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Assessment of Roughhead Grenadier, *Macrourus berglax*, in NAFO Subareas 2 and 3

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ABSTRACT

According to the autumn Canadian survey (2J+3K) and the Spanish 3NO survey, the roughhead grenadier total biomass indices would indicate a general increasing trend from 1995 onwards. The catch / biomass (C/B) indexes obtained using the Canadian autumn survey and the Spanish 3NO biomass index in the period 1995-2004 show a clear decrease trend from 1995 to 2004, due to an increasing trend in the survey biomass and a decrease of catches.

The Z estimate from the catch curve based upon commercial catch at age data (1992-2004) was 0.355 for ages 8 to 20, the value estimate from the catch curve of the UE Flemish Cap survey (1994-2004) was 0.511 for the same ages and 0.394 for the catch curve of the Spanish 3NO survey data (1997-2004).

The Separable VPA (Pope and Shepherd, 1982) stock assessment model was fitted to the stock data, years 1993 to 2004 and ages 3 to 20, for the roughhead grenadier Subarea 2 and 3. The model seems to fit adequately the data. The results of the Separable VPA were used to start a traditional VPA.

The mean fishing mortality for ages 8 to 20 in the period 1993-2004 was 0.259 and is similar to those calculated by the catch curves with the catch matrix data (0.255) and with the Spanish 3NO survey data (0.294) for the same ages. Moreover the trend of F bar (8-14) of the VPA is similar to the catch/survey biomass ratio for the Canadian Autumn survey (2J3K) and the Spanish 3NO survey. However the VPA biomass trend is total different from the biomass trend of the Canadian Autumn (2J3K) and Spanish 3NO surveys, in the last years the biomass of the surveys show a great increase and the VPA biomass is stable at the lowest levels of the series. Recruits at age 3 have the same problem, survey show in 2004 the biggest recruitment of the series while VPA show for 2004 a normal recruitment.

FISHERY

Roughhead grenadier is taken as by-catch in the Greenland halibut fishery in the Regulatory Area mainly in Div. 3LMN. The fishery for roughhead grenadier is unregulated, however, roughhead grenadier is becoming an important commercial fish in NAFO Regulatory Area and reliable information is needed for its assessment.

COMMERCIAL CATCHES

The revised catch history after 1987 is presented in Table 1 and Fig. 1. Catches increased sharply from 1989 (333 tons) gradually until 6 725 tons in 1992. From 1993 to 1997 the level of the catches was around 4 000 tons. In 1998 it was reached the highest level of the catches observed (7 231 tons), since then, it has continued decreasing steadily up to 2004 (3 182 tons). Most of the catches are taken in Div. 3LMN.

RESEARCH SURVEY DATA

• Canadian autumn survey

Stratified random bottom trawl surveys have been conducted in Div. 2GHJ and 3KL in autumn since 1978, usually in October-November. Since 1990 the survey also covered Div. 3NO. Until 1995 an Engel trawl was used, changed since then to a Campelen 1800. Surveys depth is up to 1 500 m in Div. 2GHJ and 3K and to 730 m in Div. 3LNO, extended to 1 463 m after 1995. A description of those surveys is in McCallum and Walsh (1996) and Power and Parsons (1998). In 2002 Div. 2G and H were not covered by the survey and in Div. 3M a total of 26 hauls were made at depths between 732-1 463 m. In 2004 operational difficulties lead to incomplete coverage of the survey in NAFO Divisions 3LNO (Brodie, 2005 and Healey and Dwyer, 2005).

The roughhead biomass indexes from this series of surveys are presented in Table 2. The estimates from 1995 onwards are not directly comparable with the previous time series because of the change in the survey gear. Taking into account the incomplete coverage of some strata in divisions 2GH and 3LMNO from 1995-2004 (Brodie, 2005; Healey and Dwyer, 2005), the indices of Div. 2J and 3K are comparable from 1995 onwards. From 1995, the biomass of this survey in Div. 2J and 3K shows an increase trend, reaching its maximum in 2004 as shows Fig. 2. As has been observed in recent years (Junquera et al. 1999), the largest biomass indexes were obtained at depths between 1 000-1 200 m in all areas.

• Canadian spring survey

Stratified random bottom trawl surveys have been conducted in Div. 3L, 3N and 3O in spring since 1978. A description of those surveys is found in McCallum and Walsh (1996). Until 1996 an Engel trawl was used, changed to a Campelen 1800 since then. The depth range of the surveys is up to 731 metres.

The roughhead biomass obtained in this series of surveys from 1991 is presented in Table 3. But again in this case a direct comparison of the biomass levels through the whole time series is not possible due to the change in the survey gear in 1995. Figure 3 shows the biomass of this survey since 1996. From 1998 the biomass level does not present a clear trend and is largely concentrated in Div. 3L. Biomass estimates from the spring survey series are considerably lower than the ones obtained in the autumn series, as the first surveys cover only the southern Divisions and the shallower depths, where according to the other results this species is less abundant.

• Canadian deepwater survey

Canada conducted deepwater bottom trawl surveys (750-1 500 m.) in 1991, 1994 and in 1995 in Divisions 3 KLMN. The 1991 survey was carried out in August, the 1994 in February and the 1995 in spring. The results of those surveys were reported by Atkinson *et al.* (1994) and Bowering *et al.* (1995), and are presented in Table 5. It is observed an increasing trend from 16 215 tons in 1991 to 46 668 in 1995. Most part of the biomass was taken in Div. 3L and 3M, which confirms that the stock in those Divisions is distributed beyond the depths covered by the spring surveys in those Divisions. The increased estimates for Div. 3L and 3M in 1994 were probably due, at least in part, to the increased survey area (Atkinson *et al.*, 1994). The results suggest somewhat higher biomass in southern 3L and 3N.

• EU (Spain and Portugal) summer survey

EU- Spain and Portugal conduct a stratified bottom trawl survey in Div. 3M since 1988, up to depths of 730. The survey procedure is described in Saborido-Rey and Vázquez (2003). Since 1991, the survey was made with the R/V *Cornide de Saavedra*. In 2003 this vessel was replaced by the R/V *Vizconde de Eza*. The former series of *Cornide de Saavedra* was transformet to the new R/V *Vizconde de Eza* units following the method presented by Gonzalez Troncoso (2005). The roughhead grenadier biomass index from this survey series, updated from Murua *et al.* (2005), is presented in Table 5 and Fig. 3. A peak biomass of 3 021 was observed in 1993, but since then has been somewhat stable up to 2002, at between 1 000 and 2 000. From 2002 onwards the biomass showed an increasing trend, reaching the historical maximum of 3 597 tons in 2004. Roughhead grenadier biomass is only significantly found at depths beyond 500 m every year. Figure 4 presents the age distributions of the EU Flemish Cap survey from 1994 to 2004, where it can be clearly appreciated a strong upcoming 2001 year-class in 2003 and 2004.

- **Spanish 3NO Survey**

Spain conduct a stratified random spring bottom trawl survey in the NAFO Regulatory Area Div. 3NO since 1995. In 2001 the vessel and the trawl gear were replaced. The transformed entire series of mean catches, biomass and length distributions for Roughhead grenadier were presented by Gonzalez-Troncoso *et al.* (2005). From 1997 to 2002 the biomass indices of this survey did not show a clear trend, however, since then the biomass increase and in 2004 reached the historical maximum (11 402 tons) (Table 6 and Fig. 2). The MNPT length distributions of the survey series (Fig. 5) showed a strong 2001 year-class during last two years survey as it was observed in the EU Flemish Cap survey.

BIOLOGICAL DATA

Roughhead length frequencies from the Spanish, Portuguese and Russian trawl catches for 2004 in Div. 3LMNO are available from Gonzalez *et al.* (2005), Vargas *et al.* (2005) and Vaskov *et al.* (2005) respectively. The Spanish and Portuguese lengths frequencies are presented as pre-anal fin length, while the Russian ones as total lengths. The roughhead length compositions from the Russian catches have been converted to AFL using the total length/AFL relationship presented by Murua and Motos (1997).

Catch at age data of Roughhead grenadier Subarea 2 and 3 from 1992 to 2003 was presented by Gonzalez-Costas and Murua (2005) and it has been updated with the 2004 data presented by Gonzales *et al.* (2005), Vargas *et al.* (2005) and Vaskov *et al.* (2005). Table 7 presents the catch at age numbers from 1992 to 2004 as well as the mean length and mean weight by age. Most of catches are composed between ages 4 and 13, with a mode at age 8.

ASSESSMENT

Although the Canadian autumn survey series (2J+3K) and the Spanish 3NO survey do not cover the entire distribution of the stock, they are considered as the best survey information to monitor trends in resource status because their depth coverage is going down to 1 500 m.

According to the autumn Canadian survey (2J+3K) and the Spanish 3NO survey, the roughhead grenadier total biomass indices would indicate a general increasing trend from 1995 onwards. The biomass trend indicated by the EU Flemish Cap survey (<720 m) was similar to that of the Canadian autumn and Spanish 3NO survey. However, the total biomass index of Canadian spring did not show an increasing trend and was stable in the last years. The catch/biomass (C/B) indexes obtained using the Canadian autumn survey and the Spanish 3NO biomass index in the period 1995-2004 (Fig. 6) show a clear decrease trend from 1995 to 2004, due to an increasing trend in the survey biomass and a decreased of catches.

The Z estimate from the catch curve based upon commercial catch at age data (1992-2004) was 0.355 for ages 8 to 20, the value estimate from the catch curve of the UE Flemish Cap survey (1994-2004) was 0.511 for the same ages and 0.394 for the catch curve of the Spanish 3NO survey data (1997-2004) (Fig. 7). The differences between the Z values estimated based upon catches, Spanish 3NO survey and the Flemish Cap survey can be explained due to different depth coverage of sampling. The Flemish Cap survey does not cover depths down to 720 m and, consequently, the catch of older ages is diminished and the slope of the relationship is more pronounced. Contrary to that, the Spanish 3NO survey and the fishery cover the same depth distribution and catch more or less the same ages.

In previous studies Murua (2002; 2003) suggested a difference in M between sexes, in order to analyse this, an estimate of Z by sexes have been performed using the catch at age by sexes of Spanish 3NO survey (Fig. 8). The results indicate a total mortality value of 0.339 and 0.713 for females and males respectively, both values higher than the ones obtained by Murua (2003) based upon data collected on the Flemish Cap survey, which covers the shallowest distribution of roughhead grenadier.

The Separable VPA (Pope and Shepherd, 1982) stock assessment model was fitted to the stock data for the roughhead grenadier Subarea 2 and 3. The model was fitted, in a first step, to the whole data available, years 1992 to 2004 and ages 1 to 24 to analyse the consistence of the catch at age matrix. Figure 9 shows the residuals of separable VPA, and it is observed that most of the errors came from the 1992 data and from the ages less than 3 years and older than 20 years. With this information the model was fitted to a new data, years 1993 to 2004 and ages 3 to 20

(plus group). With these new data, the model fit adequately to data (Fig. 10). Figures 11 and 12 show the results of the Separable VPA fit for the selection patten and fishing intensity.

The results of the Separable VPA were used to start a traditional VPA, results are presented in Table 8. The mean fishing mortality for ages 8 to 20 in the period 1993-2004 was 0.259 and is similar than those calculated by the catch curves with the catch matrix data (0.255) and with the Spanish 3NO survey data (0.294) for the same ages (Figure 13). Moreover the trend of \bar{F} (8-14) of the VPA is similar to the catch/survey biomass ratio for the Canadian Autumn survey (2J3K) and the Spanish 3NO survey (Fig. 14). However the VPA biomass trend is total different from the biomass trend of the Canadian Autumn (2J3K) and Spanish 3NO surveys (Fig. 15), in the last years the biomass of the surveys show a great increase and the VPA biomass is stable at the lowest levels of the series. Recruits at age 3 have the same problem, survey show in 2004 the biggest recruitment of the series while VPA show for 2004 a normal recruitment (Fig. 16).

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Table 1.- Revised roughhead grenadier Subarea 2 and 3 STACFIS catches by Division.

Year	STACFIS RHG Nominal catches (t) by Division									TOTAL
	2G	2H	2J	3K	3L	3M	3N	3O	Other	
1987					912	7	82			1001
1988		1			907		52			960
1989		2		3	289	28	11			333
1990		1	32		2211	688	312			3244
1991 ^a			12	113	2543	497	1093	10		4268
1992			23	274	2582	2961	760	125		6725
1993			10	193	996	1428	1680	61	27	4395
1994	1		2	35	585	2301	1062	28	9	4023
1995	22	6	16	16	1199	1625	1074	20	4	3982
1996					1945	888	1300	2		4135
1997	36	5	63	100	1774	922	1797	43		4740
1998					2766	2190	2230	84	92 ^c	7270
1999 ^b				61	2037	3127	1705	180	49 ^c	7160
2000 ^b				139	1382	2109	888	38		4767
2001 ^b				97	1465	753	754	48		3117
2002 ^b				147	1905	869	700	36		3657
2003 ^b	1	4	16	91	1342 ^c	886	1201 ^c	443 ^c		3984 ^c
2004 ^b	4	8	19	58	1310	844	897	42		3182

^a Catch could not be well estimated; based on revised data is estimated to be 8 000 to 14 000 tons mixed roundnose and roughhead grenadiers. (Power and Parson 1988).

^b Provisional.

^c In 2003, STACFIS could not precisely estimate the catch.

Table 2 .- Canadian Autumn survey biomass by Division.

Year	Canadian Autumn Survey Biomass (tons)								Total
	2G	2H	2J	3K	3L	3M	3N	3O	
1978	1119	1528	8967	12538					24152
1979			5567	10427					15994
1980			9747	10560					20307
1981	2048	2520	5485	7741					17794
1982			7188	8664					15852
1983			6284	8025					14309
1984			5776	7322					13098
1985			2203	4891	8563				15657
1986			4172	2600	6924				13696
1987			2919	3075					5994
1988			2743	2357					5100
1989			2346	930					3276
1990			2993	3730	5678				12401
1991	1	28	1401	3173	4053		156	72	8884
1992			1264	412	1163		72	0	2911
1993			563	809	864		441	79	2756
1994			433	443	717		274	46	1913
1995			566	3066	1713		1434	155	6934
1996	582	1290	2695	4770	17563	6791	327	49	34067
1997	1856	1781	3101	5419	12599	6659	1550	75	33040
1998	412	1640	3638	6255	15912	5438	8194	552	42041
1999	533	1474	3318	5292	15670	3714	1801	173	31975
2000			2900	6145	10363	4059	5048	665	29180
2001		740	3946	10197	17790	5721	5796	852	45042
2002			3638	6854	15319	3231	5591	975	35608
2003			2719	7261	14407	5685	1892	433	32397
2004		1823	4352	10465	1326		5296	47	23309

Table 3 .- Canadian Spring survey biomass by Division.

Year	Canadian Spring Survey Biomass (tons)			
	3L	3N	3O	Total
1991	249	15	5	270
1992	1110	18	13	1141
1993	455	84	21	561
1994	612	28	43	683
1995	323	24	12	358
1996	2777	77	29	2883
1997	2727	375	1	3103
1998	4221	698	159	5078
1999	2987	777	278	4043
2000	3621	1267	207	5095
2001	3707	1161	80	4948
2002	2527	502	88	3116
2003	3609	671	17	4297
2004	3658	638	65	4361

Table 4.- Roughhead grenadier biomass index (tons) from the deepwater Canadian surveys and percentages of biomass by Divisions (from Bowering *et al.*, 1995)

Year	Biomass (t.)	Percentage of biomass (%)			
		3K	3L	3M	3N
1991	16215	26	39	34	
1994	26588	16	34	39	11
1995	46668	15	48	25	13

Table 5 .- EU Flemish Cap (Div. 3M) survey biomass by strata, total and their standard variation.

Strata	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1																	
2								8									
3																	10
4																9	
5																	
6									22								
7					0								3	0		0	10
8		10		1					11	3		7		16	2	13	28
9	47	4		5	28	21	3	21	153	18	40	45	29	29		30	282
10	1								6	1		18	68	18		0	48
11												3	8	6			3
12	112	103	40	108	100	413	55	126	46	137	55	191	81	236	154	165	292
13	21	64	18	18	60	18	32	75	5	18	78	92	50	116	121	123	299
14	200	145	107	85	139		73	67	270	77	194	135	103	292	124	346	877
15	92	5	29	64	52	321	82	180	84	69	101	72	103	60	16	87	259
16	349	140	212	229	432	1333	523	256	397	211	405	150	225	338	272	352	594
17	134	45	31	180	123		98	129	27	116	204	96	67	370	380	101	244
18	311	128	143	356	215		756	414	154	224	189	313	219	383	27	877	423
19	743	227	273	289	429	915	352	282	187	322	424	129	92	216	116	245	228
Total (1-19)	2009	871	852	1335	1577	3021	1975	1558	1362	1197	1691	1250	1047	2079	1211	2348	3597
SD	264	142	149	250	270	487	169	223	277	169	243	338	196	284	176	611	362

Table 6 .- Spanish 3NO survey biomass by strata, total and their standard variation.

Strata	1997	1998	1999	2000	2001	2002	2003	2004
353	0	0	0	0	0	0	0	0
354	0	0	0	0	0	0	0	0
355	0	0	0	1	0	0	0	0
356	0	2	0	0	0	0	0	5
357	1	0	3	6	2	14	20	0
358	0	0	5	0	0	10	0	0
359	0	0	0	0	0	2	0	18
360	0	0	0	0	90	0	0	0
374	0	0	0	0	0	0	0	0
375	0	0	0	0	0	0	0	0
376	0	0	0	0	0	0	0	0
377	0	0	0	0	0	2	0	0
378	6	0	4	2	0	0	0	0
379	0	0	0	5	4	2	1	34
380	2	0	0	1	0	0	1	2418
381	0	0	0	1	0	0	0	53
382	0	0	0	0	0	0	0	2
721	0	5	13	4	1	7	0	20
722	0	31	28	37	18	78	33	35
723	0	3	32	36	22	9	113	136
724	6	13	41	44	79	110	55	125
725	0	1	34	126	13	25	3	863
726	0	15	47	96	25	18	0	383
727	4	2	5	23	2	5	193	138
728	6	7	121	54	7	4	226	136
752	106	94	102	339	75	22	892	1160
753	200	452	343	624	407	65	688	810
754	1149	1041	460	1233	1395	1549	1086	562
755	n.s.	1571	871	1007	899	50	633	531
756	30	62	266	178	113	104	65	91
757	210	389	78	847	179	147	79	121
758	434	701	428	522	629	1246	367	305
759	n.s.	789	263	397	679	782	881	475
760	57	128	55	260	97	161	576	1065
761	313	418	270	178	236	81	194	396
762	502	618	350	398	54	6	276	287
763	n.s.	260	288	364	364	28	68	672
764	62	44	36	41	46	170	176	357
765	141	80	69	95	49	28	115	59
766	109	104	73	43	38	113	73	92
767	n.s.	93	72	38	45	129	43	53
TOTAL	3340	6922	4357	7000	5568	4968	6860	11402
SD	290	644	431	807	700	1365	1316	2043

Table 7. - Catch at age numbers of the Roughhead grenadier NAFO Subarea 2 and 3, as well as the mean weight and length by age.

Abundance													
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	4015	0	1276	0	0	0	47	105678	118	397	484	1745	127
2	32675	37900	39785	14170	5093	42364	21782	129419	32334	15762	6004	37461	4056
3	62493	125464	130563	142713	95128	241501	144669	156143	190221	107185	99759	172996	121237
4	103515	83910	177653	319309	315476	467969	391704	223852	302378	217109	256630	464119	267429
5	197522	151123	205608	370483	709214	653031	791095	641078	527982	421557	483287	372390	563716
6	508971	366628	394680	564837	1162396	925505	1620101	949703	1118199	915576	1046058	562838	595256
7	792864	496122	527552	619505	924380	992327	2212826	961740	982683	1049510	973771	1190123	736414
8	1122312	948145	901398	879044	999031	1270530	3015016	1237561	1341920	1169704	1266419	1708755	1001776
9	1079639	1088143	1061679	911875	921953	1071115	2226078	1040108	1692732	913046	873862	1354953	712128
10	841149	761160	798988	685964	698674	717076	1216448	808124	1044521	565130	454136	772799	499301
11	798146	535726	587450	518743	608704	582942	800521	918977	472835	357370	443332	395749	272811
12	751577	456199	458358	377202	456632	476790	586220	542169	414313	243226	317515	300307	289150
13	581997	373304	322175	230586	278554	327191	376383	622668	234349	137969	168123	141190	171244
14	477520	305061	244921	170442	144886	233190	263854	471140	185664	89352	91212	63059	88233
15	259033	196682	148473	97761	83705	118696	132473	228458	121040	53952	58607	53929	46263
16	162051	120754	90481	76395	60403	80719	82658	106189	62548	36845	60044	71310	40994
17	100425	74262	55310	44953	48179	61559	46647	68900	27522	24892	68823	33417	21275
18	76282	65373	46289	34512	41578	43885	48320	97060	22066	21902	51435	12159	18385
19	53919	51888	36662	23579	30192	32846	42275	78589	30941	17283	27893	15590	8228
20	30009	22751	22571	15449	8871	21390	28848	81283	18898	12004	16356	7035	4806
21	17980	16527	13370	8864	1996	13502	19408	56097	18411	7093	12197	297	2679
22	8430	4482	6720	3196	948	5188	8372	28017	13093	4742	4971	2341	264
23	8561	4042	4935	1534	2034	3581	6746	23244	9841	3718	5442	472	475
24	8481	803	3802	968	0	1821	2945	7743	10342	2667	3232	646	1010
Total ages	8079616	6291449	6280698	6112082	7598026	8384718	14085434	9583939	8874953	6387992	6789591	7735681	5467259
Total Catch SC	6725	4395	4023	3982	4135	4740	7270	7160	4767	3117	3657	3984	3182

Mean Weight (gr)													
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	11		16				30	10	14	13	22	34	4
2	40	51	49	80	165	107	107	127	116	99	61	91	41
3	86	77	85	113	156	147	143	180	158	137	154	148	102
4	119	111	115	143	184	211	177	244	194	176	218	213	192
5	186	184	173	230	216	262	229	317	243	227	268	278	269
6	258	236	236	325	260	300	281	365	276	271	306	299	317
7	337	320	313	434	348	355	342	434	327	324	353	333	375
8	440	414	412	524	451	421	403	487	393	397	414	423	473
9	594	500	509	612	560	516	490	591	498	499	498	483	568
10	748	585	590	677	653	618	600	677	568	587	607	616	726
11	922	736	716	776	767	743	749	785	725	709	692	854	836
12	1063	886	836	885	851	855	876	949	828	824	840	979	1072
13	1226	1101	1039	1106	984	1033	1052	1151	1068	1033	989	1155	1361
14	1446	1324	1280	1443	1245	1252	1299	1305	1353	1343	1412	1521	1546
15	1683	1546	1530	1705	1696	1534	1544	1657	1561	1652	1565	1903	2234
16	1928	1777	1729	1966	1837	1799	1823	1832	1787	1851	1852	1998	2330
17	2212	1989	2005	2220	2083	2257	2100	2023	2010	2132	2078	2407	2393
18	2478	2326	2333	2459	2197	2421	2466	2358	2441	2429	2440	3056	2496
19	2669	2508	2553	2643	2283	2534	2707	2474	2716	2662	2822	2954	2675
20	3052	2777	2889	2887	2643	2870	2942	2887	3207	3000	3140	2899	2719
21	3363	2898	3076	3029	3105	3198	3063	3739	3739	3263	2939	4177	3773
22	3993	3422	3637	3487	3192	3471	3663	3584	3851	3754	3807	3682	4384
23	4092	3299	3525	3556	2514	3485	3592	3699	4289	3787	3240	4206	4534
24	4998	4172	4453	4067		4541	4108	4442	4670	4493	4206	4220	4820

Mean Length (cm)													
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	4.7		5.5				5.1	3.6	4.7	4.1	4.0	4.8	2.2
2	7.4	8.1	8.0	9.2	9.9	8.8	8.6	8.9	8.9	8.9	7.3	7.7	5.3
3	9.8	9.5	9.8	10.2	10.4	9.8	10.1	9.9	9.9	9.9	9.7	9.7	8.9
4	11.0	10.7	10.9	10.9	11.2	11.1	11.2	11.3	11.0	11.1	11.1	11.2	11.1
5	12.7	12.8	12.5	12.4	12.6	12.4	12.6	12.7	12.5	12.7	12.5	12.5	12.7
6	14.2	14.0	14.0	13.8	13.7	13.7	14.0	13.7	13.7	13.9	14.1	13.6	13.9
7	15.4	15.5	15.4	15.3	15.0	15.3	15.4	15.5	15.1	15.2	15.4	15.0	15.3
8	16.6	17.0	16.9	16.8	16.5	16.6	16.4	16.8	16.3	16.4	16.5	16.7	17.1
9	18.1	18.1	18.2	18.2	18.1	17.9	17.6	18.5	17.8	17.8	17.7	17.7	18.2
10	19.5	19.1	19.2	19.2	19.3	19.2	18.9	19.6	18.7	18.9	18.9	19.3	19.8
11	20.9	20.6	20.5	20.4	20.7	20.6	20.3	20.8	20.3	20.2	19.8	21.5	20.5
12	22.0	22.0	21.6	21.2	21.4	21.6	21.5	22.2	21.2	21.2	21.0	22.5	22.1
13	23.3	23.7	23.2	22.7	22.5	23.0	22.9	23.8	23.1	22.8	22.1	23.7	24.0
14	24.8	25.3	25.0	24.9	24.3	24.6	24.6	24.8	25.0	24.9	25.1	26.1	25.1
15	26.4	26.7	26.6	26.7	27.2	26.4	26.3	27.1	26.5	26.9	26.0	28.5	29.2
16	27.7	28.0	27.7	28.1	28.0	27.8	27.7	28.1	27.5	27.9	27.8	28.9	29.8
17	29.2	29.2	29.2	29.4	29.5	30.3	29.4	29.1	28.8	29.5	29.1	30.9	29.7
18	30.6	30.8	30.9	30.8	30.2	31.2	31.3	30.8	30.8	31.0	30.9	33.8	30.7
19	31.5	31.7	31.8	31.5	30.6	31.7	32.3	31.4	32.0	32.0	32.7	33.4	31.3
20	33.0	32.8	33.2	32.8	32.1	33.2	33.3	33.1	34.1	33.5	34.1	33.1	31.6
21	34.1	33.3	34.0	33.4	34.1	34.3	33.8	33.8	36.1	34.5	33.2	37.8	36.5
22	36.6	35.3	36.0	35.3	34.5	35.4	36.0	35.8	36.5	36.3	36.5	36.2	38.5
23	37.0	34.7	35.5	35.2	31.6	35.3	35.8	36.2	38.0	36.4	34.3	37.9	38.9
24	40.2	37.8	38.7	37.5		38.9	37.5	38.7	39.3	38.8	37.8	38.0	39.8

Table 8 VPA results for recruitment, total biomass, spawning stock biomass (SSB), Yield/SSB and F bar (8-14) as well as the total catches.

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 8-14
	Age 3					
1993	16312	34479	8352	4395	0.5262	0.2338
1994	15851	32933	7479	4023	0.5379	0.236
1995	12933	37056	6406	3982	0.6216	0.208
1996	12127	33570	4890	4135	0.8457	0.228
1997	13558	34900	6241	4740	0.7595	0.2621
1998	12489	32332	6030	7270	1.2057	0.4394
1999	13089	35407	8124	7160	0.8813	0.5116
2000	11312	25241	4918	4767	0.9693	0.4732
2001	10790	20919	2915	3117	1.0693	0.3318
2002	15977	22758	2688	3657	1.3606	0.3761
2003	15274	22761	2016	3984	1.9762	0.4295
2004	13908	22695	1750	3182	1.8185	0.3589
Arith.						
Mean	13635	29588	5151	4534	1.0477	0.3407
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

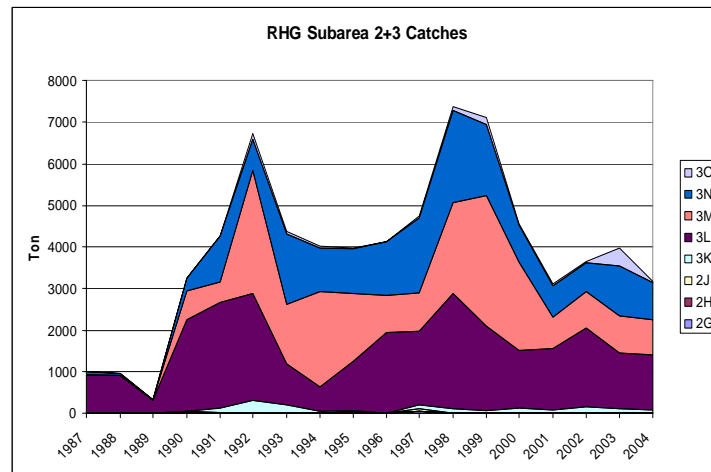


Fig. 1.- Revised roughhead grenadier Subarea 2 and 3 STACFIS catches by Division.

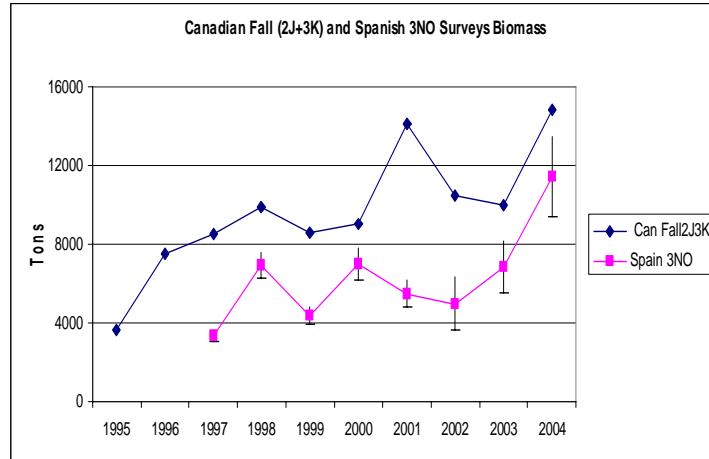


Fig. 2 . Canadian Autumn survey (Div. 2J3K) and Spanish 3NO survey biomass (+- SD), both up to 1500 m depth.

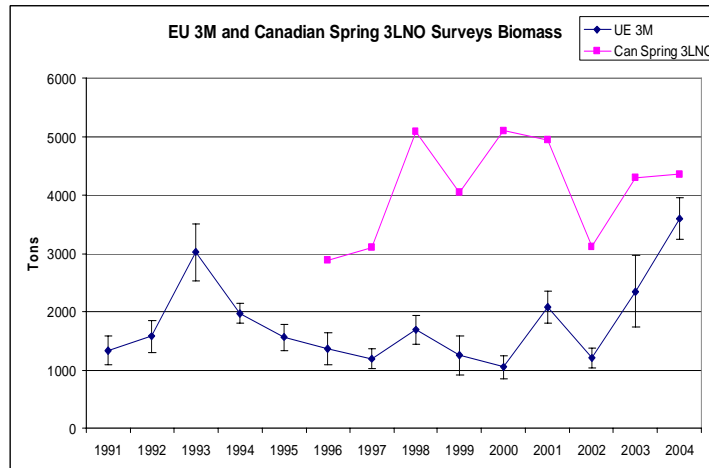


Fig. 3 . Canadian Spring survey (Div. 3LNO) and EU Flemish Cap survey (Div. 3M), both up to 730 m depth.

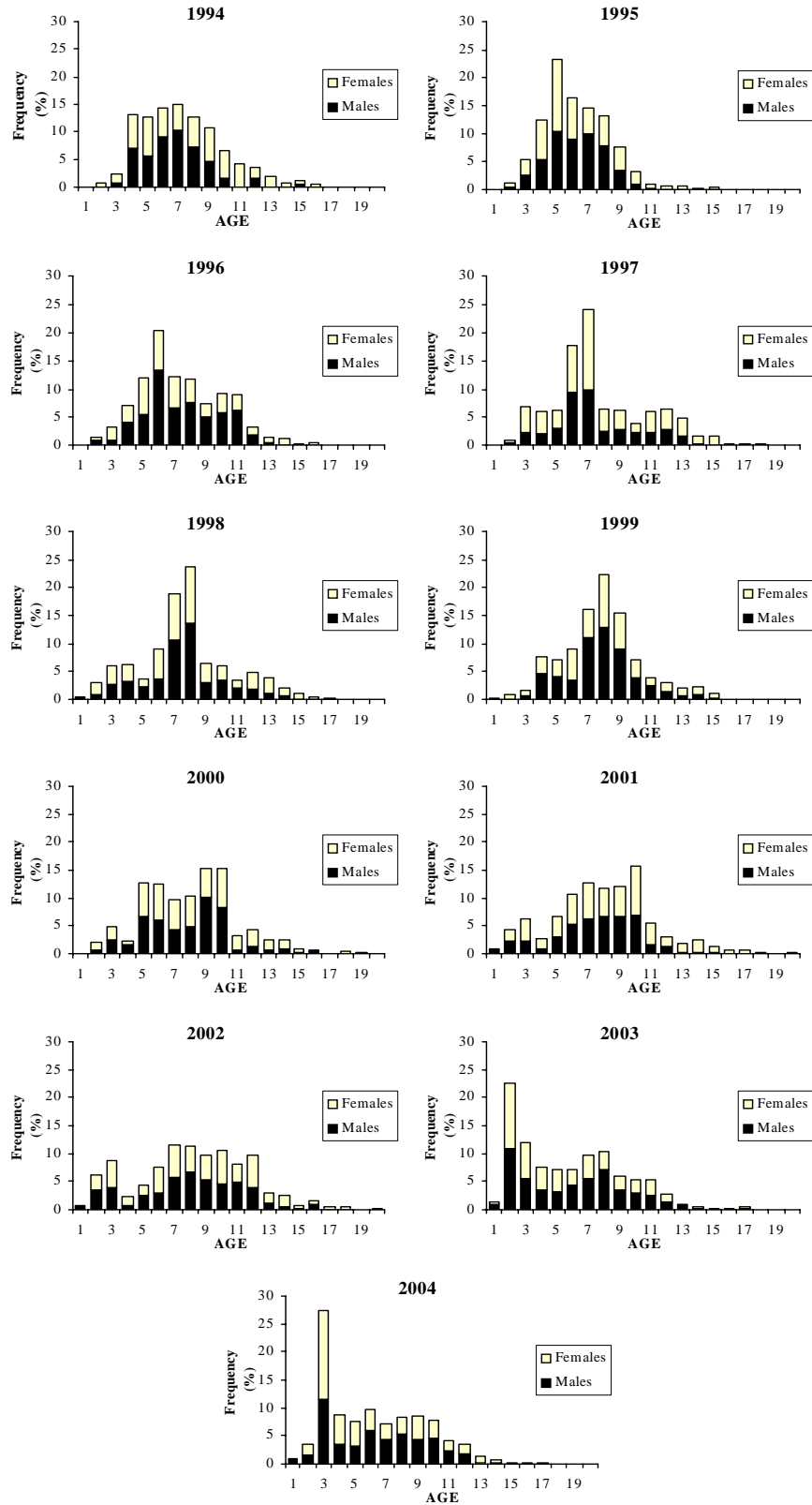


Fig. 4 . – EU Flemish Cap survey age distribution, by sex (from Murua and González, 2005).

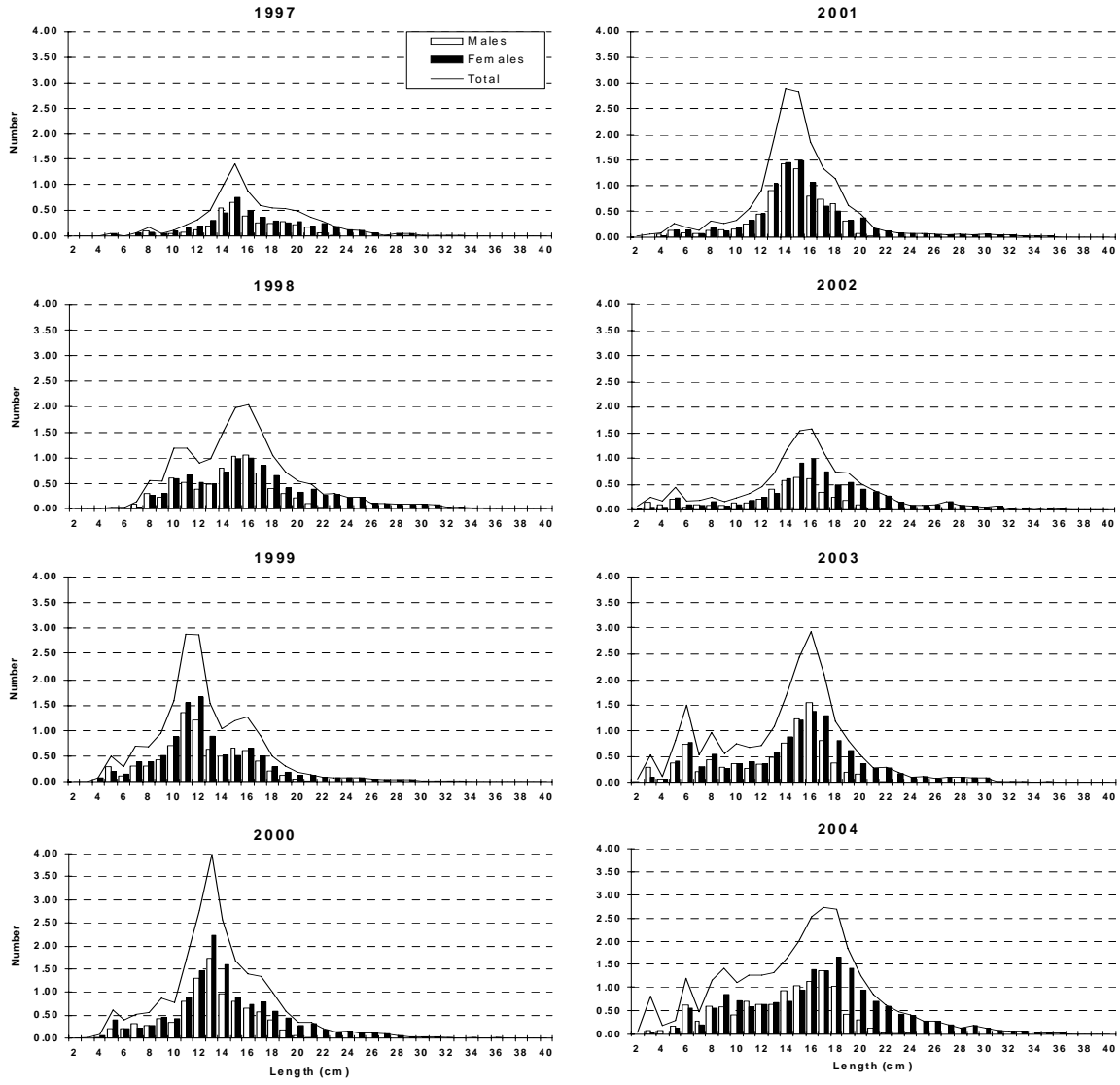


Fig. 5. Mean numbers per town (MNPT) by length of the Spanish 3NO survey (from Gonzalez-Troncoso *et al*, 2005).

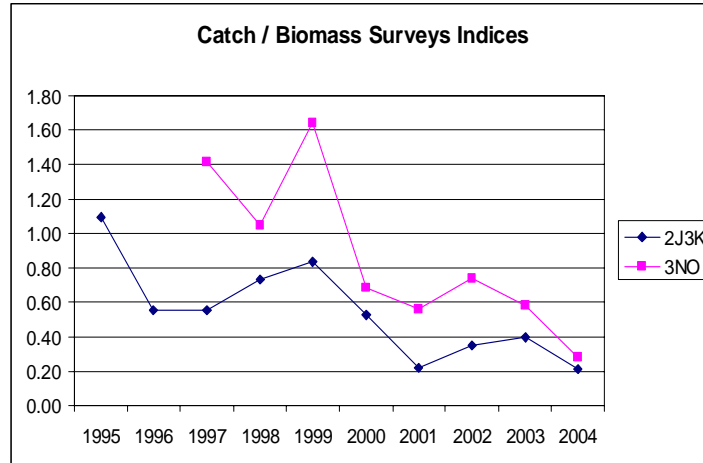


Fig. 6.- Catch / Biomass Canadian Autumn (2J3K) survey and Spanish 3NO survey ratio.

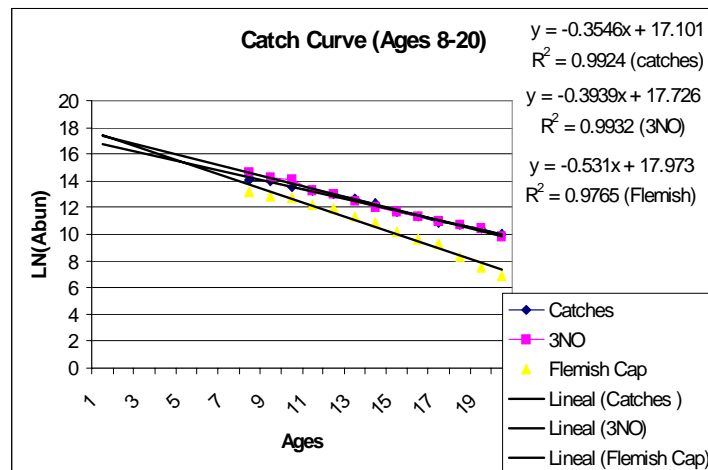


Fig. 7.- Catch curve fit for catch at age data, Spanish 3NO survey and EU Flemish Cap survey.

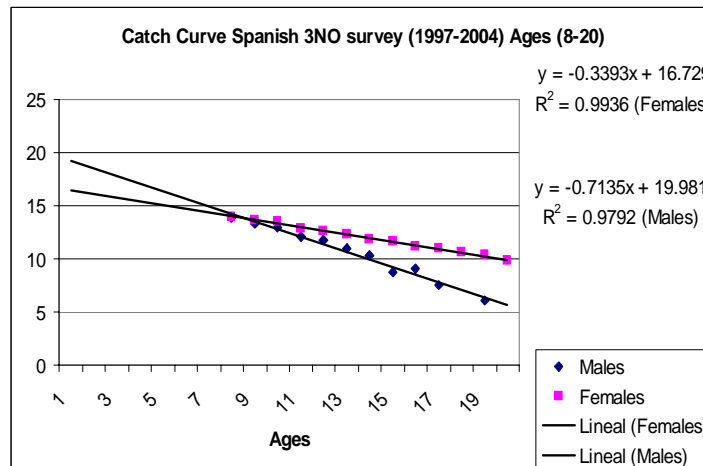


Fig. 8.- Catch curve by sex of the Spanish 3NO survey data.

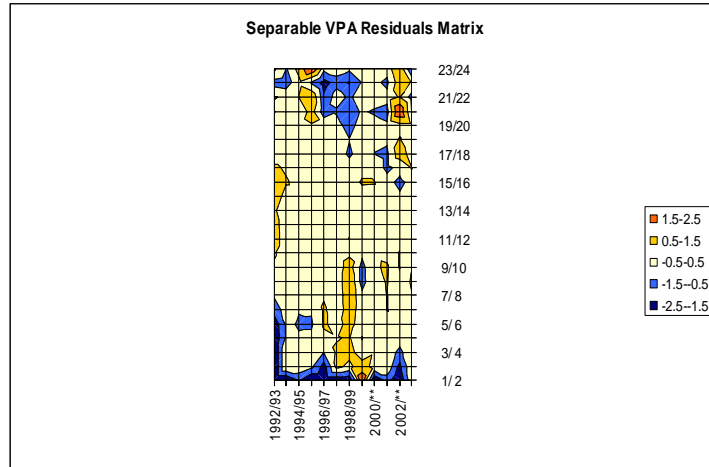


Fig. 9.- Separable VPA residuals by year (1992-2004) and ages (1-24).

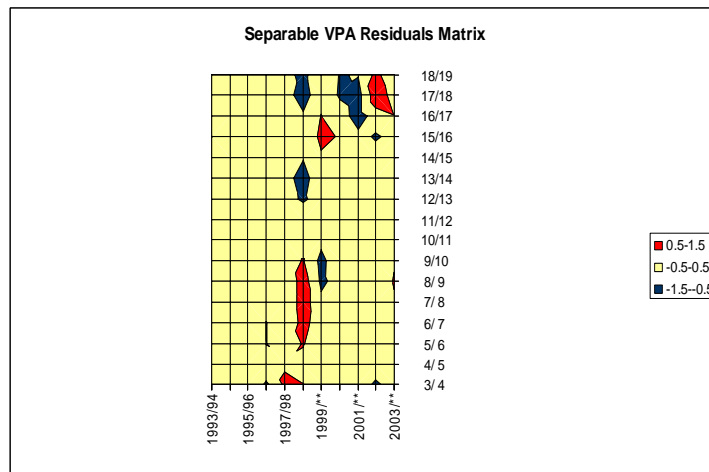


Fig. 10.- Separable VPA residuals by year (1993-2004) and ages (3-19).

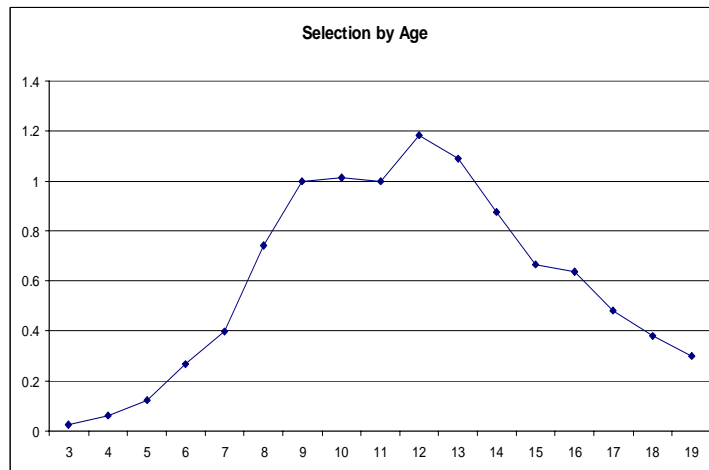


Fig. 11.- Separable VPA selection patter by age.

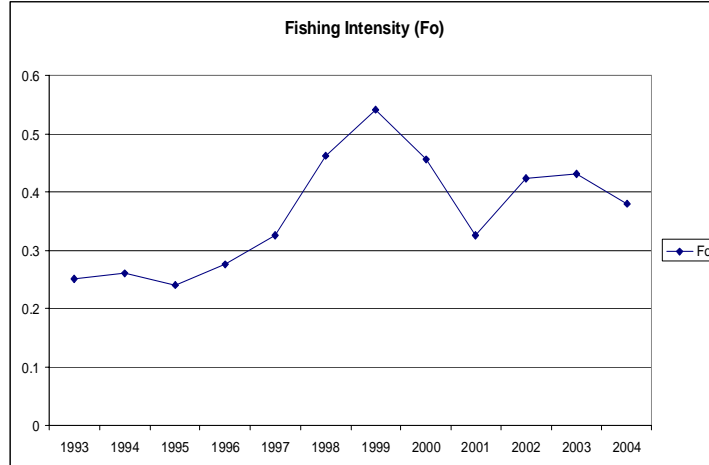


Fig. 12 .- Separable VPA Fishing intensity by year.

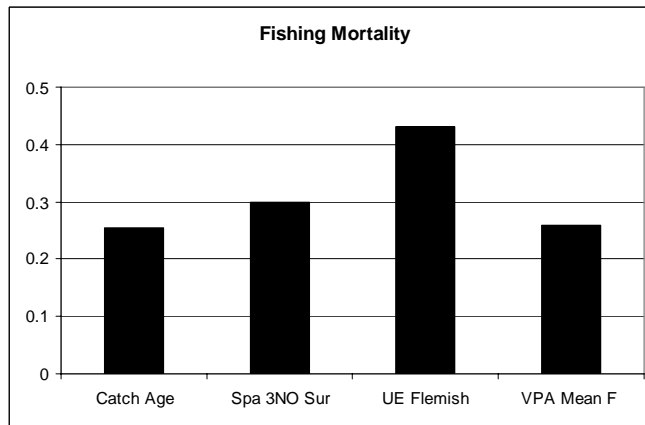


Fig. 13 . Mean fishing mortality for ages 8 to 20 calculated through the Catch curve for catch matrix (1992-2004), Spanish 3NO survey (1997-2004), EU Flemish Cap survey (1994-2004) and mean VPA F (1993-2004).

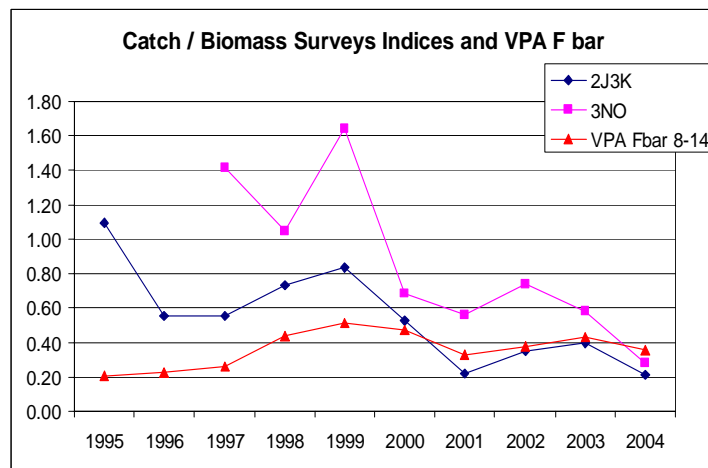


Fig. 14 .- Catch/Biomass ratio of the Canadian autumn and Spanish 3NO surveys and VPA F bar ages 8 to 14.

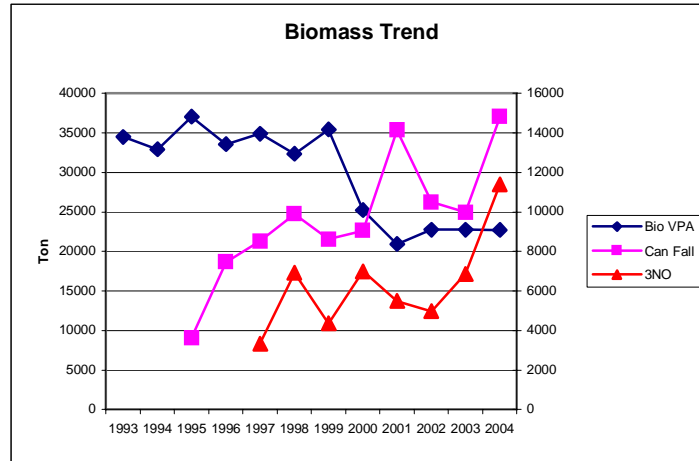


Fig. 15 .- Canadian autumn (2J3K) survey, Spanish 3NO survey and VPA biomass.

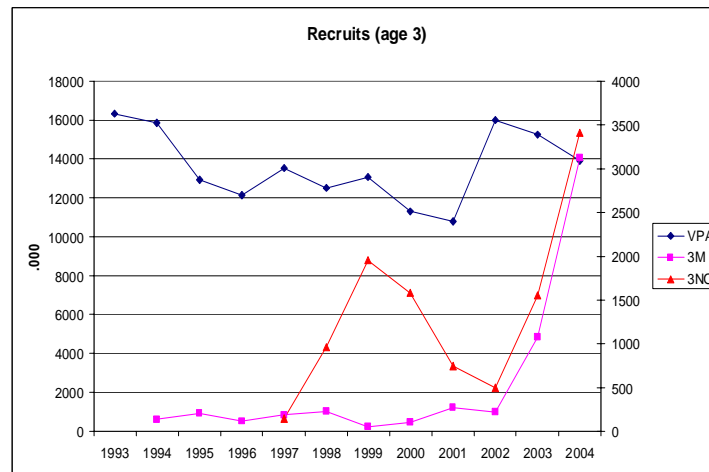


Fig. 16 .- EU Flemish Cap (3M) survey, Spanish 3NO survey and VPA recruitment at age 3.