CHAPTER 3 RESULTS OF THE TRAWL SURVEY

3.1 DISCUSSION OF METHODS

A description of the fishing gear and the acoustic instruments and their state is shown in Annex III.

In the trawl survey programme all catches were sampled for composition in weight and numbers by species. The bottom trawl has a headline of 31 m (float line), footrope 47 m, estimated headline height 5 m and distance between wings during towing about 18 m. 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 previous reports. Fish occurring above the headline of the trawl, more than 5 m from the bottom, must be assumed to cause an underestimate. The extent of this behaviour have varied between the surveys. Mid-water occurrence during the night has previously been observed but with varying frequency, and therefore fishing has been restricted to day-time as much as possible. Mid-water day-time occurrence has previously been found as a problem for the assessment, mostly in the northern region. A correction for the bias in the swept area estimates has since January 1991 been applied, using the acoustic estimates of fish found more than 5 m from the bottom. In this procedure a target strength used for cod was applied: TS = 20 log l - 68.

Table 1 shows the observations and measurements of density of fish in mid-water during trawling in this survey. The extent of mid-water occurrence during daytime is seen to be low in all three regions, and the average acoustic correction is about 9%, 5% and 10% in the southern, central and northern regions respectively.

3.2 SOUTHERN REGION, ORANGE RIVER TO ST. FRANCIS BAY

The complete record of the fishing stations is shown in Annex II.

The catch compositions are shown in Table 2 which lists the catch rates standardized to kg/hour by main groups for the shelf and the slope separately. The mean catch rate for hake on the shelf is on the same level as during the previous survey in May 1992. The hake mean catch rate on the slope hauls has a high statistical variance in both surveys and part of this

difference can be associated low statistical precision. Kingklip catch rates are higher than in November 1991, but below the promising rates of May 1992. Monk rates are back to the level of November 1991, after a sudden increase in May 1991. It should be noted that both kingklip and monk show a patchy distribution, giving very high variance in the regional mean catch rates.

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/nm^2.

ORANGE RIVER - ST. FRANCIS BAY	DAY	NIGHT
Trawl		
No. stations	49	15
Mean density	18.0	13.2
Acoustic obs.		
No. stations	11	4
Mean density	6.8	3.1
Average acou. corr.	9%	6%
ST. FRANCIS BAY - AMBROSE BAY	**DAY**	**NIGHT**
Trawl		
No. stations	64	13
Mean density	35.0	12.7
Acoustic obs.		
No. stations	23	6
Mean density	5.0	7.8
Average acou. corr.	5%	28%
AMBROSE BAY - CUNENE RIVER	**DAY**	**NIGHT**
Trawl		
No. stations	50	0
Mean density	23.5	
Acoustic obs.		
No. stations	21	0
Mean density	5.8	
Average acou. corr.	10%	

The depth distribution of the two hake species, expressed by catch rates converted to densities, are shown in Table 3. The mean density of cape hake on the shelf (100-250m) is about the same as in May, while at the slope the density is reduced. Contrary to findings of previous surveys the mean density is about the same in the 100-250m and in the 250-350m depth zones, but this is associated with different cohorts in the two habitats with younger fish on the shelf. The deep water hake has it highest density in the 350-450m bottom depth zone as previous, but the density is reduced compared to May 1992.

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

SHELF 50-259 m

ST.NO.	DEP.	Hakes	Monk	Kingklip	Soles etc.	Squid	Other
1328	165	382.4					110.6
1329	205	423.3					9.3
1330	210	168.4		6.0		3.2	27.4
1332	98	84.0		70.0	33.0	4.9	515.8
1333	151	64.2	1.9			16.3	66.9
1334	175	256.9	0.7	1.0	0.9	31.6	70.4
1335	176	162.4		67.7	6.5	0.5	77.0
1340	212	121.1	6.5		0.5	0.9	87.9
1341	173	133.7	15.2	0.3	1.4	27.0	55.9
1342	159	159.4	3.5		4.0	24.0	75.2
1343	176	112.0	0.9	1.4	1.6	1.0	19.3
1344	89	144.8		150.0	0.5	1.0	54.8
1345	171	297.1	1.4		1.5	11.2	136.7
1346	177	180.2	6.2		2.8	26.9	66.4
1347	193	458.9				16.7	256.7
1348	168	49.3				0.7	105.0
1352	211	231.2					83.4
1353	193	379.0				15.2	324.8
1354	176	339.3				7.3	22.5
1360	200	419.9				7.3	633.6
1361	148	322.6				3.2	104.5
1370	175	648.0					112.8
1371	127	485.5		13.9			10.9
1372	170	547.2				2.2	121.8
1383	159	1461.5					46.8
1390	242	1414.8					162.0
1391	165	568.6					112.6
1392	119	352.9					721.6
1393	175	1789.8					101.4
MEAN		419.3	1.3	10.7	1.8	6.9	148.1

SLOPE 260-650 m

ST.NO.	DEP.	Hakes	Monk	Kingklip	Soles etc.	Squid	Other
1336	383	226.0	1.9	7.0		7.4	29.7
1337	544	28.6				2.5	45.6
1338	412	236.7	9.9	7.5	0.4	8.7	12.8
1339	292	1053.4		7.6		2.6	1086.4
1349	584	473.9		3.9		12.2	113.6
1350	435	1321.1		71.8		25.5	78.8
1351	325	902.4		77.8		12.5	32.0
1355	601	349.6				4.9	202.6
1356	491	529.6				15.0	112.3
1357	395	728.7		14.3		31.3	131.7
1358	330	692.8				17.2	126.4
1359	298	75.0		8.9			764.4
1362	316	581.1	2.5	15.0			36.8
1363	385	1157.0					166.8
1364	496	294.0				6.3	69.4
1365	599	130.2				28.6	238.9
1366	445	431.0		2.0		4.3	72.7
1367	397	979.2	36.0	6.4		14.0	98.3
1368	351	887.7				17.1	115.6
1369	280	268.4		133.8		4.3	26.3
1373	264	371.3	13.1		1.0	3.3	66.4
1374	307	765.6	12.2	1.7		0.4	89.1
1375	372	1231.9				20.9	136.9
1376	437	685.0				17.7	134.4
1377	560	785.4	21.2			22.1	665.2
1378	599	1539.6				303.0	776.7
1379	501	406.6	42.4			26.0	228.7
1380	401	509.2				5.9	128.6
1381	349	321.8	7.2	1.7		4.4	106.1
1382	277						
1384	341	605.8	3.0	20.4		1.6	101.2
1385	435	809.0	6.5			20.1	106.8
1386	643	63.5				81.3	255.2
1387	542	164.8				107.9	344.5
1388	450	487.8				14.0	253.3
1389	307	1264.8					79.4
MEAN		593.3	4.3	10.6	0.1	23.4	195.4

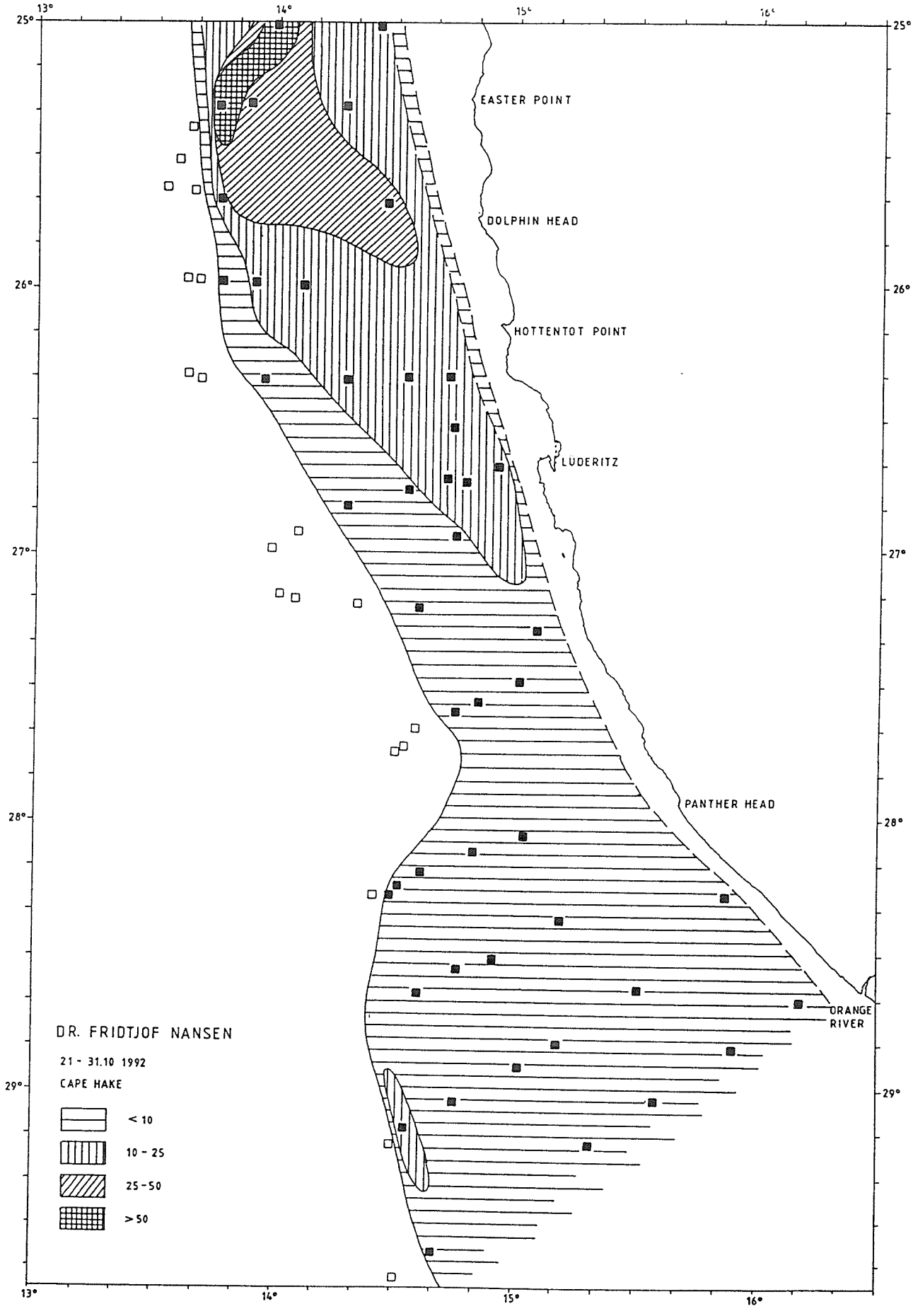

Figure 4. Southern Region. Distribution of Cape hake.

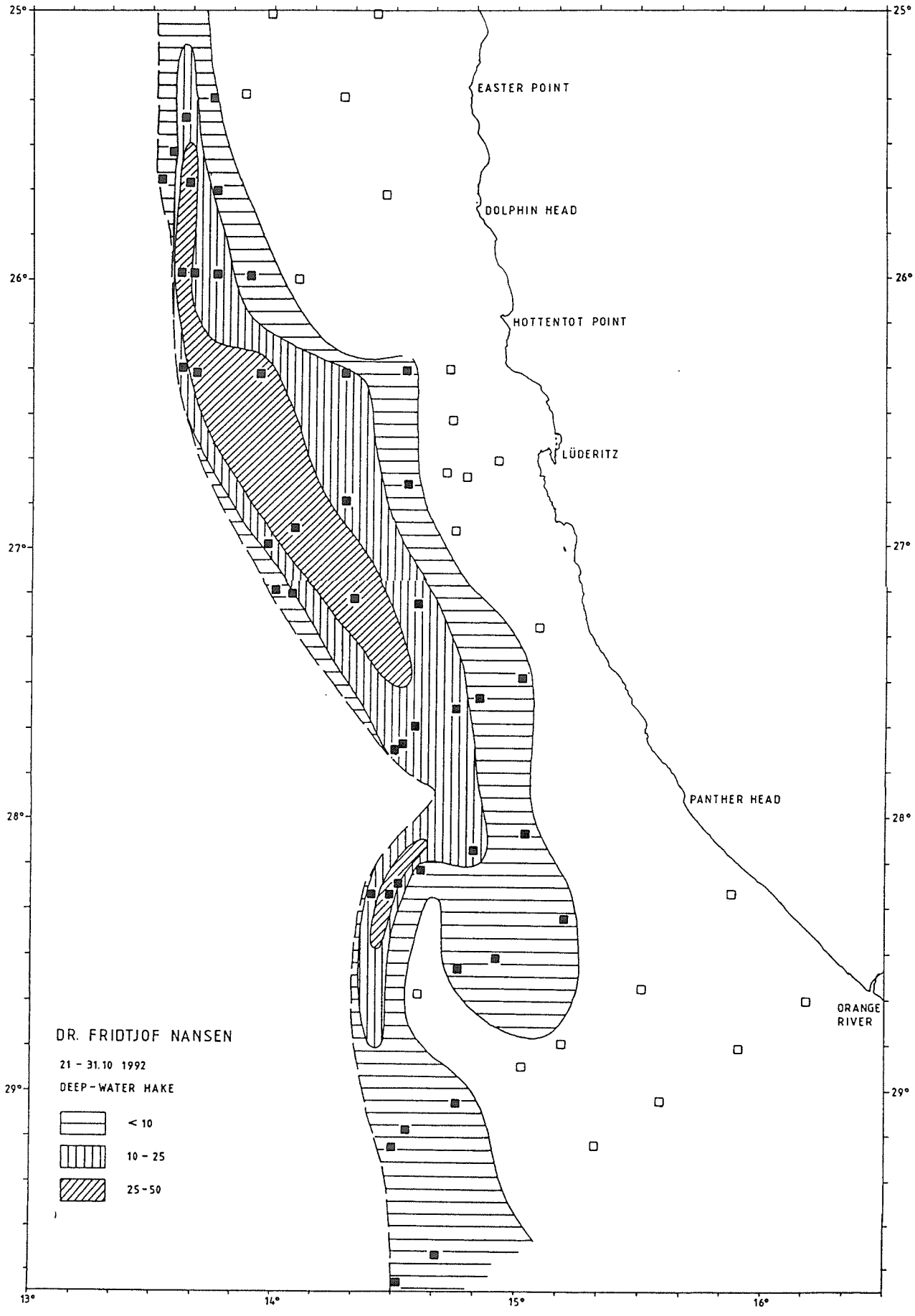

Figure 5. Southern region. Distribution of deep water hake.

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.

	100-250 m	250-350 m	350-450 m	450-550 m	550-650 m
Cape hake					
Density	11.6	12.2	1.1	0.2	
Catch rate	350	370	30	5	
Deep w. hake					
Density	1.7	7.9	23.8	10.1	18.2
Catch rate	50	240	710	300	550
No. of hauls	29	11	12	6	6

The distribution of the two hake species based on plots of densities by fishing stations is shown in Figure 4 and 5. The densities include the acoustic estimates of fish present above the 5 m bottom channel during trawling as discussed above. The Cape hake was only found in low densities south of Lüderitz, a picture consistent with the findings of the three previous surveys. In 1990 however, aggregations of cape hake was found also in the south during two surveys. The distribution of deep water hake follows the same pattern as found during the two previous surveys, with an aggregation between 26° and 28°S.

Biomass estimates based on a post-stratification of the estimated densities, as shown in the figures of fish distribution, give 160 000 tonnes for the Cape hake and 125 000 tonnes for the deep water hake, Table 4. This is a reduction of 40 000 and 20 000 tonnes for the respective two species compared to the previous survey in May. The 95% confidence limit gives a range of ± 14% on the Cape hake estimate.

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

The size compositions of the Cape hake are shown in Annex I. On the shelf (50-260m) the dominating cohort has a modal size of 21 cm, while at the slope bigger fish is dominating. Figure 6 show the cumulative relative size distribution in number and biomass of the cape hake. The figure shows that on the shelf 92% in numbers and 70% of the biomass is below 30 cm length, while at the slope the corresponding figures are 30% and 5% in numbers and biomass respectively. For the whole bottom depth zone 50-650m the "fishable" biomass beyond 35 cm length is 9% in numbers and 47% in weight. This corresponds to about 100 million fish and 75 000 tonnes, estimated.

In lack of length-at-age data a first attempt has been made to split the young fish into age cohorts by optimizing normal distributions on the empirical length distributions. A close fit to the lower part of the distribution was found with two cohorts with mean length on 22.5 and 27.6 cm respectively. The result from the analysis and the derived estimates on abundance are shown in Table 5.

Table 5. Southern Region, Orange River to St. Francis Bay. Cape hake. Estimated age-cohorts from optimized normal distributions.

Mean length	Sigma	Fraction of young fish	Fraction of all fish	Biomass million N
22.5	2.5	0.71	0.62	680
27.6	2.8	0.29	0.25	275

The size composition of the deep water hake, see Annex I, shows a dominance of fish with the 30 cm modal length, probably the 1989 year-class, but bigger fish are also well represented. The cumulative size distributions, Figure 7, show that about 66% of the biomass or roughly estimated 80 000 tonnes is of more than 35cm length. This corresponds to 27% of the number of fish.

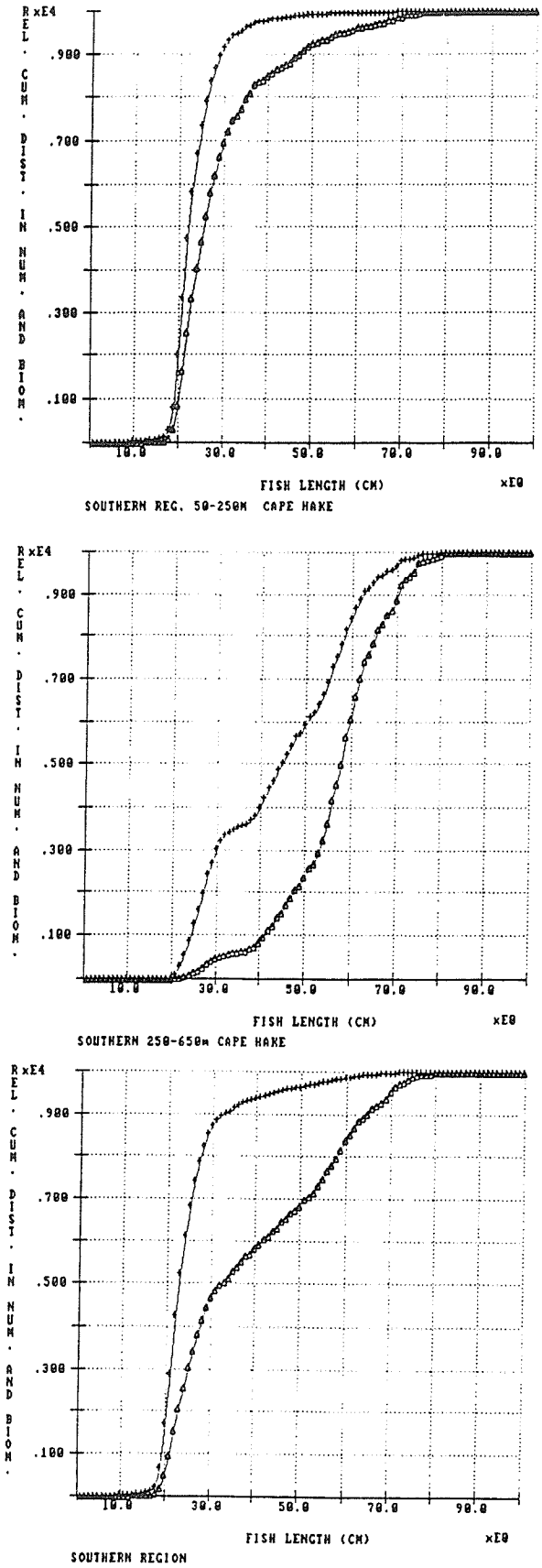

Figure 6. Southern Region. Cumulative relative size distribution of Cape hake at the shelf (50-250m), at the slope (250-650m), and combined.
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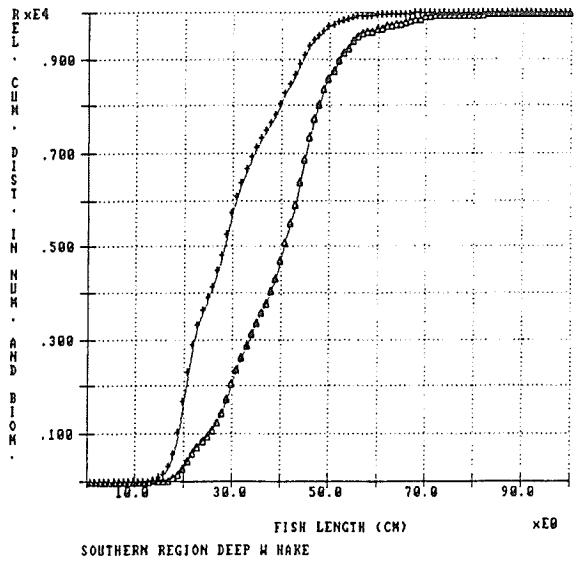


Figure 7. Southern Region. Cumulative relative size distribution of deep water hake at the slope (250-650m).
Legend: + + +: Numbers Δ Δ Δ: Biomass

3.3 CENTRAL REGION, ST. FRANCIS BAY TO AMBROSE BAY

The catch compositions for the shelf and the slope are shown in Table 6 by main groups. For the hakes the mean catch rate on the shelf is about 60% higher than in the two previous surveys, while on the slope the rates are about as during the two previous surveys. The catch rates for horse mackerel have increased to four times the level of November 1981 and twice the level of May 1992, and have reached the same level as during the February survey 1991. The catchrates of monk and squid was low and in line with the findings from the previous surveys.

The depth distribution of the two hake species is shown in Table 7. In the shallow range, 100-250 m the catch rates and the derived density estimates have increased about 50% since the last survey. This is due to heavy immigration of young fish around 23cm modal length settling into the demersal community. In the deeper depth ranges the densities are very consistent with the findings of the two previous surveys.

Table 6. Central Region. Catch rates by main groups in bottom trawl hauls standardized to kg/hour for the shelf and slope.

SHELF 50-259 m

ST.NO.	DEP.	Hakes	Monk	Kingklip	Horse mck.	Squid	Other
1394	217	405.6			8.8	4.0	34.6
1401	198	440.0					11.3
1402	228	183.4	4.1			8.8	226.1
1411	240	545.0	4.0		27.4	2.3	105.4
1412	202	843.3			17.4		6.2
1413	143	2823.5					
1414	103	236.8					63.2
1415	120	2727.3					
1416	153	3000.0					
1417	173	3665.8			682.0		3.9
1418	200	1260.0	3.6		532.9	0.5	114.5
1419	243	1497.6	85.9		3679.2	13.9	191.5
1427	214	1191.5			970.5	1.3	249.4
1428	155	1748.0			540.0		85.0
1429	152	4628.6			55.8		
1430	116						1200.0
1431	140	4842.0			169.2		156.6
1432	183	1544.4	1.8		336.6		45.6
1441	257	466.4	4.0		69.2	5.4	122.0
1442	133	2917.2			4474.8		44.2
1443	108	0.2					100.0
1444	121	4102.0				14.0	35.1
1445	88						4.1
1446	114	30.0					300.0
1447	125	3132.0			113.7	8.1	169.9
1448	163	3376.8	2.7				59.4
1449	228	476.6	2.9		422.6	11.5	75.4
1450	254	1024.8	1.7		1801.8	7.8	179.6
1457	244	3404.7	1.5		443.2		19.3
1458	154	1266.2			120.0	0.5	107.8
1459	98	7.6					264.0
1460	143	1880.5					8.1
1461	213	900.2	5.8		58.0	0.8	253.2
1465	250	720.3	4.2		70.0	0.6	219.8
1466	151	2185.1			672.0	2.2	65.0
1467	122	1231.6			5.7		4.9
1468	118	2226.0	0.3		11.1		60.3
1469	247	632.6	5.5		205.1		217.7
MEAN		1620.1	3.4		407.6	2.2	126.4

Table 6 (continued)
SLOPE 260-600 m

ST.NO.	DEP.	Hakes	Monk	Kingklip	Horse mck.	Squid	Other
1395	360	256.0	12.7	1.4	14.1	8.7	51.7
1396	548	172.0				13.9	491.1
1397	500	197.1				21.0	240.2
1398	400	586.3	8.9			5.9	96.1
1399	296	1065.9	14.0			6.1	101.5
1400	260	681.5				10.6	125.6
1403	273	224.6	6.3		0.5	1.3	152.1
1404	301	300.8	17.2			4.8	125.2
1405	359	512.2				9.8	71.8
1406	460	171.0	2.7			4.7	68.7
1407	551	134.3	4.9			19.3	187.8
1408	399	315.4	2.9			28.6	175.5
1409	304	433.1			22.1	2.8	172.2
1410	269	1831.7	5.7		415.6		179.4
1420	300	475.7			28.9	9.4	156.5
1421	377	167.5			21.1	21.0	175.3
1422	474	169.4	2.7		0.9	71.4	182.7
1423	580	24.8				21.2	192.2
1424	358	668.6				55.9	80.9
1425	285	143.4	3.1		148.1	5.5	207.1
1433	310	235.0	10.7		13.0		50.4
1434	348	296.8			2.7	7.4	79.3
1435	446	475.5	32.7			17.9	218.3
1436	399	288.5				17.5	155.3
1437	543	48.1				13.8	38.2
1438	376	265.7	1.3		0.3	8.4	68.3
1439	331	516.7		4.6		2.8	62.0
1440	306	569.8			35.3		86.1
1451	301	895.5			207.2		79.8
1452	377	349.8	0.4			7.9	250.0
1453	476	180.4				6.3	297.1
1454	437	191.8				9.0	150.3
1455	353	1173.9	3.7			0.5	157.8
1456	305	480.6			111.6	9.8	157.4
1462	303	573.8			88.3		101.7
1463	370	394.6		2.4		13.7	197.7
1464	309	518.3	1.9		9.3		148.4
1470	318	1779.4				20.6	201.9
1471	360	437.0	1.6			2.0	105.6
1472	460	209.5				7.3	85.9
MEAN		460.3	3.3	0.2	28.0	11.7	148.1

Table 7. Depth distribution of the two hake species, St. Francis Bay Ambrose Bay. Mean densities tonnes/nm^2 and mean catch rates. Kg/hour.

	100-250 m	250-350 m	350-450 m	450-550 m	550-600 m
Cape hake					
Density	53.6	20.1	10.5	0.8	0.1
Catch rate	1610	600	320	25	2
Deep w. hake					
Density		0.3	3.1	4.5	2.7
Catch rate		10	95	130	80
No. of hauls	33	20	14	7	2

Figure 8 and 9 show the distribution of the two hake species over the central area. The high density belt of Cape hake inshore from off Conception Bay to off Cape Cross is remarkably similar to the distribution pattern in November 1991, and represents mainly a new recruit class with a modal length of 22 cm, assumed to be the 1991 year-class. Similar high density areas of juvenile fish inshore was found in the 1990 and 1991 surveys when the 1989 and

1990 year-classes were recruited to the stock. In deeper waters spots of high densities of large size fish were located. The length frequency distributions (Annex I) show that the dominating part of the population on the shelf is between 20 and 30 cm. The relative slack upper tail of the distribution probably indicates two cohorts in the size assembly: the above mentioned 1990 year-class and at the upper tail, the shelf-remnants of the previous year-class.

In Figure 10 and 11 the relative size distribution by number and biomass are shown as cumulative distributions for the two hake species. The relative part of the adult stock that is fish of 35 cm and larger, is 5% by numbers and 33% by weight of the population in the central region. The corresponding figures for the deep-water hake are 65% by numbers and 85% by weight.

In a cohort analysis on the length frequency distributions two normal distributions with means 22.5 and 27.6 cm gave the closest fit as in the southern region. The result from the analysis is shown in Table 8.

Table 8. Central Region, St. Francis Bay to Ambrose Bay. Cape hake. Estimated age-cohorts from optimized normal distributions.

Mean length	Sigma	Fraction of young fish	Fraction of all fish	Biomass million N
22.5	2.04	0.7	0.72	3 500
27.6	3.01	0.2	0.18	880

Table 9 shows the regional biomass estimates by surveys. The 540 000 tonnes on the Cape hake from the last survey represents a doubling of the estimated biomass from May 1992 and is also about 80% higher than the previous year, in November 1991. The recruits below 35 cm makes up 370 000 tonnes while in November 1991 this group represented 160 000 tonnes. The "fishable" biomass is estimated to 170 000 tonnes while in November 1991 it was 140 000 tonnes. The main increase is therefore due to very strong recruitment from the 1991 year-class, partially mixed with the shelf remaining part of the 1990 year-class. The 95% confidence limit on the Cape hake estimate is ±9%.

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

	Cape hake	Deep water 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

For the deep water hake the estimate is 15 000 tonnes, a figure very consistent with the results from the two previous surveys.

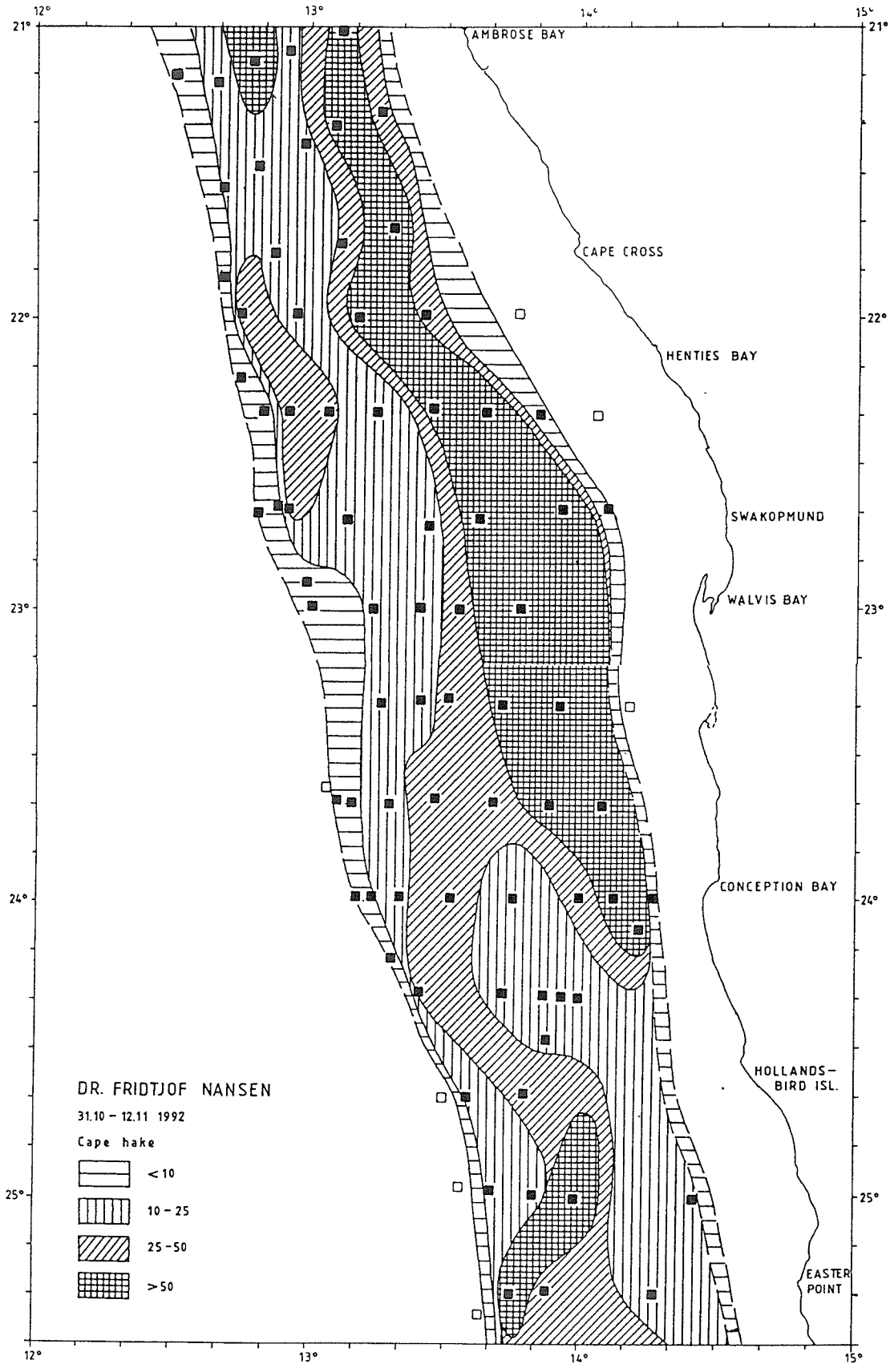


Figure 8. Central Region. Distribution of Cape hake.

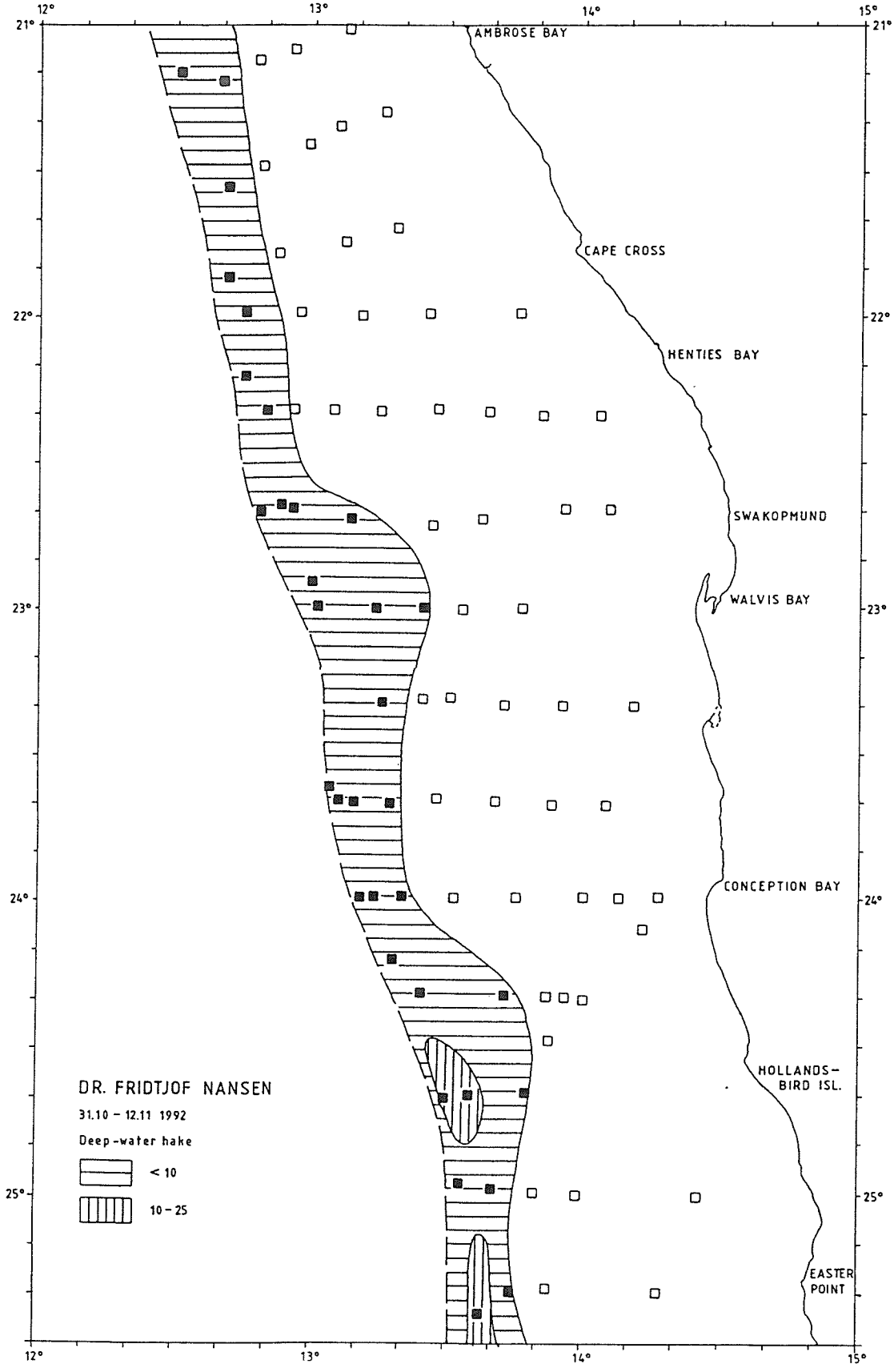
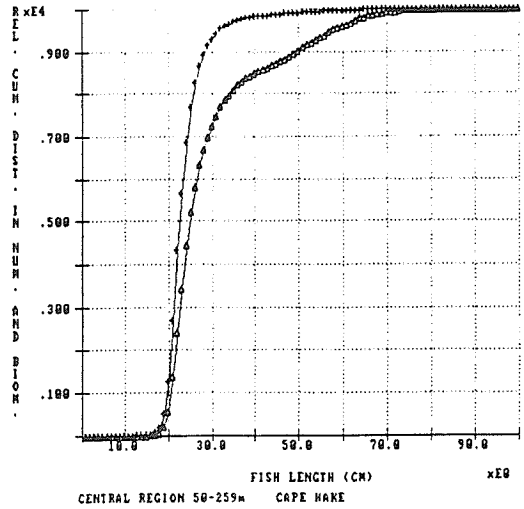
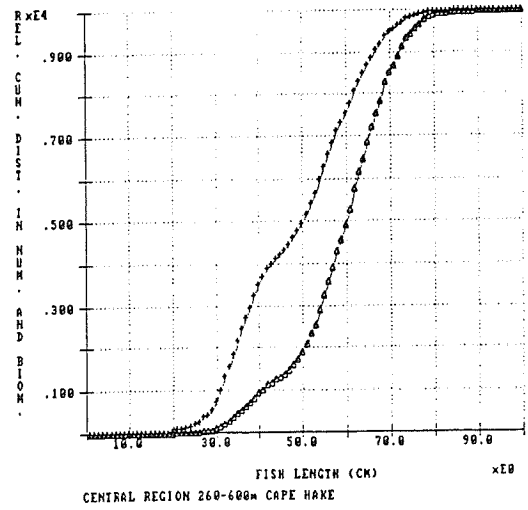


Figure 9. Central Region. Distribution of deep water hake.





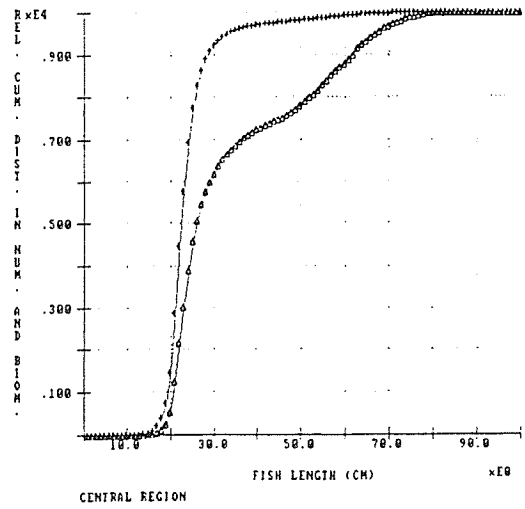


Figure 10. Central Region. Cumulative relative size distribution of Cape hake at the shelf (50-259m), at the slope (260-650m), and combined.
Legend: + + +: Numbers Δ Δ Δ: Biomass

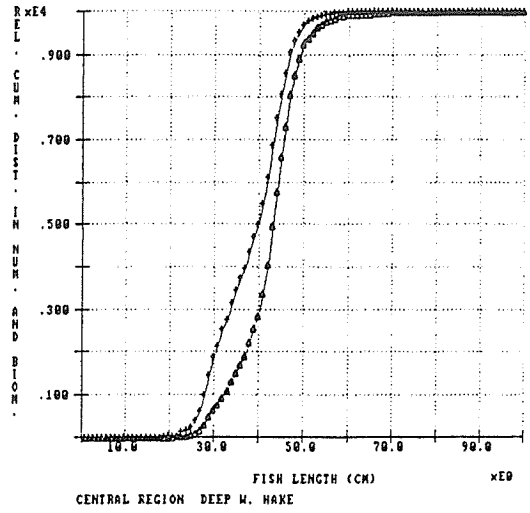


Figure 11. Central Region. Cumulative relative size distribution of deep water hake at the slope (250-650m).
Legend: + + +: Numbers △ △ △: Biomass

3.4 NORTHERN REGION, AMBROSE BAY TO CUNENE RIVER

Table 10 shows the catch rates by main groups for the shelf and the slope separately. The mean rates for the hakes have increased on the shelf and is slightly reduced on the slope since the previous survey in May 1992. The mean rate on large-eye dentex has declined since the last survey, but are considerable higher than in November 1991. The mean by-catch of horse mackerel was about 700 kg/hour and follows an increasing trend since the sudden decline in November 1991.

Table 11 shows the depth distribution of the hakes. The Cape hake is found in highest densities on the shelf due to dominance of strong year-classes of young fish. In the 250-350 depth range the mean rates have declined slightly since the previous survey, from 780 to 560 kg/hour.

Table 11 Depth distribution of the hake species, Ambrose Bay to Cunene River. Mean densities tonnes/nm^2 and mean catch rates. Kg/hour.

	100-250 m	250-350 m	350-450 m
Cape hake			
Density	29.6	18.6	17.6
Catch rate	890	560	530
Deep w. hake			
Density		0.1	2.9
Catch rate		1.8	85
Benguela hake			
Density	0.3		
Catch rate	8		
No. of hauls	23	16	10

Figure 12 shows the distribution of Cape hake in the region, calculated from the catch rates and with adjustments for fish in mid-water.

The size compositions are shown in Annex I. The size of the Cape hake has been consistently highest in the northern region in all surveys. Figure 13 show the relative cumulative size distribution of the Cape hake on the shelf and the slope. The young fish below 35 cm length makes up 75% of the number and 37% of the biomass of fish on the shelf, while at the slope the respective figures are 6% and 2%. For the northern region in total the young fish constitutes 73% in number and 25% by weight of the biomass.

The modal analysis gave close fit to 4 normal distributions, with means on 17.5, 23.5, 27.0 and 33.5 cm, Table 12.

Table 10. Northern Region. Catch by main groups in bottom trawl hauls standardized to kg/hour for the shelf and slope.

SHELF 50-259 m

ST.NO.	DEP.	Hakes	Monk	Dentex	Horse mck.	Squid	Other
1474	112	522.6			125.4		3.5
1475	163	2005.9		8.2	267.8	1.3	8.6
1476	254	588.0	1.6		60.0	7.4	323.5
1480	115	962.3			449.8	7.0	19.0
1481	148	78.7		734.1	817.0	0.8	42.8
1482	215	151.9			106.2	0.1	93.2
1486	177	256.0		292.0	43.0		169.2
1487	235	590.3	0.7	289.8	6.1	0.7	200.9
1491	255	670.2			11.4	11.4	686.0
1492	223	328.1		337.0	364.0		175.8
1493	117	231.2			210.4	8.1	268.9
1494	183	898.0		97.6	1934.0	3.0	537.8
1496	247	3962.4		186.7	9.1		79.4
1498	193	1736.4		76.2	165.6		861.3
1499	127	464.6		1195.4	1771.6		546.1
1500	122	218.1		181.2	57.1	0.4	90.6
1501	220	405.3		58.2	23.2		66.0
1505	232	2143.0		176.0	91.2	0.8	677.3
1506	141	2825.2		729.3	1821.6	0.7	154.4
1510	232	420.8		23.8	1320.0	2.6	4.0
1511	253	36.0		0.9	51.0		11.6
1515	134	365.0	9.1	48.8	117.6	0.6	95.3
1516	207	129.0			6537.7		
1517	248	138.6		29.7	62.4		20.0
1521	148	301.5	0.8	9.0	8.1	1.2	11.8
1522	115	1794.0			1704.0	4.8	45.0
MEAN		854.7	0.5	172.1	697.5	2.0	199.7

SLOPE 260-700 m

ST.NO.	DEP.	Hakes	Monk	Dentex	Horse mck.	Squid	Other
1473	447	271.8				1.70	258.6
1477	326	651.1	18.0		4.1	3.36	48.4
1478	379	405.6				5.36	117.1
1479	334	504.4	2.9		16.8	4.26	132.1
1483	300	1097.1	5.0		74.7	20.00	279.4
1484	371	178.4	1.0			4.30	137.8
1485	366	249.0				6.08	96.0
1488	295	910.0	3.3	273.4	20.3	5.34	131.7
1489	277	886.3	1.4	17.1	88.2	3.74	267.3
1490	403	893.9				13.20	345.3
1495	360	369.4		7.2		13.40	165.1
1497	404	1740.4	17.2			5.60	333.8
1502	407	1703.4	1.3			7.96	384.6
1503	602	31.0				1.76	300.9
1504	363	477.2				20.60	222.6
1507	335	1110.6	6.3			6.81	181.5
1508	313	303.2		9.9	3.1	5.46	117.2
1509	283	81.0	2.1	21.6	31.7		208.3
1512	295	369.3	2.2	10.6	30.0	1.28	69.6
1513	334	794.4	2.8			4.32	219.1
1514	375	288.9				5.19	156.9
1518	283	165.0	0.3	2.9	117.9		44.4
1519	294	1427.4	2.6		67.5	2.98	92.3
1520	265	257.6		3.6	132.0		139.5
MEAN		631.9	2.8	14.4	24.4	5.95	185.4

Table 12. Northern Region, Ambrose Bay to Cunene River. Cape hake. Estimated age-cohorts from optimized normal distributions.

Mean length	Sigma	Fraction of young fish	Fraction of all fish	Biomass million N
17.5	1.5	0.15	0.09	65
23.5	1.8	0.7	0.41	310
27.0	2.5	0.15	0.09	65
33.5	3.5	-	-	-

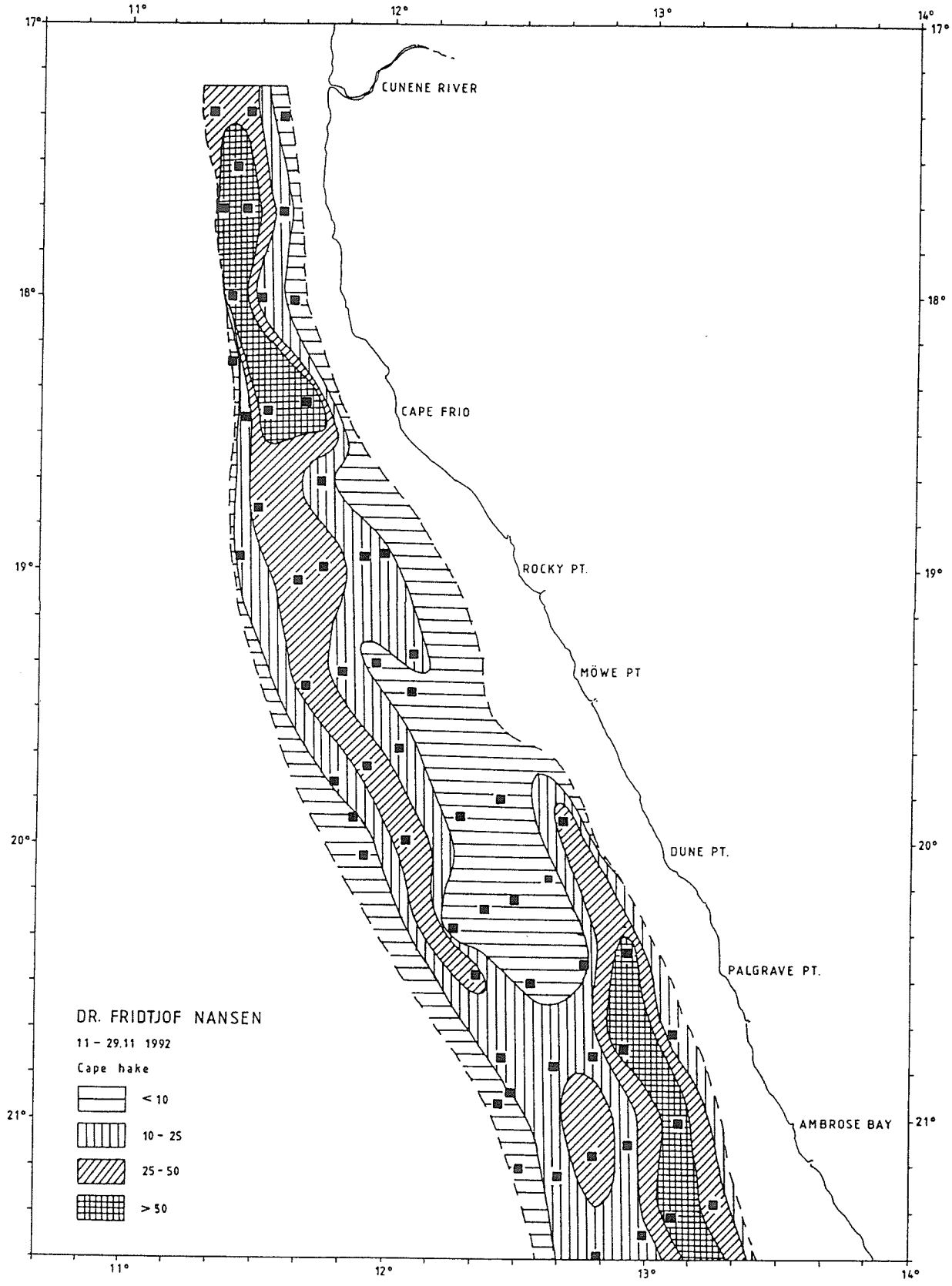
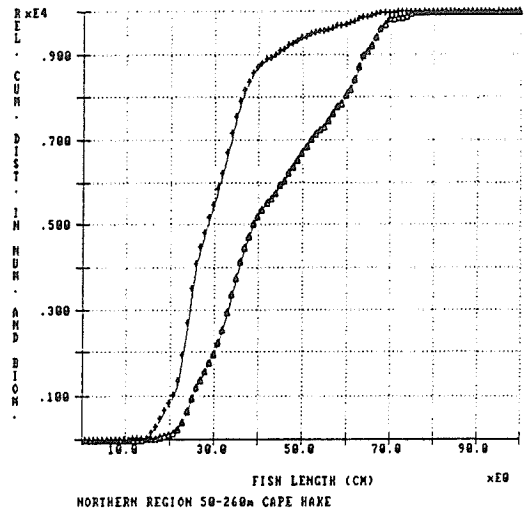
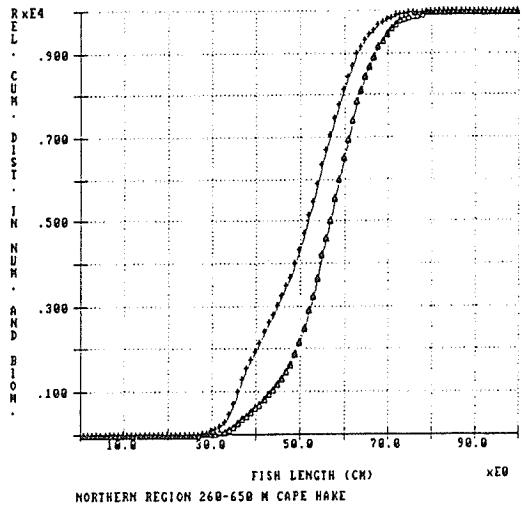


Figure 12. Northern Region. Distribution of Cape hake.





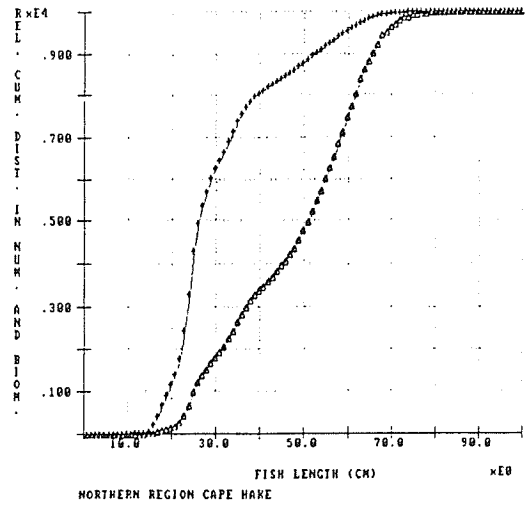


Figure 13. Northern Region. Cumulative relative size distribution of Cape hake at the shelf (50-260m), at the slope (250-650m), and combined.
Legend: + + +: Numbers Δ Δ Δ: Biomass

The total biomass of Cape hake in this region is 190 000 tonnes, of which 143 000 tonnes are of fishable size (36 cm and larger). This is identical to the estimated fishable biomass from the previous survey in May. The time series of the estimates, Table 13, shows a not significant increase in the biomass of Cape hake in the northern region. The confidence limits of the estimate is ± 13%.

Table 13 Ambrose Bay to Cunene River. Estimates of total biomass by surveys, 1 000 tonnes.

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

4 CONSIDERATIONS OF THE SURVEY RESULTS

The present survey is the 6th 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 14 shows the effort spent in these hake investigations.

Table 14. Effort in Namibian hake surveys 1990-1992. 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 Bay	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	21.0
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
2/1992					
21.10-29.11	No. stations	64	78	50	192
	" samples	188	194	155	537
	" measured	13.9	13.3	9.1	36.3

A summary of the estimates of the mean density of the hakes by depth strata is shown in Table 15. The mean density of the deep-water hake has declined only slightly from its sudden rise registered during the previous survey. This difference is probably within the precision range of the estimates. The Cape hake shows increase in the shelf waters down to 250m, especially in the central area. The increase is mainly from a new cohort, the 1991 year-class, settling on the bottom. In the deeper waters there is a decline in the densities in the south and in the north, while in the central region there is an increase. The differences can be explained mainly by migration between the regions, as on average for the whole slope the density level is practically the same as during the previous survey in May.

Table 15. Depth distribution of the hake species. Mean densities in tonnes/nm^2.

	100-250 m	250-350 m	350-450 m	450-550 m	550-650 m
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	
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	10.1	18.2
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	0.1
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	4.5	2.7
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		

Table 16 shows the biomass estimates for the two stocks by regions and the corresponding data for the five previous surveys. For the Cape hake there is a remarkable increase of 200 000 tonnes in the biomass due to entrance of the new cohort into the demersal community. This cohort is especially abundant on the shelf between 100 and 250 m in the central region. Beyond 250m the larger fish dominates. The total fishable biomass, defined as fish beyond 35 cm length, is 490 000 tonnes, an insignificant decline from the 500 000 tonnes estimated in May. The effect of the fishing thus seems to have been compensated by growth in the remaining population and through migration by new recruits from the shelf into the fishing zone.

Table 16. Summary of estimates of biomass of the two hake species by surveys and areas. Tonnes.

	TOTAL BIOMASS					
	Feb-Mar 1990	Sep-Oct 1990	Jan-Feb 1991	Oct-Nov 1991	Apr-May 1992	Oct-Nov 1992
SOUTHERN REGION						
Cape hake	130 000	130 000	126 000	80 000	200 000	160 000
Deep w. hake	22 000	25 000	31 000	83 000	145 000	125 000
CENTRAL REGION						
Cape hake	180 000	219 000	150 000	302 000	261 000	542 000
Deep w. hake	4 000	6 000	6 000	13 000	15 000	15 000
NORTHERN REGION						
Cape hake	180 000	105 000*	200 000	140 000	185 000	190 000
Deep w. hake				2 000	4 000	8 000
TOTAL	516 000		513 000	620 000	810 000	1 040 000
TOTAL FISHABLE	220 000		300 000	370 000	503 000	490 000

* + hake in mid-water.

Attempt has been made in the report to estimate the strength of the new year-class, the 1991 year-class, which now has settled into the demersal community. The estimates on recruits based on the current survey data are shown in Table 17 together with previous observations. The recent estimate is 2.4 times higher than the successful recruitment of 1990, and represent a new maximum in the time-series. The new recruitment is considered very favourable for the fisheries in the years to come. However, the very high densities of young fish at the shelf can be the subject of density dependent growth and mortality, as for example reduced growth and increased predator pressure due to increased food competition in the fish community. Cannibalism from the older hake could also increase. To follow the "health" condition of the recruits it is advisable to monitor them by monthly samples from the high density areas and by this acquire information on the individual growth and changes in community structure.

Table 17 Estimates of strength of recent year-classes 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.

Year	1988	1989	1990	1991
Region south	980	100	160	680
" centre	1 320	170	1 710	3 500
" north	10	10	20	310
Total	2 310	280	1 890	4 490
Survey/Year	3/90	2/91	2/91	2/92

During the survey about 3 000 otoliths were collected from the whole size range of the two hake species. In order to be able to decompose the size distributions into age cohorts, the reading of these otoliths should have high priority. The established survey methods are well suited to assess the strength of the two-year and three-year classes about two and one year before they enter the fishery, and with an age/size key for the population available, better predictions on expected future yields from these recruits can be made.