TRANSBOUNDARY OR NOT? HAKE-RELATED FINDINGS OF R/V DR FRIDTJOF NANSEN BASED RESEARCH, 2002-2011. A SUMMARY.

MAREK R. LIPINSKI, TORE STRØMME, SOPHIE VON DER HEYDEN, ERLING STENEVIK, BRITTA GROTE, PAUL KAINGE ET AL.

Abstract

Question of whether hake resources are transboundary or not belongs to the inductive science, i.e. arguments are decided upon the weight of accumulated evidence and expert decision and not upon deduction process. It is because accumulated evidence can always be interpreted in several ways.

All publications quoted except Field et al. (2008) stem from Nansen research.

Findings: Spawning of hakes takes place in August-October along the western Agulhas up to southern St. Helena Bay. It is possible now to differentiate between species on egg and larva level (von der Heyden et al. 2007 J Fish Biol 70: 262-268). Spawning activity of Merluccius paradoxus in this time and area is more intense than that of M. capensis (on the basis of the distribution of eggs and larvae; Stenevik et al. 2008 J Plankt Res 30(10): 1147-1146). It is possible that both hake species spawn in other times and areas, but spawning of M. paradoxus in January-April was found to be weak and M. capensis also not strong (both on the basis of Nansen demersal surveys mainly on the west coast, Multinet sampling and genetic identification). There is an indication of M. paradoxus larval drift (and possible growth as they drift) northwards. There is a strong indication that both hake species spawn in different depths and geographic locations, and therefore drift of their eggs and larvae is different (Stenevik op. cit.). There is an indication that condition of hake larvae is good and survival may be determined largely by the maternal condition (Grote et al. 2011, Marine Biology in press DOI 10.1007/s00227-011-1626-6; confirming results of modeling by Field et al. 2008 5th World Fisheries Congress TERRAPUB: 17-26).

Stock structure of both hake species is complex. Preliminary findings (von der Heyden et al, 2007, 2010, Molec Phylog Evol 42: 517-527; and 55: 1183-1188) indicate a remarkably homogenous population of M. paradoxus with low mtDNA control region diversity, and much more complex population of M. capensis (also results of Bloomer et al., 2009 BENEFIT Report). However, an interesting but relatively weak differentiation was recovered between M. paradoxus populations of Namibia and South Africa. As other published (e.g. Kainge et al. 2007 Afr J Mar Sci 29: 379-392) and unpublished (Nansen reports) evidence points out to the South African origin of M. paradoxus, there is a need for further research to provide an explanation for these findings.

Main evidence for the M. paradoxus growing in a main nursery and subsequently migrating north into the Namibian waters is so far only gathered in Dr Fridtjof Nansen reports. This evidence is two-fold: firstly, as geographic shifts of various length classes along the southern African west coast; secondly, as shifts of abundance. For example, main juvenile abundance was recorded repeatedly between Hondeklip and northern Orange Banks; very big

fishes are only found in South Africa. Also, in 2010 main shift of abundance was recorded, with markedly increased numbers of fish in SA and a decline in Namibia. In 2011, there was substantial increase of M. paradoxus numbers in Namibia and in SA these numbers returned to an average level. This suggests a shift between SA and Namibia within one year. This shift is being documented with a detailed length frequency analysis which should provide substance for this interpretation.

Introduction

It perhaps can be agreed that main scientific question of the BCC transboundary research is whether hake stocks are moving freely across the SA-Namibia border, and if so, which species is moving and how big is this phenomenon. In another words, can M. paradoxus and M. capensis be considered as transboundary shared resources or not.

Material and Methods

Demersal surveys of Dr Fridtjof Nansen were conducted between 2002 and 2011, usually covering shelf and slope area between Cape Agulhas and Namibian border. One south coast survey was also made in 2010. In the years 2004-2007 research was also conducted in the Namibian waters between the borderline with South Africa and Luderitz. Main period of research was January-March, but additional cruises were also conducted in some years in April-May and September-October.
Results of January-March cruises were combined with same results obtained in Namibia, using same survey design and gear but a different vessel.
Transect survey design was used in all surveys. Catchability coefficient was assumed to be 0.8.
Standard way of trawling (30 min.) was repeated in all cruises. The Gisund Super trawl was used. If the catch was too large, a sub-sample was taken. All species in the sample or sub-sample were identified and quantified (weighted and counted, or weighted and measured). Fish densities were expressed as t/NM^2, and plotted by hand on the maps. Biomass was calculated using standard area-density method. Standard deviation was not calculated due to the transect design limitations. Fishable and non-fishable biomass was split in 36 cm length (36> non fishable; 36<= fishable).

Results

Copies of published papers will be provided, therefore these results (concerning mainly eggs, larvae and juveniles of both hake species, and genetic results) are not repeated here.
Since 2010 Dr Fridtjof Nansen Report (latest available) summarizes all previous results, its Results section is reproduced here, as well as length frequency successions for 2005, 2009 and 2010. Similar results for 2011 are in preparation and should be available in early June 2011.

Biology

Figures 4.3a-b show the distribution of deep water hake (*M. paradoxus*) in the survey area. In the south coast the species is located in a narrow band on the slope along the whole coast, with a higher concentration off Port Elizabeth, Figure 4.3a. This is mainly adult fish bigger than 30cm in length. In the regular coverage on the west coast dense concentrations of adult fish are found on the slope between Cape Agulhas and north to 31°N, very similar to the pattern of the three previous years. Also, in consistence with the previous years, dense concentrations of juvenile fish are found mid-shelf between Doring Bay and Hondeklip Bay, with a ' transit gate' to the slope off St. Helena Bay. The high densities of juvenile fish does not extend north of Hondeklip Bay, in contrast to the distribution pattern prior to 2008. No spill-over of juveniles north over the Orange Banks into Namibia was observed indicating that the years 2003-2006 when this was observed, represents a different environment regime, yet to be explained.

The distribution of shallow water hake (*M. capensis*) is more uniform (Fig. 4.4a-b) and at generally low level except for aggregations of juvenile fish in the shallow waters off Port Elizabeth, Figure 4.4a and between Doring Bay and Hondeklip Bay, Figure 4.4b.

The density estimates from the point samples have been converted into biomass estimates by length classes. The similar data from the Namibian trawl survey running in the same period have been processed following similar procedures. The joint estimates on deep water hake are shown in Table 4.1. Figure 4.5 shows the regional distribution of deep water hake from combining the Namibian and South African data for the west coast. For the sake of consistent comparison with the previous surveys in the series, the estimates of the south coast are treated separately below. Figure 4.6a shows a graphical representation of the estimates by numbers of deep water hake (west coast only), with the Namibian estimates stacked on top of the South African while Fig 4.6b shows the % share of the biomass of the respective countries in numbers by length. There is an increasing share of fish from Namibia from 20 cm onto about 50cm in line with previous years. However the share of adult fish in South African waters is consistently much higher than in previous years (Fig. 4.6b}. Beyond 57cm the Namibian share is decreasing and from approximately 65cm all the fish is found in South Africa. This is the same general trend as from previous surveys.

Results indicate general southern shift of the adult population of deep water hake into South African as compared with previous years.
Table 4.2 shows the estimates of the hakes on the southern coast, not previously covered by “Dr. Fridtjof Nansen” as part of the series of surveys on the transboundary resources. For comparison the west coast estimates referred to above are also included. The total estimate of deep water hake on the south cosat is 100 thousand tonnes, of which 14 thousand tonnes is non-fishable while 86 thousand tonnes is fishable. The non-fishable biomass is only about 5% of the total non-fishable biomass in South African waters, while the fishable biomass on the south coast is 34% of the total fishable biomass in South African waters at the time of the survey. Related to the whole transboundary survey region including Namibia (Table 4.3) the fishable biomass on the south coast constitutes 28% of the total fishable biomass. The very low abundance of non-fishable biomass (fish less than 36cm) on the south coast, 5% in weight and 2% in numbers, indicates that this fish has its nursery area outside the south coast region, i.e. on the west coast.

The results from this transboundary survey indicates strongly that in the whole region from Port Alfred on the south coast to the Cunene in Namibia is recruited by fish that has its juvenile origin in the Hondeklip Bay area and should therefore biologically be understood as an integrated stock system. The absence of juvenile deep water hake on the south coast in January 2010 is remarkable and should be checked against previous national South African surveys in this area.

In this survey very few fish of length less than 20cm was found in Namibian waters. This is consistent with the finding that there is no fish spilling over the Orange Banks from South Africa into Namibia (Figure 4.5).

Figure 4.7 shows the distribution of ‘baby’ hake 5-6cm as observed from all trawl hauls, bottom and pelagic. The main part of the fish is located mid-shelf off Port Nolloth, between 180 and 240m bottom depth. The highest densities are found in the northern and deeper part. Although most of this fish is pelagic its consistent presence in the bottom trawl in this area, and not outside, indicate that this is the nursery area for the very young deep water hake. It is not mixed with shallow water hake at this location.

A small patch of baby was also observed off False Bay, Figure 4.7. A similar small patch was also observed in 2009, but then off the Cape Peninsula. This indicate that there could be a minor nursery area in this region, but that it is not stable and of minor importance as compared to the main area off Port Nolloth.

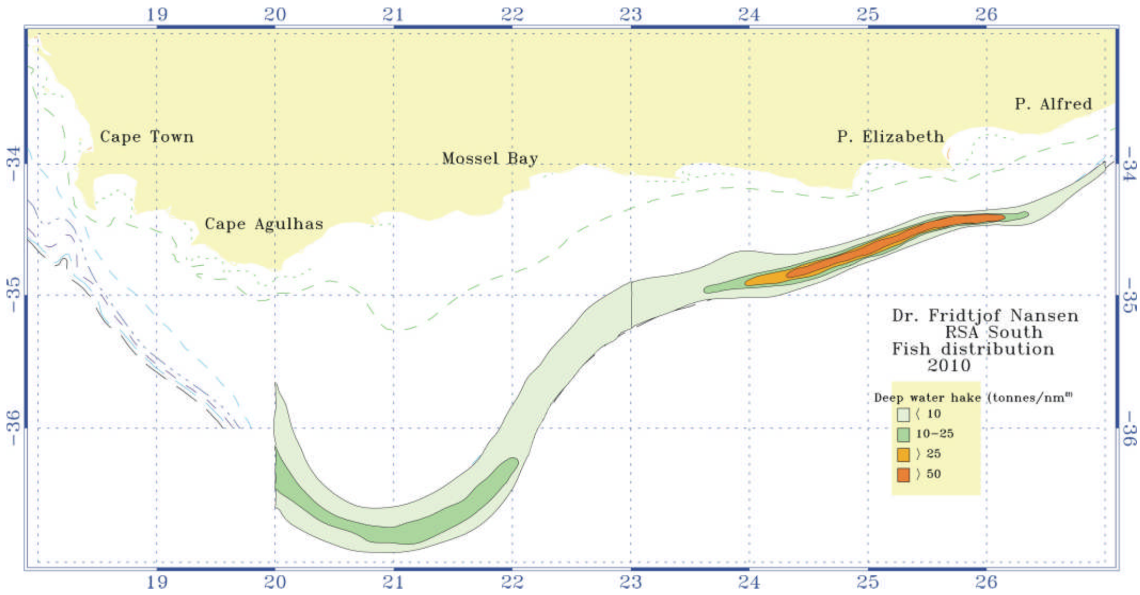


Figure 4.3a Distribution of deep-water hake (*Merluccius paradoxus*) Cape Agulhas-Port Alfred.

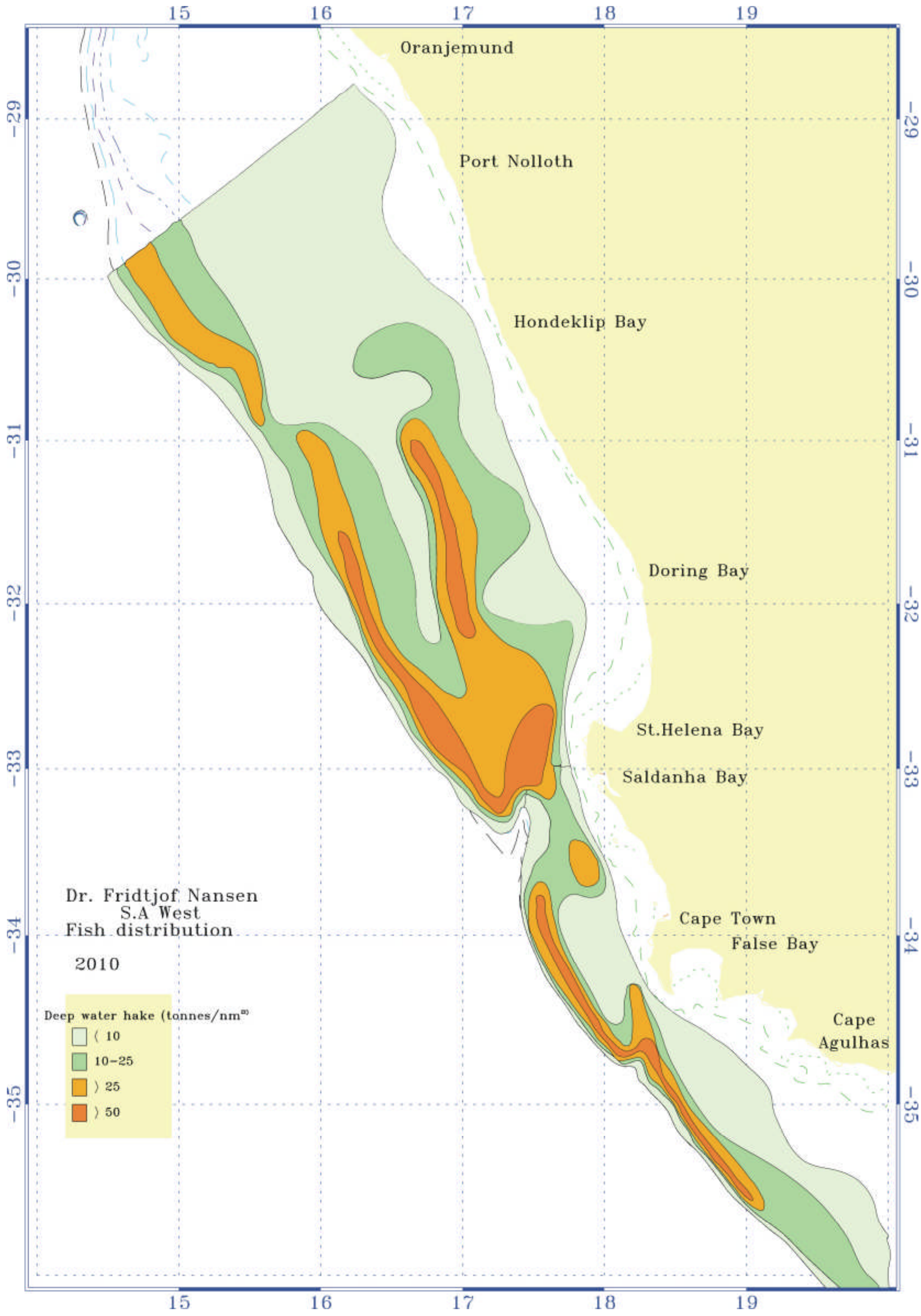


Figure 4.3b Distribution of deep-water hake (*Merluccius paradoxus*) Cape Agulhas-Orange River.

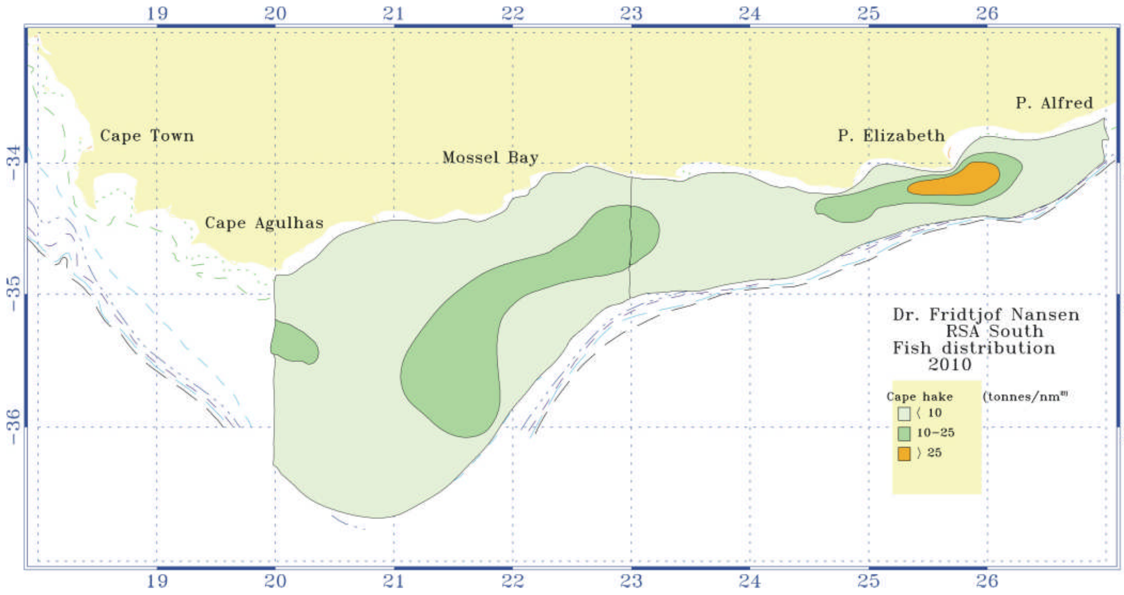


Figure 4.4a Distribution of Cape hake (*Merluccius capensis*) Cape Agulhas-Port Alfred.

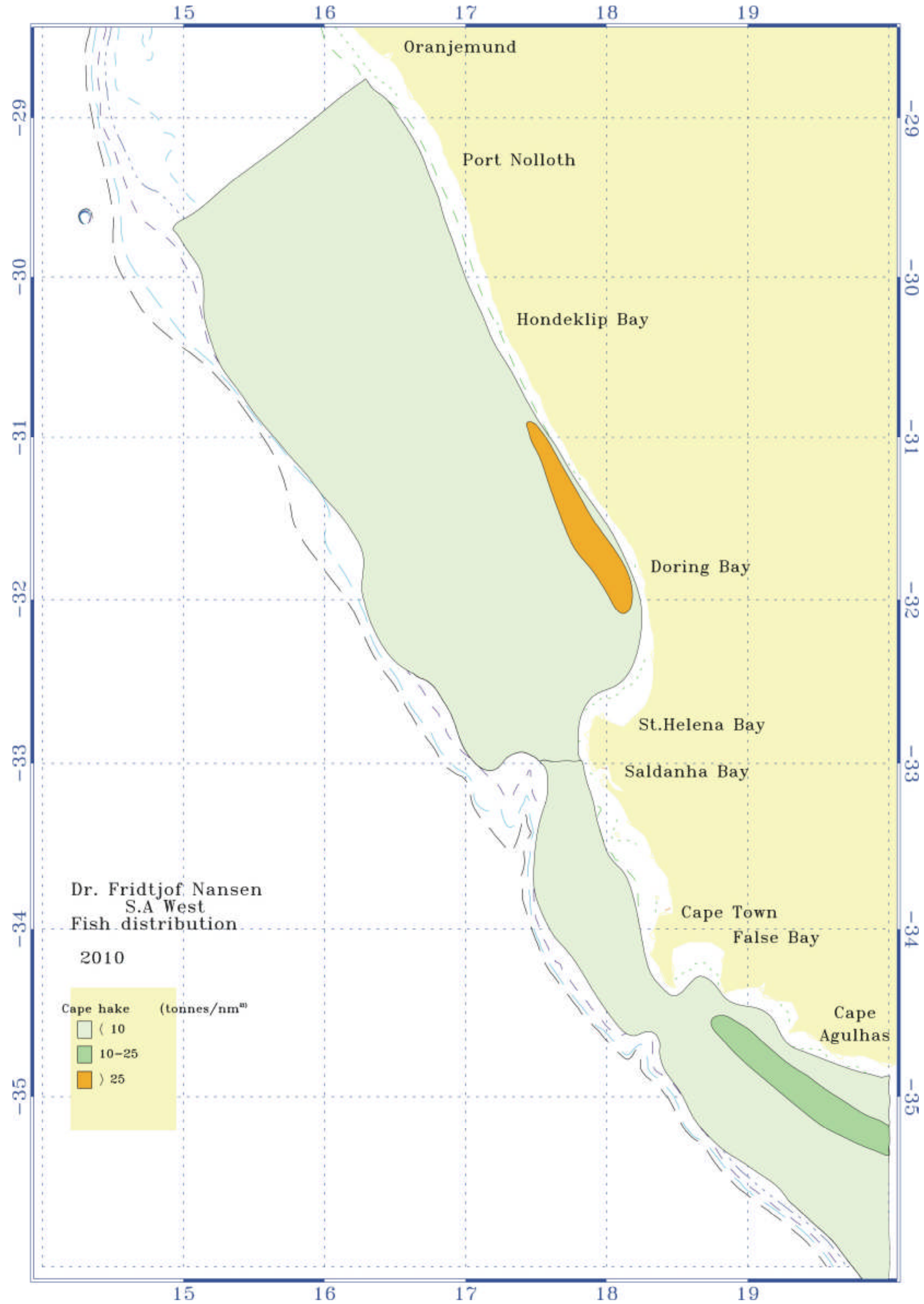


Figure 4.4b Distribution of Cape hake (*Merluccius capensis*) Cape Agulhas-Orange River.

Table 4.4 shows the biomass estimates of deep water hake split by fishable and non-fishable biomass in Namibia and South Africa west coast for the years 2003, 2005-2010. Figure 4.8a and 4.8b show the Namibian and South African biomasses plotted against each other for the non-fishable and fishable biomass respectively. Both the level and ratio of non-fishable biomass between the two countries seems to be rather stable in the period until 2008 while a decline in Namibia was observed in 2009, Figure 4.8a. The non-fishable biomass that can also be seen as a recruitment index is a record high in 2010. The total index is roundly 360 thousand tonnes of which roundly 300 thousand tonnes are located in South Africa. The recruitment in South Africa is exceptionally high, while in Namibia it is still below the mean of the time series, Figure 4.8a.

The fishable biomass, Figure 4.8b shows a relative stable level in the years 2003, 2005 and 2006. The gradual increase in the biomass 2007-2009 seems to indicate close to a linear relationship between the two countries' share of the biomass. In 2010 there was

Table 4.1 Regional abundance estimates of *M. paradoxus. South Africa south coast not included.*

Length	Biomass in tonnes			Number in millions		
	Namibia	S. Africa	Total	Namibia	S. Africa	Total
0		1	1		1.6	1.6
5	52	910	962	11.1	249.2	260.3
10	217	4101	4318	17.9	314.3	332.2
15	1437	31832	33269	34.6	831.6	866.2
20	15689	70349	86038	202.7	952.9	1155.6
25	18404	98546	116950	135.0	737.6	872.6
30	24704	81303	106007	114.8	379.2	494.0
35	19152	46694	65845	57.7	138.8	196.4
40	12031	36244	48275	24.7	73.5	98.2
45	12135	35548	47683	17.5	52.0	69.5
50	10931	27787	38718	11.8	29.9	41.7
55	4990	17438	22428	4.2	14.3	18.5
60	994	8656	9650	0.7	5.6	6.2
65	102	4151	4253	0.1	2.1	2.2
70	14	2077	2091	0.0	0.9	0.9
75	0	1359	1359	0.0	0.5	0.5
80	0	562	562	0.0	0.2	0.2
85		175	175		0.0	0.0
90		0	0		0.0	0.0
95		19	19		0.0	0.0
100						
Total	120853	467751	588604	632.9	3783.9	4416.8
Non-fishable	65282	296928	362210	532.7	3500.4	4033.1
Fishable	55571	170823	226394	100.2	283.5	383.6

considerable increase of the biomass of M. paradoxus since the previous year.. The increase in South African waters has been as much as 40%, compensated by a decline in Namibian waters of 27%. This points to a major shift in the distribution of the deep water hake stock at the same time as it is in an expanding phase. These findings should be further analysed together with data from the fishing in the later years to reveal if the changes could be driven by environmental, biological or anthropogenic (fishing) factors or a combination of these. It is vital that the time series on the regional hake is upheld to monitor and determine if this shift in distribution pattern is only temporal or represents a major shift in the ecosystem.

Table 4.2 Abundance estimates of *M. paradoxus, South Africa including south coast.*

Length	Biomass in tonnes			Number in millions			% weight	% number
	SA west	SA south	Total	SA west	SA south	Total	SA south	SA south
0	1	0	1	1.6	0.0	1.6	0.00	0.00
5	910	0	910	249.2	0.0	249.2	0.00	0.00
10	4101	0	4101	314.3	0.0	314.3	0.01	0.00
15	31832	2	31833	831.6	0.0	831.6	0.01	0.01
20	70349	22	70371	952.9	0.3	953.2	0.03	0.03
25	98546	485	99031	737.6	3.2	740.8	0.49	0.43
30	81303	10092	91394	379.2	42.9	422.1	11.0	10.2
35	46694	22148	68842	138.8	65.1	203.9	32.2	31.9
40	36244	23396	59640	73.5	47.2	120.8	39.2	39.1
45	35548	23740	59288	52.0	35.0	87.0	40.0	40.3
50	27787	9971	37759	29.9	10.9	40.8	26.4	26.8
55	17438	3577	21016	14.3	2.9	17.2	17.0	16.8
60	8656	2792	11447	5.6	1.8	7.3	24.4	24.3
65	4151	1817	5968	2.1	0.9	3.0	30.4	30.8
70	2077	951	3028	0.9	0.4	1.2	31.4	31.3
75	1359	705	2064	0.5	0.2	0.7	34.2	33.8
80	562	335	897	0.2	0.1	0.3	37.4	37.3
85	175	244	419	0.0	0.1	0.1	58.2	56.9
90	0	34	34	0.0	0.0	0.0	100.0	100.0
95	19	0	19	0.0	0.0	0.0	0.0	0.0
100	0	0	0	0.0	0.0	0.0		
Total	467751	100312	568063	3783.9	211.1	3995.0	17.7	5.3
Non-fishable	296928	14428	311357	3500.4	59.6	3560.0	4.6	1.7
Fishable	170823	85883	256706	283.5	151.5	434.9	33.5	34.8

Table 4.3 Regional abundance estimates of *M. paradoxus including South Africa south coast.*

Length	Biomass in tonnes			Number in millions			%weight	% number
	Namibia	S. Africa	Total	Namibia	S. Africa	Total	S Africa	S. Africa
0	0	1	1	0.0	1.6	1.6	100	100
5	52	910	962	11.1	249.2	260.3	95	96
10	217	4101	4318	17.9	314.3	332.2	95	95
15	1437	31833	33271	34.6	831.6	866.2	96	96
20	15689	70371	86060	202.7	953.2	1155.9	82	82
25	18404	99031	117436	135.0	740.8	875.8	84	85
30	24704	91394	116098	114.8	422.1	536.9	79	79
35	19152	68842	87993	57.7	203.9	261.5	78	78
40	12031	59640	71671	24.7	120.8	145.5	83	83
45	12135	59288	71424	17.5	87.0	104.5	83	83
50	10931	37759	48689	11.8	40.8	52.6	78	78
55	4990	21016	26006	4.2	17.2	21.4	81	80
60	994	11447	12442	0.7	7.3	8.0	92	92
65	102	5968	6070	0.1	3.0	3.1	98	98
70	14	3028	3042	0.0	1.2	1.2	100	100
75	0	2064	2064	0.0	0.7	0.7	100	100
80	0	897	897	0.0	0.3	0.3	100	100
85	0	419	419	0.0	0.1	0.1	100	100
90	0	34	34	0.0	0.0	0.0	100	100
95	0	19	19	0.0	0.0	0.0	100	100
100	0	0	0	0.0	0.0	0.0		
Total	120853	568063	688915	632.9	3995.0	4627.9	82	86
Non-fishable	65282	311357	376639	532.7	3560.0	4092.8	83	87
Fishable	55571	256706	312277	100.2	434.9	535.1	82	81

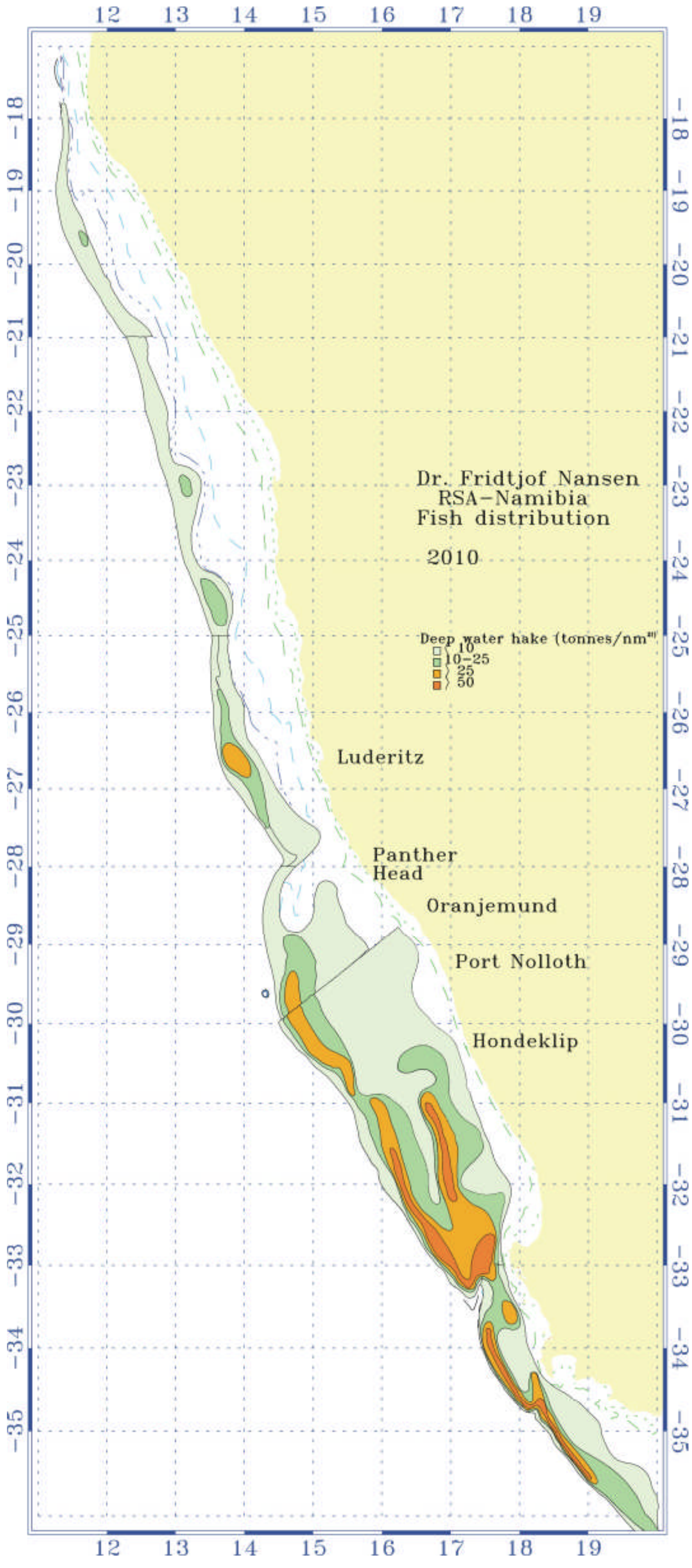


Figure 4.5 Distribution of deep-water hake (*M. paradoxus*) from Cunene to Cape Agulhas 2010

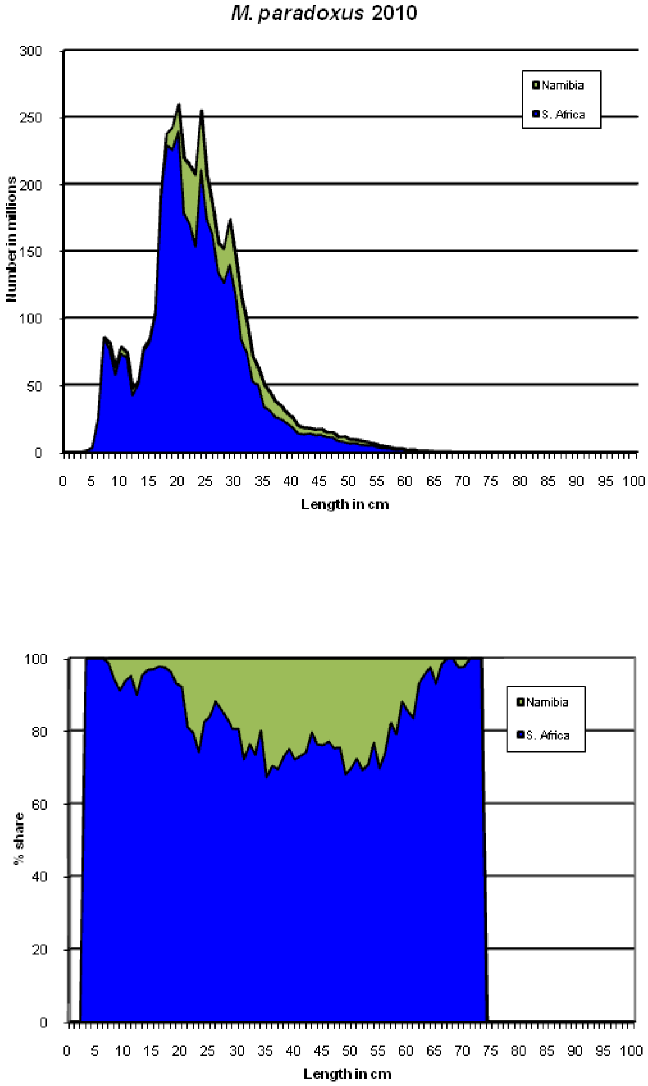


Figure 4.6 a) Estimated abundance in numbers of deep-water hake by 1 cm length classes. Namibia (green) added on top of South-Africa (blue).
b) % share between South-Africa (blue) and Namibia (green) of deep-water hake in numbers by 1 cm length classes in January-February 2010.

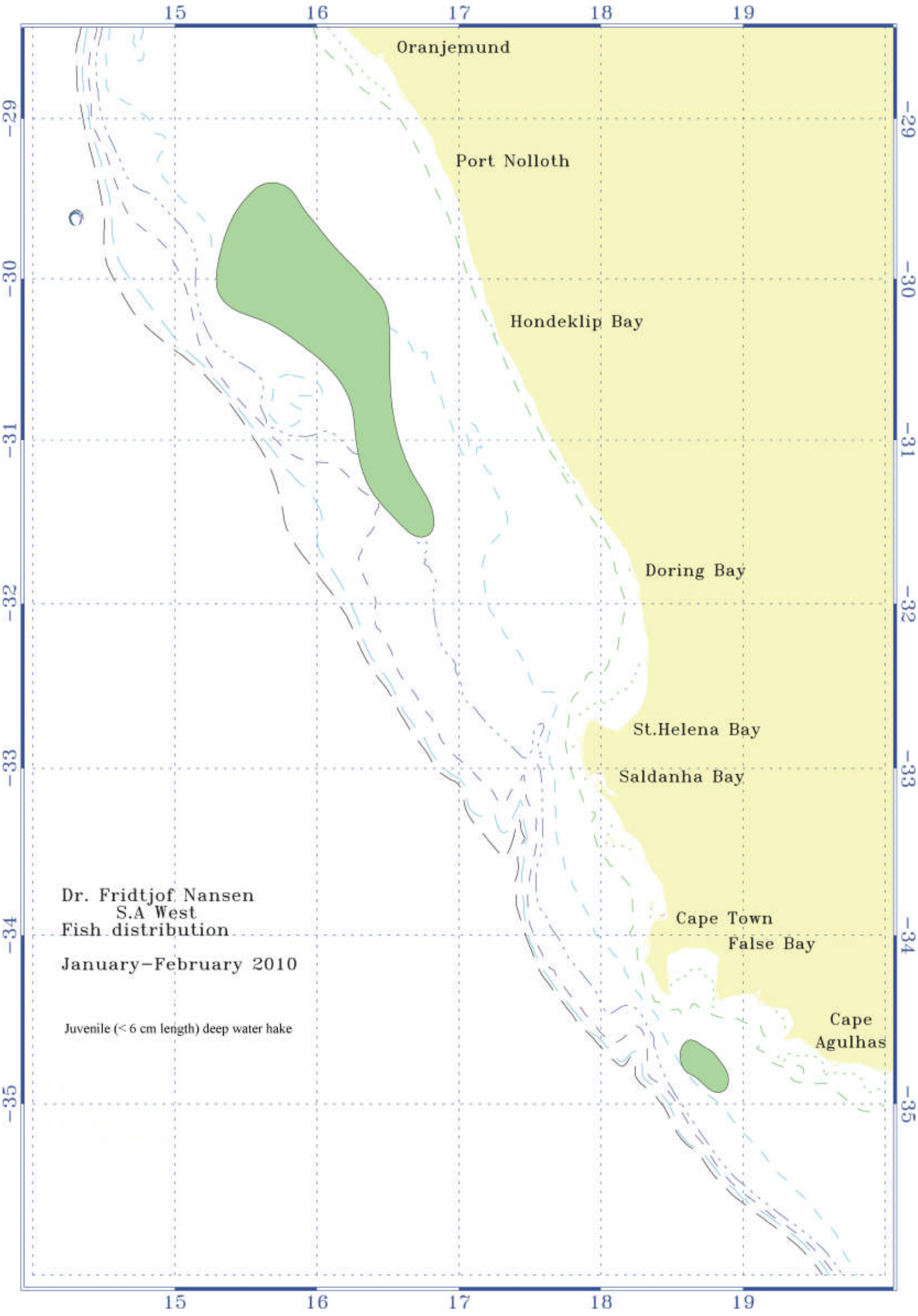
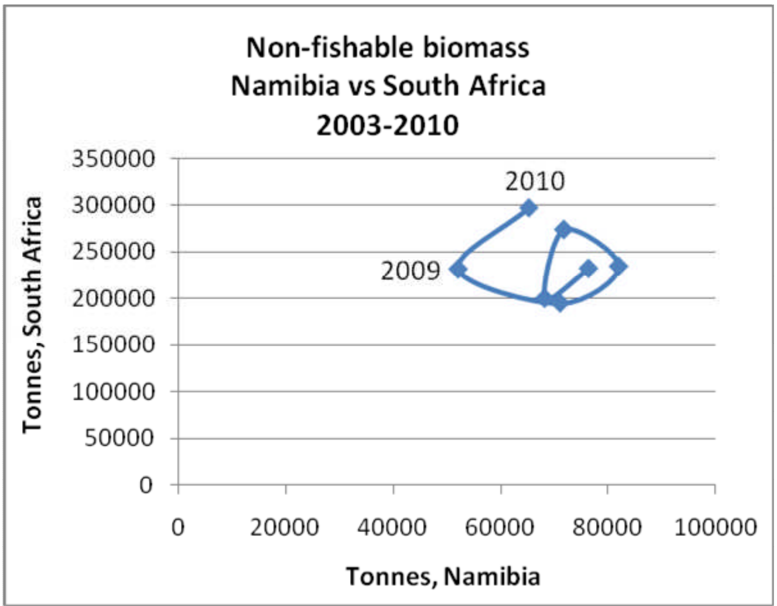


Figure 4.7 Presence of baby hake (<6 cm length) in trawl catches.

Table 4.4 Non-fishable and fishable biomass deep water hake Namibia and South Africa west coast 2003-2010.

Year	Non-Fishable		Fishable	
	Namibia	South Africa	Namibia	South Africa
2003	76361	232227	40080	79455
2005	68235	200077	46962	88850
2006	71781	273640	43414	66823
2007	81984	234518	66044	79894
2008	71080	194948	92272	117127
2009	52139	231501	76081	121594
2010	65282	296928	55571	170823



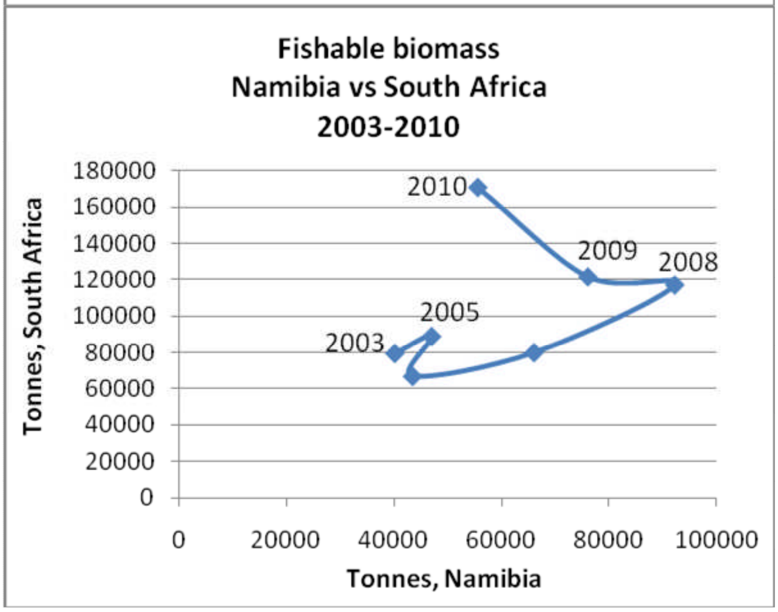


Figure 4.8. Relationship between biomass estimates on deep water hake in Namibia and South Africa. Above: Non-fishable biomass (<36cm), Below: fishable biomass.

Table 4.3 shows the density estimates of *M. paradoxus* by bottom depth strata and by regions, three regions in Namibia and four in South Africa. Table 4.3 shows the similar data for M. capensis. The areas of these depth strata and regions are listed in Annex 3.

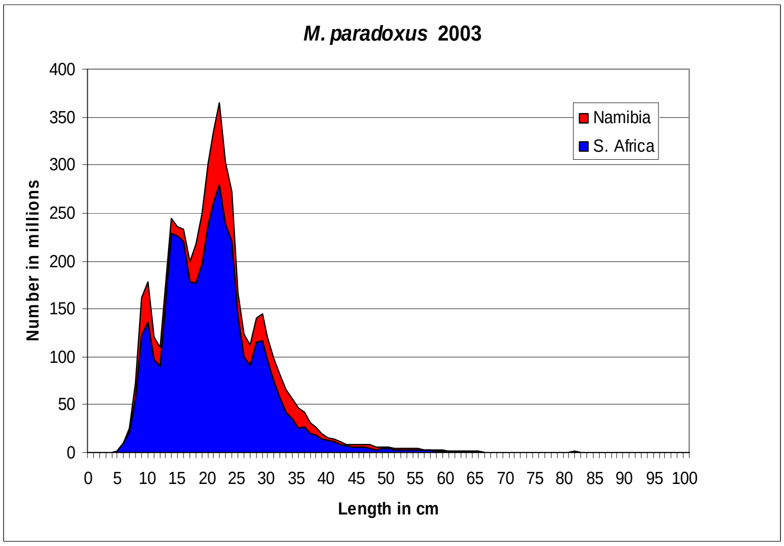
Table 4.5 Density estimates of *M. paradoxus* by depth strata and regions.

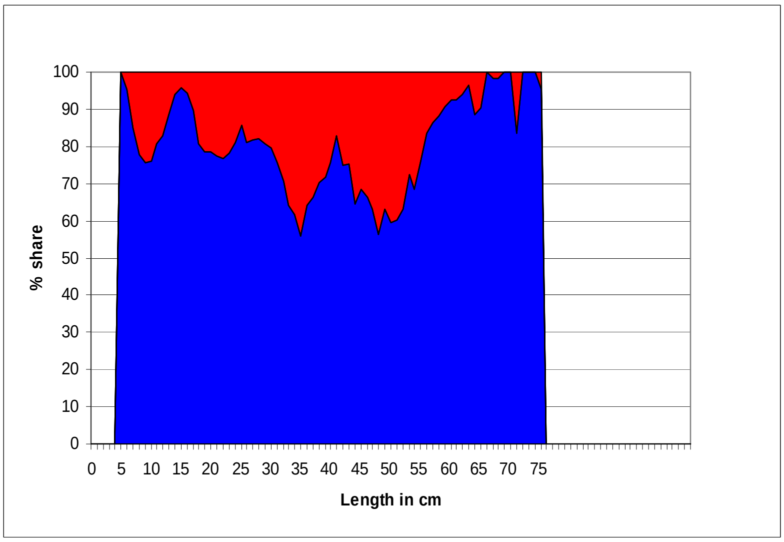
Region	0-99m	100-199m	200-299m	300-399m	400-499m	500-599	600-699
Cunene-21°S	n.a.	0	0	0	4.93	4.23	3.21
21°S-25°S	n.a.	0	0	3.05	4.35	4.23	4.23
25°S-Orange River	0	2.12	1.80	3.40	17.55	8.17	4.53
Orange River-S. Hondeklip Bay	n.a.	3.96	5.47	21.63	30.10	19.09	2.89
S. Hondeklip Bay-N. Saldanha Bay	0	4.18	38.46	38.63	68.02	21.57	4.68
N. Saldanha Bay- Cape of Good Hope	n.a.	19.52	16.88	99.94	32.05	10.07	n.a.
Cape of Good Hope – Cape Agulhas	0	1.52	6.08	67.34	93.36	4.51	n.a.

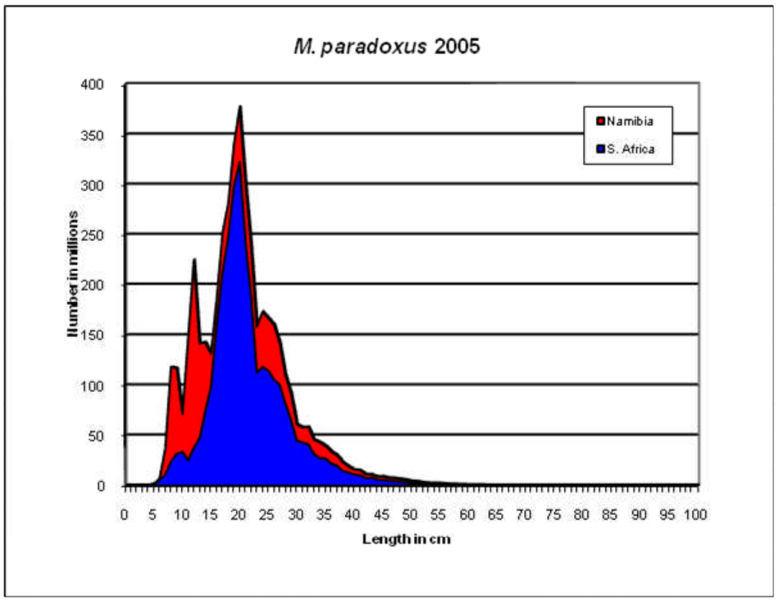
Table 4.6 Density estimates of *M. capensis* by depth strata and regions.

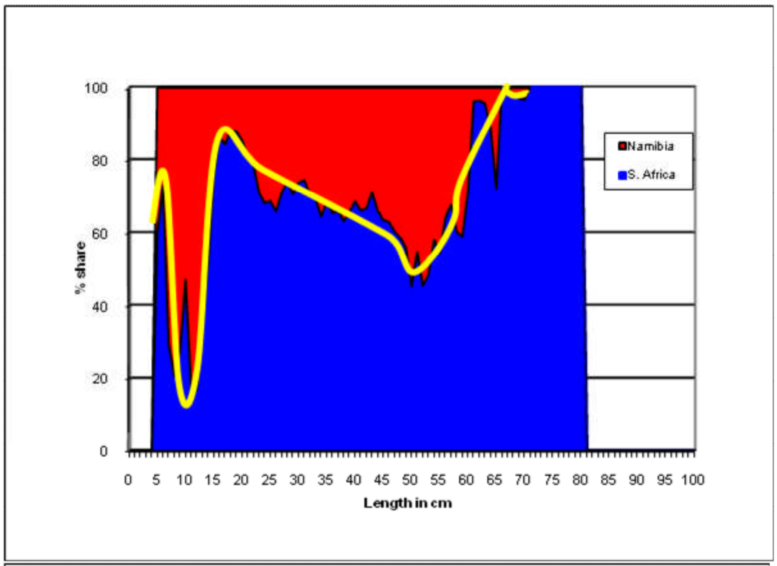
Region	0-99m	100-199m	200-299m	300-399m	400-499m	500-599	600-699
Cunene-21°S	n.a.	72.27	58.84	25.66	9.33	0	0
21°S-25°S	n.a.	21.65	26.36	15.94	0	0	0
25°S-Orange River	7.46	19.74	16.80	6.67	0.10	0	0
Orange River-S. Hondeklip	n.a.	2.47	1.62	0.90	0.08	0	0

Bay							
S. Hondeklip Bay-N. Saldanha Bay	0.13	12.69	0.88	1.12	0.36	0	0
N. Saldanha Bay-Cape of Good Hope	n.a.	2.50	1.17	5.26	0.06	0	n.a.
Cape of Good Hope – Cape Agulhas	0.72	8.85	3.20	0.65	0	0	n.a.

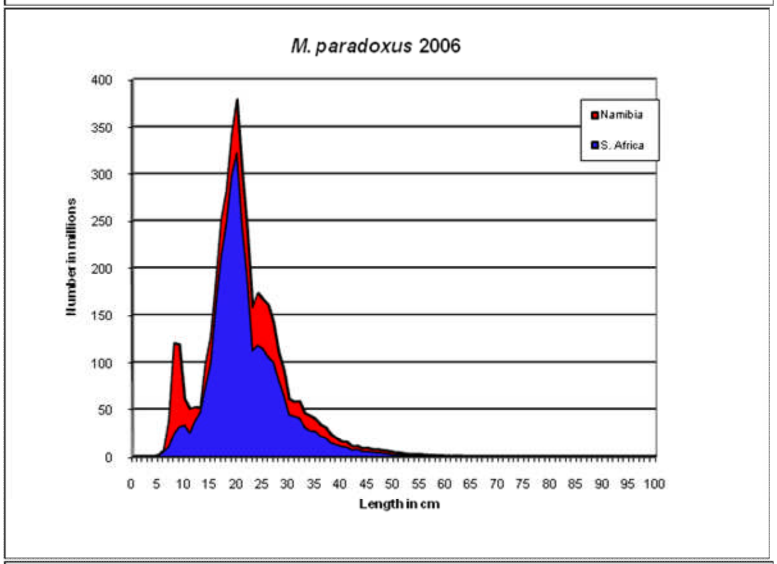

M. paradoxus 2003
Number in millions
400
350
300
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Length in cm
Namibia
S. Africa


% share
100
90
80
70
60
50
40
30
20
10
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
Length in cm

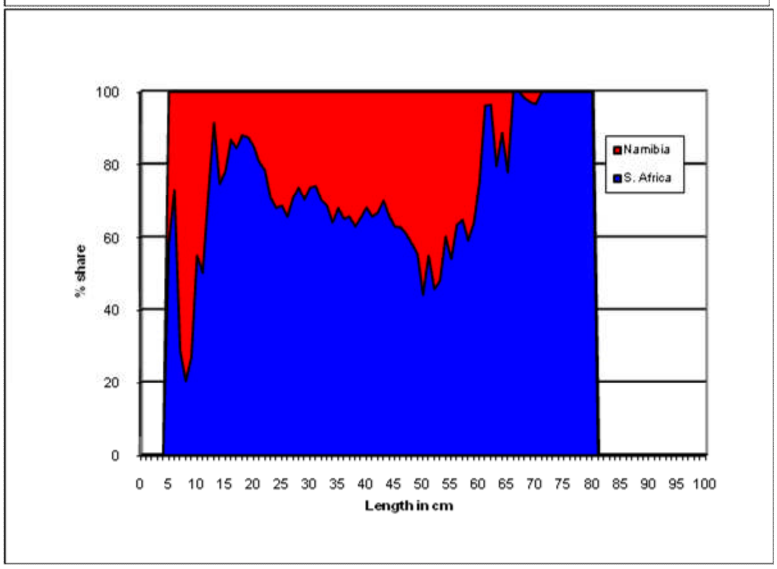

M. paradoxus 2005
Number in millions
400
350
300
250
200
150
100
50
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Length in cm
Namibia
S. Africa



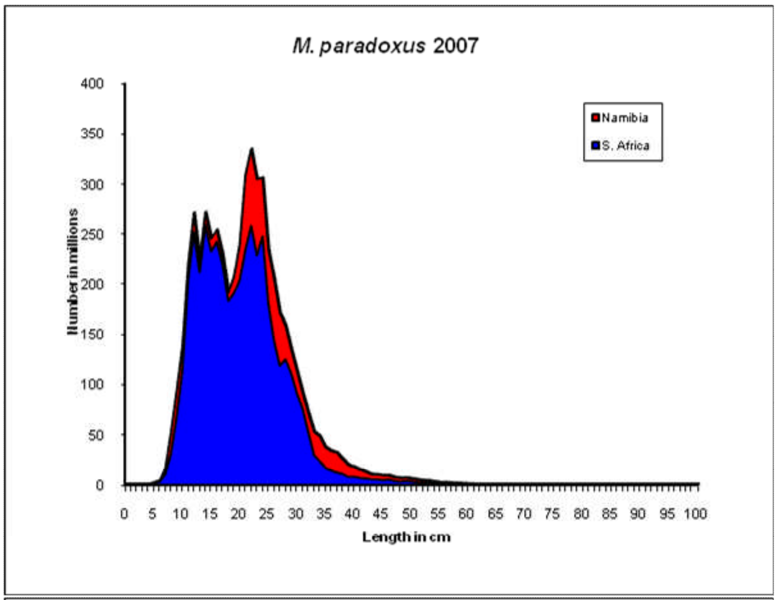
% share
Length in cm
Namibia
S. Africa

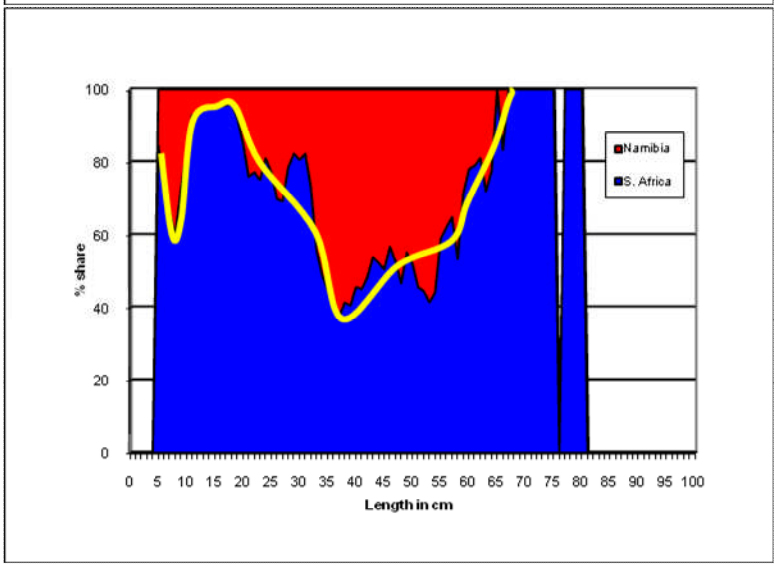


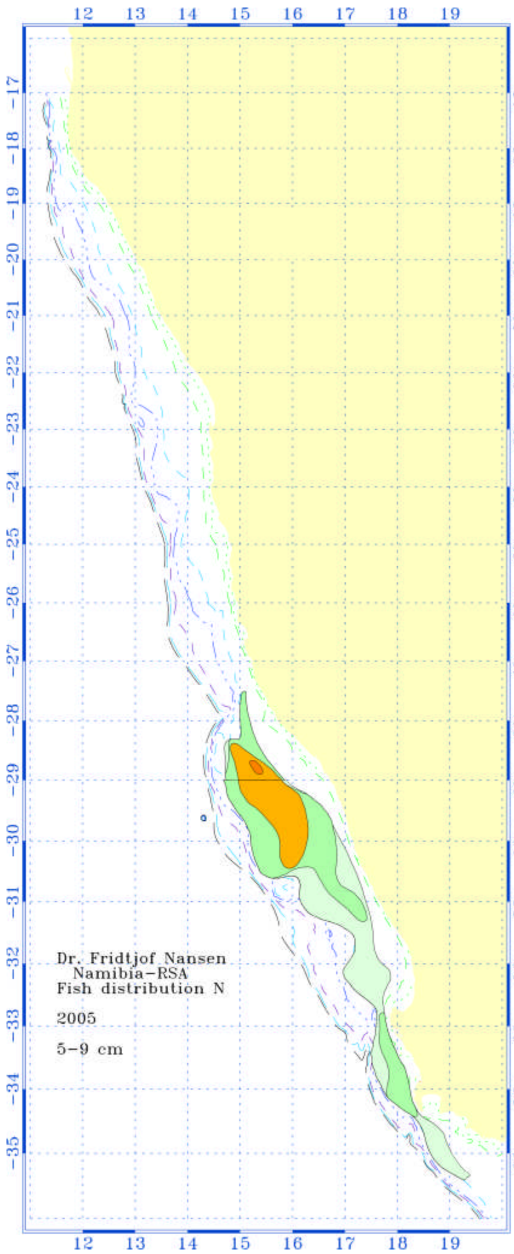
M. paradoxus 2006
Number in millions
Length in cm
Namibia
S. Africa

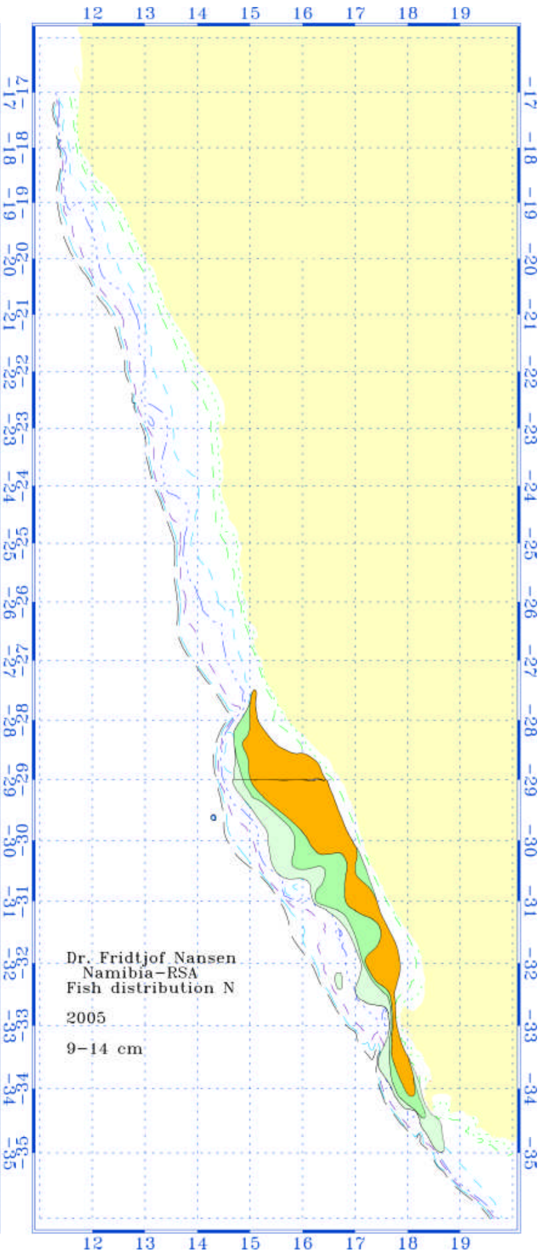


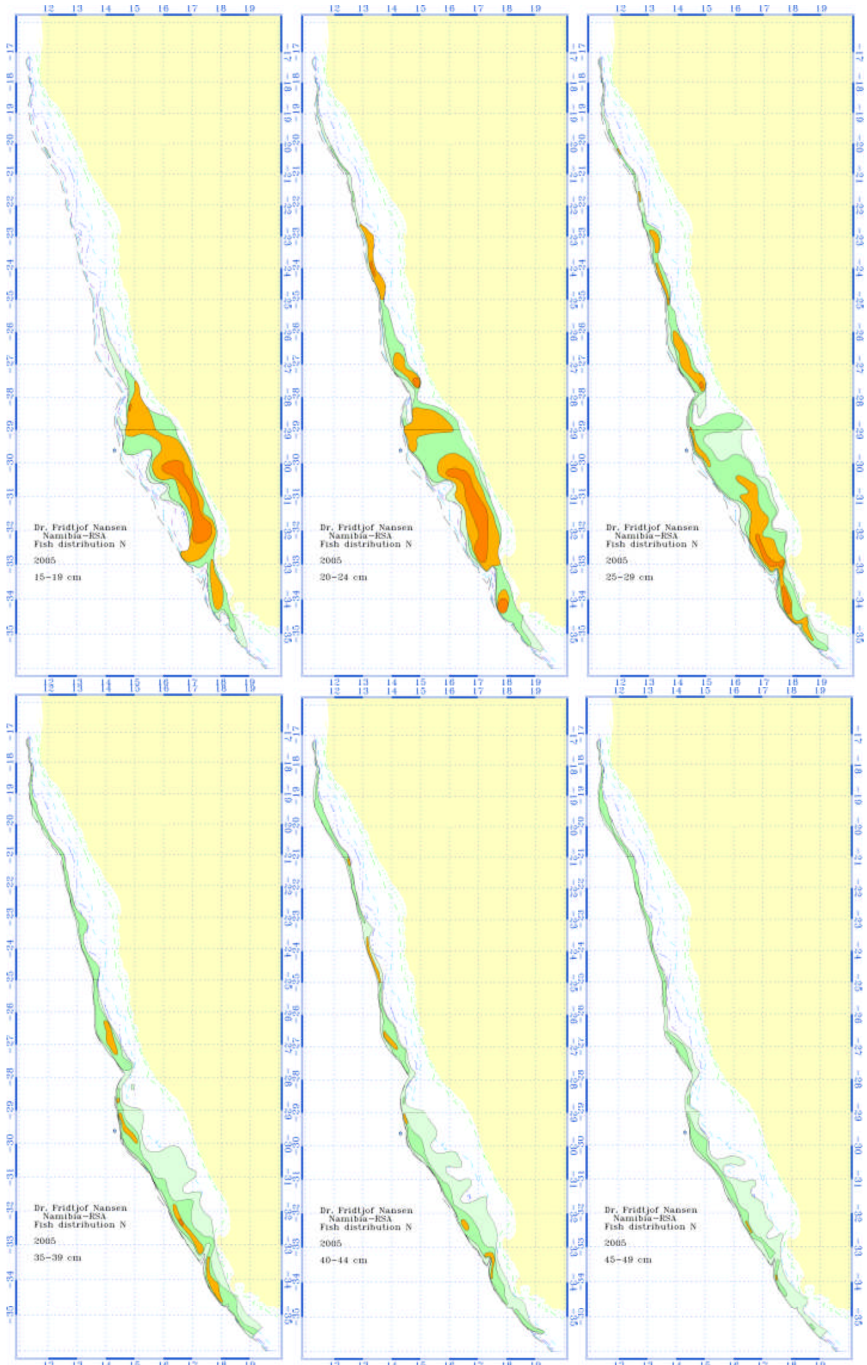
% share
Length in cm
Namibia
S. Africa

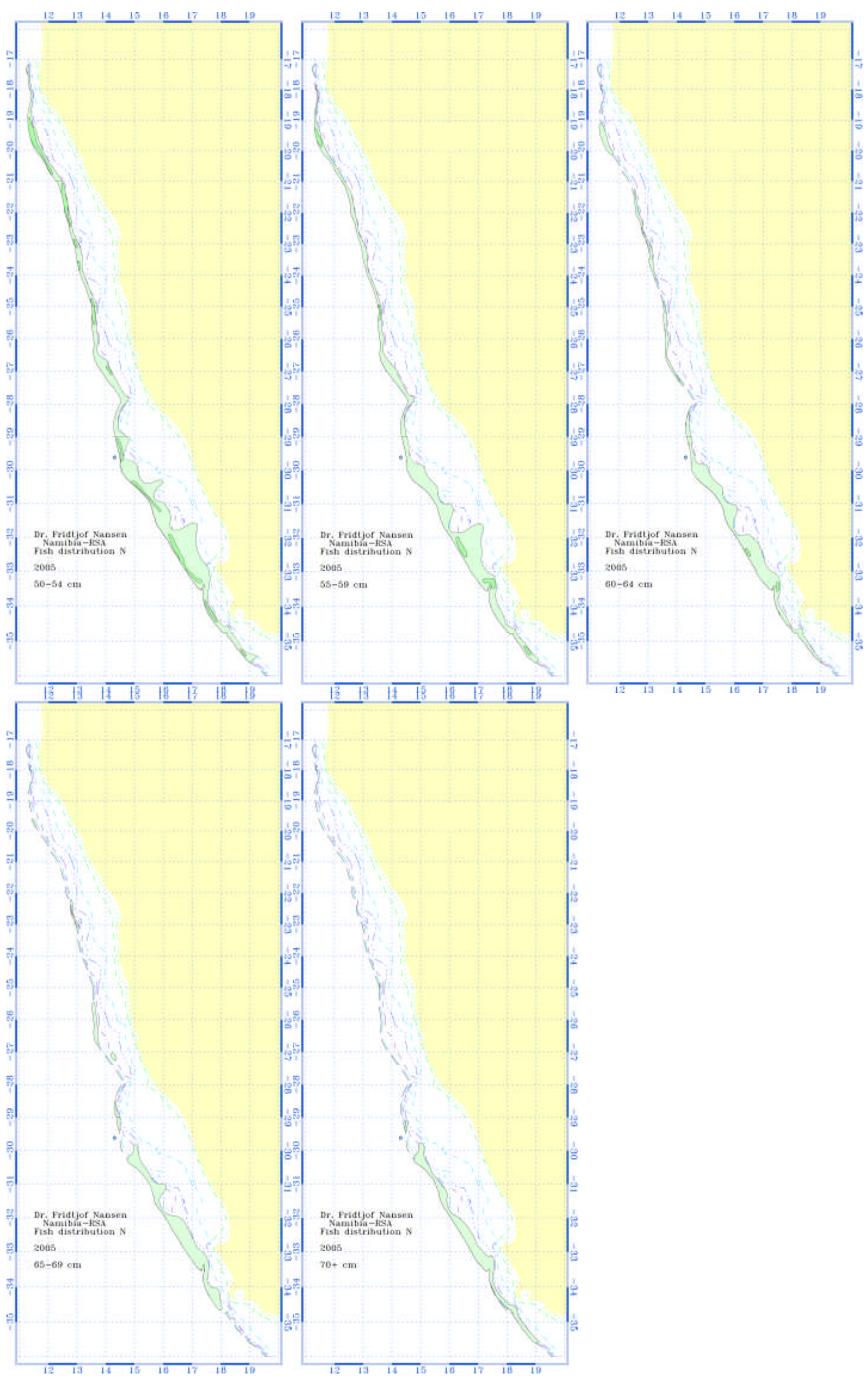

M. paradoxus 2007
Namibia
S. Africa
Number in millions
Length in cm


Namibia
S. Africa
% share
Length in cm


Dr. Fridtjof Nansen
Namibia–RSA
Fish distribution N
2005
5–9 cm


Dr. Fridtjof Nansen
Namibia–RSA
Fish distribution N
2005
9–14 cm


Dr. Fridtjof Nansen
Namibia–RSA
Fish distribution N
2005
15–19 cm
Dr. Fridtjof Nansen
Namibia–RSA
Fish distribution N
2005
20–24 cm
Dr. Fridtjof Nansen
Namibia–RSA
Fish distribution N
2005
25–29 cm
Dr. Fridtjof Nansen
Namibia–RSA
Fish distribution N
2005
35–39 cm
Dr. Fridtjof Nansen
Namibia–RSA
Fish distribution N
2005
40–44 cm
Dr. Fridtjof Nansen
Namibia–RSA
Fish distribution N
2005
45–49 cm



LF successions for 2009, 2010 and 2011 to follow

Considerations of the results of the surveys, *M. paradoxus*

The findings from the survey January-26 February combined with similar findings from the Namibian survey in the period 14 January-19 February confirms some the general features as regards the distribution of *M. paradoxus*:

- Minimal spawning takes place at this time of the year, confirmed through few signs of maturing gonads.
- The early pelagic stage is mainly confined to the central-outer part of the shelf off Port Nolloth in a small area off the Cape Peninsula.
- Juveniles between 15 and 24cm are mainly concentrated on the shelf between Hondeklip Bay and St. Helena Bay. In contrast to some earlier years there are no spill over of juvenile fish northwards over the Orange Banks into Namibia. The main interface between Namibia and South Africa seems to be along the slope. The same pattern occurred in the period 2007-2009 while in the preceding years there was a continuous channel of fish extending into Namibia over the Orange Banks during the January surveys. There might though be a seasonal pattern not revealed in the timeseries as all surveys are in January-February.
- The massive migration towards the slope starts in the 25-29cm group and when the fish is bigger than 30cm this movement is mainly completed.
- The adult fish is found from Cunene in the north and southwards beyond Cape Agulhas. The biggest fish, bigger than 70cm is, in consistency with previous surveys, only recorded in South Africa.
- The main part of the stock is at the time of the survey in 2010 located in South Africa which holds about 75% of the fishable biomass (fish bigger than 35cm) and 82% of the non-fishable biomass.
- The regional standing stock has been on a rising trend in the last four years. The regional estimate of fishable biomass has increased from 110 thousand tonnes in 2006 to roundly 230 thousand tonnes in 2010, representing a 109% increase.
- Generally for all years; for the size range 55 to 60cm fish length there is an increased share of the biomass in Namibian waters compared to smaller and bigger fish classes, perhaps indicating a periodic immigration from south in therms of the life cycle.

- From 2009 to 2010 there has been a major shift in the distribution of adult hake between the two countries. At the same time as the combined biomass has increased 15%, the increase has been 40% in South Africa, compensated by a 27% decline in Namibian waters. This breaks a linear trend that has been observed between the country biomasses in the period 2003-2009 and warrants further investigations and continued monitoring if this represents a regime shift or a temporal anomaly.
- The south coast of South Africa was in 2010 covered for the first time as part of the BCC surveys on transboundary stocks in order to have full synoptic survey and to investigate to what extent the southern stock component showed connectivity to the fish on the west coast. The deep water hake in this region is estimated to 100 thousand tonnes, which represents 15 % of the total paradoxus estimate and 18% of the South African estimate.
- The deep water hake in this region consists mainly of fish in the size range 35-70cm. The young fish less than 36cm (“non-fishable biomass”) on the south coast comprises less than 5% in terms of biomass of this fish in South African waters. This is a remarkable finding as it indicates that the southern component is mainly supplied by recruits from the west coast. The whole region from Port Alfred to the Cunene could therefore be understood as an integrated connected system as regards the stock of deep water hake.
- Blue Sea and “Dr. Fridtjof Nansen” use identical trawls and similar survey design and sampling protocol. The catchability coefficient in the biomass estimates applied is 0.8. Since the catchability coefficient of the trawl used on Dr. Fridtjof Nansen and Blue Sea has not been calibrated against absolute densities in the path of the trawl, the biomass estimates given here should not be considered as absolute biomass, but as indices of biomass. Thus the essential information is in relative comparisons and trends.