varied between the surveys. Mid-water occurrence during the night has always been observed although with varying frequency. Fishing has, however, been restricted to day time as much as possible, and mid-water occurrence during the day was first found as a problem for the assessment in the northern region during the September-October survey 1990 when abundant echo traces of hake above the bottom were observed both day and night. Quantification was, however, difficult with the instrumentation then available, but the new SIMRAD EK 500 system which was taken into use in the first 1991 survey provided improved means of observing and measuring the densities of hake in mid-water. A correction for the bias in the swept area estimates was then introduced using the acoustic estimates of fish found more than 5m from the bottom. The frequent presence of spurious recordings such as of myctophids, gobies, euphaucids and others often complicates the acoustic density estimates of hakes and prevents an ordinary acoustic biomass estimate of mid water hake in the area, but wherever possible, attempts were made to separate and assess mid-water hake during trawling. A target strength used for cod was applied, (with condition factor c = 0.65):

$$TS = 20 \log l - 68.$$

The observations of mid-water occurrence of hake made since survey 1/91 show that this type of behaviour has varied considerably. In survey 1/91 the mean acoustic addition to the density indices from the swept area daylight trawl hauls was quite high, 26% and 28% for the South and Central Regions respectively and 80% for the North Region with an average of 46%. In all of the three subsequent surveys 2/91, 1/92 and 2/92 the mean acoustic additions were low, 4, 5 and 8% only as an overall mean. For the present survey, see Table 1, which is conducted at the same season as that of 1/92, January and February, pelagic occurrence was again common, with a mean acoustic correction in the northern region of 23% and an overall mean for all regions of 11%.

Table 1. Hakes. Frequency of observations of hake in mid-water during trawling. No of trawl stations with swept area densities and no. of stations with observations of hake above 5 m from bottom with acoustic density estimate. Density tonnes/nm².

ORANGE RIVER - ST. FRANCIS BAY	DAY	NIGHT
Trawl		
No. stations	48	23
Mean density	32.6	16.3
Acoustic obs.		
No. stations	14	13
Mean density	5.5	4.8
Average acou.cor.	5%	16%
ST. FRANCIS BAY - AMBROSE BAY	DAY	NIGHT
Trawl		
No. stations	47	7
Mean density	24.0	9.7
Acoustic obs.		
No. stations	19	4
Mean density	3.4	12.2
Average acou.cor.	6%	73%<
AMBROSE BAY - CUNENE RIVER	DAY	NIGHT
Trawl		
No. stations	43	12
Mean density	17.2	14.2
Acoustic obs.		
No. stations	28	8
Mean density	6.0	15.6
Average acou.cor.	23%	73%

In addition to the cases recorded come a similar number of stations where mid water occurrence was suspected, but could not be clearly demonstrated or estimated due to spurious recordings of other organisms at the critical depths.

At night much more of the hake lifts off the bottom and the acoustic density estimates then often exceed those from the swept area hauls.

The high rate of mid water occurrence observed during the present survey makes the biomass estimates less reliable and it seems probable that they have cause a negative bias and that the total stock will thus be underestimated.

3.2 SOUTHERN REGION, ORANGE RIVER TO ST. FRANCIS BAY

The complete record of the fishing stations are shown in Annex III.

Table 2 shows the catch rates standardized to kg/hour by main groups for the shelf and the slope separately. The mean catch rates for the hakes are at about the level found in survey 1/92. For monk the rates are lower than in the two previous surveys, while for kingklip and squid they remain about the same.

The depth distribution of the two hake species based on the catch rates converted to densities are shown in Table 3. For both species the densities are similar to those of the last two surveys, but with an exceptionally high value for the deep water hake in the 250-350m range. This is caused by a few very heavy catches at 340m of depth in the area off Panther Head.

The distribution of the two hake species based on plots of densities by fishing stations are shown in Figures 4 and 5. These include the acoustic estimates of fish present above the 5 m bottom channel during trawling as discussed above. The distributions of the two species are similar to those found in Survey 1/92 with relatively high densities of Cape hake extending from 25°S to about 27°S. The deep water hake shows spots of high density in the steep slope in the south towards the border.

Table 2. Southern Region. Catch rates by main groups by swept area bottom trawl for the shelf and slope.

SHELF 50-259 m

ST.NO.	DEP.	Hakes	Monk	Kingklip	Soles etc.	Squid	Other
1566	165	7.6					109.1
1567	205	190.5					21.8
1568	218	316.6					12.8
1569	87	39.3		4.8	1.2	8.2	30.7
1570	92	209.0		65.2	99.7		1188.8
1571	146	165.0	0.9	1.0	2.1	76.2	159.4
1572	173	216.2	3.2	1.8	2.1	1.1	97.9
1573	186	51.0		51.0	5.3	4.4	104.6
1577	217	115.3	21.6			8.0	427.0
1578	174	151.0		4.7		1.0	83.5
1579	160	127.8	12.2				1790.1
1580	163	267.3	0.8			19.4	437.2
1583	168	288.8	3.3				1610.1
1584	195	133.0	4.7	4.4		2.4	178.8
1585	177	124.0	14.5		1.3	2.2	182.0
1591	203	532.7			0.6	26.3	40.8
1592	121	71.0					1368.4
1594	155	406.6		76.8	4.3		18.7
1595	175	161.9		110.0	4.5		64.4
1596	181	326.3		0.3	1.8	30.6	138.7
1597	194	96.6	7.5		2.8	12.3	767.5
1598	184	1839.8					4455.6
1607	247	2743.6			1.8		27.3
1608	163	510.0					
1609	133	378.0		129.1		1.3	3.1
1611	251	2368.0					3.2
1625	189	21.0					112.2
1626	142						240.0
1627	183	14.5					581.8
1628	229	827.2			0.7		13.1
1636	151	831.1			1.2		306.6
1637	185	2157.1					107.3
1638	245	41.5				0.4	10.0
1643	239	1012.8	0.7				129.3
MEAN		524.2	2.1	13.2	3.8	5.7	437.0

SLOPE 260-650 m

ST.NO.	DEP.	Hakes	Monk	Kingklip	Soles etc.	Squid	Other
1574	381	702.1	2.8	16.4	0.6	56.1	160.0
1575	421	3631.8		45.2		4.1	13.3
1576	297	671.8	9.7	4.3		26.0	1342.7
1581	517	68.6				3.3	13.7
1582	422	14.3		2.6		1.5	1.1
1587	544	23.6	4.9			2.0	125.9
1588	445	4.6		6.2		1.0	13.1
1589	327	291.7		6.0		2.3	4.7
1590	305	1601.7		3.6		18.0	33.9
1599	340	13637.0		6.8		25.9	352.0
1601	421	943.7		25.0		20.7	79.6
1602	365	2029.8				7.0	26.9
1603	567	19.4				1.1	25.9
1604	481	347.7				7.6	15.4
1605	395	272.4	2.3	1.9		31.6	40.3
1606	321	1468.7		10.5		27.1	32.5
1612	304	169.4		87.3		1.0	2.1
1613	355	741.2		8.8		2.6	30.6
1614	392	945.8		12.8		81.0	2.5
1615	441	160.4		2.6		30.0	26.0
1616	499	158.5				32.5	61.7
1617	609	308.4				13.9	77.0
1618	573	459.2					400.0
1619	438	229.8				12.1	71.5
1620	398	693.8		15.2		17.7	147.6
1621	372	4219.4		1.7			150.0
1622	321	2172.4	3.6			22.8	2.9
1623	276	86.4		21.9	2.5		25.1
1629	336	501.4	10.9			28.2	28.4
1631	403	846.0	18.0	44.4		41.2	109.6
1633	539	540.8				68.6	388.0
1634	477	684.0				51.8	71.5
1635	402	490.0		1.1		13.4	47.8
1639	347	244.0		7.6		16.2	64.6
1640	425	530.0	9.0			33.0	81.3
1641	501	565.6				6.6	214.6
1642	299	2535.2	23.2				126.9
MEAN		1162.5	2.3	9.0	0.1	19.2	119.2

Table 3. Depth distribution of the two hake species, Orange River to St. Francis Bay. Mean densities tonnes/nm² and mean catch rates kg/hour.

	100-250m	250-350m	350-450m	450-550
Cape hake				
Density	14.2	25.7	7.2	0.3
Catch rate	430	770	220	10
Deep w. hake				
Density	0.2	44.2	26.3	10.3
Catch rate	10	1326	790	310
No. of hauls	32	12	16	9

Biomass estimates based on a poststratification of the estimated densities as shown in Figure 4 and 5, give 210 000 tonnes for the Cape and 150 000 tonnes for the deep water hake, see Table 4. These estimates are higher than those of previous recent surveys.

Table 4 Orange River to St Francis Bay. Estimates of total biomass by surveys, 1 000 tonnes.

	Cape hake	Deep water hake
1/90	130	22
3/90	130	25
1/91	113	31
2/91	80	82
1/92	200	145
2/92	160	125
1/93	210	150

The size compositions of the Cape hake from pooled samples weighted by catch rates are shown by depth ranges and total for the region in Annex I. There is as usual an increase of size with depth. The dominating cohort with a modal size around 25-26 cm must be identical to that found in this region in the October-November 1992 survey with a mode of 21-22cm.

The fishable part of the Cape hake in this region defined as fish 36cm and larger is estimated at 15% by numbers and 55% by weight. This corresponds to about 134 million fish with a biomass of 115 000 tonnes. This is an increase from about 100 million fish and 75 000 tonnes in Survey 2/92.

The recruit group of Cape hake in the 20cm range with a modal size of 25-26cm , assumed to have been spawned in 1991, has an abundance of about 670 million, about the same as estimated in the October-November 1992 survey.

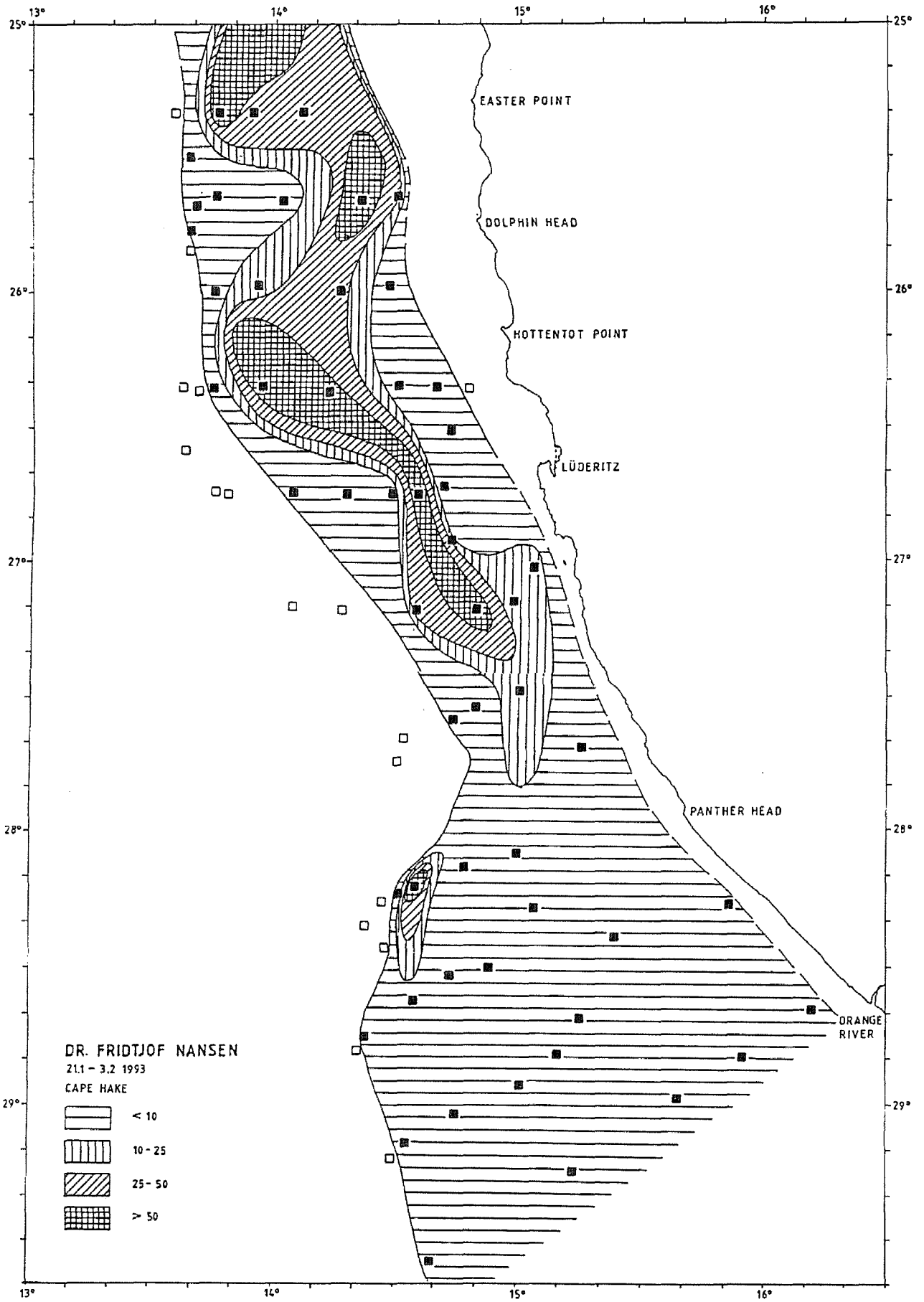

Figure 4 Orange River to St. Francis Bay. Distribution of Cape hake.

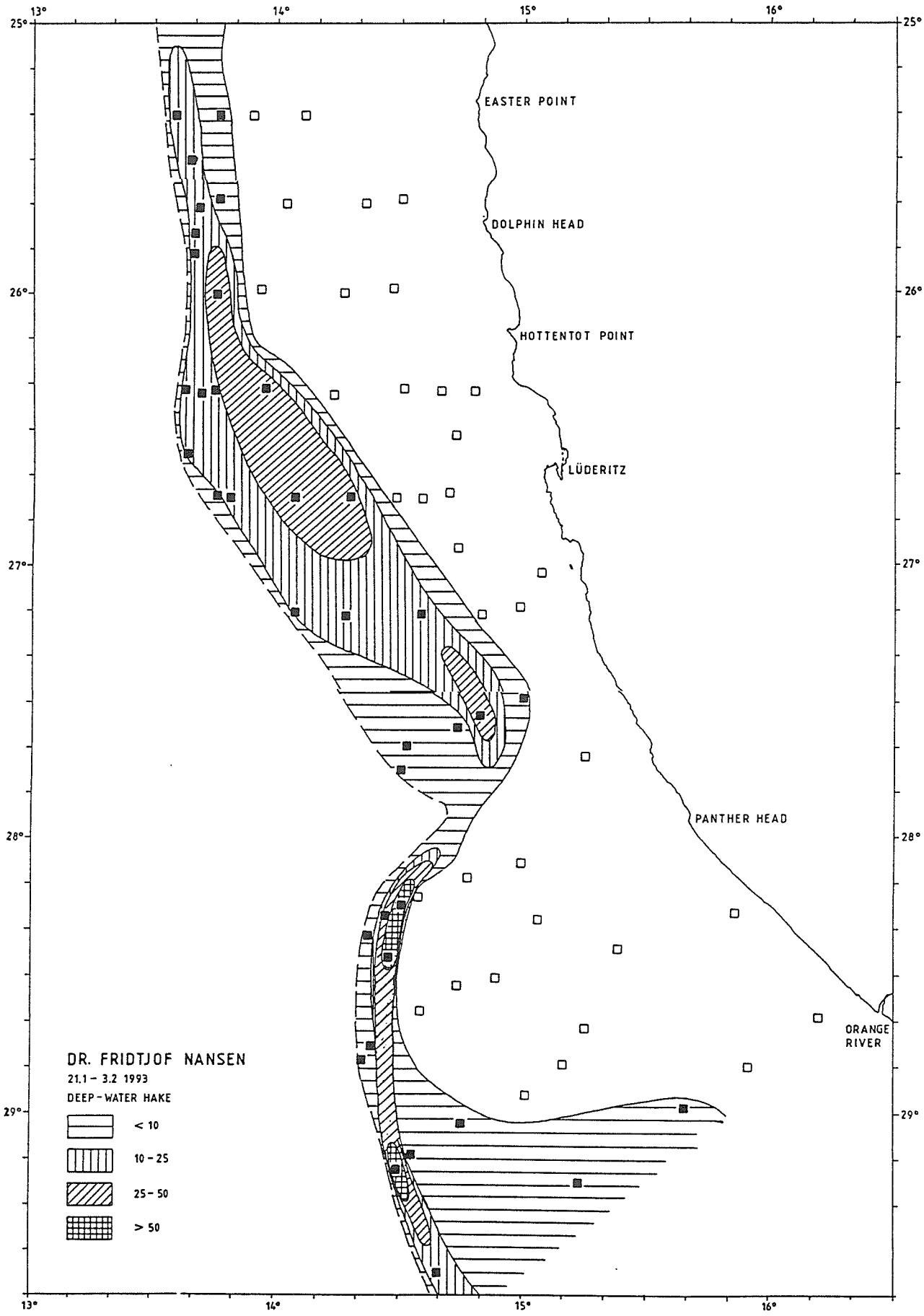

Figure 5 Orange River to St. Francis Bay. Distribution of deep water hake.

The size composition of the deep water hake, see Annex I is multimodal. The modes at 25 and 35cm can be related to those at about 20 and 30cm found in the October-November 1992 survey.

The fishable part of the stock is 53% by numbers and 82% by weight corresponding to about 200 million fish with a biomass of 123 000 tonnes.

Some sampling was made of the state of maturity of the gonads of female fish using a scale of 1-5, see Annex 2. The observations represented 19 samples with a total of 234 fish for Cape hake and 10 samples with 106 fish for deep water hake. The results can be summarized as follows:

Stage		1	2	3	4	5
Cape hake	%	6	63	27	0.1	4
Deep w. hake	%	12	76	9	0	3

For both species the majority of the fish was thus found to be in a resting condition

3.3 CENTRAL REGION, ST. FRANCIS BAY TO AMBROSE BAY

Table 5 shows the catch composition for the shelf and the slope by main groups. The mean catch rates for hake are considerably lower than those obtained in the October-November 1992 survey. The by-catch rates for monk and squid are largely unchanged from the most recent surveys.

The density by depth ranges of the two hake species is shown in Table 6. For the Cape hake there is a marked reduction in abundance in the shallow ranges compared with the findings of Survey 2/92. There is no great change for the deep water hake.

Table 5. Central Region. Catch rates by main groups in swept area bottom trawl hauls, kg/hour.

SHELF: 100-259m

ST.NO.	DEP.	Hakes	Monk	Kingklip	Soles	Squid	Other
1645	161	970.66	0.50		16.80	1.60	573.20
1646	200	2113.46				2.30	701.04
1649	257	292.20	22.20	0.44			113.68
1653	207	343.00			2.46	2.80	44.70
1657	214	211.40	1.30				535.92
1661	122	33.60					177.92
1662	163	2487.84					5.18
1663	170	5125.12				1.40	83.42
1664	214	430.80	1.86				30.58
1669	259	546.40	11.86				100.88
1670	157	953.07	22.50		88.13		356.44
1671	151	2240.00					12.00
1672	134	1786.40			13.40	16.24	8.96
1673	143	759.90	32.88		3.96	12.96	127.68
1674	258	221.80	5.64			1.10	156.64
1679	179	2161.12	14.40			4.64	3231.20
1680	129	1390.08			2.40	3.36	31.84
1681	122	900.00					
1682	122	21.88				0.18	6.02
1683	135	354.71			0.79	0.50	92.67
1684	198	386.84			4.97	4.13	229.56
1685	249	913.76	3.06			1.12	284.02
1690	191	391.08	0.08			3.60	124.70
1691	153	309.74	5.66			1.76	15.06
1696	172	546.35					240.89
1697	147	643.06	0.54		13.00		53.54
1700	203	490.91					4707.27
1701	121	412.16					25.76
MEAN		979.91	4.37	0.02	5.21	2.06	431.10

SLOPE 260 - 650m

ST.NO.	DEP.	Hakes	Monk	Kingklip	Soles	Squid	Other
1647	351	267.60	4.54	3.60		60.24	317.36
1648	300	162.34	17.96			2.10	124.84
1650	328	262.66	19.60				196.24
1651	395	297.00	1.44	1.14		12.94	64.48
1652	502	221.20		0.60		14.60	77.52
1654	277	136.80	0.80			2.66	103.94
1655	312	152.16	4.50				145.30
1656	272	206.07	6.38				221.25
1658	562	83.44	4.13	0.94			325.08
1659	344	189.76					118.00
1660	277	251.57	1.14			3.79	73.66
1665	295	360.10					111.96
1666	493	325.08	1.72	1.06		8.60	119.72
1667	602	29.20				9.80	120.44
1668	405	227.54	1.64	0.16		5.38	78.66
1675	354	353.65	9.93	4.55			34.48
1676	503	71.86	4.84			15.33	137.13
1677	304	280.00					85.06
1678	270	140.60	3.52			2.84	142.68
1686	319	304.00	5.60			8.72	323.16
1687	150						
1688	352	435.60	5.96			9.99	167.83
1689	308	543.64	1.11			2.49	54.77
1692	300	790.16				3.88	157.96
1693	499	93.90				14.42	261.90
1694	370	805.94				40.26	123.80
1695	278	326.52				14.48	140.65
1698	360	140.50				5.78	57.72
1699	293	191.60	2.20	0.08		1.22	74.66
MEAN		263.81	3.35	0.42		8.26	136.56

Table 6 Depth distribution of the two hake species St. Francis Bay to Ambrose Bay. Mean densities: tonnes/nm² and mean catch rates, kg/hour.

	100-250m	250-350m	350-450m	450-650m
Cape hake				
Density	34.1	9.5	8.9	0.3
Catch rate	1 020	285	265	10
Deep w. hake				
Density		0.3	2.8	4.3
Catch rate		10	85	130
No. of hauls	25	18	7	6

Figure 6 shows the distribution of Cape hake over this region. This has the same main features as that of the last survey, but the belt of high density towards the coast is drastically reduced.

The size composition of pooled samples of Cape hake from fishing stations weighted by the catch rates are shown by depth ranges and for the total region in Annex I. The juvenile group dominates in the shallow range with a modal peak length of about 24cm as compared with a 22cm mode in the last survey. In deeper waters an increase of the lowest mode can be recorded from 25-30cm to 30-35cm.

The biomass estimate of Cape hake for this region based on the post stratification shown in Figure 6 is 280 000 tonnes. The fishable part of this, measured as fish of 36cm and larger is 10% by number and 54% by weight corresponding to about 145 million fish with a biomass of 150 000 tonnes. As shown in Table 7 this surveys biomass estimate of hake in the central region is only about half of that of Survey 2/92. The main decline is found in the juvenile component, fish smaller than 36cm which is now estimated at about 130 000 tonnes compared with 370 000 tonnes in November 1992. The cause of this decline is uncertain. It seems unlikely that survey variability or emigration can be the explanation. Cannibalism could account for some decline, but hardly this drastic reduction. A possible cause could be shoreward displacement of oxygen deficient water which is known to occur in the mud belt where much of the juvenile hake is found and which may cause mass mortality oof fish..

There has been i minor decline in the adult fishable stock of Cape hake in the Central Region which now is 150 000 tonnes compared with about 180 000 tonnes in the last survey. This could be explained by migration towards the South Region where the biomass has increased. There was a tendency for the large sized fish to be found at shallower depths than previously and mixed with juvenile hake.

The deep water hake was found in a narrow belt along the slope at 350-550m of depth. The size composition , see Annex I, shows modal peaks at about 32cm and 47cm compared with 29cm and 44cm in the previous survey. Of the 12 000 tonnes biomass 48% by numbers and 74% by weight was of fishable size.

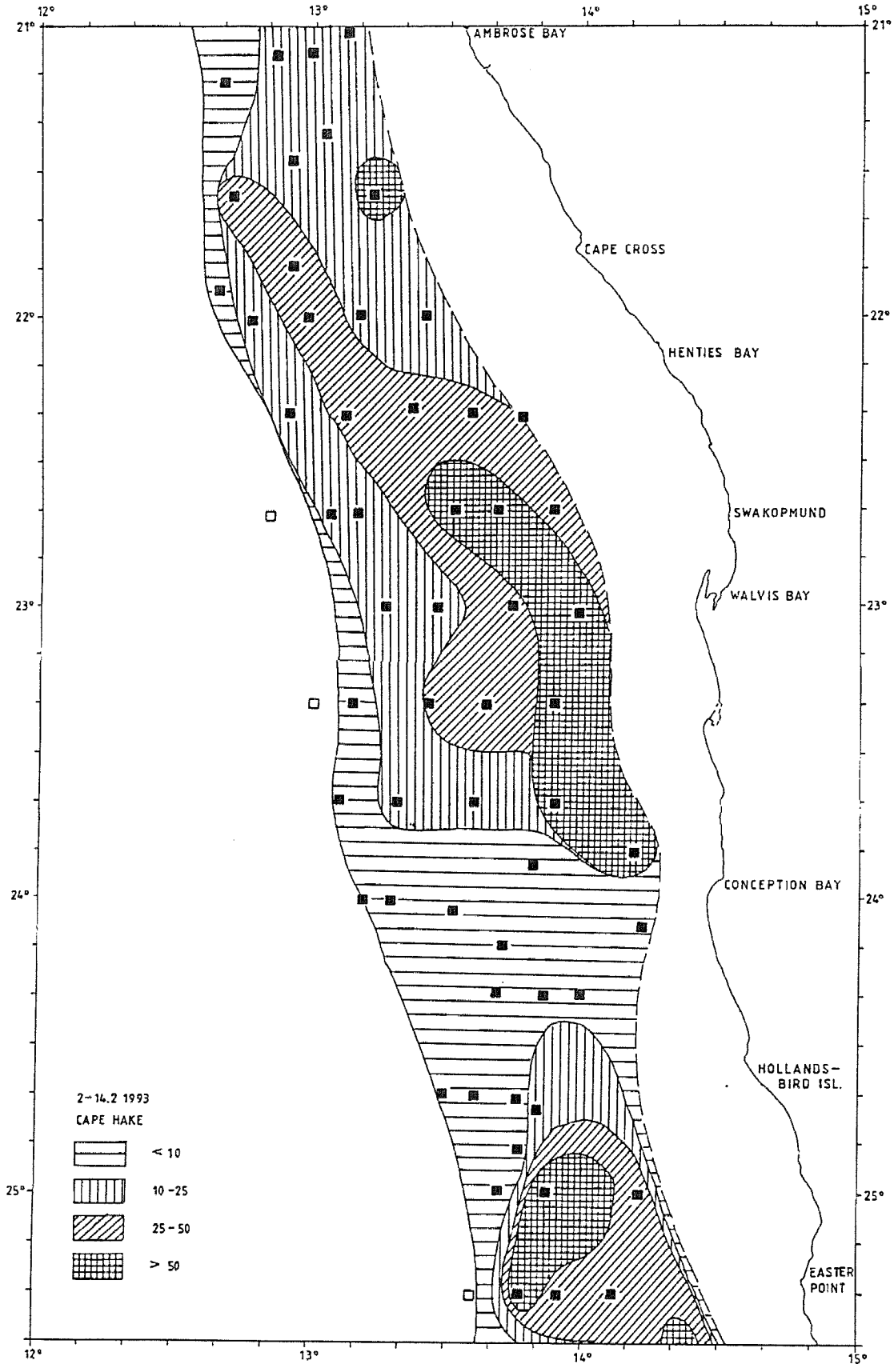

Figure 6 St. Francis Bay to Ambrose Bay. Distribution of Cape hake.

Table 7 Central Region. St Francis Bay to Ambrose Bay. Estimates of total biomass by surveys, 1 000 tonnes.

	Cape hake	Deep sea hake
1/90	180	4
3/90	219	6
1/91	150	6
2/91	302	13
1/92	261	15
2/92	542	15
1/93	280	12

Maturity sampling of female fish of Cape hake of 30-70cm of length from 14 stations comprising 449 observations showed the following state:

Maturity stage:	1	2	3	4	5	
%		9	32	24	27	8

This indicates that about 50 % of the adult fish in the Central Region was in a spawning or prespawning condition with the main other part resting.

3.4 NORTHERN REGION, AMBROSE BAY TO CUNENE RIVER.

Table 8 shows the catch rates by main groups for the shelf and slope separately. The mean rate for hake is lower on the shallow shelf than that of the two previous surveys. The rates for monk shows a slight increase as does those for squid in the slope. The abundance of the dentex will probably vary with the season.

Table 8 Northern region. Catch rates by main groups in bottom trawl hauls standardized to kg/hour.

SHELF 100-259 m

ST.NO.	DEP.	Hakes	Monk	Dentex	Horse mck.	Squid	Other
1701	121	412.16					25.76
1702	112	16.00					117.60
1703	157	506.00	0.36				56.28
1704	259	140.22	1.16		2.50		24.37
1708	213	978.00		272.00	49.20		21.20
1709	152	17.40		0.32	0.70		11.94
1710	123	186.80			4.02		2.82
1711	156	210.12			49.20		15.24
1712	225	171.75			888.39	0.52	81.87
1715	198	82.40	0.16	1.00	2.30	0.04	26.54
1721	249	183.40			44.00		26.88
1722	191	125.70				0.18	41.10
1723	226	3.92			2.36	0.04	65.22
1730	132	80.70		3.24	24.00		4.86
1731	159	100.45		84.48	12.10	0.77	28.33
1732	223	397.40			98.00		32.20
1738	249	482.65		59.15	5.26		425.03
1739	158	1585.16		34.22	432.77		
1740	171	573.00			949.60	30.40	275.40
1741	164	243.28		138.00	229.00	9.60	317.20
1742	248	586.07		68.28	17.75	8.82	310.46
1748	162	629.40		86.80	243.00		6.14
1749	165	2064.96		480.60	92.34		765.18
1750	169	418.52		611.46	171.66	6.06	1257.52
1753	151			819.72	5179.80	1.32	
1755	195	658.07		661.94	836.13		33.45
MEAN		417.44	0.06	127.74	359.00	2.22	152.79

SLOPE 260-700m

ST.NO.	DEP.	Hakes	Monk	Dentex	Horse mck.	Squid	Other
1705	316	129.10	30.30	7.06			21.90
1706	398	134.50	0.98			2.40	40.72
1707	303	357.37		45.38		0.84	7.13
1713	275	22.80	1.16				54.05
1714	314	285.09	0.54	53.81	2.63	0.23	186.89
1716	321	466.00	12.00	2.48	1.40		57.50
1717	494	44.32				5.22	129.42
1718	379	600.56				13.62	188.66
1719	333	3841.60	2.36	5.48		4.24	71.56
1720	301	741.00	2.42	1344.00	448.00		
1724	327	476.14	3.84	38.20	2.28	1.48	64.92
1725	373	110.12				0.74	54.60
1726	451	154.26	10.60			10.24	202.84
1727	352	774.02				13.96	127.66
1728	327	364.96	0.68	2.32		2.04	177.38
1729	290	82.00	1.08	34.64			154.68
1733	287	721.82		102.91		1.16	5.67
1734	300	918.00		80.00	3.84	2.56	161.84
1735	328	419.60	4.76			31.40	104.68
1736	409	384.91	0.72			39.91	308.87
1737	441	449.47	10.41		4.05	59.63	264.05
1743	331	139.24	0.17		3.10	3.85	351.81
1744	612	349.44				8.96	168.80
1747	297	768.80	28.20			1.80	225.40
1751	308	1044.80			1.44	0.40	14.44
1752	267	2593.55	8.42	8.71	8.90	3.48	145.84
1756	300	372.00			5.40	10.10	334.60
1757	401	878.48	51.84			62.87	451.11
1758	496	381.40					173.00
MEAN		623.87	5.88	59.48	16.59	10.72	155.58

Table 9 shows the depth distribution of the hakes. There is a decrease in the rate for Cape hake in the shallow range. The highest density was now found in the 250-350m range, but the distribution extended below 500m.

Table 9 Depth distribution of the hake species, Ambrose Bay to Cunene River. Mean densities: tonnes/nm² and mean catch rates, kg/hour.

	100-250	250-350	350-450	450-550	550-650	650-750
Cape hake						
Density	13.7	23.2	14.7	2.8	0.2	
Catch rate	410	700	440	84	6	
Deep w.hake						
Density			0.8	3.4	6.1	0.2
No of hauls	24	19	7	3	2	1

Figure 7 shows the distribution of Cape hake in the northern region by levels of density calculated from the catch rates and with adjustments for fish in mid-water. The pattern of distribution is similar to that found previously in this region with bands of high density in deeper waters extending right up to Cunene. There was also an area of relative high density of juvenile fish north of Cape Frio. These fish were mixed with horse mackerel and dentex.

Biomass estimates give a total of 150 000 tonnes, see Table 10 with a fishable part (36cm and larger) of 113 000 tonnes representing 140 million fish, a decline of about 30 000 tonnes compared with the last surveys. It seems probable, however, that the biomass is underestimated in this survey due to the high occurrence of hake in mid-water.

The size compositions of the Cape hake is shown in Annex I. The group with a mode at about 27cm is assumed to be identical with the cohort with a mode of 24-25 cm in October-November. In that survey its numerical abundance was estimated at 310 million compared with a present estimate of 270 million fish. A group around 40cm can also be identified, presumably corresponding to the 1990 yearclass. Because of the process of depth related size of hake the modal length of these larger fish can not be used for growth estimation or for simple identification of cohorts.

Table 10 Northern Region, Ambrose Bay to Cunene. Estimates of total biomass by surveys. 1 000 tonnes.

	Cape hake	Deep sea hake
1/90	180	
3/90	105+ midw.	
1/91	200	
2/91	140	2
1/92	185	4
2/92	190	8
1/93	150	4

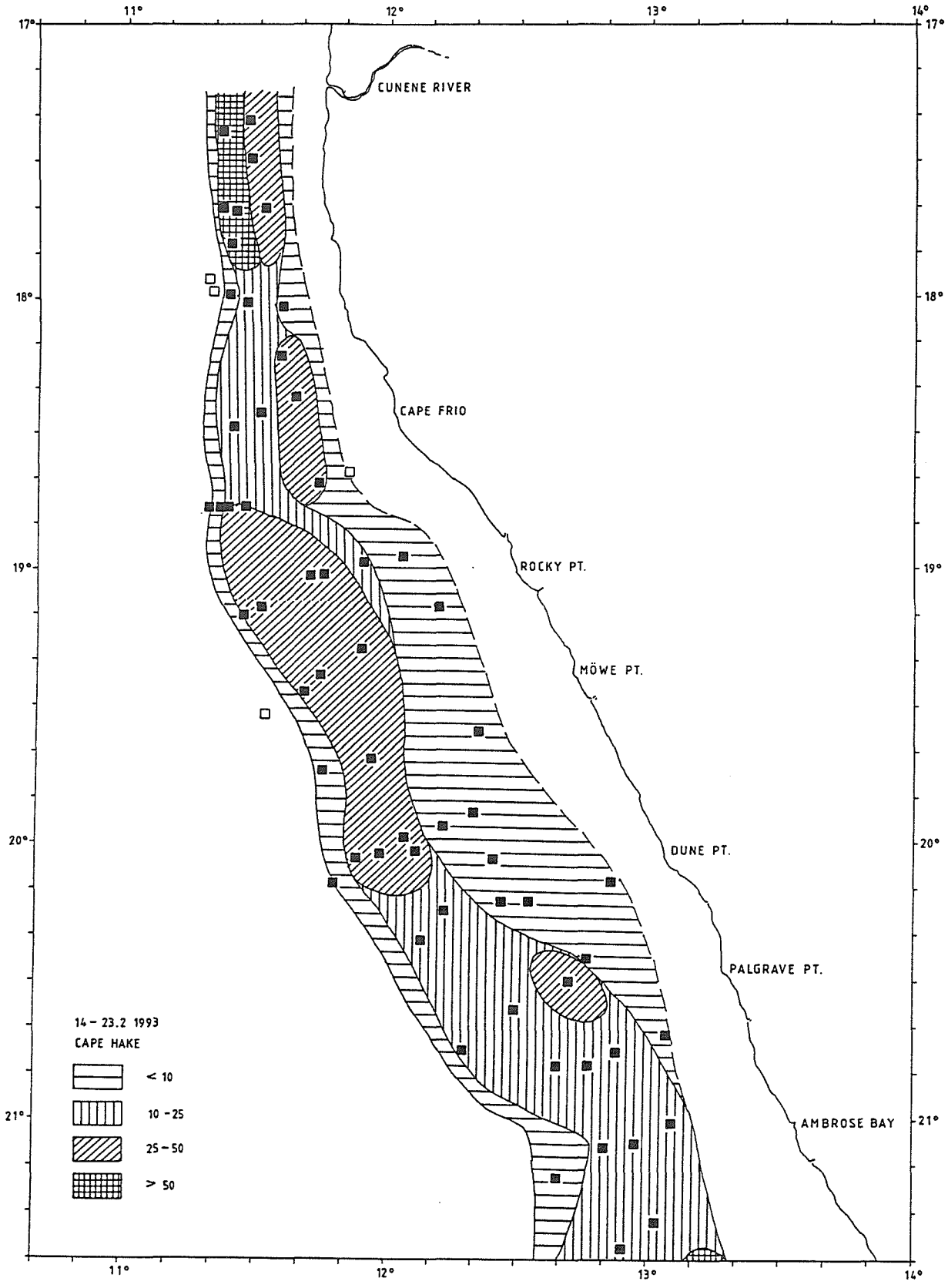

Figure 7 Ambrose Bay to Cunene River. Distribution of Cape hake.

Maturity sampling of a total of 806 female fish of Cape hake of 30-70cm of length from 18 fishing stations spread in the region showed the following state:

Maturity stage:	1	2	3	4	5
%	15	72	10	2	1

This indicates that the adult fish in the northern region is in a resting stage. Similar observations from previous surveys seem to demonstrate that this northern region represents a feeding area for the hake.

CHAPTER 4 CONSIDERATIONS OF THE SURVEY RESULTS

The present survey is the 7th in a series started in early 1990 and in each of which the distribution of the hake stocks over the whole Namibian shelf has been covered. Table 11 shows the effort that has been spent in these hake investigations. The mid-water behaviour of the hake caused a problem of biomass estimate in survey 3/1990. Improved acoustic instrumentation alleviated that problem in the subsequent surveys, but in survey 1/1993 this behaviour is again thought to have caused some underestimate of biomass, especially in the northern region.

Table 11 Effort in Namibian hake surveys 1990-1991. Number of swept area fishing stations, number of samples (mostly by sex) and number of length measurements in thousands.

Survey		Orange R.- St. Francis	St. Francis Ambrose	Ambrose-Cunene	Total
1/1990					
25/1-10/3	No. stations	59	73	37	169
	" samples	37	73	25	114
	" measured	6.0	10.7	2.6	18.6
3/1990					
11/9-6/10	No. stations	44	51	34	129
	" samples	68	106	77	251
	" measured	9.3	10.3	5.6	25.2
1/1991					
25/1-28/2	No. stations	41	77	56	174
	" samples	104	170	114	388
	" measured	6.8	13.3	6.9	27.0
2/1991					
23/10-21/11	No. stations	52	69	49	170
	" samples	110	132	110	352
	" measured	7.1	14.3	9.6	31.0
1/1992					
23/4-21/5	No. stations	57	60	47	164
	" samples	136	141	102	379
	" measured	9.0	11.2	8.2	28.4
2/1991					
20/10-1/12	No. stations	64	78	50	192
	" samples	188	169	143	500
	" measured	13.1	13.4	7.8	34.3
1/93					
20/1-25/2	No. stations	72	56	56	184
	" samples	197	162	118	477
	" measured	12.7	11.9	7.6	32.2

The trends in the findings for the deep water hake seems to indicate that this stock has received parts of its recruitment from areas outside the Namibian EEZ. This is evidently not the case for the Cape hake where recruitment cycles can be observed and described.

A summary of the estimates of the mean density of the hakes by depth strata is shown in Table 12. The difference in depth distribution between the two species is clearly demonstrated especially in the southern region where the deep water hake has its highest abundance. There as been a change in density by depth over the survey period with increasing densities at greater depths. This demonstrates an increasing amount of large sized hake in the stocks. For the Cape hake the density in the shallow range, 100-250m is mainly determined by the abundance of the young recruits, fish of less than about 30 cm of length which is restricted to a depth range of about 130 to 200-250m. In the central region densities were high in this range in the two surveys in 1992 and also in the northern region in survey 2/1992, but with a marked decline in survey 1/93.

Table 12 Depth distribution of the hake species. Mean densities in tonnes/nm^2.

	100-250m	250-350m	350-450m	450-550m
SOUTHERN REGION				
Cape hake				
1/90	21.9	4.4		
3/90	11.5	6.1	0.1	
1/91	11.3	8.8	0.9	
2/91	6.3	12.5	0.7	0.7
1/92	12.6	28.4	4.6	
2/92	11.6	12.2	1.1	0.2
1/93	14.2	25.7	7.2	0.3
Deep water hake				
1/90		1.4	5.0	1.2
3/90	0.1	6.3	1.2	0.4
1/91		4.4	6.0	1.1
2/91	0.3	8.9	14.9	4.9
1/92		8.9	34.8	4.0
2/92	1.7	7.9	23.8	14.2
1/93	0.2	44.2	26.3	10.3
CENTRAL REGION				
Cape hake				
1/90	27.1	7.4	0.4	
3/90	38.6	8.3	2.5	
1/91	14.5	9.1	2.2	
2/91	34.2	19.0	7.2	1.0
1/92	36.5	14.6	8.5	1.7
2/92	53.6	20.1	10.5	0.8
1/93	34.1	9.5	8.9	0.3
Deep water hake				
1/90			1.6	1.4
3/90	0.2	0.4	0.9	0.9
1/91	0.2	0.1	0.8	
2/91		0.3	5.3	5.6
1/92		1.3	6.8	1.6
2/92		0.3	3.1	4.1
1/93		0.3	2.8	4.3
NORTHERN REGION				
Cape hake				
1/90	41.3	20.9	1.0	
3/90	25.9	15.1		
1/91	15.0	27.0	11.5	
2/91	13.6	23.5	24.3	4.3
1/92	25.4	26.1	15.5	
2/92	29.6	18.6	17.6	
1/93	13.7	23.2	14.7	2.8

Table 13 shows the biomass estimates for the two stocks by regions and the corresponding data for the six previous surveys. The most remarkable finding of the present survey is the decline of the total biomass of the Central Region from the Oct-Nov 1992 results from 540 000 tonnnes to 280 000 tonnes. As discussed above this consists mainly in a reduced abundance of recruit fish below 36cm of length from a level of 370 000 tonnes in the last survey to 130 000 tonnes at present. Some survey variability may be involved, but the charts of biomass distribution show clearly that the extended inshore high density area of juveniles of the Oct-Nov 1992 survey is now greatly reduced and the mean catch rates from the shallow part of the central region dropped correspondingly. The reduction by number is some 2 000 million fish and there is no increase of juveniles in the other regions. Predation by cannibalism and otherwise could not account for this level of reduction and mass mortality caused by environmental disruptions seems the most likely cause. Intrusion of upwelled oxygen deficient water onto the shallow shelf is known to occur in this region.

Table 13 Summary of estimates of biomass of the two hake species by surveys and areas. 1000 tonnes.

	TOTAL BIOMASS						
	Feb-Mar 1990	Sept-Oct 1990	Jan-Feb 1991	Oct-Nov 1991	Apr-May 1992	Oct-Nov 1992	Jan-Feb 1993
SOUTH REGION							
Cape hake	130	130	126	80	200	160	210
Deep w.hake	22	25	31	83	145	125	150
CENTR.REGION							
Cape hake	180	219	150	302	261	542	280
Deep w.hake	4	6	6	13	15	15	12
NORTH REGION							
Cape hake	180	105*	200	140	185	190	150
Deep w.hake				2	4	8	4
TOTAL	516		513	620	810	1040	810
TOT.FISHABLE	220		300	370	503	490	520

Otherwise the present survey describes a state of the hake stocks similar to that of survey 2/92 with a total biomass of well over 800 000 tonnes and a fishable stock of about 500 000 tonnes. This probably represents an underestimate due to the frequent mid-water occurrence of the fish. There is an increase in the fishable stock in the southern region.

The bulk of the biomass of deep water hake is as previously found in the southern region. The stock estimate of about 160 000 tonnes is about the same as in Apr-May 1992.

The recruitment to the stock of Cape hake can be estimated from the numerical abundance of the 2 year old fish. The estimates for the 1991 yearclass based on the current survey data are shown in Table 14 together with previous observations. For the southern and northern

regions the new estimates of the 1991 yearclass are close to those of Oct-Nov 1992, but for the Central Region it is as discussed above reduced by some 60%. The 1991 yearclass is still at the same level of abundance as those of 1988 and 1990.

Table 14 Estimates of strength of recent yearclasses of Cape hake. Cohort population numbers at about two years of age for the groups assumed to have been spawned in 1988, 1989, 1990 and 1991. Millions of fish.

Yearclass	1988	1989	1990	1990	1991	1991
Region south	980	100	160	300	680	670
centre	1 320	170	1710	1620	3500	1230
north	10	10	20	240	310	270
Total	2 310	280	1890	2160	4490	2170
Survey/Year	1/90	1/91	2/91	1/92	2/92	1/93

Examination of gonad stages of adult female Cape hake in samples from all the three regions showed that the fish was predominantly in a resting stage in the southern and northern regions while about half of the fish in the central region were in a prespawning or spawning stage.