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 4 shows the catch rates standardized to kg/hour by main groups in both mid water - and bottom hauls from the shelf and the slope hauls separately. Hakes form the main part of the catches and the two species will be analysed separately below.

Table 4. Orange River to St. Francis Bay. Catch rates by main groups in pelagic and bottom trawl hauls standardized to kg/hour for the shelf- and the slope hauls.

SHELF

ST.NO.	DEP.	Pelagic	Hakes	Other dem.	Squid	Sharks	Other
2	165		904.4				42.1
4	76	12.0	8036.0				
5	113	10.3	1314.5	10.9		63.8	67.1
6	144		747.6	2.6	12.4		62.8
7	172	13.5	183.0	1.4	26.6		186.6
8	180	60.0	142.8	1.8	47.3	0.8	86.3
9	182	84.4	51.8	0.4	34.2	2.4	106.2
13	213	35.8	65.8	30.8	28.0	6.2	32.6
14	178	27.6	206.2	0.6	19.2	38.6	91.2
16	186	4.6	236.0	8.5	53.1	3.8	38.5
17	5	17.0	4.6		19.2		101.2
18	100		2214.0			108.0	321.8
19	142	15.4	76.8	0.9	4.6	132.3	103.7
20	175	11.6	162.4	14.4	6.3	126.6	20.7
21	181	137.1	94.2		21.6		335.5
22	174	374.2	135.0	150.0	26.3	24.0	16.3
24	167	31.4	109.4	6.0	28.4	5.3	36.0
25	198	10.8	30.0	0.4	19.2		129.6
26	188	14.4	22.2	1.4	27.5		126.1
27	190	1320.8	170.8	1430.0	0.8	2.4	141.9
29	186	619.0	180.0				16.5
30	86		39.6				48.6
31	127	0.6	46.8		4.2	32.2	1.5
32	95	5.2	64.0	0.0	0.4	34.0	5.8
33	5	1230.6			0.4	81.4	
36	239		831.6		19.4	7.0	30.0
37	184		1736.0		24.8		10.4
39	105						
41	70	134.4					40000.0
43	133		2.4				16.8
44	164		70.4				4.4
45	201		27.8				1.4
53	211		114.5				60.0
58	197		529.2				80.3
61	5						288.0
62	201		726.4				
69	203		1361.4				59.8
MEAN		112.7	557.7	44.8	11.4	18.0	1153.2

SLOPE

ST.NO.	DEP.	Pelagic	Hakes	Other dem.	Squid	Sharks	Other
10	400		14.2				56.9
11	302	2.3	98.0	7.1	4.0	2.5	29.0
12	418		174.5	11.6	1.6		32.3
23	333		26.1	34.2			115.6
28	300		134.6	3.0		4.0	18.6
34	303	0.5	99.0	11.0	12.9	2.2	19.9
35	372		1017.7	5.1	17.0		153.3
38	284		385.2	52.6	86.2		102.3
40	309		189.0	2.4			163.1
46	322		131.1	45.2			35.2
47	375		375.9		9.4		12.7
48	514		39.6	5.1	20.4	82.2	10.8
49	510		40.5		15.0	9.4	43.4
50	403		124.6		16.8		62.0
51	350		121.2		21.6		28.8
52	299		134.0				82.2
54	410		99.4		2.0	1.8	130.4
55	361		30.0	12.2	20.8	0.6	41.2
56	266		128.4	1.0	0.8		8.7
57	450		15.0		54.6	3.4	43.7
63	297		593.0		78.0		267.2
64	350		58.0		36.0	4.8	34.8
65	420		46.0		30.0	1.2	42.0
66	399		19.6		31.0	19.2	37.2
67	298	50.0	241.8		18.0		104.1
68	255	2.0	492.8		20.9		154.4
MEAN		2.1	185.7	7.3	19.1	5.0	70.4

The broad shelf south of 27°30'S seems to have faunistic components different from that further north. Pelagic fish formed part of many of the bottom trawl catches and consisted of a number of forms. The clupeids were nearly exclusively round herring *Etrumeus whiteheadi* with a few pilchards, and the carangids were horse mackerel *Trachurus capensis*. The southern rover *Emmelichthys nitidus* was caught at about 100 fathoms of depth as was also the main part of the hairtails. Snoek was a minor by-catch over wide parts of the main shelf.

John dory *Zeus faber* gave some high catch rates, up to 1 400 kg/hour in the bottom trawl. Kingklip *Genypterus capensis* was also important among the demersal species other than hakes with catch rates up to 50 kg/hour and a main distribution between 200 and 400 m. Catches of monk *Lophius upsicephalus* were fewer and smaller, only one ranging above 10 kg/hour.

The squids consisted of two species, the small sized southern cuttlefish *Sepia australis* appearing in small quantities in the shelf catches and the flying squid *Todarodes sagittatus* with high incidense as a by-catch in the slope with mean catch rates of 15-20 kg/hour down to 500 m.

Pooled length distributions of samples of the main species are shown in Annex I.

The hakes

The two species Cape hake *Merluccius capensis* and deep water hake *Merluccius paradoxus* appeared to be well separated in their depth distribution at about 300 m of depth, see Table 5 which shows the mean densities by depth ranges and the corresponding mean catch rates with the type of trawl used by the vessel. The density of the Cape hake is more than three times higher over the shelf than in the upper slope, while the deep water hake has its highest density in the 350-450 m range with quite low densities above and below this range. The three highest catch rates for the Cape hake were: 8.8, 2.2 and 1.7 tons/hour, while those for the deep water hake were 1.0, 0.38 and 0.13 tons/hour.

Table 5. Depth distribution of the two hake species, Orange River to St. Francis Bay. Mean densities t/nm and mean catch rates kg/hour.

	100-250m	250-350m	350-450m	450-550
Cape hake				
Density	21.9	4.3		
Catch rate	660	130		
Precision (%)	88	91		
No of hauls	29	12		
Deep w. hake				
Density		1.4	5.0	1.2
Catch rate		40	150	35
Precision (%)				

When plotted in a chart the observations of densities by fishing stations of Cape hake fall into a pattern of levels which reflect the distribution of this species over the shelf, see figure 7. South of Lüderitz the shorewards limit of the distribution was close to the 100 m depth line at some 10 nm off the coast, while northwards the hake was located

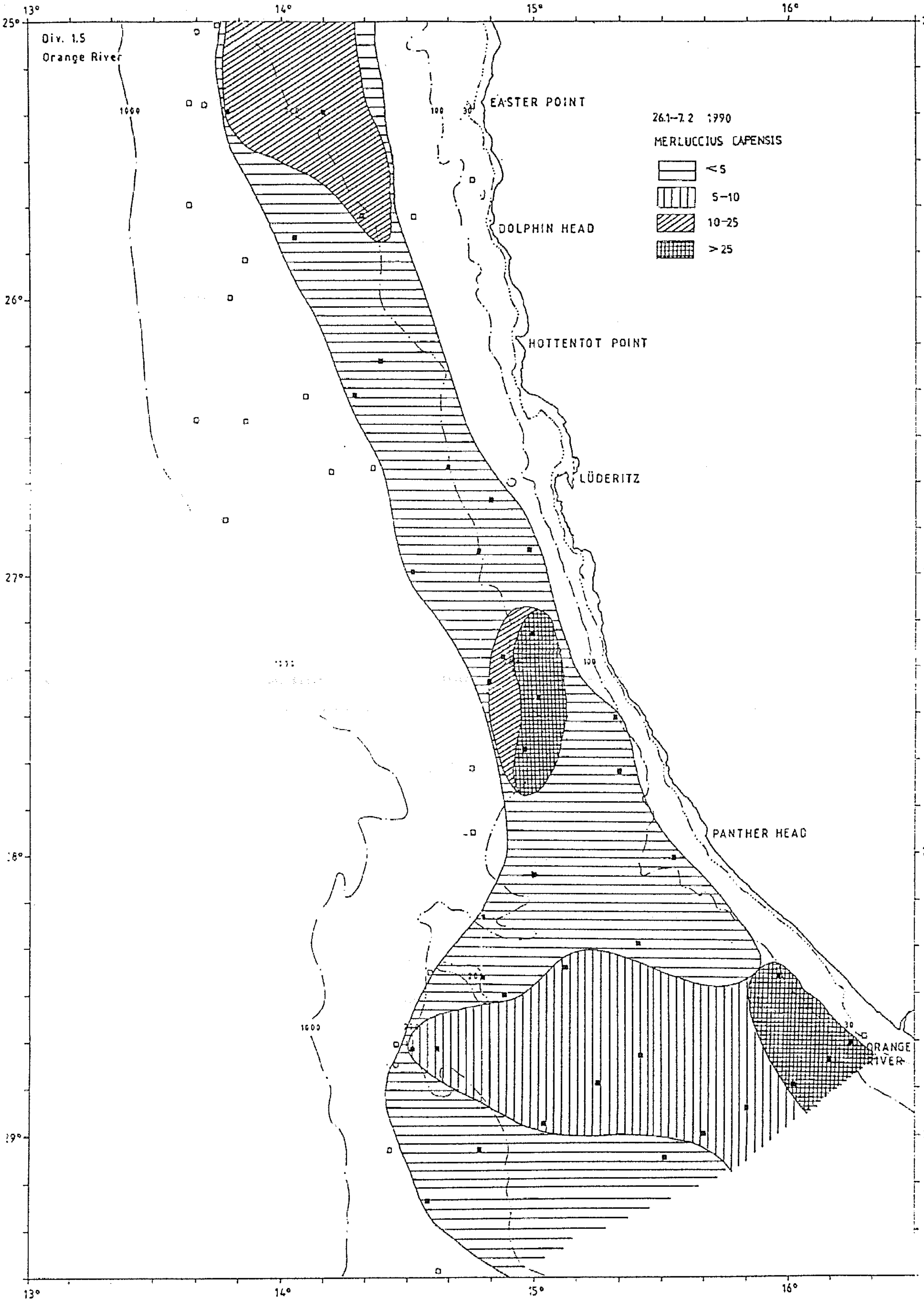

Figure 7. Distribution of Cape hake, Orange River to St.Francis Bay. Density strata based on catch rates at fishing stations. Tons/nm^2.

further offshore. This shift could be related to increasing densities of jellyfish in inshore waters towards the north. Patches of high density were found over the mid- and inshore shelf in the south, but over wider, more offshore parts in the north.

For the deep water hake there is an indication of a decline of density along the slope northwards from a mean of 4.8 t/nm^2 for the area south of Lüderitz to 2.5 t/nm^2 in the northern part.

There is a well known depth dependence of the size composition of hakes and pooled size compositions of samples of Cape hake catches from the shelf down to 250 m of depth and from the slope beyond 250 m are shown in Annex I. The trawl used is fine-meshed and is likely to give representative distributions below 20 cm of fish length. The modal group around 10 cm of length was only occasionally caught and was sometimes found in dense aggregations in mid water during day time. This group, probably 1+ by age was thus not available for the survey. The modal group of 24-25 cm, probably the age group 2+, seems to have been fully available and was, as shown in Annex I, not only present and the dominating group over the shelf down to 250 m, but was also partly available in the slope below 250 m. Protection of small sized young hake in the 20 cm length class is thus not possible through area closures.

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 strata. This is shown as "Total stock" in Annex I. Only part of this will be available for commercial fishing with an effective trawl mesh size of 110 mm. Asuming a selection factor of 3.3 for the hake and a range of 20 cm between the 10% and the 90% retention lengths as deduced from Ivanova et al (1989), a selection curve has been applied to the length distribution of the stock and its equivalent weight distribution. The fishable part of the stock would according to this estimate be about 15% by numbers and 52% by weight.

If a series of historical data from surveys with small meshed sampling trawls were available, the abundance of the modal size group in the 20 cm range, the 2+ group could be used as a measure of strength of the incoming recruitment to the stock of Cape hake. Several nations have undertaken trawl surveys of the hake grounds off Namibia, but a direct comparison with our findings proves difficult since the fishing gear and methods have differed from that used in the present survey. The survey programme of the Sea Fisheries Research Institute of South Africa covers Div. 1.6 immediately south of Div. 1.5. A considerable increase in the abundance of 1 and 2 year olds, as compared to observations since 1984, were reported from the northern part of Div. 1.6 from their survey in July 1989 (Augustyn et al, 1989). The stocks in these parts must be closely related. The Spanish surveys which cover the area from the Orange River to Walvis Bay also reports relatively high numbers of the 1 and 2 groups as compared with the two preceding years from their coverages in January and July 1989 (Gordoa and Macpherson, 1989).

Although there is thus, for the time being no strict basis for evaluating the recruitment to the stock, there are some grounds for stating that it seems likely that the relatively high abundance of the 2+ group observed in this survey, indicates a recruitment which is higher than in the previous, at least two years. Until further more precise information becomes available one can at least conclude that if protected from fishing by improved management the present 2+ group can contribute to some recovery of the adult stock.

A change of size composition with depth was also observed for the deep sea hake see Annex I, which shows the size compositions down to and below 350 m, but it was less marked than in the other species. There is less small sized fish present. Assuming as above, an effective mesh size of 110 mm, 40% by numbers and 60% 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. 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). 60 successful hauls were made for this purpose in the area.

For the Cape hake the data can be used in two different ways based on analysis of the distribution by area and of densities by depth strata. For the first, the mean densities of the patches and strata of distribution shown in figure 7 are related to their extention by area and an integration made. In the second method the mean densities by depth strata as shown in Table 5 above are related to the estimates of extension of these strata recorded in. Table 1. The results are shown in Table 6.

Table 6. Estimates of biomass of hakes, Orange River to St. Francis Bay. Tons.

Cape hake from distribution chart					120 000 - 140 000
From density by depth strata:					
	100-250m	250-350m	350-450m	450-550m	Total
Cape hake	247 000	14 000			261 000
Deep sea hake		4 500	15 000	2 500	22 000

The range in the estimates from the distribution charts relate to the somewhat subjective way in which the delimitations of the denser aggregations may be made.

As shown above, only 52% of the Cape hake and 60% of the deep sea hake represent the fishable component of the stocks. Our estimate for the fishable biomass of hake in the area from the Orange River to St. Francis Bay is thus about 135 000 t for the Cape stock when using the depth stratified data and 68 000 t when using the post stratified data from the distribution chart. Because of the patchy distribution of the Cape hake over the shelf, it is thought that the method which takes this patchiness into account will be more reliable. For the deep water stock the fishable part is 13 000 t. Our best estimate of the fishable part of the biomass of hake in Div. 1.5 is thus 80 000 t.

4.2 St. Francis Bay to Ambrose Bay

Composition of catches

Table 7 shows the catch rates standardized to kg/hour by main groups in both mid water and bottom hauls from the shelf and the slope hauls separately. Hakes form the main part of the catches and the two species will be analysed separately below.

Cape horse mackerel formed the main part of the catch of pelagic fish in this area. This species also appeared in the bottom trawl catches, especially in the slope at 250-350 m depth. Only low catches were made of demersal fish other than hake. Kingklip did not appear in this area. Catches of monk averaged 3 kg/hour in 21 hauls and West Coast sole 11 kg/hour in 7 hauls. The squids consisted almost exclusively of flying squid *Todarodes sagittatus* with highest catch rates averaging about 35 kg/hour in the 300-500 m range. The mean size of the squid at these depths approached 0.5 kg.

The hakes

The mean density of Cape hake was higher in this area than in Div. 1.5 while that of the deep water hake was considerably lower, see Table 8. The two species are well separated by depth distribution. The three highest catch rates for Cape hake were 6.5, 3.1 and 2.6 tons/hour while those for deep water hake were 180, 130, and 90 kg/hour.

The plots of catch rates for the Cape hake give a density distribution as shown in figure 8. The shoreward limit of distribution is sharp and seemed to be related to the occurrence of soft muddy bottom, but increasing densities of jellyfish were also observed towards the shore. The belt of high densities over the mid shelf was a consistent finding.

The size distributions based on a large number of samples pooled are shown by depth ranges for the two species in Annex I. The 1+ group of Cape hake was also in this area found in dense aggregations in mid water in several locations and this group appeared only occasionally in the swept area hauls. The 2+ group dominate the high density aggregations on the shelf and is also represented in the deep grounds. Also for this area an estimate of the size composition of the total stock has been made by adjusting for the size related depth distribution. Weighting by total biomass in the two depth strata gives the compositions shown as total stock in Annex I. The deep water hake is represented by fish of larger size than in Div. 1.5.

The size composition for the total stock of Cape hake in this area with the high dominance of the 2+ group is very similar to that found in the southern area, Orange River to St.Francis Bay. Also for the northern stock of Cape hake (Div. 1.3 +1.4) there has been a decline of stock biomass and recruitment over several years, but the Spanish survey programme referred to above reported some increase of recruitment in 1989. It seems reasonable to draw a similar provisional conclusion regarding recruitment in this area as that discussed for Div. 1.5 above: the indications are that the recruitment is better than in the recent few years and if protected by improved management the 2+ group will contribute to some recovery of the adult stock.

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

SHELF

ST.NO.	DEP.	Pelagic	Hakes	Other dem.	Squid	Sharks	Other
73	223		264.0		6.4		152.0
81	203		997.2				45.0
82	5	360.0					
83	110		1.3			2.8	51.6
84	159	210.6	1026.4				
85	201		6500.0				
86	243		217.4		22.4		83.6
94	227	108.4	152.8	3.6	4.0	1.6	67.2
95	184		934.8	18.6			20.4
96	164	5.0	1488.0				
97	5	116.5					
98	5	89.1					
99	111						
100	156		1127.1				78.0
101	174	4.0	252.0	10.2	4.2		76.4
102	221	220.2	53.6	1.2	4.0	1.2	34.8
109	147	1042.6	1133.4			18.6	5.4
110	141		3110.4	33.6			
111	133		691.2	10.8		4.2	
112	5	215.2					
113	5	177.4					
114	5	102.6					
115	112						
116	128		160.3				14.0
117	134		510.4				17.6
118	183		778.6	6.8			34.0
119	244	174.2	418.6	1.2	4.8		0.9
121	10	148.4	2.2				
122	10	208.8					
126	196	7.8	542.4	1.8			
127	139		1846.8				
128	126		1393.2				
129	10	235.4					
130	10	115.7					
131	10	83.0					
132	5	258.4					
133	5	269.0					
134	136		88.4				8.0
135	189	321.0	2613.0				30.0
137	10	363.2					
142	5	672.0					
144	220	3.8	57.6				2.5
145	192		115.8				1.5
146	60	41.6				0.50	
147	147		1740.8				
148	112	5.6					153.6
149	50						
150	5	37.2					3.6
151	5	72.0					
152	5						
153	5	1.8					
154	106		0.4				7.0
155	5	475.5					
156	125		34.8				117.6
157	164		151.2				19.2
163	142	1950.0	6645.2	3.6			2.4
164	5	80.5					
165	5	159.8					
166	5	72.0					
167	5						
168	5	80.0					
MEAN		139.1	574.5	1.5	0.7	0.4	16.8

SLOPE

ST.NO.	DEP.	Pelagic	Hakes	Other dem.	Squid	Sharks	Other
74	272		29.4		5.0		43.0
75	352	9.0	68.4	3 4	4.0	11.2	40.2
76	450		34.9	0 5	44.5	9.6	41.5
78	382		46.0		42.4	61.2	33.0
79	302		315.8		7.0		124.0
80	251		142.0	6 0	5.7		60.0
87	279	10.8	287.7		13.3	1.0	81.5
88	302	8.0	85.4		3.0	4.8	22.4
89	450		59.6	1.0	46.4	49.4	169.2
90	5						279.2
91	502	1.4	14.6	5.7	10.8	197.2	106.6
92	375		180.6	9.2	58.3	25.4	94.7
93	271	89.4	164.0	3.0		4.0	43.0
103	322	64.2	115.2		10.4	4.0	428.0
104	415		14.8	1.8	18.8	16.9	71.5
105	503		11.0		6.6	10.9	51.9
106	487		65.8	4.0	32.0		110.4
107	353		31.4	0.9	29.0	8.5	24.0
108	252	1339.2	52.8				
120	292	26.6	67.2		4.2		12.4
123	432		8.5		10.8	9.2	103.8
124	299	105.6	240.6	1.9	24.0	2.4	63.2
125	260	92.0	103.2		2.4	10.8	6.6
136	265	133.0	866.0				57.1
138	381	9.0	62.0		44.4	450.2	149.9
139	351	6.0	131.2	7 0	46.8	15.6	24.9
140	278	1666.8	373.7	1.7			57.6
141	275	308.4	356.6	3.6		2.4	29.2
143	301	16.6	142.3	1.8	58.0	1.4	102.4
158	257	81.6	153.0	1 0			58.7
159	303		62.0		20.4	3.6	47.8
160	416		25.4		60.2	13.8	287.0
161	140					9.3	0.5
162	488	1.0	96.3			58.7	215.6
MEAN		116.7	129.6	1.5	17.9	28.8	89.4

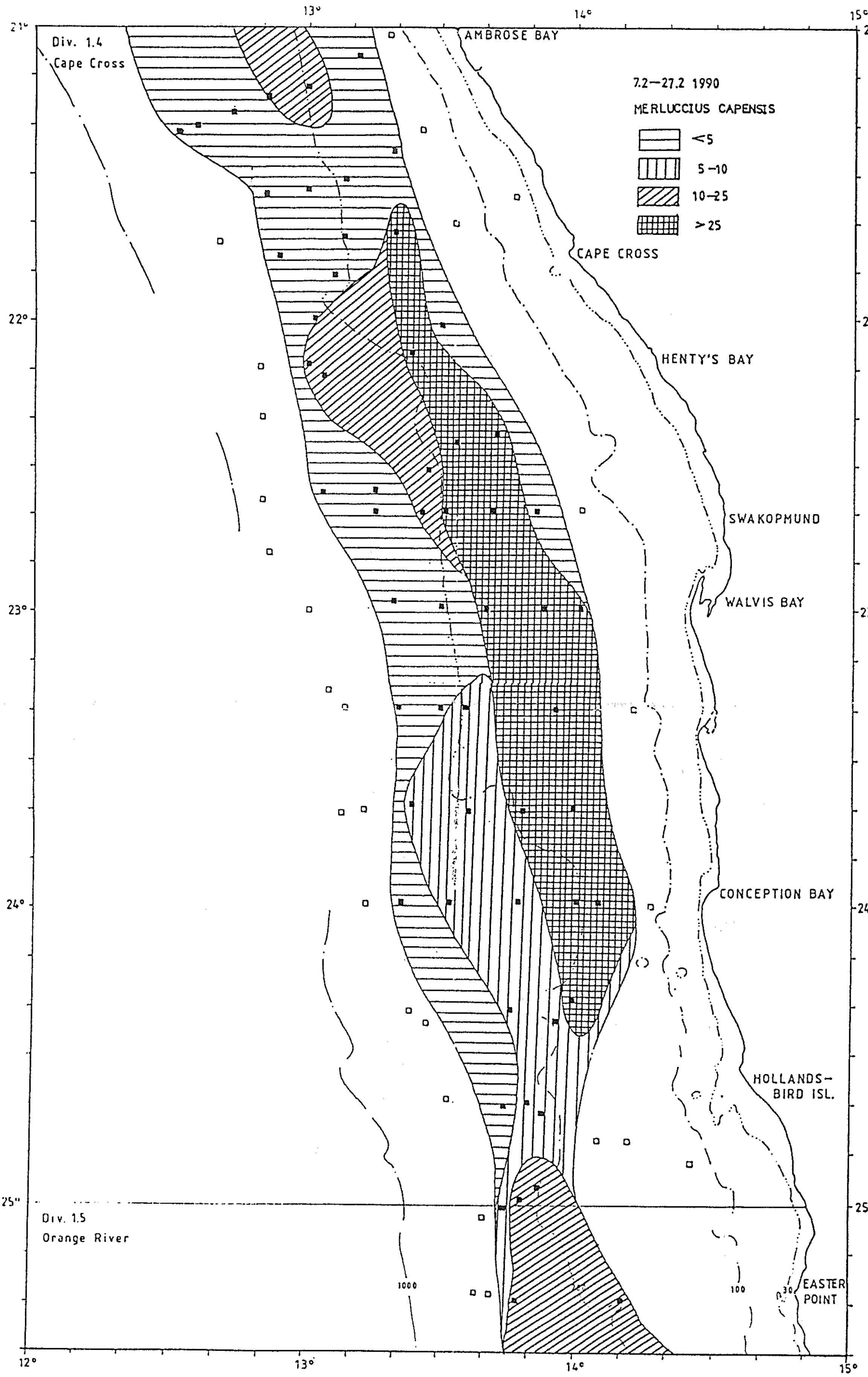

Figure 8. Distribution of Cape hake, St.Francis Bay to Ambrose Bay. Density strata based on catch rates at fishing stations. Tons/nm^2.

Table 8. Depth distribution of the two hake species, St. Francis Bay to Ambrose Bay. Mean densities t/nm and mean catch rates kg/hour.

	100-250m	250-350m	350-450m	450-550
Cape hake				
Density	27.1	7.4	0.4	
Catch rate	810	220	10	
Precision (%)	51	41	45	
No of hauls	36	21	13	
Deep w. hake				
Density			1.6	1.4
Catch rate			50	40

The application of a mesh selection of a 110 mm trawl shows that only 12% by numbers and 24% by weight of the Cape hake in this area would be fishable, but all of the deep water hake is of fishable sizes.

Estimates of biomass from the two ways of processing the swept area trawl data are shown in Table 9. There is less difference between the two methods in this area than in Div. 1.5, but also here it is thought that the post-stratified density grouping gives the most reliable result. The fishable part is estimated to only 43 000 t. In addition comes the 4 000 t of deep water hake giving a total of about 50 000 t.

Table 9. Estimates of biomass of hakes, St. Francis Bay to Ambrose Bay. Tons.

Cape hake from distribution chart 180 000

From density by depth strata:

	100-250m	250-350m	350-450m	450-550m	Total
Cape hake	225 000	26 000	700		252 000
Deep sea hake			3 000	1 400	4 000

4.3 Ambrose Bay to Cunene River

Composition of catches

Table 10 shows the catch composition by main groups. Pelagic fish and hakes dominate, and high catches are frequent. Dentex appear north of 20°S with highest catches north of Cape Frio. The catches of pelagic fish were mostly of Cape horse mackerel with some of pilchard and anchovy inshore. The horse mackerel also appeared in the demersal trawl hauls. Large eye dentex, *Dentex macrophthalmus* was the only demersal species other than hake which appeared in significant amounts in the bottom trawl. The highest rates were from the 100-200 m depth range. The flying squid was caught in the slope with catch rates up to 40 kg/hour. Some few catches were made of African mud shrimp *Solenocera africana* at 200-300 m and of striped red shrimp *Aristeus varidens* at 400-500 m.

Table 10. Ambrose Bay to Cunene River. Catch rates by main groups in pelagic and bottom trawl hauls standardized to kg/hour for the shelf- and the slope hauls.

SHELF

ST.NO.	DEP.	Pelagic	Hakes	Other dem.	Squid	Sharks	Other
169	44	0.0					0.0
170	104	0.3					250.0
171	122		6.8				240.0
172	228	39.0	503.8	2.0			47.6
178	5	15068.4					
179	36	12.5					1.6
180	44	0.2					0.1
181	91	0.2					18.6
188	147	7476.0	1797.6	252.0			70.5
189	5	12.0					
190	10	672.0					
191	161	36.0	2076.0	510.0			375.0
198	220	4.6	118.0	25.8	10.0	8.0	58.0
199	83	2500.0					55.5
200	132		383.6				16.4
201	165	1680.0	2032.0	384.0		13.2	128.0
202	221	30.8	1029.6	2.0			91.0
209	216	375.2	739.2	46.2		11.6	100.8
210	105	0.2					120.1
211	86	0.0					
212	141	0.0					
213	238	3451.6	7548.4			12.4	20.4
220	76	1200.0				17.4	
221	28	848.4					4.2
223	195	174.3	371.6	45.8	3.6	105.5	652.6
224	122	1104.0	386.0	916.8			120.4
225	5	900.0					
226	117	1440.0	600.0	3289.2		178.4	773.2
227	195	9.9	827.2	22.0	7.6	8.8	341.5
229	143	3848.0	686.4	884.0	10.4		192.4
231	60	4800.0					
232	12	9.6					
233	35	150.0					
234	10	1600.0					
235	80	11538.4	1.8				
236	10	480.0		0.8			
237	70	180.0	0.4	0.3			1.4
238	127	10752.0	2784.0	240.0			64.0
239	15	101.4					2.2
240	10	280.0					
241	65	107.1					
242	123	0.2	20.4				0.3
243	110	3600.0	7.9				
244	5	1978.8					21.6
245	10	1.8					
246	15	2.6					
247	5	8000.0					
248	5	1802.0					
249	10	540.0					
250	10	208.0					
251	23	513.0					
252	65	4600.0					
253	8	750.0					
MEAN		1752.4	413.6	124.9	0.6	6.7	71.0

SLOPE

ST.NO.	DEP.	Pelagic	Hakes	Other dem.	Squid	Sharks	Other
173	313		338.2	1.0	28.8	4.8	156.5
174	349		9.6		10.6	25.0	61.5
175	450		52.1	2.2	8.4	132.5	280.7
176	550		46.5		4.8	8.3	91.3
177	90				6.4		20.0
182	277	39.0	332.8	2.8			387.4
183	313	1.4	8.6	5.4	3.4	7.2	61.6
184	400		37.9	4.0	30.0	19.2	174.9
185	499		12.1			37.2	99.7
186	296	0.9	25.8	2.0		1.9	72.6
187	257	15.4	48.8				3.4
192	253	26.4	1026.0	22.8	24.0		234.2
193	340	112.0			10.8	32.2	166.5
194	504		14.4		2.9	36.8	386.7
195	373		58.5	15.8	2.0	7.0	153.8
196	452		78.7			67.5	263.6
197	572		12.8			4.1	160.7
203	402		110.7	3.2	14.0	51.9	142.4
204	506		136.0		30.0	66.9	180.8
205	604		19.4		17.0	80.5	174.6
206	371		12.0	11.6	12.0	26.0	171.4
207	323	4.0	9.0		5.6		24.8
208	264	360.8	400.4	145.2		17.0	204.0
214	70	8.4					
215	275	86.4	420.0	4.8	8.4		37.2
216	456	0.1	15.0		10.4	14.4	153.4
217	261	57.2	4500.0		41.6	7.8	632.0
218	416		45.4	1.8	12.0	6.0	120.2
219	570	12.0			3.2	1.6	71.2
222	349		537.6		8.4	33.6	156.8
228	301		231.4		16.2	39.6	235.2
MEAN		23.3	275.4	7.1	10.0	23.5	163.8

The hakes

A further increase was found in the mean density of Cape hake compared with the two southern areas, but the deep water hake was only found in low densities in the 450-550 m range, see Table 11. The two species are well separated by their depth distribution. The three highest catch rates for Cape hake were 7.5, 4.5 and 2.8 tons/hour while those of the deep water species were: 140, 110, and 80 kg/hour.

Table 11. Depth distribution of the two hake species, Ambrose Bay to Cunene.
Mean densities t/nm and mean catch rates kg/hour.

	100-250m	250-350m	350-450m	450-550
Cape hake				
Density	41.3	20.9	1.0	
Catch rate	1240	630	30	
Precision (%)	98	127	116	
No of hauls	13	12	5	
Deep w. hake				
Density				1.0
Catch rate				30

The density distribution for Cape hake, figure 9, shows the same pattern as in the southern areas with a belt of high densities over the middle part of the shelf. Also here the inshore limit was found just outside the belt of soft muddy bottom along the shore.

The size distribution by depth ranges of 18 and 20 pooled samples respectively are shown in Annex I. Fish sizes are higher than in the previous area and 3+ and higher age groups seem to dominate. There is the usual increase of size with depth and a size distribution for the total stock has been estimated by weighting the depth strata series by the respective biomasses calculated for these strata.

The application of a mesh selection of a 110 mm trawl, shows that 33 % by numbers and 49 % by weight of the Cape hake in this area would represent the fishable stock.

The biomass estimates with the two different approaches are shown in Table 12. The levels are similar to those found between St. Francis Bay and Ambrose Bay. Using the post stratified density groupings the fishable biomass is estimated to 88 000 t.

Table 12 Estimates of biomass of hakes, Ambrose Bay to Cunene. Tons.

Cape hake from distribution chart 180 000

From densities by depth strata:

	100-250m	250-350m	350-450m	450-550m	Total
Cape hake	210 000	56 000	1 500		268 000
Deep sea hake				800	800

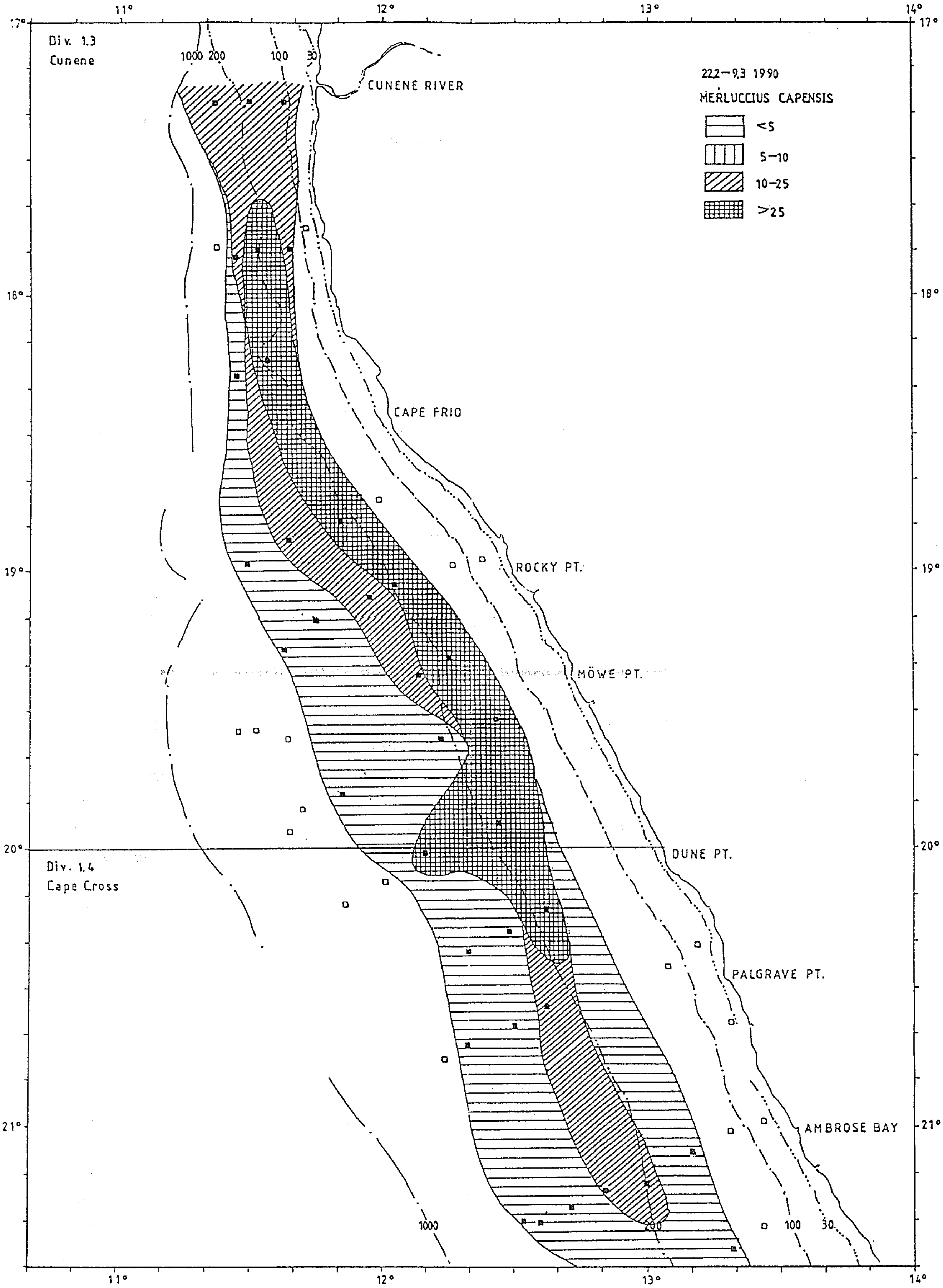

Figure 9. Distribution of Cape hake, Ambrose Bay to Cunene River. Density strata based on catch rates at fishing stations. Tons/nm^2.

5. REVIEW OF INFORMATION OF THE STATE OF THE MAIN STOCKS AND ADVICE ON MANAGEMENT.

A considerable amount of information exists on the history of the fisheries and the main stocks of the Namibian Sea. Most of this is available in ICSEAF documents and in reports from the Sea Fisheries Research Institute of South Africa. It is thought that the present survey has provided comprehensive updated results which when evaluated on the background of the available previous data can provide important information for decisions regarding the management of the stocks.

The inshore stocks of small pelagic fish

The 230 000 t biomass of **pilchard** found mainly between Walvis Bay and Cape Frio representing one yearclass only shows a size of this stock which is thought to lie within the depleted level reported in later years. The pilchard stock has for some 15 years been in a state of depletion originally caused by overexploitation. The persistence of this state over such a long period must at least in part be due to the policy which has been followed of exploiting the stock at a rate which probably represents its maximum potential in the depleted state. Ecological factors may, however, also have contributed to the prevention of a recovery and of these the high density of Cape horse mackerel may be the most important. The findings of the present survey supports the advice which has been submitted over a long period of years, that fishing on this stock should preferably cease, alternatively be strictly limited particularly on juvenile fish.

The 215 000 t biomass of **anchovy** was found in discrete small patches inshore from Conception Bay to the northern border. Only one yearclass was represented. This result is a confirmation of the stock size of 175 000 t reported from July 1989 and no recovery of the stock has thus taken place. In the mid 1980's the Namibian anchovy fishery came to depend on a high proportion of juveniles and the stock was depleted with no effective management. A recovery of the fishery in 1987 and partly 1988 may have been based on recruitment from the South African stock. In the present situation the fishery should be restricted as much as possible in order to increase the adult component and thus improve outlook for recruitment and reduce fluctuations of the stock biomass.

The Cape horse mackerel stock

This species was found in abundance over the whole shelf from off Walvis Bay to the Cunene River. Particularly in the southern part of the area of distribution a clear size dependence of the fish was found with distance from shore, with the juvenile 1+ group dominating out to 100 m of depth followed by a mixture of the 1+ and the 2+ group between 100 and 200 m and only 2+ fish and older further out. The 1+ group represents about 65% of the stock by numbers, but 80% of the biomass is adult fish. The estimates of biomass are given with a range related to uncertainties regarding the acoustic properties of this species, with a total stock biomass of 1.4 - 2.7 mill tons with a proportion of 2:3 between the southern and the northern areas.

It is not unlikely that it was the depletion of the pilchard stock which left room for the expansion of the stock of Cape horse mackerel to its present large size. The stock has supported catches of 400 000 to 600 000 t since 1978. The ICSEAF assessment of November 1989 based on data up to 1988 recommends a TAC for 1990 of 410 000 t. The biomass estimates from the present survey can not be used directly for assessments of sustained yields, but the findings especially the representation of the various age groups do not seem to be inconsistent with adiagnosis of a relatively healthy stock. The abundant 1+ group indicates a relatively high recruitment. When deciding on and allocating total allowable catches for horse mackerel, account should be taken of bycatches of hake in this fishery. The horse mackerel taken by purse seine in the inshore fishery consists nearly exclusively of the juvenile 1+ group. Improved resource utilization would result from a shift of this fishery further offshore where 2+ group fish is also available.

The stocks of hake in Div. 1.5 and Div. 1.3 and 1.4

The separation of the hakes in Namibian waters into a stock in Division 1.5, the southern stock and one in Div. 1.4+1.3, the northern stock has been practiced by ICSEAF and is provisionally followed in this report without any comment as to its merits.

Consideration of the findings of the survey

Cape hake was found with about the same densities over the whole survey area, whereas densities of the deep sea hake declined markedly northwards. The estimated biomass of deep sea hake between the Orange River and Ambrose Bay was only about 8% of the total hake biomass, a much smaller proportion than those reported from the Spanish surveys of the same area in recent years.

The estimated total biomass of the Cape hake stocks is 130 000t for the southern stock and 360 000 t for the northern stock see Table 13. The juvenile 2+ group dominates in both stocks. Although this domination of the juvenile group is a relative phenomenon only in our data and in part an effect of recent years heavy fishing on the older yearclasses, a comparison with results from South African and Spanish surveys in 1989 indicates that this years recruitment to the stock may be better than those of the last few years. An important issue is then to ensure through proper management that this recruit group will contribute to a recovery of the adult stock over the next years. This is discussed further below.

For further use in assessments the biomass estimates are converted to fishable biomass, the part which would be available to fishing with a trawl mesh of 110 mm see Table 13. The fishable part of the estimated biomass including both species is 80 000 t for the southern stock and 140 000 t for the northern stock.

These data together with an evaluation of the present catch level in the fishery and the rate of natural mortality allows an assessment of the long term yield which the stocks would sustain under the conditions of recruitment of recent years. Only rough levels of yield can be expected from such calculations. In this case use was made of Cadima's estimator which has been critized for giving a certain overestimate of the yields. The projected 1990 catch assuming a theoretical extention of the fishing effort applied in recent years was 80 000 t for the southern stock and 120 000 t for the northern stock. The estimated long term yields are 50 000 t and 80 000 t for the two stocks. These are then indications of the allowable catches which would be sustained by the stocks with recent years recruitment.

Table 13. Summary of estimates of biomass for the two hake species by areas. Tons.

	Total biomass	Fishable biomass	Total fishable biomass
Orange River - St. Francis Bay			
Cape hake	130 000	68 000	
Deep s.hake	22 000	13 000	80 000
St. Francis Bay- Ambrose Bay			
Cape hake	180 000	43 000	
Deep s.hake	4 000	4 000	
Ambrose Bay- Cunnene River			
Cape hake	180 000	88 000	
Deep s.hake	800	800	140 000

Another approach is to assume that the observed fishable biomass will represent the mean biomass available to fishing through 1990. An application of the Fmax which in the case of the northern stock has been estimated to 0.25 (Schumacher, 1986) to the stock biomasses gives yields of 20 000 t for the southern stock and 35 000 t for the northern stock. This represents an underestimation since under constant recruitment the biomass would increase if the fishing pressure were reduced. Also the recruitment is likely to increase as compared to recent years, but use must be made of this component to rebuild the adult stock.

The state of the hake stocks and advice on management.

The Namibian hake stocks sustained catch levels of 500 000 t to 600 000 t for nearly a ten year period up to the late 1970's. Fishing was much reduced in the early 1980's due to poor catch rates, but high recruitment attracted new effort and catches reached 400 000 t in 1985. Later analyses have shown that use was not made of the high recruitment to rebuild the stocks and in the late 1980's the stocks were brought to their present low level through fishing at a level of more than the double of Fmax, the fishing mortality giving the maximum sustainable yield. An adequate future management of the hake stocks would include the need to limit the fishing effort to about halfof that applied in recent years. Total hake catches in 1987 and 1988 were around 300 000 t. The catch statistics for 1989 is not yet available, but judging from the Spanish survey results there was a further decrease of biomass from 1988 to 1989 and based on this the 1989 catch could be as low as 200 000 t. A 50% reduction in effort would thus represent a catch of between 100 000- 150 000 t.

In the long term a direct regulation of fishing effort may be the most rational way of controlling the fishing mortality, but this assumes detailed information on the fishing power of the various types of vessel engaged in the fishery. In the short term regulation by total allowable catches, TAC's is the only practicable approach.

Table 14 summarizes the available information for assessing the 1990 TAC. Since the first assessment is likely to be an underestimate and the second an overestimate a TAC of 100 000 t could be an appropriate choise. This represents the lower level of the very rough calculation of a 50% reduction of fishing effort. The catch already taken in 1990 should be deducted before setting the TAC.

Table 14. Review of information for assessing hake TAC's for 1990.

From survey biomass estimates		50% reduction of recent fishing effort
Fmax on biomass	MSY from biomass and recent yield	
55 000t	130 000t	100 000-150 000t

Although it is assumed that a reduction of fishing mortality to the level of Fmax will allow at least part of the improved recruitment in 1990 to contribute to a recovery of the adult stock one should also consider the merits of protecting the small sized hake from excessive fishing through increase of the minimum trawl mesh size. Even the nominal selection curve of a 110 mm mesh will include fish down to 25 cm of length and in practice fleet selection will result in higher proportions of small sized fish. The present mesh size allows the fleet to have high catch rates by concentrating fishing in areas of high density of juveniles. This could be prevented by increasing the mesh size to 120 mm which would take little fish below 30 cm. An increase of the minmum catching size would have beneficial effects in resulting in a higher standing biomass of the spawning stock and a less fluctuating fishable biomass. Economically the value of the yield would increase as a result of the higher value of large sized fish. Serious consideration should therefore be given to the introduction of a higher mesh size in the Namibian hake fishery.

Literature

Augustyn, C.J., Badenhorst, A. and R.W. Leslie. 1989. Biomass indices for Cape hake and other demersal species and trends in recruitment of Cape hake in South African waters between 1983 and 1989. ICSEAF Paper, SAC/89/S.P./24.

Boyd, A. J., Salat, J. and M. Maso. 1987. The seasonal intrusion of relatively saline water on the shelf off northern and central Namibia. S.Afr.J.mar. Sci.5:107-120.

Gordoa, A. and E. Macpherson. 1989. Biomass indices for Cape hake and other commercial species in Namibian waters (Divisions 1.4 and 1.5) from 1989 surveys. IC SEAF Paper SAC/89/S.P./36.

Ivanova, N. M., Dimitrikov, S. P., Ivanova,V.V., Kadilnikov, Yu.V. and G.N.Chetyrkina. 1989. Study of the influence of the Polish type enforcement topside chafer on trawl codend selectivity in the Cape hake fishery. ICSEAF Paper SAC/89/S.P./6 .

Schumacher, A. 1986. Assessment of the Cape hake population in ICSEAF Divisions 1.3+1.4. ICSEAF Paper SAC/86/S.P./43.

Svellingen, I.K. 1989. Analyse av svømmeblæreobservasjoner for bestemmelse av target strengt. Manuscript.