Annex V Work note on recruitment variations in the Namibian stock of Cape hake.

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It is important to be able to evaluate the levels of recruitment observed in recent years in the light of information from the history of the previous fisheries on the Cape hake stock especially since it is a general experience that recruitment from hakes and other cod like fishes may fluctuate considerably from year to year and between periods. In this brief note the RV 'Dr. Fridtjof Nansen' data will be compared with the results of a series of Spanish surveys and with those of a VPA analysis of fishery – and biological data collected through ICSEAF.

All survey results agree in showing distinct cohorts which can be followed up to a size well over 30 cm. The main spawning is assumed to take place in August-September (Sedleskaya, 1988). The 0-group is still mainly pelagic in January-March with a size of 10-12cm, the cohort is 20-25cm at 1.5 to 2 years of age and about 30cm at 2.5-3 years of age. The growth rate is likely to be density dependent with lower growth for abundant cohorts.

Table 1 shows estimates of the strength of the yearclasses 1988-1992 from the RV 'Dr. Fridtjof Nansen' surveys 1990-1994 (Anon 1994a). These represent numerical abundance of cohorts at 1.5-2 years of age. The estimates vary greatly between yearclasses, from 0.3 to 4.9 billion, but also between estimates of the same yearclass from different surveys. Especially notable is this for the 1991 yearclass where the estimate declined from 4.9 billion in November-December 1992 to 2.2 billion in February-March 1993. This decline was observed mainly in the Central Region and is thought to have been associated with the phenomenon of mass fish mortality which occur periodically in the Walvis Bay region (Copenhagen *et al.* 1953). Ignoring this high estimate 4 out of the 5 yearclasses investigated show estimates of approximately 2 billion fish. It is important to know whether this represents a high, average or low level of recruitment to the stock. In absolute terms these data may be affected by bias related to the swept area method on which they are based, but they should represent comparable indices.

Table 1 Estimates of strength of recent yearclasses of Cape hake. Cohort population numbers at about two years of age for the groups assumed to have been spawned in 1988, 1989, 1990, 1991 and 1992. Millions of fish.

Yearclass	1988	1989	1990	1990	1991	1991	1991	1992
Southern region	980	100	160	300	990	670	390	250
Central region	1 320	170	1 710	1 620	3 500	1 230	1 370	1 880
Northern region	10	10	20	240	440	270	130	70
Total	2 310	280	1 890	2 160	4 930	2 170	1 890	2 200
Survey/Year	1/90	1/91	2/91	1/92	2/92	1/93	2/93	1/94

A set of data similar to that of the RV 'Dr. Fridtjof Nansen' is available from the Spanish Benguela surveys which covered the period 1983 to 1988 with annual or biannual coverages in January-February and July-August, (Macpherson *et al*, 1984, 1985, 1986, 1987 and Gordoa and Macpherson 1988). Table 2 reviews these data which cover the yearclasses 1981 to 1986. In identifying the cohorts use has been made of the growth pattern described above resulting in some disagreements with the identification made by the authors. The simple mean of all estimates at ages from 1.5 to 3 years will be negatively biased when compared with the RV 'Dr. Fridtjof Nansen' estimates at 1.5 to 2 years of age.

Table 2 Strength of yearclasses 1981 - 1986. Estimates based on Spanish trawl survey data 1983-1989. Number of fish in billion.

	Yearclass					
	1981	1982	1983	1984	1985	1986
At 1.5-2 years	3.4	4.0, 7.0	1.3	3.0, 4.7	0.6	0.1
At 2.5-3 years	5.4, 2.2	2.0	4.7, 5.0	1.0	0.6, 0.8	
Simple mean	3.7	4.6	3.7	2.9	0.7	0.1
Plus 25%	4.6	5.8	4.6	3.6	0.9	0.1

There is also a negative bias caused by an incomplete coverage of the Spanish surveys which did not include the shelf north of 23°S, Walvis Bay. (This area was to be covered by a Soviet survey programme which does not seem to have materialized). As shown in Table 1 the Central and Southern Regions were the main areas of recruitment for the Cape hake and this is likely to be a general pattern of distribution. A rough assessment of the RV 'Dr. Fridtjof Nansen' data indicates that on average about 3/4 of the 1.5 to 2 year old fish is found on the shelf south of Walvis Bay. The Spanish estimates should thus be increased by 25%.

Whether these estimates are directly comparable to those of the RV 'Dr. Fridtjof Nansen' could only have been properly checked by comparative fishing experiments. The estimated effective fishing width of the Spanish trawl gear was first reported to be 15.7m (Macpherson *et al*, 1985), but in a later communication referred to as 18.3m (Macpherson, personal communication 1990). On the basis of the trawl design a fishing gear expert assessed the width to be 20m. (Bill West, IMR internal memorandum). There is thus some uncertainty regarding the effective fishing width of the spanish trawl, but it is anyhow not very different from the 18.5m estimated for the RV 'Dr. Fridtjof Nansen' trawl.

The resulting totals range from 0.1 to 5.8 billion and compared with the RV 'Dr. Fridtjof Nansen' data they show recruitment in the early 1980s to have been more than the double of the 2 billion

level of recent years. The high recruitment from that period is well known from the history of the fishery and was especially ascribed to the yearclasses 1982 and 1983. The Spanish data show high recruitment also from the adjoining 1981 and 1984 yearclasses. This may, however, partly be an effect of "overflow" from the abundant cohorts 1982 and 1983 through the use of age length keys.

VPA analyses from the ICSEAF period represent a further source of historical information on recruitment in this stock. Table 3 shows recruitment estimates of a VPA analysis including data up till 1985 from Schumacher (1988). Natural mortalities incorporate estimates of cannibalism.

Table 3 VPA, Cape hakes, Divisions 1.3 and 1.4.Recruitment at age 1 in millions. (Source:Schumacher (1988), Table 1.)

1968	5178	1974	4308	1980	1408
1969	4481	1975	2776	1981	2218
1970	5877	1976	2408	1982	4836
1971	2801	1977	2286	1983	5315
1972	1989	1978	1046	1984	1874
1973	3308	1979	879	1985	2303

Under the ICSEAF system the Namibian hake stocks were considered as two management units, one covering Division 1.3 and 1.4 and one for the shelf south of 25°S, the Division 1.5. Catches were only identified to species in research vessel surveys. In order to be comparable with the recruitment estimates from the RV 'Dr. Fridtjof Nansen' surveys, the VPA should have excluded the deep water hake caught in Divisions 1.3 and 1.4 and included the Cape hake catches in Division 1.5. Data on the proportion of the fishable biomass of the two species by regions is available for recent years from the RV 'Dr. Fridtjof Nansen' surveys (Anon, 1994,b) and show the following:

Table 4. Mean fishable biomass of Cape hake and deep water hake by regions. Data from 7 surveys 1991-1994.

Southern region		
Cape hake	102 000	tonnes
Deep water hake	104 000	"
Central region		
Cape hake	111 000	tonnes
Deep water hake	17 000	"
Northern region		
Cape hake	114 000	tonnes
Deep water hake	5 000	"

In this period half the biomass in the Southern region which corresponds to Division 1.5 was Cape hake, while deep water hake was only 9% of the biomass north of 25°S. These proportions may change between periods, but the Spanish surveys 1983-1988 showed an average proportion of 31% of deep water hake of a total mean biomass of 960 000 tonnes south of 23°S which could well indicate a 50/50 proportion south of 25°S (Gordoa et al, 1988). The reported geographical distribution of catch rates in these surveys showed only insignificant rates of deep water hake north of 25°S.

The mean of the reported hake catches in the VPA period 1968-1985 is 290 000 tonnes and 178 000 tonnes for Divisions 1.3+1.4 and 1.5 respectively. Use of the biomass proportions from the RV 'Dr. Fridtjof Nansen' surveys gives a mean Cape hake catch in this period of 353 000 tonnes. It thus seems reasonable to assume that the VPA based on the Division 1.3+1.4 data underestimate the recruitment to the total Cape hake stock by about 20 per cent.

The VPA estimates may also be negatively biased if catches have been underreported as has some times been claimed for periods of this fishery.

A comparison with the Spanish series for the early 1980s shows high recruitment for both sets of data in this period. But the mean yearclass strength 1981-1984 is considerably lower in the VPA series: 3.7 billion against 4.7 billion for the Spanish data which tend to confirm the existence of a negative bias in the VPA.

These three sets of recruitment estimates may be linked up. The methodical basis for the RV 'Dr. Fridtjof Nansen' data is the same as that of the Spanish series. Although a difference in bias can not be excluded it is not likely to be substantial. There is a good correspondence between the estimates from the Spanish surveys in the early 1980s and those of the VPA especially if it is assumed that the VPA underestimates the total Cape hake recruitment. There is thus a basis for considering the VPA and the RV 'Dr. Fridtjof Nansen' data as a time series in which the following periods can be described with recruitment in billion fish:

1968-1974	Generally high recruitment	Range 2.0-5.9	Mean 4.0
1975-1980	Low to moderate recruitment	Range 0.9-2.8	Mean 1.8
1981-1985	Moderate to high recruitment	Range 1.9-5.3	Mean 3.3
1988-1992	Low to moderate recruitment	Range 0.3-2.3	Mean 1.8

There may be evidence of a spawning stock-recruitment relationship in the history of this stock. The severely depleted stock in the late 1970s produced the weakest yearclasses of the VPA series.

Otherwise yearclass strength seems to vary apparently stochastically within a range of six times or more. In similarity with many Gadid species which demonstrate comparable patterns of yearclass fluctuations it must be inferred that yearclass strength in the Cape hake is initially determined at an early stage by the survival success of larvae or post larvae, but may later be modified by phenomenon of mass mortality and by cannibalism.

Against this historical background the predominant recruitment levels of about 2 billion for the 1988 to 1992 yearclasses must be assessed as moderate. The estimate of nearly 5 billion for the 1991 yearclass in survey 2/1992 is at the level of previous high recruitment years and confirms the high reproductive capacity of the stock.

An additional conclusion is that more comprehensive pre-recruit and recruitment studies should be given high priority.

REFERENCES

Abello,P., A.Gordoa, M.Manrique, M.Maso and E. Macpherson, 1988. Biomass indices and recruitment levels for hake andf other commercial species in ICSEAF Divisions 1.4 and 1.5: results from the Spanish Benguela XI research cruise (1987). *Colln scient.Pap.int.Commn SE.Atl.Fish.* 15(I):7-21

Anon, 1994a. Surveys of the fish resources of Namibia. Preliminary Cruise Report "Dr Fridtjof Nansen" Survey 1/94. Ministry of Fisheries and Marine Resources, Swakopmund, Institute of Marine Research, Bergen

Anon, 1994b. Surveys of the fish resources of Namibia. Preliminary Cruise Report "Dr Fridtjof Nansen" Survey 2/94. Ministry of Fisheries and Marine Resources, Swakopmund, Institute of Marine Research, Bergen

Copenhagen, W.J. 1953. The periodic Mortality of Fish in the Walvis Region. A Phenomenon within the Benguela Current. Department of Commerce and Industries, Division of Fisheries. Investigational Report No 14.RSA.

Gordoa, A. and E.Macpherson, 1988. Biomass indices and recruitment levels for hake and other commercial species in ICSEAF Divisions 1.4 and 1.5, from the surveys made in 1988, ICSEAF Eight Special Meeting, SAC/88/S.P./44

Macpherson, E., B.Roel and B.Morales, 1985. Reclutamiento de la merluza y abundancia y distribucion de diferentes especies comerciales en las Divisiones 1.4 y 1.5 durante 1983-1984. *Colln scient.pap.int.Commn SE.Atl.Fish.* 12(II):1-62

Macpherson, E., B.Roel and B.Morales, 1986. Evolucion del reclutamiento de la merluza y distribucion y abundancia de varias especies comerciales en 1985 en las Divisiones 1.4 y 1.5. *Colln scient.pap.int.Commn SE.Atl.Fish.* 13(II):113-136

Macpherson, E., B.Roel and B.Morales, 1987. Indices de biomasa y niveles de reclutamiento de la merluza y otras especies comerciales en las Divisiones 1.4 y 1.5 a partir de los resultados obtenidos en las campanas de 1986. *Colln scient.pap.int.Commn SE.Atl.Fish.* 14(II):55-112

Schumacher, A. 1988. Validation study on calibrating virtual population analysis (VPA) for the Cape hake stock in ICSEAF Divisions 1.3 and 1.4. *Colln scient.pap.int.Commn SE.Atl.Fish.* 15(II):197-213

Sedletskaya, V.A., 1988. Reproduction of Cape hake (*Merluccuis m. capensis*) and Cape horse mackerel (*Trachurus t. capensis*) in Namibia. *Colln scient.Pap.int.Commn SE.Atl.Fish.* 15(II):215-222