Northwest Atlantic Fisheries Organization

Serial No. N4670 **NAFO SCR Doc. 02/58**

SCIENTIFIC COUNCIL MEETING – JUNE 2002

An Assessment of the Cod Stock in NAFO Division 3M

by

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Abstract

The cod stock on Flemish Cap, NAFO Division 3M, remains collapsed. The situation was originally attributed to the severe overfishing of last abundant year-classes, but the recruitment failed since 1995 and the stock did not recovered. Commercial catches are insignificant and two surveys in the area in 2001 did not observed good recruitment. The situation remains steady at a very low level, and it is unlikely a recovery of the stock in a short o medium term

Introduction

The stock is under moratoria since 1999, and its status had been qualified as collapse, attributed to three possible factors: a stock decline due to overfishing, an increase in catchability at low abundance levels and a very poor recruitment since 1995. The analysis made last year concluded that both total biomass and SSB were at such low level as been not able to produce good recruitments in recent years (Cerviño and Vázquez 2001).

Since 1974, when a TAC was established for the first time, catches ranged from 48 000 tons in 1989 to a minimum of 55 tons estimated for 2000. Annual catches were about 30,000 tons in the last 80's, when the fishery was under moratoria, and they decline since then as a consequence of the stock collapse.

Assessment

Catches

There has not been directed fishery for cod in Flemish Cap in 2001, but some catches are obtained as by-catch in other fisheries on the bank. Only Portugal has reported catches in 2001 as by-catch in the redfish fishery (Alpoim *et al*. 2002). Catches of Non-Contracting Parties were estimated as 205 tons in 1998, 350 tons in 1999 and null in 2000, based on Canadian Surveillance reports. The cod by-catch in the shrimp fishery must be almost null due to the use of sorting grates. Past reported catches and independent estimates are presented in Table 1.

Catch at age in numbers

Biological information on commercial cod catches taken as by-catch of the redfish fishery were available from the Portuguese fleet: one sample in July amounting 23 individuals (Alpoim *et al*. 2002), and the Russian fleet: one sample of 52 fish (Vaskov *et al*. 2002). Length frequency distribution of both samples are quite similar and also consistent with the results of the EU survey (Vázquez 2002): all of them show two well defined modal distributions at 18 and 36 cm, corresponding to ages 1 and 2 respectively, and a wide group of fish 50 to 100 cm, ages 4 to 10. Fish of both samples were aged, but age-length values did not match with the EU survey results, which are judged more accurate.

Only the Portuguese length distribution was considered representative of the catch, taken into account that only that sample corresponds to reported catches. Length distribution was transformed to catch at age data (Table 2) using the age-length key from the EU survey in July 2001 (Vázquez 2002). The same procedure has been followed in 1999 and 2000 data due to the lack of the corresponding age-length key, and was justified on the similarity observed in previous years.

Mean weight-at-age in the catch was also calculated applying the weight-at-length relationship obtained in the survey to the observed length at age distribution.

Survey indices of abundance at age

Abundance indices at ages 1 to 8+ for years 1988 to 2001 from the EU survey (Vázquez 2002) are shown in Table 3. This table represent the clearest view of the state of the stock: the recruitment of the 1995-1999 year-classes was very scarce, well below the level observed in previous years; and oldest fish became more and more scarce. Abundance at age 1 is considered an imprecise estimate of recruitment: abundance at age 2 matches better with the abundance in the following ages and, consequently, it is considered a best indices of recruitment. Taking into account this caveats, the abundance of the 2000 year-class cannot be yet evaluated, but the signal is that their abundance is also low, being the sixth consecutive poor year-class. No recovery of the stock can be expected before good recruitment is observed, and four more years will be at least necessary for they contribute to the spawning stock.

A bottom trawl survey was carried out on Flemish Cap by the Russian RV Mozdok in May-Jume 2001 (Vaskov *et al.* 2002, Shibanov *et al.* 2002). Total biomass estimates compared with previous estimates of Russian and EU surveys in presented in table 4. Total biomass estimated in 2001 in both surveys is more than 10 times smaller than the mean of the 1988-1993 period. It is 21 times in the EU survey, 14 times in the Russian survey and, as it will be forward shown, 8 times in XSA results. In conclusion, both surveys indicate the same decline in total biomass. Even no length distribution is provided, mean weight was 1.575 kg, which compared with the 0.961 kg mean weigh in the EU survey, indicates that also the Russian survey did not find any good recruitment.

Maturity ogive.

Maturity ogives for the longest available historical series were recently reviewed (Saborido pers. comm.), including data from the Canadian surveys in years 1978-1985. New data from years 1986-1989 are an average of years 1985 and 1990. The new percentages (Table 6) are then applied instead of those currently used. The effect is a noted change in our perception of the past levels of the spawning stock biomass. New figures are considered more accurate estimates.

Natural mortality was assumed at 0.2.

Results

An XSA-Extended Survivor Analysis (Darby and Flatman 1994) was carried out with these inputs and the following settings:

Catch data for 30 years. 1972 to 2001. Ages 1 to 8+
Tuning with EU survey for 1988 to 2001 and ages 1 to 7

Tapered **time weighting** was not applied.

Catchability analysis
Catchability dependent on stock size for ages younger than 3
Catchability independent of age for ages older than 4

Terminal population estimation
Terminal year survivor estimates shrunk towards last year F
Oldest age survivor shrunk towards F mean of ages 4-6
5.0 s.e. of the mean to which the estimates are shrunk
0.5 Minimum standard error for population estimates from each cohort

No changes were introduced in these settings in relation to the last year analysis (Vázquez and Cerviño 2001). Catchability was considered dependent on stock size for age 1 and 2 instead of only age 1 because data for age 2 give a bad catchability fit and the two parameters model improves the fit. Terminal population was shrunk towards last year F and the s.e. of this shrinkage is high: 5.0, to avoid bias in terminal population estimates given that F-at-age was quite different in 2001 regarding to past years.

Log catchability and its standard error are shown in Table 5, where high standard errors are mainly observed for ages 5 and 6. Results of the catchability analysis for the EU survey are presented in Figure 1 and catchability residuals seem to be reasonably consistent for all ages.

Tables 7 and 8 show the XSA results of abundance and F at age since 1988. Mean fishing mortality at ages 3-5 declined since the peak in 1995 to the low value in 2001. Fishing pattern become quite variable in last years compared with the one observed for previous years, and peak fishing mortality follows the progress of dominant year-classes. These occurrences must be a consequence of low level of catches and the small sample size: the catch sampling are quite dependent of survey results used for tuning.

Total abundance (Table 8) peaks in 1992 with 154 millions fish and has been decreasing since then until 1999, with less than 2 millions, with a slight recovery in 2000 and 2001. All cohorts since 1992 have been poor and those since 1995 extremely poor. The adult stock, age 5+, declined progressively in the last years, and will be continued to decrease in the coming years.

Biomass, spawning stock biomass, recruitment at age 1 and mean F at ages 3 to 5 were calculated from XSA results and are presented in Table 9. Recruitment at age one present three peaks (Figure 2), 1974, 1986 and 1991-92, consequently total biomass presents also three peaks in 1976, 1989 and 1992, the latest being the less important. The relative high abundance of those year-classes is also observed in the SSB they produced years later, those peaks of 1979 and 1990-92, but no later that should be corresponded to the latest recruitment peak of 1991-92. This could be a consequence of the overfishing at that time; in 1989-90 catch peaks coinciding with high biomass (Figure 3); the biomass decreased in following years but F increased in the 1992-95 period, overfishing the year-classes that produced the last recruitment peak. After 1995 biomass decreased to a level around 3 thousand tons.

The stock-recruitment relationship using both SSB and recruitment at age one from XSA results is presented in Figure 4. Recruitment and SSB since 1992 are the lowest in the series. The plots show the same two different zones, already pointed in previous analyses (Cerviño and Vázquez 2000), where the probability of getting good recruitments is different. This was the base to estimate a preliminary figure for B_{lim} as 14 000 tons; the average recruitments is 14 millions fish when SSB was below 14 000 tons and it was 48 millions when SSB was above this amount.

Results of a retrospective analysis are presented in Figure 5. Fishing mortality was underestimated in last years and, consequently, total biomass and the spawning stock biomass were overestimated. This is also observed when comparing current results with those presented in previous years. Total population and SSB from 1995 onwards were overestimated, although the trends remain the same. Current analysis indicates a minimum of both total biomass and SSB in 1999-2000, and a slight increase in 2001 due to occurrence of the last recruitment and low fishing mortality regime.

It could be argued that last age residuals are quite low and could be dominating the XSA fit. It would be expected that an increase in the minimum standard error for population estimates in each cohort, set equal to 0.5 in this assessment, could balance the residuals among all ages. Some extra runs with FishLab (Kell & Smith, *in prep.*) were done using minimum s.e. from 0.5 to 1.2, in order to check this question. The efficiency of this new settings was evaluated regarding, first, the Log-Likelihood measurement of the fit goodness and, second, the ratio of age 7 root squared residuals on mean (ages 1 to 6) root squared residuals; a value of 1 for this ratio suggests a god balance of residuals among different ages. Results of this analysis are presented in the following table.

Minimum s.e.	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
-LogL	-34.47	-34.21	-34.13	-34.13	-34.16	-34.20	-34.26	-34.32
Res. (age 7) / res. (ages 1-6)	0.33	0.45	0.54	0.59	0.62	0.64	0.64	0.65

The results show that the best fit is achieved at minimum s.e. of 0.7-0.8, based on the light improve in LogL. The balance in residuals improves with higher values of the minimum s.e., but a small improvement with values larger than 0.8 suggest that this value, 0.8, is the best option. Since the assessment results with this new option do not change our perception of the stock status, the results presented are those using minimum s.e. equal to 0.5 for coherence with last year analysis (Vázquez y Cerviño, 2001).

Discussion

The total biomass indices from the EU survey and XSA results show the same view in most recent years. Both indices decline up to 1999-2000 and have a slight increase for 2001. The decline is also observed in the Russian survey, when comparing the 2001 level with the mean of the 1988-1993 period. Comparatively, the XSA indicates the smaller decline than surveys, being the EU survey where decline is deepest.

Recruitment at age one in VPA also shows a pattern similar to the EU survey along the analysed period. This coincidence in views from the surveys and the XSA results, both en total biomass and recruitment, is almost unavoidable due to the low level of commercial catches that makes the analysis strongly dependent of survey results. The very scarce information that commercial fishing produces cannot substantially modify the views of the surveys results used for tuning. This is not a undesirable feature of the XSA, but a more general statement of the VPA, which needs a consistent set of commercial catch data. Consequently the surveys remain as the main source of information at the current low level catch, and their views on the level of the recruitment of last years are the clearest indication of the stock status.

The clearest conclusion of the analysis, already pointed in previous years, is that both total biomass and SSB are at the lowest observed level, and recruitment remain among the weakest observed. The SSB at the low current levels was not able to produce good recruitments in recent years. With the present age structure of the population it is unlikely a recovery of the stock in a short or medium term.

Acknowledgements

This study was supported by the European Commission (DG XIV, Study 00-028), CSIC, IEO, IPIMAR, and the Basque Government.

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Table 1 – Total cod catch on Flemish Cap. Reported nominal catches since 1959 and estimated total catch since 1988. (tons)

	Esti-						**Reported**						
year	**mated**	Faroes	Japan	Korea	Norway	Portugal	Russia	Spain	UK	France-m	Poland	others	total
1959					11		6470	466				2	6949
1960		260			166	9	11595	607			2	96	12735
1961		246			116	2155	12379	851	600	2626	336	1548	20857
1962		188	1		95	2032	11282	1234	93		888	363	16176
1963		969	35		212	7028	8528	4005	2476	9501	1875	853	35482
1964		1518	333		1009	3668	26643	862	2185	3966	718	1172	42074
1965		1561			713	1480	37047	1530	6104	2039	5073	771	56318
1966		891			125	7336	5138	4268	7259	4603	93	259	29972
1967		775			200	10728	5886	3012	5732	6757	4152	802	38044
1968		852	223		697	10917	3872	4045	1466	13321	71	235	35699
1969		750	30		1047	7276	283	2681		11831		42	23940
1970		379	34		1347	9847	494	1324	3	6239	53	1	19721
1971		708	6		926	7272	5536	1063		9006	19	1647	26183
1972		6902			952	32052	5030	5020	4126	2693	35	693	57503
1973		7754			417	11129	1145	620	1183	132	481	39	22900
1974		1872			383	10015	5998	2619	3093		700	258	24938
1975		3288			111	10430	5446	2022	265		677	136	22375
1976		2139			1188	10120	4831	2502		229	898	359	22266
1977		5664	24		867	6652	2982	1315	1269	5827	843	1576	27019
1978		7922	22		1584	10157	3779	2510	207	5096	615	1239	33131
1979		7484	74		1310	9636	4743	4907		1525	5	26	29710
1980		3259	37		1080	3615	1056	706		301	33	381	10468
1981		3874	9		1154	3727	927	4100		79		3	13873
1982		3121	10	4	375	3316	1262	4513	33	119			12753
1983		1499	1		111	2930	1264	4407				3	10215
1984		3058	9		47	3474	910	4745				459	12702
1985		2266	5		405	4376	1271	4914				438	13675
1986		2192	6			6350	1231	4384				355	14518
1987		916	269			2802	706	3639		2300			10632
1988	28899	1100	5	6		421	39	141				6	1718
1989	48373		38	321		170	10	378					917
1990	40827	1262	24	815		551	22	87				1	2762
1991	16229	2472	54	82	897	2838	1	1416	26			1203	8989
1992	25089	747	2	18		2201	1	4215	5			6	7226
1993	15958	2931		3		3132		2249				1	8316
1994	29916	2249			1	2590		1952					6885
1995	10372	1016				1641		564					3221
1996	2601	700				1284		176	129			16	2305
1997	2933					1433		1	23				1475
1998	705					456							456
1999	353					3							3
2000	55					30	6						36
2001	37					54							54

Table 2 – Catch in numbers ('000).

	age							
year	1	2	3	4	5	6	7	8+
1972	0	0	278	19303	12372	6555	3083	3177
1973	0	0	2035	116	11709	3470	853	1085
1974	0	0	5999	11130	2232	1894	271	257
1975	0	0	7090	2436	1241	238	281	258
1976	0	0	17564	10653	386	100	63	5
1977	0	0	119	17581	8502	436	267	318
1978	0	0	428	3092	18077	3615	329	270
1979	0	0	167	2616	5599	5882	316	137
1980	0	0	551	500	1423	1051	1318	96
1981	0	0	1732	6768	161	326	189	539
1982	0	0	21	3040	1926	310	97	357
1983	0	0	2818	713	765	657	94	131
1984	0	0	9	2229	966	59	90	146
1985	0	0	19	5499	3549	1232	931	218
1986	0	2549	2266	4251	2943	1061	169	162
1987	814	1848	3102	1915	1259	846	313	112
1988	1	3500	25593	11161	1399	414	315	162
1989	0	52	15399	23233	9373	943	220	205
1990	7	254	2180	15740	10824	2286	378	117
1991	1	561	5196	1960	3151	1688	368	76
1992	0	15517	10180	4865	3399	2483	1106	472
1993	0	2657	14530	3547	931	284	426	213
1994	0	1219	25400	8273	386	185	14	182
1995	0	0	264	6553	2750	651	135	232
1996	0	81	714	311	1072	88	0	0
1997	0	0	810	762	143	286	48	0
1998	0	0	8	170	286	30	19	2
1999	0	0	15	15	96	60	3	1
2000	0	0	54	1	1	4	1	0
2001	0	9	0	4	2	0	2	2

Table 3 – Indices of abundance at age from the EU survey ('000) and biomass in tons by swept area method.

	Age								
Year	1	2	3	4	5	6	7	8+	biomass
1988	4576	72615	40564	10665	1230	191	223	110	37133
1989	20803	11028	84280	49151	18573	1270	157	80	103644
1990	2492	11937	4755	15469	14660	4298	350	240	55360
1991	137814	25600	15381	1928	6283	1674	296	60	36597
1992	71190	37060	4748	2033	332	1255	222	20	24295
1993	4364	132237	28403	1010	1269	168	491	100	55642
1994	3147	3835	24599	4562	120	66	7	130	24062
1995	1546	11365	1238	3595	885	33	25	20	8815
1996	39	2964	6131	820	2247	187	8	10	8196
1997	39	139	3146	4360	358	902	20	10	9063
1998	25	76	85	1137	1449	73	144	10	4532
1999	6	78	102	105	655	415	19	10	2596
2000	175	13	276	173	84	407	163	50	2782
2001	459	1643	11	105	70	12	135	116	2425

Table 4 – Total biomass estimates in EU and Russian surveys.

Year	EU (1)	Russia: (2)	(3)	
1983		23,070		
1984		31,210		
1985		28,070		
1986		26,060		
1987		10,150	21,600	
1988	37,133	7,720	34,200	
1989	103,644	36,520	78,300	
1990	55,360	3,920	15,200	
1991	36,597	6,740	8,200	
1992	24,295	2,490	2,400	
1993	55,642	8,990	9,700	
1994	24,062	-	-	
1995	8,815	8,260	-	
1996	8,196	730	-	
1997	9,063	-	-	
1998	4,532	-	-	
1999	2,596	-	-	
2000	2,782	-	-	
2001	2,451	784	-	tons

1) Biomass estimated from bottom trawl survey.
2) Biomass estimated from bottom trawl survey (Kiseleva and Vaskov 1994; Kiseleva 1996, 1997; Shibanov *et al*. 2002).
3) Biomass estimated of bottom trawlable plus pelagic biomass (Borovkov *et al.* 1993; Kiseleva and Vaskov 1994).

Table 5 – Log catchability and standard error from XSA output.

Age	3	4	5	6	7
Mean Log q	0.3005	0.1735	0.1735	0.1735	0.1735
S.E(Log q)	0.5759	0.7381	0.9473	0.8147	0.2407

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.83	2.092	2.04	0.93	14	0.72	-0.84
2	0.94	1.134	0.30	0.96	14	0.53	0.22

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	1.04	-0.687	-0.64	0.96	14	0.61	0.30
4	1.21	-2.285	-1.89	0.90	14	0.78	0.17
5	1.08	-0.532	-0.90	0.77	14	1.05	0.27
6	0.96	0.249	0.14	0.77	14	0.81	0.11
7	1.00	-0.128	-0.08	0.98	14	0.21	0.05

Table 6 – Maturity ogive in percentage of spawning female at age.

	age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1972	0	0	0	0	50	100	100	100
1973	0	0	0	0	50	100	100	100
1974	0	0	0	0	50	100	100	100
1975	0	0	0	0	50	100	100	100
1976	0	0	0	0	50	100	100	100
1977	0	0	0	0	50	100	100	100
1978	0	0	1	9	47	88	98	100
1979	0	0	0	2	15	68	96	100
1980	0	0	0	0	6	68	98	100
1981	0	0	0	6	52	95	100	100
1982	0	0	0	4	78	100	100	100
1983	0	0	0	7	71	99	100	100
1984	0	0	0	4	71	99	100	100
1985	0	0	0	3	74	100	100	100
1986	0	0	4	18	63	75	85	100
1987	0	0	4	18	63	75	85	100
1988	0	0	4	18	63	75	85	100
1989	0	0	4	18	63	75	85	100
1990	0	0	7	34	52	50	71	100
1991	0	0	0	23	78	91	84	100
1992	0	0	0	23	79	86	74	100
1993	0	0	2	16	73	100	95	100
1994	0	0	2	57	97	100	100	100
1995	0	0	0	77	100	100	100	100
1996	0	0	2	56	100	100	100	100
1997	0	0	8	69	91	96	100	100
1998	0	0	33	87	100	100	100	100
1999	0	0	33	87	100	100	100	100
2000	0	0	33	87	100	100	100	100
2001	0	0	33	87	100	100	100	100

Table 7 – Fishing mortality from VPA.

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.0001	0	0.0003	0	0	0	0	0	0	0	0	0	0	0
2	0.0613	0.0042	0.0157	0.0278	0.3631	0.0589	0.7138	0	0.0403	0	0	0	0.6527	0.0092
3	0.4120	0.4147	0.2405	0.5016	0.9807	0.6944	1.2318	0.3224	0.3063	0.6976	0.0985	0.1637	0.5138	0
4	0.5335	0.8331	1.0262	0.3545	1.3658	1.2349	1.1947	1.4479	0.7927	0.6294	0.2993	0.2705	0.0146	0.0627
5	0.5381	1.2839	1.3469	0.5758	2.3158	1.1464	0.3916	2.7307	1.0504	1.1368	0.5139	0.2753	0.0256	0.0366
6	0.7989	0.8837	1.5035	0.7808	1.3837	2.6892	0.7362	4.386	0.8224	0.9307	0.7818	0.1889	0.0163	0
7	1.3724	1.5793	1.1878	1.1638	2.9371	0.9849	1.7493	3.4958	0	1.8975	0.1331	0.1564	0.0042	0.0101
8+	1.3724	1.5793	1.1878	1.1638	2.9371	0.9849	1.7493	3.4958	0	1.8975	0.1331	0.1564	0.0042	0.0101
F 3-5	0.4945	0.8439	0.8712	0.4773	1.5541	1.0252	0.9394	1.5003	0.7165	0.8213	0.3039	0.2365	0.1847	0.0331

Table 8 – Abundance at age (‘000) from VPA.

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	16888	22063	27622	68798	62715	3225	4462	2768	141	164	222	28	1332	1689	0
2	65101	13826	18064	22608	56326	51347	2640	3653	2267	115	134	181	23	1091	1384
3	83764	50133	11273	14559	18002	32076	39635	1059	2991	1782	94	110	149	10	885
4	29834	45422	27112	7257	7219	5528	13114	9468	628	1803	726	70	76	73	8
5	3716	14327	16167	7955	4168	1508	1316	3251	1822	233	787	441	44	62	56
6	832	1776	3249	3442	3662	337	392	729	173	522	61	385	274	35	49
7	466	306	601	591	1291	751	19	154	7	62	168	23	261	221	29
8+	234	278	182	120	527	369	236	252	0	0	18	8	0	220	358
total	200834	148131	104268	125331	153910	95141	61816	21333	8029	4681	2210	1246	2159	3400	2768

Table 9 – Recruitments at age 1 (‘000), total biomass, spawning stock biomass (SSB), landings (tons), mean F at ages 3-5 and biomass index from EU survey.

year	recruits (age 1)	Total biomass	SSB	landings	Yield/SSB	F 3-5
1972	18861	83839	40474	57503	1.4207	0.6892
1973	66655	46551	21415	22900	1.0693	0.5691
1974	134636	37829	14414	24938	1.7301	1.2894
1975	24746	49619	8240	22375	2.7155	0.6055
1976	11146	113363	9973	22266	2.2326	0.3343
1977	3579	87518	22761	27019	1.1871	0.4647
1978	22791	56861	27387	33131	1.2097	0.4532
1979	16216	46618	20822	29710	1.4269	0.7250
1980	8547	31999	11521	10468	0.9086	0.5110
1981	23235	32181	10317	13873	1.3446	0.4527
1982	22417	30641	14856	12753	0.8584	0.4901
1983	13949	42831	15005	10215	0.6808	0.2363
1984	15862	39513	18187	12702	0.6984	0.2287
1985	62916	37393	21954	13675	0.6229	0.5497
1986	127455	35649	13376	14518	1.0854	0.7474
1987	80414	54666	12032	10632	0.8836	0.4452
1988	16888	67889	15443	28899	1.8713	0.4945
1989	22063	109225	30358	48373	1.5934	0.8439
1990	27622	66568	27396	40827	1.4902	0.8712
1991	68798	46102	22620	16229	0.7175	0.4773
1992	62715	60307	22698	25089	1.1053	1.5541
1993	3225	48218	9423	15958	1.6934	1.0252
1994	4462	47810	16490	29916	1.8142	0.9394
1995	2768	21881	18309	10372	0.5665	1.5003
1996	141	5503	3150	2601	0.8257	0.7165
1997	164	4517	2792	2933	1.0504	0.8213
1998	222	3081	2857	705	0.2467	0.3039
1999	28	2132	1983	353	0.1780	0.2365
2000	1332	2182	1921	55	0.0286	0.1847
2001	1689	3088	2400	37	0.0154	0.0331

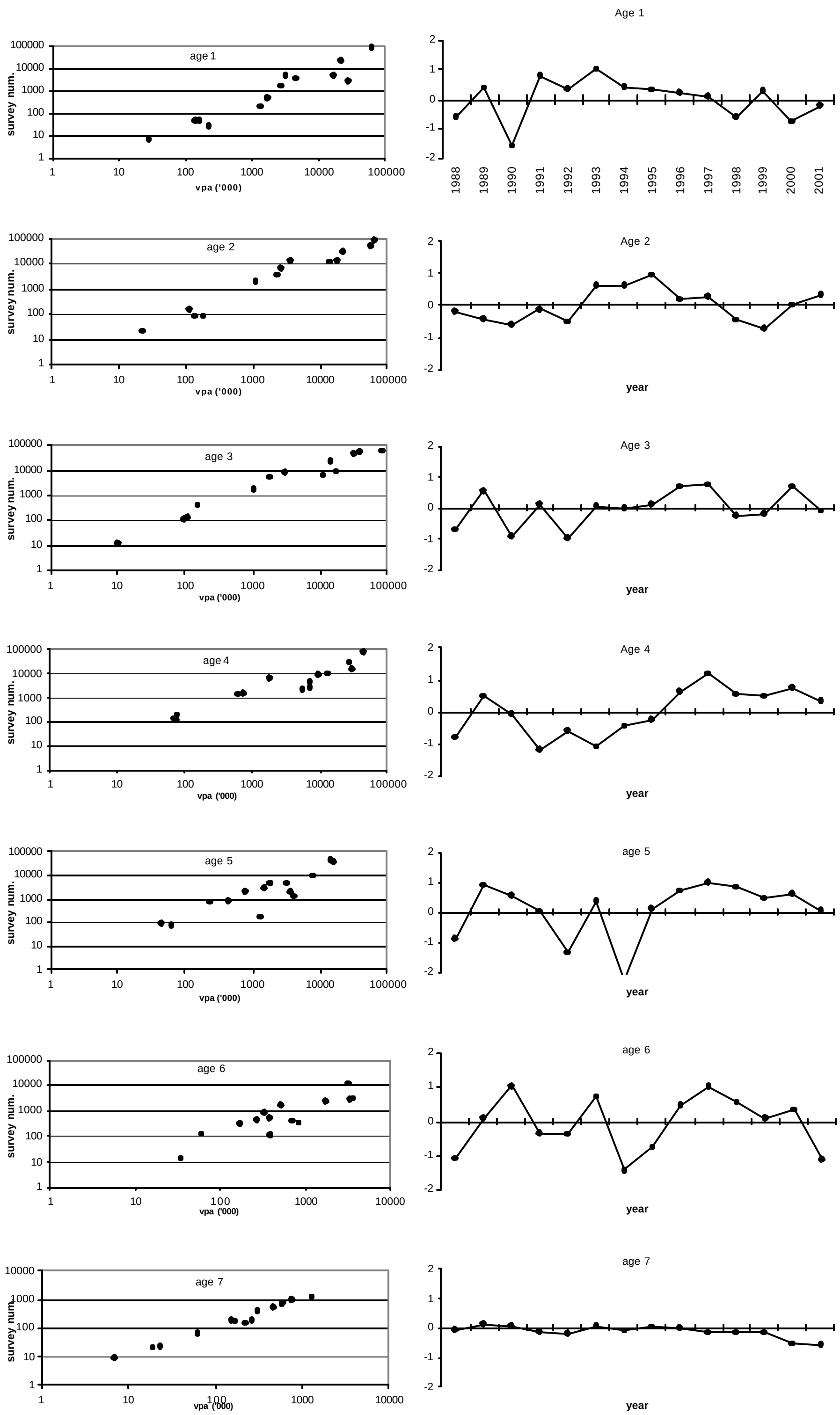

Figure 1 – Plots of catchability analysis by age. Left: abundance index from EU survey against VPA results. Right: catchability residuals.

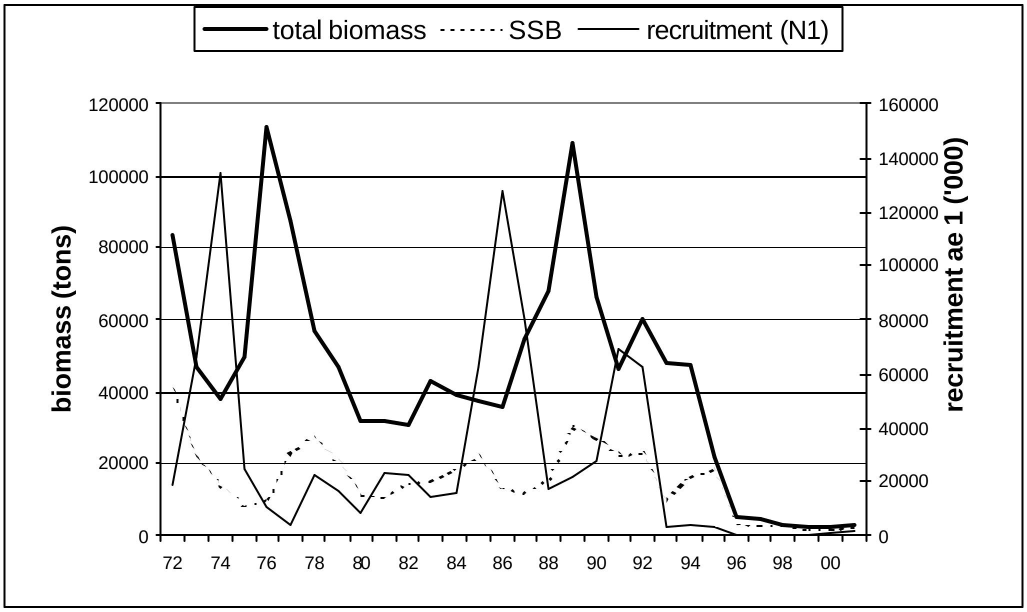

Figure 2 – Total biomass, spawning stock biomass and abundance of recruitment at age 1 according to XSA results.

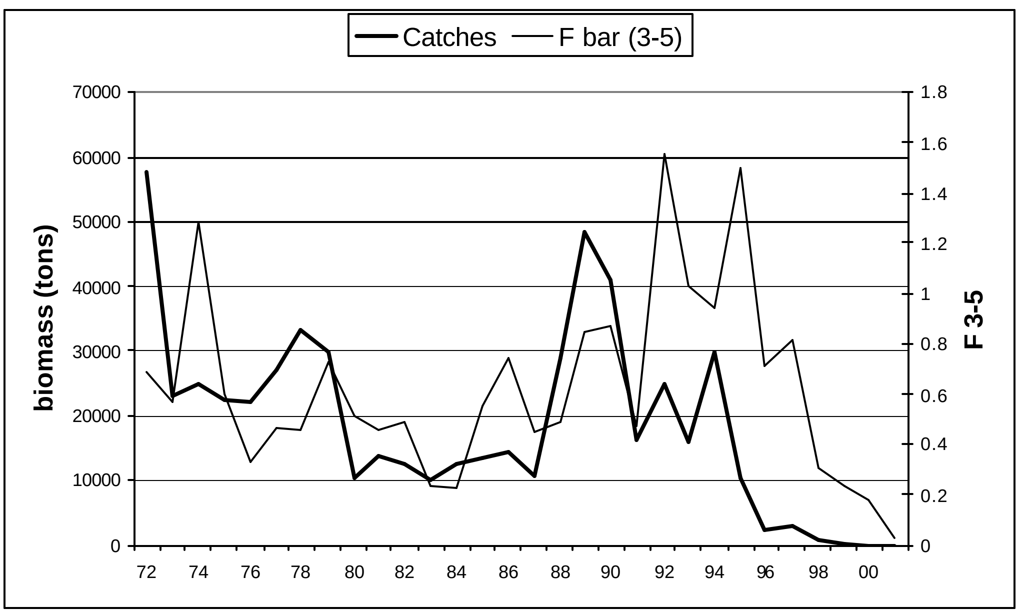

Figure 3 – Total annual catch and fishing mortality (F 3-5) according to XSA results

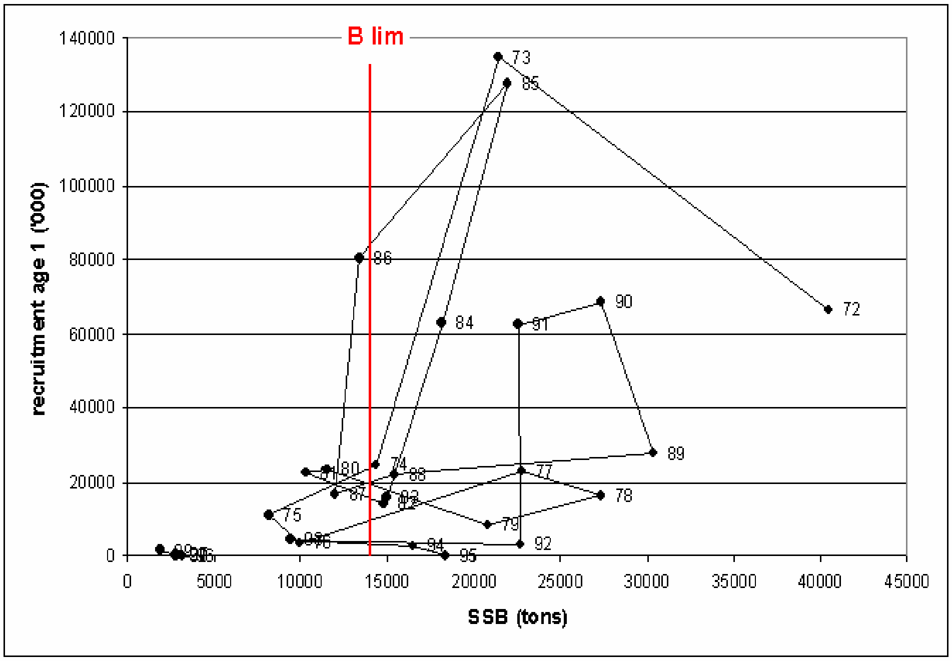

Figure 4 – Spawning stock biomass (SSB) and recruitment at age 1 from 1972 to 2000. Tag shows the year of SSB.

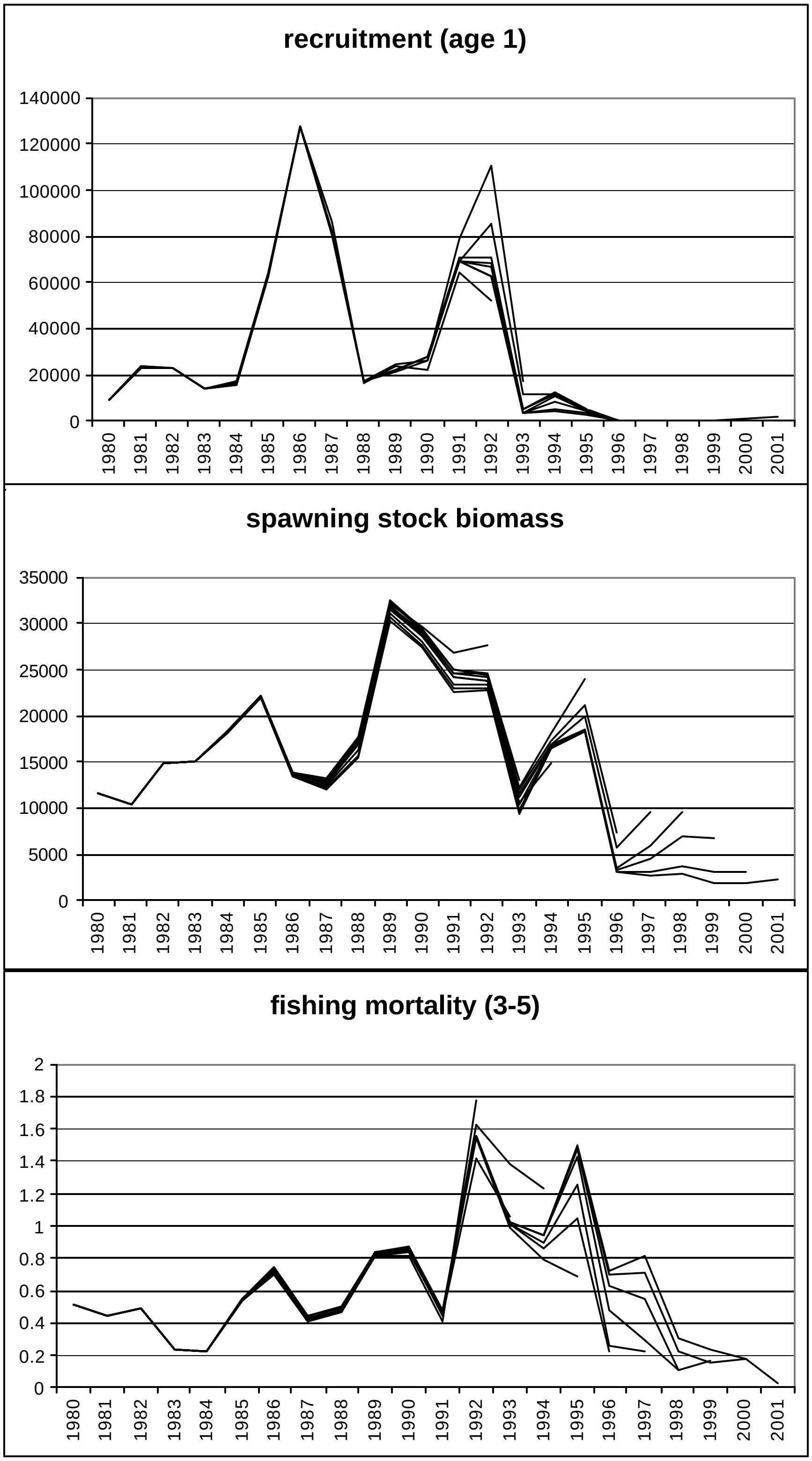

Figure 5 – Retrospective analysis for recruitment at age 1, SSB and F 3-5.