CHAPTER 3 OBSERVATIONS ON PILCHARD IN THE CAPE FRIO AREA

Aims and methods

The aim of this survey was to determine the biomass of pilchard in the Cape Frio/Rocky Point region of northern Namibia.

A preliminary survey was planned between a commercial purse seiner and the R/V" BENGUELA", to be followed by two separate biomass estimation surveys by the "Dr. FRIDTJOF NANSEN" and R/V "BENGUELA". If time permitted the R/V "BENGUELA" would cover the area a second time, thus allowing a comparison of the estimates between the two research vessels and between two consecutive surveys with the same vessel.

Unfortunately the scientific equipment on the R/V "BENGUELA" was inoperative and therefore she was unable to take part in the survey.

The "Dr. FRIDTJOF NANSEN" only had part of one night for the core survey area (21H00 to 05H00) and part of two nights for the adjacent areas. The surveys of the areas immediately north and south of the Cape Frio region gave an indication of the dispersion of pilchard in this northern region.

Results

The purse seiner determined the main distribution of the pilchard as being from 10 nm north of Rocky Point (18°52'S) to False Cape Frio (18°30'S) with the area of densest concentration being from 12 nm to 24 nm north of Rocky Point (18°50'S to 18°42'S). During the day the fish formed dense shoals in waters of 25 to 35 m depth, while at night they dispersed into two layers.

The upper layer, which occurred extensively from waters of 40 m bottom depth to a depth of more than 100 m, was from the surface to just below transducer level (some 4 to 6 m below the surface). A surface trawl showed that this was small horse mackerel with a modal peak length of 14 cm (range 12 to 16 cm).

The second layer was from about 10 to 20 m below the surface. This lower layer was considerably less extensive occurring in waters of 40 to 60 m deep A trawl targeted on this layer and on several small dense shoals within the layer yielded 96% large pilchard (modal total length 22 cm, range 19 to 24 cm) with 4% small horse mackerel (modal total length 12 cm, range 9 to 15 cm).

Both layers occurred as far north as 18°46'S, while during the latter part of the night the pilchard formed shoals resulting in some very high integrator values.

The biomass estimate for this area of pilchard was 35 000 tonnes.

The surveys to the north and south of this core area determined that small amounts of pilchard were present in these area. Close to Möwe Bay an estimated 3 250 tonnes was surveyed, while at Rocky Point a further 8 150 tonnes was found. To the north of Cape Frio a few shoals of pilchard were found 15 nm south of the Cunene (17°28'S), while a small amount also occurred

5 nm north of Cape Frio (18°25'S). No biomass estimates were produced for these latter concentrations.

It must be concluded that the fish surveyed in this region by the "Dr. FRIDTJOF NANSEN" in June have moved out of our region, possibly into Angolan waters. Surveys of southern Angolan waters by the Dr FRIDTJOF NANSEN report, finding in February and August 1985 and February 1989 large concentrations of *Sardinops ocellata* (25 000 tonnes, 120 000 tonnes and 50 000 tonnes respectively), while surveys conducted in April and November 1985 and 1989 found less than 10 000 tonnes on each occasion. This suggests some movement of fish between Angolan and Namibian waters.

CHAPTER 4 RESULTS OF THE FISHING EXPERIMENTS, CATCH COMPOSITIONS AND SWEPT AREA BIOMASS ESTIMATES OF DEMERSAL FISH

All catches were sampled for composition in weight and numbers by species and size sampling was made of important species, using total length. The complete records of fishing stations are shown in ANNEX II.

4.1 ORANGE RIVER TO ST.FRANCIS BAY

Compositions of catches

To show changes by depth the catches from the shelf down to 250 m of depth are analysed separately from those of the slope 250-500 m. Table 3 shows the catch rates standardized to kg/hour by main groups in hauls from the shelf and the slope separately. Hakes form the main part of the catches and the two species will be analysed separately below.

Cape horse mackerel was after the hakes the most abundant species in the catches with high rates especially in the southern part of the area. The species was represented by large size mature fish, see Annex I. The catches of other demersals shown in Table 2 consisted of small by-catches of monk *Lophius upsicephalus*, kingklip *Genypterus capensis*, John dory *Zeus faber*, and west coast sole *Austroglossus microlepis*. Catch rates for John dory and kingklip were very low compared with those obtained in Survey I in February. Snoek *Thyrsites atun* was on the other hand considerably more abundant at this season appearing in bottom trawl catches even at 350 m of depth. The squids consisted of the lesser flying squid *Todaropsis eblanae* and flying squid *Todarodes sagittatus* in the slope, mainly from 250 to 550 m and a few cuttlefish in shallower waters.

Table 3. Orange River to St. Francis Bay. Catch rates by main groups in bottom trawl hauls standardized to kg/hour for the shelf and the slope hauls.

SHELF 50-259 m

ST.NO.	DEP.	Hakes	Horse mck.	Other dem.	Snoek	Squid	Other
356	79	57.0	0.2	1.4	4.0	2.2	54.7
357	82	82.6	2.0	2.7	3.9	7.8	130.6
358	144	126.8	20.4	1.6	7.6	5.2	2.4
359	173	88.0	162.4	6.4	19.2	10.8	56.4
360	173	163.8	38.3	5.4	1.6	1.5	26.0
366	209	388.6	3427.2	12.8	31.0	16.0	156.2
367	165	125.3	4.7	14.8			30.9
368	164	219.2	21.8	18.9	5.4	5.8	150.8
369	182	183.0	233.4	6.6	3.0	3.9	73.8
370	161	359.2	50.4	4.8	2.6	15.6	17.6
371	140	105.4	156.4	0.2	52.2	2.1	32.8
372	174	344.8			30.6	1.8	121.2
373	183	329.0	1.6	5.2	110.0	8.6	90.6
377	212	272.9	2.2		317.5	7.4	61.9
378	191	185.4	60.0		12.2	0.1	15.3
379	153	92.8		12.0	2.6	0.2	15.0
382	251	630.0				2.4	9.0
383	174	213.0	6.0			2.0	21.2
384	155	50.0	3.8				58.6
385	199	176.0	7.6				100.2
386	250	348.0	11.6	1.6			102.4
388	212	1137.6	7.2	2.0		3.0	3.0
389	253	805.0	10.0	3.6		18.0	49.0
390	246	22.4	3.3			2.0	24.9
394	249	830.4	8.2			21.6	25.3
395	195	226.0	4.6			10.0	35.2
396	150	280.0	3.2				23.2
397	204	773.7				8.4	5.1
400	249	1147.0				9.2	4.5
401	197	1438.4					3.2
402	157	468.0	11.0				21.0
MEAN		376.4	137.3	3.2	19.5	5.4	49.1

SLOPE 260-600 m

ST.NO.	DEP.	Hakes	Horse mck.	Other dem.	Snoek	Squid	Other
361	398	27.0				0.1	5.3
362	510	10.0				8.6	87.4
363	449	130.6		5.1		2.6	40.1
364	351	279.6	17.6	2.8		3.6	28.6
365	292	456.5	470.8	27.4	48.6	40.7	36.5
374	351	49.4		20.0			33.2
375	454	1.8		0.6		1.5	54.0
376	353	364.6	28.6		402.4		69.6
380	392	5.0	1.2		3.2	0.2	7.8
381	349	32.0			128.8	4.0	5.0
387	351	475.6				8.6	4.5
391	350	381.2	8.1			99.9	43.3
392	454	1.5		0.1		1.3	12.8
393	349	539.0				54.2	89.5
398	402	23.6		7.0		98.0	275.8
399	310	779.4				7.2	36.8
MEAN		222.3	32.9	3.9	36.4	20.7	51.9

Total number of stations : 16

The hakes

The two species Cape hake *Merluccius capensis* and deep water hake *Merluccius paradoxus* were as previously found to be fairly well separated in their depth distribution at about 300 m of depth, see Table 4 which shows the mean densities by depth ranges and the corresponding mean catch rates with the type of trawl used.

Table 4. Depth distribution of the two hake species, Orange River to St.Francis Bay.
Mean densities tonnes/nm^2 and mean catch rates kg/hour.

	100-250m	260-350m	360-450m	460-550
Cape hake				
Density	11.5	6.1	0.1	
Catch rate	350	180		
Deep w. hake				
Density	0.1	6.3	1.2	0.4
Catch rate		190	36	12
No of hauls	28	9	6	1

Compared with the situation in February the density of the Cape hake has shifted somewhat towards deeper water.

When plotted in a chart the observations of densities by fishing stations of Cape hake form a pattern of levels which reflects the distribution of this species over the shelf, see Figure 4. The inshore hauls approaching the 100 m depth line show generally low densities. The patches of high density were found between 150 and 250 m particularly in the range 200 to 250 m. The fish was in a spawning and pre-spawning condition.

For the deep water hake there is an indication of decline of densities along the slope northwards from a mean of 6.6 tonnes/nm from off Lüderitz south to 1.0 tonnes/nm in the northern area.

Annex I shows the pooled size compositions of the Cape hake by depth ranges. The well known increase of size with depth is clearly demonstrated, but one should note that small sized fish 25-30 cm of length is present also below 250 m. A comparison with the size compositions for the corresponding depth ranges from Survey I in February shows a shift to the right of the modal sizes of the two lowest groups demonstrating fish growth over the intervening period. The similarity of the two sets of size compositions is a strong indication that the same population of Cape hake has been sampled in the two surveys.

An approximate estimate of the size composition of the total stock of Cape hake in Div. 1.5 can be obtained by combining the two size compositions weighted by the fish biomass of the depth strata. (A more appropriate weighting would be by numbers of fish in each strata. This method will be used when length/weight relationship becomes available). This is shown as "Total stock" in Annex I. As in February this composition is dominated by the 2+ group, but with the modal length increased by growth. The 1+ group which occurred with a modal length of 10-11 cm in Survey I now appeared with a mode in the 16-17 cm range. This group does not show high abundance in the catches. This small size of fish may not have entered fully into the area

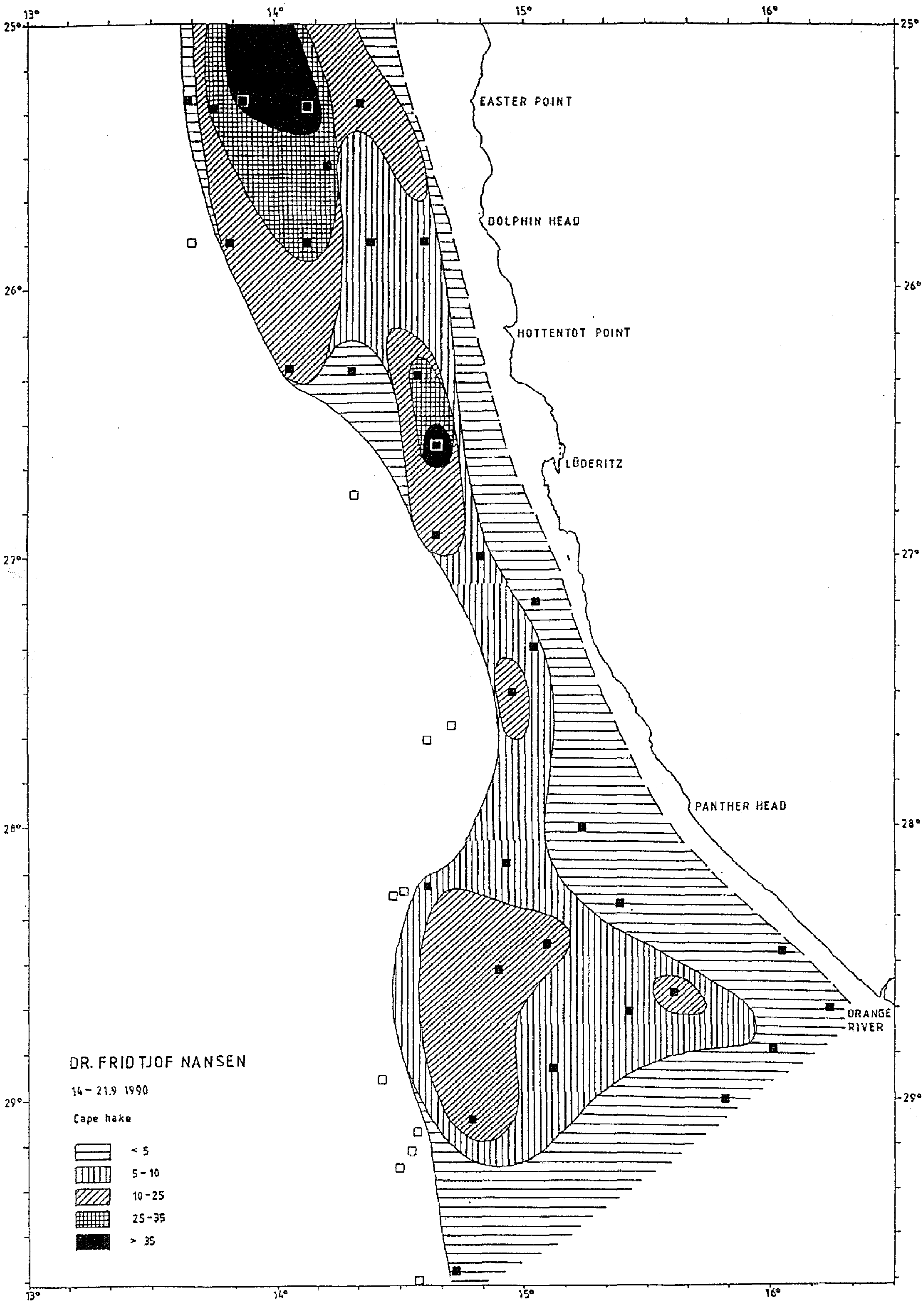

Figure 4. Orange River to St. Francis Bay. Distribution of Cape hake. Density strata based on observation of catch rates at fishing stations. Tonnes/nm^2.

surveyed, but one should perhaps not have too high expectations to the recruitment from this yearclass.

Assuming an effective trawl mesh size of 110 mm and a selection factor of 3.3 for the hake with a 20 cm range between the 10% and the 90% retention lengths the fishable part of the "Total stock" in Div. 1.5 would be 20% by numbers and 36% by weight. These may be somewhat underestimated because low numbers of large sized fish tend to disappear in percentage frequency distributions of large number of pooled samples.

The size composition of the deep water hake for all depth ranges is shown in Annex I. Compared with the February survey results there is now a dominant group of young fish at about 30 cm. In addition a juvenile group at about 20 cm of length (not included in the distribution in Annex I) appeared in two of the catches.

Assuming as above an effective mesh size of 110 mm, 35% by numbers and 46% by weight would be available as the fishable stock.

The prelocated trawl stations which are distributed in a semi-random way to cover the various depth zones in which the hakes are found can be used for estimates of the total biomass of the stocks by the swept area method. The assumptions used here for these calculations are: a catchability coefficient q = 1 i.e. all fish in the path of the trawl between the wings are caught, and the effective wing spread = 18 m (1/100 of a nautical mile). 44 successful hauls were made for this purpose in the area.

For the Cape hake an estimate based on post-stratification by levels of densities (Figure 4) gives a total stock biomass of 130 000 tonnes. The corresponding estimate from the February survey was 120 000-140 000 tonnes.

A biomass estimate of the deep sea hake applying the mean densities by depth strata to their areal extentions gives a total of 25 000 tonnes, compared to 22 000 tonnes in Survey I. The fishable part would be 12 000 tonnes.

4.2 ST. FRANCIS BAY TO AMBROSE BAY

Composition of catches

Table 5 shows the catch rates standardized to kg/hour by main groups from the shelf and the slope hauls separately. Besides hake the catch rates of horse mackerel at intermediate depths in the northern part of the area were very high especially when considering that the hauls are positioned randomly in advance. The other demersal fish consisted mostly of monk with a few catches of west coast sole at intermediate depths.

Table 5. St. Francis Bay to Ambrose Bay. Catch rates by main groups in bottom trawl hauls standardized to kg/hour for the shelf and the slope hauls.

SHELF 50-250 m

ST.NO.	DEP.	Hakes	Horse mck.	Other dem.	Snoek	Squid	Other
403	162	200.0					
404	227	3278.7		30.0			217.2
409	253	442.0	6.8	78.0		18.2	58.8
410	199	1120.5	8.3	243.8	39.0	12.0	12.8
411	115						240.0
412	202	1110.8					25.4
413	245	478.0					12.0
419	228	1128.4		16.8		25.2	208.6
420	179	395.5	1.8			0.3	15.5
421	167	879.6	7.2				15.6
422	236	904.8				3.4	22.8
427	251	646.5					18.0
428	149	94.8					
429	140						
430	120	63.6	27.6				
431	128	1600.0	640.0	80.0			20.0
432	130	1505.2	6486.8		14.0		
433	135	515.2	5353.6				11.2
434	184	380.8	21.6			0.2	5.2
435	256	1003.6	37.7	11.7		10.4	328.1
442	250	948.0		4.8		4.8	192.0
443	209	3238.4	704.0	8.8			35.2
444	170	4935.0	2310.0				126.0
445	126	970.2	204.6	4.8			123.6
446	112						
447	135	1105.5	653.4				
448	177	1794.0	1150.0				115.0
449	253	178.2	49.0	13.6		1.0	21.1
452	200	3468.4	1263.6				361.4
453	144	1350.8	3520.0			0.2	18.0
454	109						
459	251	768.8	37.5	1.9			59.1
460	184	306.0	3060.0	12.0			128.0
MEAN		1054.9	774.1	15.3	1.6	2.3	72.4

SLOPE 260-600 m

ST.NO.	DEP.	Hakes	Horse mck.	Other dem.	Snoek	Squid	Other
405	274	1155.0	5.2	7.6		58.6	282.1
406	363	445.0		32.0		6.0	300.0
407	389	52.0		5.8		4.6	37.0
408	316	298.4		47.9	1.6	4.0	182.9
414	270	0.9					2.1
415	306	22.8					6.1
416	460				1.4	3.0	7.7
417	382	42.6	2.0	10.2		13.5	163.7
418	270	982.8	21.0	51.8		2.9	121.1
423	310	132.5	4.0	7.4		10.8	28.5
424	400	53.9		38.5		9.4	265.2
425	484	72.0				13.2	384.0
426	354	122.0	2.4	6.2		4.2	52.8
436	292	328.8	10.8				47.2
437	307	172.0	22.0	16.4		14.0	31.6
438	351	60.0	2.0	13.4		8.8	92.4
439	499	10.2		10.4			317.8
440	447	15.6	4.0			6.0	226.9
441	355	120.6		3.6		6.4	81.2
450	303	166.0	20.0	37.0			15.0
451	262	52.2	2.0	5.0		2.4	15.4
456	556	19.2		95.4	2.4		312.0
457	450	8.2		2.8		4.8	302.2
458	321	184.0	2.2	14.0		8.8	91.2
MEAN		188.2	4.1	16.9	0.2	7.6	140.3

The hakes

The density of Cape hake was higher in this area than in Div. 1.5 while that of the deep water hake was lower, see Table 6. The density of Cape hake is by far highest in the 100-250 m range.

Table 6. Depth distribution of the two hake species, St.Francis Bay to Ambrose Bay.
Mean densities tonnes/nm^2 and mean catch rates kg/hour.

	100-250m	260-350m	360-450m	460-550
Cape hake				
Density	38.6	8.3	2.5	
Catch rate	1160	250	75	
Deep w. hake				
Density	0.2	0.4	0.9	0.9
Catch rate	6	12	30	30
No of hauls	26	7	8	3

The plots of catch rates for the Cape hake give a density distribution as shown in Figure 5. The highest densities were found in the depth range 150-230 m. The results may to some extent have been affected by sampling problems in some areas resulting from high densities of jellyfish near the bottom and in the northernmost part of the area by fish lifting off the bottom also in daytime. The effect of both of these factors is likely to have a tendency of underestimate of the true density.

The size distributions based on a large number of samples pooled are shown by depth ranges in Annex I. Also in this area the well known increase of size with depth is clearly demonstrated. A comparison with the size compositions for the corresponding depth ranges for this area from Survey I in February shows a shift to the right of the modal size of the main group in the 20 to 30 cm range demonstrating fish growth over the intervening period. The similarity of the two sets of size compositions is a strong indication that the same population of Cape hake has been sampled also in this area. An estimate of the size composition of the total stock has been made by adjusting for the depth dependent size through weighting by the biomass of the depth strata, shown as "Total stock" in Annex I. There is little evidence of the presence of the 1+ group which appeared in February with small numbers with a modal size of about 13 cm.

The application of a mesh selection of a 110 mm trawl mesh shows that 25% by numbers and 41% by weight would be fishable. This is an increase over the similar estimates from Survey I.

An estimate of the total biomass based on post-stratification of the density estimates from the 53 swept area trawl hauls in the area gives 219 000 tonnes. The fishable part of this using a 110 mm trawl net would be about 90 000 tonnes.

A biomass estimate of deep sea hake based on the densities by depth strata and their areal extensions is 6 000 tonnes compared to 4 000 tonnes in Survey I.

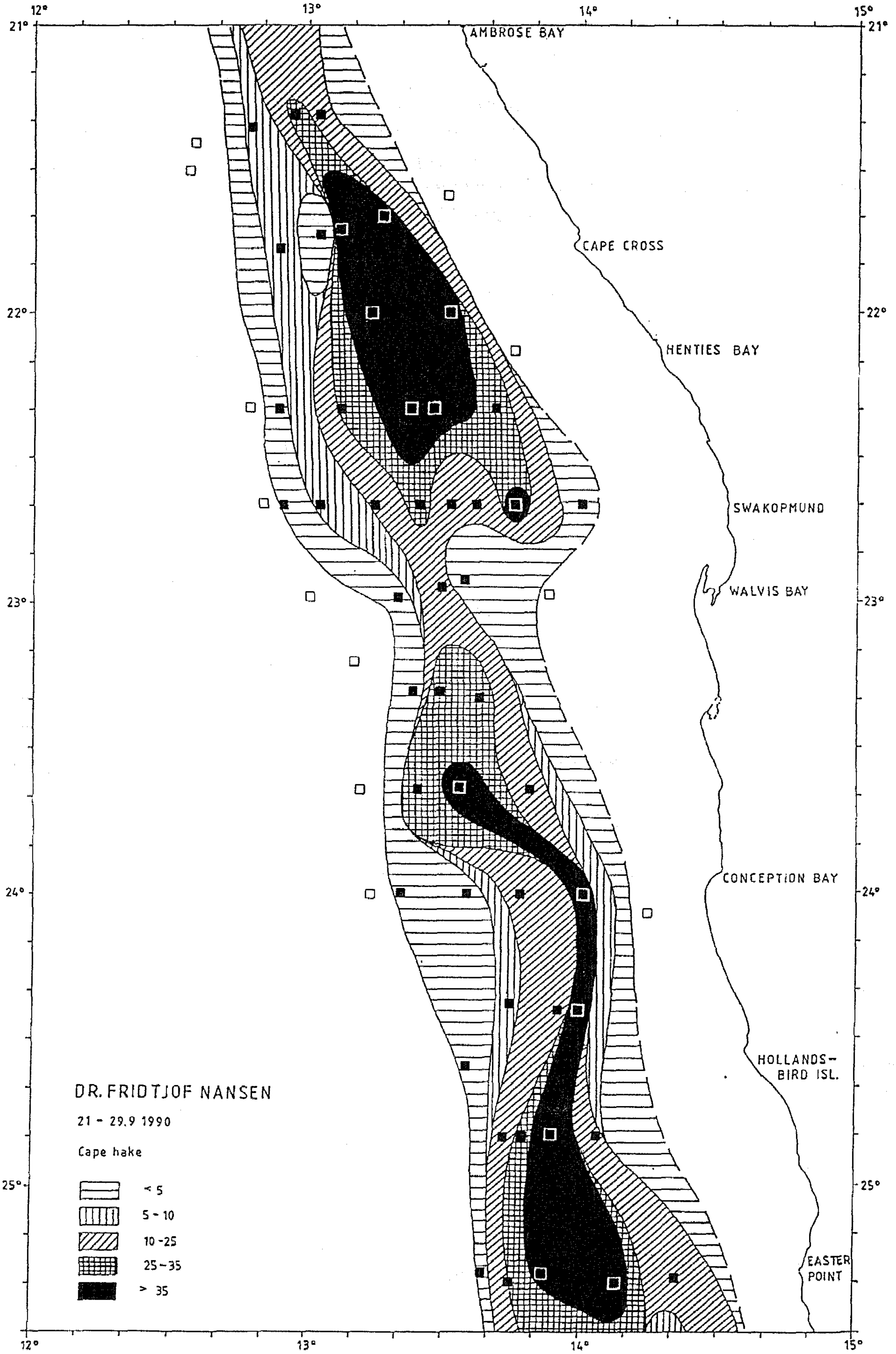

Figure 5. St. Francis Bay to Ambrose Bay. Distribution of Cape hake. Density strata based on observations of catch rates at fishing stations.

4.3 AMBROSE BAY TO THE CUNENE RIVER

Composition of catches

Table 7 shows the catch compositions by main groups. High catch rates of Cape horse mackerel were obtained at intermediate depth in part of the area and acoustic observations of occurrence in mid water of this species were widespread and abundant. Large eye dentex *Dentex macropthalmus* appeared in the shelf catches in the north. The African mud shrimp *Solenocera africana* appeared in all the catches in the 250-350 m range.

Table 7. Ambrose Bay to Cunene. Catch rates by main groups in bottom trawl hauls standardized to kg/hour for the shelf and the slope hauls.

SHELF 50-259 m

ST.NO.	DEP.	Hakes	Horse mck.	Other dem.	Sharks	Squid	Other
461	181	710.6	18.7				41.7
469	141	1825.2	924.3	54.6	65.7		97.5
470	181	1328.0	68.0		8.0		22.0
471	240	945.0	189.0	108.0	110.1		426.6
475	254	722.5	30.2	13.4			121.0
476	204	1890.0	378.0		1.0		107.8
477	143		19500.0				
478	125	90.0	4.3	0.8			1.0
480	180	2060.0	336.0	29.3	60.0		98.0
481	240	516.0	252.0	8.0			31.8
484	239	495.0	18.0				39.9
485	197	561.0	22.0	7.3			44.0
488	158	734.4	14.4	64.8	90.0	13.0	146.3
489	237	453.0	9.0	8.0	4.0		144.1
493	220	1051.5	10.5	90.0	54.9	18.0	508.3
494	151	183.6	99.0	9.0			236.6
496	219	260.8	11.6			7.2	27.2
499	222	871.0	15.0	11.0		12.0	170.9
MEAN		822.5	1217.8	60.2	21.9	2.9	142.7

SLOPE 260-600 m

ST.NO.	DEP.	Hakes	Horse mck.	Other dem.	Sharks	Squid	Other
462	276	281.2	15.6	19.6	6.2	7.6	56.4
463	321	372.8	4.0	0.8	2.0	4.0	33.6
464	322	380.0		12.5	2.5	2.5	7.0
465	452	9.8			47.2	8.4	311.7
466	351	157.6	0.4	16.0	5.0	15.0	63.2
467	308	704.0	49.6		1.2	7.2	5.8
468	264	528.4	65.6	32.6	26.4		40.5
472	285	408.0	120.0		12.0		34.0
473	500	20.0				10.0	408.4
474	301	429.1	4.2	9.8	8.0		68.9
482	297	215.8	13.0	15.0	3.0		25.7
483	300	209.2	7.3		0.1		48.4
491	296	428.0	4.0		7.0	20.0	125.3
492	300	167.4	7.4		18.0		263.4
495	288	1074.4	6.8	18.5	41.6		840.9
497	306	740.8	7.2	67.2	14.4	7.2	67.0
498	355	504.8	4.8	12.8	26.6	13.6	62.0
MEAN		390.1	18.2	12.1	13.0	5.6	144.8

The hakes

Table 8 shows that in this area the Cape hake was found to have a higher density in deeper waters than further south, but the density over the shallow depth range 100-250 m was significantly lower than in the area St. Francis Bay to Ambrose Bay and also lower than that found in March in the northern area. The plots of catch rates for the Cape hake give a density distribution as

Table 8. Depth distribution of the two hake species, Ambrose Bay to Cunene.
Mean densities tonnes/nm^2 and mean catch rates kg/hour.

	100-250m	260-350m	360-450m	460-550
Cape hake				
Density	25.9	15.1		
Catch rate	780	450		
Deep w. hake				
Density		0.1	0.4	0.6
Catch rate			10	20
No of hauls	18	14	1	1

shown in Figure 6. As in the March survey a belt of high density is found along most of the shelf over intermediate depths.

The size distributions by depth ranges are shown in ANNEX I. As in Survey 1 the Cape hake in this northern area is distinguished by a larger size. The distributions are similar to those observed in March, but shifted to the right, presumable through the effect of growth. With a trawl mesh of 110 mm 51% by numbers and 60% by weight would represent the fishable stock.

The biomass estimate based on post-stratification of the densities from the swept area hauls gives a total of 105 000 tonnes. This is significantly lower than the estimate of 180 000 tonnes made in March.

As mentioned in part 1.3 Narrative, the behaviour of the hake in this area differed from that observed further south in that the fish occurred off the bottom in mid water not only during night time as some times observed further south and on the first survey, but also during the day. The fish was observed in a typical single fish layer extending up to 20 to 40 m and more off the bottom, easily identifiable, but its identity also confirmed by mid water trawling. Hake is known to be a mid water feeder and acoustics has been a method of assessment in other areas. As observed in this survey the pelagic hake was very often mixed with schools and layers of horse mackerel, myctophids and layers assumed to represent euphaucids which all give higher acoustic back scattering than the dispersed hake layers and thus mask their integrator contribution. Ordinary echo integration of the pelagic hake was therefore not feasible.

In order to obtain an impression of the magnitude of the underestimate which the mid water distribution of the hake must cause in the density estimates based on bottom trawl catches only, the integrator contribution was recorded in a channel covering a depth range from 5 to 15 m above the bottom. The observations are limited to areas were only hake appeared to be present in the depth recorded and represent mean integrator readings over 5 nautical miles expressed as 1/10 m reflecting surface per nm. The following results were obtained:

Depth range	No.obs.	Mean	Range
150-259m	9	1.24	0.4-2.7
260-500m	17	1.79	0.4-5.0

In the absence of specific information of the target strength of hake use was made of the relation TS=20 logl-72 used for several species in northern areas. Assuming a mean fish lenngth of

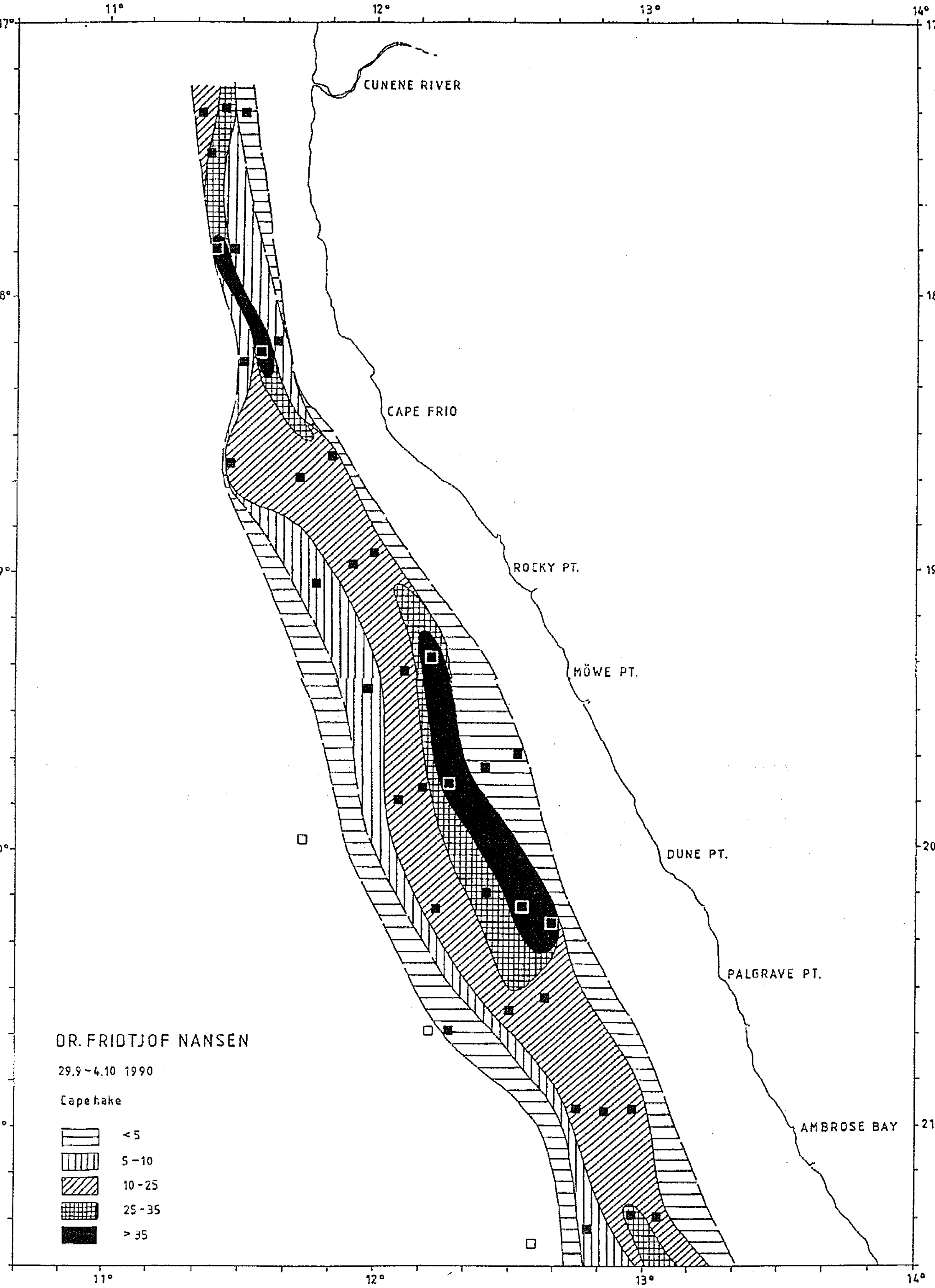

Figure 6. Ambrose Bay to Cunene River. Distribution of Cape hake. Density strata based on observations of catch rates at fishing stations

34 cm the observed integrator readings represent areal densities of 7 and 10 tonnes per nm respectively. The densities of the hake layer further up from the bottom could as mentioned above not be measured acoustically, but simple observations showed that it could range above 50 m from the bottom. If an average of a 25 m layer is assumed, the densities quoted above would be doubled. This can be calculated to increase the observed biomass by 75-100%. This is a rough estimate onely, being limited by problems of basic method. It can, however, be claimed that a source of very significant bias of the swept area estimate has been demonstrated to exist for this survey and that the true hake biomass is undoubtedly much larger, perhaps the double of the estimate. An proved assessment can only be obtained by a future survey, either at a season with a different hake behaviour or by use of more sophisticated equipment for observing and processing the acoustic back scattering of the various targets.

CHAPTER 5 CONSIDERATION OF THE SURVEY RESULTS

The swept area trawl survey, the main objective of the programme, was successfully accomplished between September 11 and October 6 with a total of 141 bottom trawl stations covering the whole Namibian shelf. Acoustic observations indicate that in the northern part of the shelf, especially from Ambrose Bay to Cunene the catches in the bottom trawl must have underestimated hake density due to occurrence in mid water. An attempt has been made to evaluate the order of magnitude of this underestimate.

The analysis of data from successive surveys may, in addition to data on fish distribution, composition and abundance and biological parameters, also provide information relating to stock identity and stock structure. Figure 7 shows the size compositions estimated for the total stocks in each of the sub-areas and for each of the surveys. The size compositions within each of the areas are seen to be similar between surveys, but with an expected shift to the right of the main group caused by growth in the intervening period. There is at the same time a similar difference in size composition between the areas in each of the surveys with a trend of increasing size towards the north, and in particular showing an apparently distinct composition of larger sized fish in the northernmost area. This demonstrates that the stocks in the sub-areas have maintained a certain measure of identity over this period of time. A difference in the state of maturity was observed with fish in the two southernmost areas found to be prespawning or actively spawning while that in the northern area was resting fish in a non-spawning state. The fish in the north also demonstrated a difference in behaviour with abundant presence in mid water also in the daytime. Further series of data are needed to firmly establish whether sub-stocks do exist and what degree of mixing occurs over a period of time.

The consistency found in the size compositions in each of the areas represents a strong indication that in a general way the survey method is functional and can be expected to give relevant results.

Table 9 shows the biomass estimates of the Cape hake and the deep water hake for each of the areas as obtained by the February-March survey and that of September-October. For the two southernmost areas the estimates are similar. Added, there is an increase of Cape hake from 310 000 tonnes to about 350 000 tonnes. For the northern area the last survey gave a significantly lower estimate. It is thought, however, that this can be fully explained by the special behaviour of the fish in this area. Hake was found in abundance in mid water above the bottom also during the day. An evaluation of the magnitude of the resulting underestimate by the swept area method,

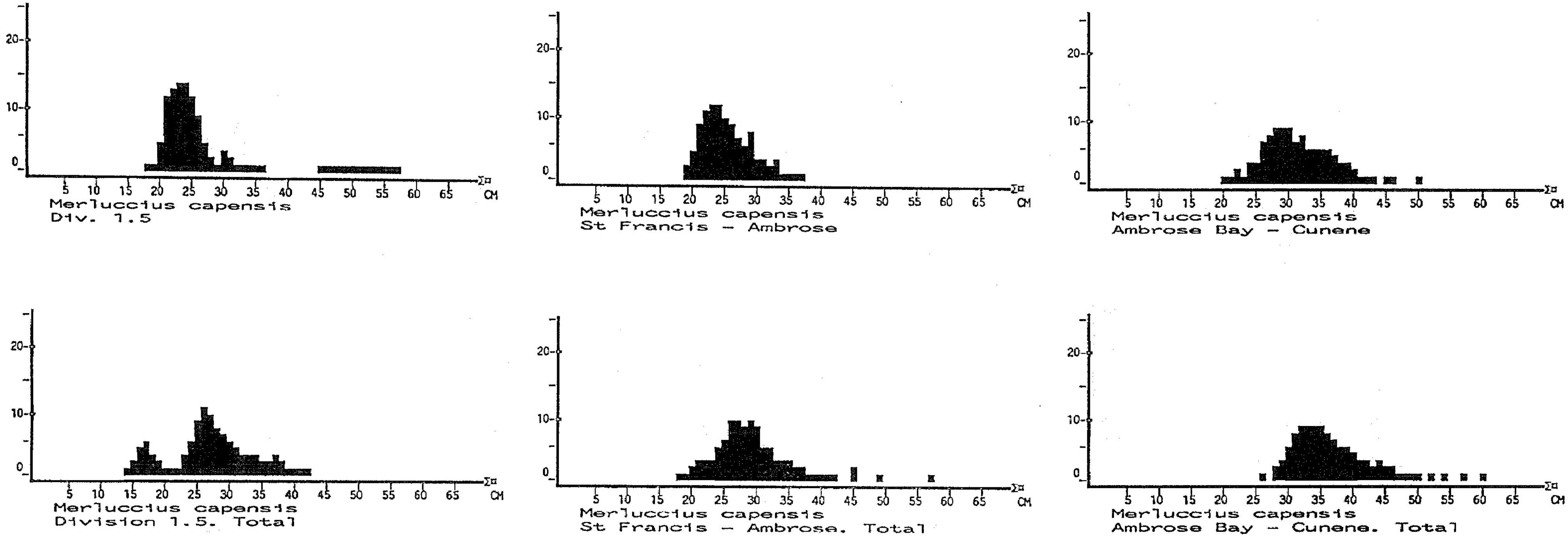

Figure 7. Estimated size compositions for the stocks in each of the areas and for each survey.

Table 9. Summary of estimates of biomass for the two hake species by surveys and areas. Tonnes.

	Total biomass Febr-March	Total biomass Sept-Oct
Orange River-St.Francis Bay		
Cape hake	130 000	130 000
Deep w.hake	22 000	25 000
St.Francis Bay-Ambrose Bay		
Cape hake	180 000	219 000
Deep w.hake	4 000	6 000
Ambrose Bay-Cunene River		
Cape hake	180 000	105 000+
Deep w.hake	800	1 000

based on sampled acoustic observations of hake density in mid water, showed that it was considerable and could well explain the discrepancy between the two survey results.

Viewed as a whole the survey results should be taken as a confirmation that the Cape hake stock is in a state of recovery. As demonstrated by the first survey there is an important young component in the stock which also now dominate in abundance, but at an expected higher fish size resulting from growth. If fishing mortality is maintained at a low level this group should contribute to an urgently needed increase in the component of larger sized fishable hake.