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An assessment of NAFO roughhead grenadier Subarea 2 and 3 stock.

by

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ABSTRACT

The aim of this paper is to present the status of NAFO roughhead grenadier Subarea 2 and 3 stock based on different assessments models using all the available information. Different assessment methods have been applied based on the data available described above. The assessment was carried out with three different methods: Extended Survivors Analysis (XSA, Shepherd, 1999; Darby and Flatman, 1994), a Stock-Production Model Incorporating Covariates (ASPIC, Prager 1994 and 2004) and a qualitative assessment based on survey and fishery information.

XSA and ASPIC results are considered uncertainties due to the low Fishing mortality estimated compare with the natural mortality level assumed in the case of the XSA and due to the lack of contrast in the data used in the ASPIC case. Although all these problem both models results present a very similar trend in the fishing mortality and biomass values and are comparable to the qualitative assessment base on the Canadian fall survey series (Div. 2J+3K) and the Spanish survey in Divisions 3NO that there are considered by the NAFO Scientific Council as the best survey information to monitor trends in resource status.

Biomass presents in all methods a general increased trend in the analysed period with its maximum level in the last years. With regard to fishing mortality estimates from different methods, it can be observed that the trends of the different estimations of F were very similar and that the actual level of F is the minimum of the period due to the increase of the biomass and the decrease of the caches in the last years. The strong 2001 year class have been weaker than expected since 2005 in both survey indices. The level of the recruitment in last period appears to be smaller than the observer before.

INTRODUCTION

Roughhead grenadier (Macrourus berglax Lacépède, 1802) is an abundant widespread fish species in the North Atlantic, usually found both on the shelf and on the continental slope (Scott and Scott, 1988; Savvatimsky, 1994). It is predominant at depths ranging from 800 to 1,500 m (Murua and De Cárdenas, 2005), although they may inhabit depths between 200 and 2,000 m (Snelgrove and Haedrich, 1985; Murua and De Cárdenas, 2005). It has, however, been rarely found in depths down to 2,700 m (Wheeler, 1969). This species is commonly found in temperatures ranging from about -0.5 to 5.4 ºC (Atkinson and Power, MS 1987).

Roughhead grenadier is becoming an important commercial fish in the waters managed by the Northwest Atlantic Fishery Organization (NAFO), especially in the NAFO Regulatory Area (NRA) and reliable information is needed for its assessment. The fishery for roughhead grenadier is unregulated as it is taken as by catch in the Greenland halibut (Reinhardtius hippoglossoides) fishery, mainly in NRA Divisions 3LMN. Most roughhead grenadier catches

are taken by trawl and the only management regulation applicable to roughhead grenadier in the NRA is a general groundfish regulation requiring the use of a minimum 130 mm mesh size.

The knowledge on the biology and population dynamics of Macrouridae is sparse (Gordon, 1979; Middleton & Musick, 1986; Atkinson, 1995; D'Onghia et al., 2000). In particular, little has been published on the biology, growth and reproduction of roughhead grenadier on both sides of the North Atlantic. Moreover, the age structure and growth of the roughhead grenadier, based on otolith readings of specimens captured in the North-West Atlantic, were estimated by Murua and González (2006).

The stock structure of this species in the North Atlantic remains unclear because there is little information on the number of different populations that may exist and their relationship. In the Northwest Atlantic Fisheries Organization (NAFO) area, roughhead grenadier is distributed throughout Subareas 0 to 3. However, for assessment purposes, NAFO Scientific Council considers the population of Subareas 2 and 3 as a single stock (NAFO, 2005). Although the knowledge available on the biology of this deepwater species is not extensive, there is more information than could be expected for such a species. And over the last few years, more biological information as well as research survey indices have been analysed (Murua et al., 2005). Therefore, the aim of this paper is to present the status of this stock based on different assessments models using all the available information.

Data

Catches

In 1998 Power and Maddock Parsons revised the roughhead grenadier catch statistics since 1987 for assessment purpose (Figure 1 and Table 1). Nevertheless, only the revised catches since 1992 are used in this paper because the length compositions, and thus, age compositions, were not available before 1992. Most of the catches were taken in Div. 3LMN by Spain, Portugal and Russia fleets. Catches of roughhead grenadier increased sharply from 1989 (333 tones) to 1992 (6725 t); since then until 1997 total catches have been about 4000 t. In 1998 and 1999 catches increased and were near the level of 7000 t. Since then, catches decreased to 3000–4000 tones in 2001–2004 and to 600-800 t in the period 2007 - 2009.

Length Distributions

Roughhead length frequencies from the Spanish, Portuguese and Russian trawl catches for 2009 in Div. 3LMNO are available from Gonzalez-Costas et al. (2010), Vargas et al. (2010) and Skryabin and Pochtar (2010) respectively. Table 2 presents the availability of the length distribution in the series. Due to the growth differences between sexes, length and age data have been analysed by sex. The Spanish and Portuguese lengths frequencies are presented as pre anal fin length (AFL), 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). The total length distributions for these three countries are presented in Table 3.

Catch-at-Age

Ageing was based on otoliths from specimens caught in NAFO Divisions 3LMN. The total catch-at-age numbers presented by González-Costas and Murua (2007) have been updated with the 2007, 2008 and 2009 data (Table 4). Table 1 presents the data available to create the catch-at-age matrix. The associated mean weights and mean length by age are presented in Table 4. Most of catches are composed between ages 4 and 13, with a mode at age 8. In the last two years the mode was a slightly different, 7 years in 2008 and 6 years in 2009.

Research Survey Data

Biomass indices for the roughhead grenadier Subareas 2 and 3 stock are available from various research surveys, with different depth and area coverage (Table 5). None of them cover the total area and depth distribution of this stock.

Canadian fall survey: Stratified random bottom trawl surveys have been conducted in Div. 2GHJ and 3KL in fall 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 1500m in Div. 2GHJ and 3K and to 730 m in Div. 3LNO, extended to 1463 m after 1995. A description of those surveys is in McCallum and Walsh (1996) and Power and Parsons (1998). Operational difficulties in some years lead to incomplete coverage (depth and surface) of

the survey (Brodie 2005; Healey and Dwyer, 2005, Healy 2009). 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 1995-2009, only the indices of division 2J and 3K are comparable from 1995 onwards. The roughhead biomass index (2J3K MWPT) from this survey since 1995 are presented in Table 6. From 1995, the biomass of this survey in Divisions 2J and 3K shows a continuous increasing trend, reaching its maximum in 2009 as shows Figure 2. Figure 3 shows the length distributions for Division 2J and 3K since 1995.

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. 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. Operational difficulties in 2006 resulted in incomplete coverage of the survey in Div. NO and the estimate for this year is not directly comparable with those earlier in the time series. Since 2007 this indices is not available for this species. Figure 4 and Table 6 present the biomass of this survey since 1996 till 2005. From 1996 to 2004, the biomass level does not present a clear trend. In 2005, the biomass index had a big increase. Biomass estimates from the spring survey series are considerably lower than the ones obtained in the autumn series, as the spring surveys cover only the southern divisions and the shallower depths, where according to other information this species is less abundant.

Canadian deepwater survey: Canada conducted deepwater bottom trawl surveys (750 – 1500 m.) in 1991, 1994 and in 1995 in Divisions 3 KLMN. The results of those surveys were reported by Atkinson et al. (1994) and Bowering et al. (1995), and are presented in Table 6. 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.

Flemish Cap (EU Spain and Portugal) 3M 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 and Casas (2005). In 2004 the depth coverage of this survey has been extended to 1463 m. The roughhead grenadier biomass indices from this survey series (Vazquez 2010) until 730 m from 1991 to 2009 and until 1400 from 2004 to 2009 m are presented in Table 6 and Figure 5. The 730 m. biomass indices present a peak in 1993. From then until 2002, the biomass index was more or less stable at values in between 1 and 2 kg per tow. From 2002 onwards, the biomass index shows an increasing trend, reaching a historical maximum in 2006. Since 2007 the indices have been variable with a general decreased trend, reaching their historical minimum in 2009. The 1400 indices show a decreased trend since the beginning of the series. Figure 6 presents the age distributions of the EU Flemish Cap survey from 1994 to 2009 until 700 meters depth by sex, where it can be clearly appreciated a strong 2001 year class in 2003 and 2004 but since 2005 this 2001 year class have been weaker than expected.

Spanish 3NO Survey: Spain conduct a stratified random spring bottom trawl survey in the NAFO Regulatory Area Division 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. (2010). The roughhead grenadier biomass index from this survey series is presented in Table 6 and Figure 7. From 1997 to 2002 the biomass indices of this survey did not show a clear trend. However, since then the biomass index has increased and in the period 2004-2006 reached the maximum level. In 2007 decreased to the 2003 level. In 2008 and 2009 the indices showed a slight increase. The age distributions of the survey series (Figure 8) showed a strong 2001 year class during 2003 and 2004 survey as it was observed in the EU Flemish Cap survey but since 2005 this year class have been weaker than expected**.** Last year survey a signal of this year class appears again with 8 years old.

Maturity Ogive

The maturity ogive used to calculate the Spawning Stock Biomass (SSB) was estimated from ovaries collected in the Flemish Cap research survey and commercial sampling in NRA Division 3LMNO during 1998-2000. The maturity

ogive was estimated microscopically, by means of histology (Murua, 2003), and this constant ogive was applied to the whole time series of the data (1992-2009).

ASSESSMENT METHODS

Different assessment methods have been applied based on the data available described above. The assessment was carried out with three different methods: Extended Survivors Analysis (XSA, Shepherd, 1999; Darby and Flatman, 1994), a Stock-Production Model Incorporating Covariates (ASPIC, Prager 1994 and 2004) and a qualitative assessment based on survey and fishery information.

Extended Survivors Analysis (XSA)

Extended Survivors Analysis was applied to the commercial catch-at-age data for roughhead grenadier in NAFO Subarea 2 and 3 from 1992-2009 to assess the current status of the stock. The XSA model formulation was based on the analysis made by Gonzalez-Costas and Murua (2007) and Gonzalez-Costas (2009) with the following configuration:

- Catch data for 18 years (1992-2009). From 1992 to 2008. Ages 3 to 17.
- Tuning series: EU Flemish Cap survey series (700 m) between 1994 and 2009 and restricted to ages 3 to 16 and the Spanish 3NO research survey series between 1997 and 2009 and ages 3 to 16.
- Tapered time weighting not applied.
- Catchability independent of stock size for all ages.
- Catchability independent of age for ages >= 15
- Survivor estimates shrunk towards the mean F of the final 2 years or the 2 oldest ages.
- S.E. of the mean to which the estimates are shrunk = 1.000
- estimates derived from each fleet = 0.300
- Prior weighting not applied.
- Plus group was established 17+ and Fbar was defined as the mean F for ages between 6 and 13 years.

With regard to the tuning indices used in the XSA assessment, only the European Union (EU) Flemish Cap research survey in NAFO Division 3M till 700 m. depth and the Spanish research survey in Divisions 3NO were used. Catch-at-age in numbers is given for both surveys as mean numbers per tow (MNPT) and present in Table 7. Natural mortality (M) at age was assumed to be constant and was set at 0.1 for all years. The reason for selecting this value for M is that the roughhead grenadier is a long-lived species that inhabits a stable deep-sea ecosystem. This value has been applied in the assessment of some stocks of roundnose grenadier with similar biology and inhabiting similar ecosystems (ICES, 2006).

Stock-Production Model Incorporating Covariates (ASPIC)

A non-equilibrium surplus production model incorporating covariates (ASPIC) was applied to nominal catch for roughhead grenadier in NAFO Subarea 2 and 3 from 1992-2009 and survey biomass indices. The logistic (Schaefer 1954 and 1957) production model used assumes logistic population growth. Initial biomass (expressed as the ratio: B1/K), K, MSY, and catchability coefficients for each biomass index (qi) were estimated using non-linear least squares of survey residuals. The survey indices and catch series used in the production model were the following:

- Nominal catches 1992-2009
- Flemish Cap survey indices (Mean Weight per Tow) till 700 m. from 1992 to 2009.
- Spanish 3NO survey indices (Mean Weight per Tow) from 1997 to 2009.
- Canadian Autumn survey 2J3K indices (Mean Weight per Tow) from 1995 to 2009.

Several runs were carried out in ASPIC version 5.33 to investigate the sensitivity of the ASPIC model to various input specifications and values (starting estimates for B1/K, K, MSY and the random number seed). The inputs for these run are presented in Table 8. The survey data was treated in all model formulation as follow: the Flemish Cap survey indices as CPUE type (CC) because this is the longer series and the most important catches come from Flemish Pass and the other two as Index of biomass type (I). Spanish 3NO survey as annual average index (I1) because it is carried out in May –June and the Canadian Autumn survey as end of the year index (I2) because normally it is carried out between October and December. Due to fit problems different runs were made with different fixed values B1/K (Table 8).

Qualitative assessment based on survey and fishery information.

This assessment is qualitative and is based on the survey trend and fishery information to try to estimate a trend in mortality based on proxies as catch/survey biomass ratios and catch curves. With this method we can have an idea of the level and trend of the fishing mortality of the stock.

RESULTS AND DISCUSSION

Extended Survivors Analysis (XSA): Model converged after 89 iterations and the model fit is considered to be acceptable. Catchability is the link between survey catches and population abundance as estimated from the catch-at-age data and the model assumes that surveys catchabilities-at-age are constant with respect to time. The Standard Error (SE) of the log catchability for the EU Flemish Cap and Spanish 3NO surveys by age are presented in Figure 9. Values higher than 0.5 can be interpreted as fit problems. The major problems occurred at younger ages for both surveys however, these ages are less frequent in the catches. The EU Flemish Cap survey log catchability SE were greater than the Spanish 3NO survey and this could be related to the differences in depth coverage in the two surveys. The log catchability residuals for each survey by year (Figure 10) show that there were no strong trends in the residual time series in the Spanish 3NO survey. The EU Flemish Cap survey log catchability residuals were greater than the Spanish 3NO survey and the large residuals occurred at younger ages. In 2009 for this survey the residuals for all ages are negatives and show a clear year effect. This effect can be followed in other species and could be related with problems in the survey in this particular year.

Total biomass, mean F between ages 6 to 13 (Fbar) and recruitment (Age 3) results are plotted in Figure 11 and presented in Table 9. Model results indicated that the stock biomass has an increase trend in the all period analyzed and that the current level of total biomass was twofold in comparison to the beginning of the time series. The biomass estimated for the beginning of 2009 was around 70,000 tonnes, which is at the same level as the highest value on 73,000 tonnes in the time series observed in 2007. Fishing mortality has declined since 1998 and it showed the second lowest value of the time series (0.021) in 2009. The current level of F is much smaller than the value of the assumed natural mortality. The current level of the recruitment is less than the level observer in the nineties. The retrospective results (Figure 12) indicate that there was a clear retrospective pattern in the model estimates in the last years, e.g., fishing mortality was underestimated whereas total biomass was overestimated. In last year's assessment, the recruitment estimates for 2003 and 2004 were much lower than was estimated in previous years. The results are considered to be uncertain due to a number of factors that might influence the quality of the outcome, such as the short time series of data, the wide age range of the population and the low Fishing mortality estimated compare with the natural mortality level assumed.

Stock-Production Model Incorporating Covariates (ASPIC): Table 8 shows the main characteristics and the results of the different runs made with ASPIC. All of the tried runs show a poor fit as we can observe in the contrast and nearnessn indices. In a good fit these values should be very close to 1. In all run with our data, principally the contract index value was very low indicating a low contrast in the data to calculate all the parameters. Other signal of the poor fit was the low R^2 value for all the indices showing that the majority of variance in survey indices was not explained by the model.

When we tried to calculate all parameters, in the first four run show in Table 8, we found many estimation difficulties in all these runs. Normally the model estimated very high values for the K parameter close to the limit boundary set in the inputs and very low values for the B1/k parameter. These highs calculated values for K have a very difficult biological explanation. To avoid this problem it was fixed the B1/K value in the inputs and it was tried to fit the model, even with the fixed parameters the model was unable to find a stable solution probably due to the lack on contrast in the survey series used. All the series have a general increase trend in all the period analysed. Even all the fit problems and uncertainties the majority of the run show a similar trend in the biomass and mortality (Figure 13).

Qualitative assessment based on survey and fishery information: Canadian Divisions 2J and 3K fall index and the Spanish research survey in Divisions 3NO have been considered in the last assessment as the best information in order to monitor trends in resource status (NAFO 2009) because they cover depths down to 1,500 metres and, hence, cover the depth distribution of roughhead grenadier fairly well (Murua and De Cardenas, 2005). The roughhead grenadier biomass indices of the fall Canadian survey (2J+3K) and the Spanish 3NO survey show a general increasing trend from 1995 onwards. However, the biomass trend of the EU Flemish Cap survey (< 720 m and till

1400 m) presented a decrease trend in the last years. The catch / biomass (C/B) indexes obtained using the Canadian fall survey and the Spanish 3NO biomass index in the period 1995-2009 (Fig. 14) show a clear decrease trend from 1995 to 2009, due to the increase in the survey biomass and the low level of catches in the last years. Figure 15 presents the abundance series (MNPT) for ages 3 of the EU Flemish Cap survey and the Spanish Div. 3NO survey from 1994 to 2006. A strong 2001 year class can be clearly seen in 2004 in both series. Since 2004 the level of the recruitment is below the mean in both series. The strong 2001 year class have been weaker than expected since 2005 in both survey indices.

The Z estimate from the catch curve based upon commercial catch at age data (1992-2009) was 0.356 for ages 8 to 20 (R^2=0.99) and 0.169 for ages 6 to 13 (R^2=68). The value estimate from the catch curve of the UE Flemish Cap survey (1994-2009) was 0.456 and 0.412 for the catch curve of the Spanish 3NO survey data (1997-2009) for ages 8 to 20 and 0.202 and 0.242 for ages 6 to 13 (Fig. 16). 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 value based on the Flemish Cap survey is likely to be an overestimation since this survey covers only the shallowest distribution of the resource. The level of Z is similar to the level calculated with the same method in the last assessments.

SUMMARY

XSA and ASPIC results are considered uncertainties due to the low Fishing mortality estimated compare with the natural mortality level assumed in the case of the XSA and due to the lack of contrast in the data used in the ASPIC case. Although all these problem both models results present a very similar trend in the fishing mortality and biomass values and comparable to the qualitative assessment base on the Canadian fall survey series (Div. 2J+3K) and the Spanish survey in Divisions 3NO that there are considered by the NAFO Scientific Council as the best survey information to monitor trends in resource status.

Biomass presents in all methods a general increased trend in the analysed period with its maximum level in the last years. With regard to fishing mortality estimates from different methods, it can be observed that the trends of the different estimations of F were very similar and that the actual level of F is the minimum of the period due to the increase of the biomass and the decrease of the caches in the last years. The strong 2001 year class have been weaker than expected since 2005 in both survey indices. The level of the recruitment in last period appears to be smaller than the observer before.

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Table 1.- STACFIS roughhead grenadier NAFO Subarea 2 and 3 nominal catches (t) by Division.

	STACFIS RHG Nominal catches (t) by Division									
Year	**2G**	**2H**	**2J**	**3K**	**3L**	**3M**	**3N**	**3O**	**Other**	**TOTAL**
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	7362
1999				61	2037	3127	1705	180	49	7159
2000				139	1382	2109	888	38	211	4767
2001				97	1465	753	754	48		3117
2002				147	1905	869	700	36		3657
2003[b]	1	4	16	91	1342	886	1201	443		3984
2004	4	8	19	58	1310	844	897	42		3182
2005		1	15	93	642	457	235	13		1456
2006			21	54	696	488	111	6	44	1420
2007			10	22	294	191	146	1		664
2008	0	0	1	3	347	355	132	9		847
2009				6	379	136	102	6		629

[a] Catch could not be well estimated; based on revised data is estimated to be 8000 to 14000 t. mixed roundnose and rouhhead grenadiers. (Power and Parson 1988).
[b] In 2003, STACFIS could not precisely estimate the catch.

Table 2 .- Roughhead grenadier Subarea 2 and 3 catches length distributions and ALK available by country and year.

Data		Length		ALK
Country	Spain	Portugal	Russia	Spain
1992	X	X		
1993	X			
1994	X			
1995	X	X		
1996	X	X		
1997	X	X	X	
1998	X	X	X	
1999	X	X	X	X
2000	X	X	X	X
2001	X	X	X	
2002	X	X	X	X
2003	X	X	X	X
2004	X	X	X	X
2005	X	X	X	X
2006	X	X	X	X
2007	X	X	X	X
2008	X	X	X	X
2009	X	X	X	X

In black only commercial information; In red commercial and Flemish Cap survey information

Table 3 .- Roughhead grenadier Subarea 2 and 3 Spain+Portugal+Russia catches length distributions (‘000) by year. Measure as pre anal fin length (AFL).

Length (cm)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	42	0	0	0	0	0	0	0	0	0	0
4	1	0	0	0	0	0	0	30	0	0	0	1	2	0	0	0	0	0
5	4	0	3	0	0	0	0	15	0	0	0	1	1	0	1	0	0	0
6	12	7	5	0	0	0	0	8	0	1	1	4	3	0	0	0	0	0
7	12	12	16	4	0	10	7	12	4	3	5	22	24	1	2	0	1	2
8	11	29	33	8	3	63	21	45	32	16	16	44	39	3	8	4	3	11
9	39	115	67	43	17	121	57	126	112	59	59	102	70	6	19	10	10	38
10	69	51	159	308	212	287	221	157	224	150	162	233	168	12	56	21	22	77
11	101	65	132	231	328	518	448	278	327	210	238	333	256	20	99	32	56	163
12	146	100	150	306	647	529	687	517	474	343	378	444	350	41	157	48	137	222
13	223	255	212	314	771	515	835	651	714	519	492	456	399	93	147	51	138	152
14	531	288	370	412	796	654	1290	591	810	853	727	761	497	133	156	49	169	111
15	742	368	418	529	705	811	2241	698	863	912	950	951	552	167	187	58	201	109
16	755	623	517	515	569	943	2287	719	1038	719	967	1134	621	214	233	49	212	88
17	710	850	774	612	615	752	1777	807	1185	657	782	1005	632	277	234	47	216	58
18	678	802	813	681	653	642	1093	660	891	589	600	769	541	268	276	46	128	66
19	720	560	690	671	504	572	902	725	680	456	389	557	371	219	197	46	91	45
20	571	421	471	418	503	528	561	709	417	279	253	356	263	172	114	40	72	26
21	551	245	299	282	511	333	402	580	241	155	158	244	191	121	60	43	29	15
22	494	203	211	185	189	228	281	358	171	95	117	154	154	82	51	34	29	16
23	350	219	174	97	155	210	216	380	139	66	75	117	90	59	37	31	17	11
24	395	231	149	91	63	154	213	276	84	53	61	94	93	55	30	27	17	12
25	198	204	150	60	60	128	115	258	99	46	57	71	66	36	31	26	8	15
26	176	188	113	66	62	79	96	167	96	41	50	49	43	22	18	23	11	15
27	121	109	88	73	14	47	49	166	65	32	40	45	41	23	16	20	19	10
28	131	74	64	59	50	45	74	125	44	29	43	36	29	14	21	18	6	9
29	117	75	47	48	60	54	29	87	37	24	42	26	27	12	12	15	2	6
30	64	52	49	17	85	41	30	69	14	19	31	39	22	8	9	10	1	5
31	46	50	28	31	17	35	38	70	21	18	25	21	20	7	6	8	1	4
32	38	55	28	25	0	23	57	60	18	8	21	13	17	9	7	4	5	5
33	22	11	15	15	0	27	12	73	9	9	16	7	7	8	4	3	1	2
34	17	13	15	9	10	18	14	35	10	9	12	8	7	4	7	3	0	2
35	8	9	9	1	0	6	13	21	9	7	10	9	5	5	5	2	1	3
36	8	4	3	0	0	5	11	21	18	3	8	6	2	4	1	1	1	0
37	1	1	4	4	0	0	7	9	15	2	2	2	2	5	1	1	0	1
38	0	0	3	0	0	1	2	9	0	1	1	1	1	2	0	1	0	0
39	1	0	0	0	0	2	0	2	0	2	1	0	0	2	0	0	1	0
40	14	0	2	0	0	2	0	0	12	1	1	0	1	0	1	0	0	0
TOTAL	8080	6291	6281	6114	7598	8385	14085	9584	8875	6386	6789	8114	5609	2104	2208	770	1606	1301
(Sp+Pt+Rus) Catch (t)	6125	2054	1720	3923	3874	4500	7231	7053	4555	2954	3254	3869	2934	1157	1182	530	685	575
Samples	219	48	288	234	229	225	34	164	214	299	276	150	188	106	152	97	61	133
Total catch (t)	6725	4395	4023	3982	4135	4740	7270	7160	4767	3117	3657	4179	3290	1456	1420	664	847	629

Table 4 .- Roughhead grenadier Subarea 2 and 3 total catches age distributions (‘000), mean weights by age in gr. and mean length at age in cm.

Abundance ('000)

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	4	0	1	0	0	0	0	106	0	0	0	2	0	0	0	0	0	0
2	33	38	40	14	5	42	22	129	32	16	6	37	4	0	1	0	0	1
3	62	125	131	143	95	242	145	156	190	107	100	173	121	4	4	1	3	13
4	104	84	178	319	315	468	392	224	302	217	257	464	267	15	17	14	27	80
5	198	151	206	370	709	653	791	641	528	422	483	372	564	41	122	65	103	109
6	509	367	395	565	1162	926	1620	950	1118	916	1046	563	595	105	212	88	267	429
7	793	496	528	620	924	992	2213	962	983	1050	974	1190	736	222	323	106	371	238
8	1122	948	901	879	999	1271	3015	1238	1342	1170	1266	1709	1002	329	325	83	266	240
9	1080	1088	1062	912	922	1071	2226	1040	1693	913	874	1355	712	410	358	56	207	90
10	841	761	799	686	699	717	1216	808	1045	565	454	773	499	387	251	82	149	46
11	798	536	587	519	609	583	801	919	473	357	443	396	273	191	191	83	83	50
12	752	456	458	377	457	477	586	542	414	243	318	300	289	143	76	56	44	30
13	582	373	322	231	279	327	376	623	234	138	168	141	171	104	56	40	36	30
14	478	305	245	170	145	233	264	471	186	89	91	63	88	67	49	33	17	22
15	259	197	148	98	84	119	132	228	121	54	59	54	46	22	23	18	12	10
16	162	121	90	76	60	81	83	106	63	37	60	71	41	10	9	15	8	8
17	100	74	55	45	48	62	47	69	28	25	69	33	21	14	17	9	6	7
18	76	65	46	35	42	44	48	97	22	22	51	12	18	12	8	9	4	3
19	54	52	37	24	30	33	42	79	31	17	28	16	8	11	3	5	1	6
20	30	28	23	15	9	21	29	81	19	12	16	7	5	7	2	5	2	3
21	18	17	13	9	2	14	19	56	18	7	12	0	3	3	2	2	0	3
22	8	4	7	3	1	5	8	28	13	5	5	2	0	3	0	0	0	0
23	9	4	5	2	2	4	7	23	10	4	5	0	0	2	0	1	0	2
24	8	1	4	1	0	2	3	8	10	3	3	1	1	0	0	0	0	1
Total ages	8080	6291	6281	6112	7598	8385	14085	9584	8875	6388	6790	7736	5467	2104	2047	770	1606	1423

Mean Weight (gr)

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	11		16				30	10	14	13	22	34	4	4				
2	40	51	49	80	165	107	107	127	116	99	61	91	41	62	16	68		90
3	86	77	85	113	156	147	143	180	158	137	154	148	102	80	109	102	56	118
4	119	111	115	143	184	211	177	244	194	176	218	213	192	114	161	167	97	164
5	186	184	173	230	216	262	229	317	243	227	268	278	269	195	212	245	162	212
6	258	236	236	325	260	300	281	365	276	271	306	299	317	262	265	342	227	262
7	337	320	313	434	348	355	342	434	327	324	353	333	375	343	343	397	302	321
8	440	414	412	524	451	421	403	487	393	397	414	423	473	437	434	503	426	444
9	594	500	509	612	560	516	490	591	498	499	498	483	568	538	561	602	486	556
10	748	585	590	677	653	618	600	677	568	587	607	616	726	669	609	807	566	648
11	922	736	716	776	767	743	749	785	725	709	692	854	836	810	788	1116	686	817
12	1063	886	836	885	851	855	876	949	828	824	840	979	1072	988	1023	1203	853	1067
13	1226	1101	1039	1106	984	1033	1052	1151	1068	1033	989	1155	1361	1131	1282	1589	1325	1287
14	1446	1324	1280	1443	1245	1252	1299	1305	1353	1343	1412	1521	1546	1198	1709	1829	1268	1544
15	1683	1546	1530	1705	1696	1534	1544	1657	1561	1652	1565	1903	2234	1783	2160	2119	1590	1617
16	1928	1777	1729	1966	1837	1799	1823	1832	1787	1851	1852	1998	2330	2282	2457	2375	1909	1914
17	2212	1989	2005	2220	2083	2257	2100	2023	2010	2132	2078	2407	2393	2578	2808	2903	2026	2301
18	2478	2326	2333	2459	2197	2421	2466	2358	2441	2429	2440	3056	2496	2948	3377	2786	1788	2459
19	2669	2508	2553	2643	2283	2534	2707	2474	2716	2662	2822	2954	2675	3426	3502	2741	3241	2562
20	3052	2777	2889	2887	2643	2870	2942	2887	3207	3000	3140	2899	2719	3199	4089	3269	2037	2843
21	3363	2898	3076	3029	3105	3198	3063	3036	3739	3263	2939	4177	3773	3411	5186	3031	3837	3465
22	3993	3422	3637	3487	3192	3471	3663	3584	3851	3754	3807	3682	4384	4287		4255	3757	3477
23	4092	3299	3525	3556	2514	3485	3592	3699	4289	3787	3240	4206	4534	3476		3830		3126
24	4998	4172	4453	4067		4541	4108	4442	4670	4493	4206	4220	4820					2873

Mean Length (cm)

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	4.7		5.5				5.1	3.6	4.7	4.1	4.0	4.8	2.2	3.5				
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	7.0	5.4	6.5		7.4
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	9.0	8.4	8.0	8.4	8.8
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	10.4	10.1	9.7	10.2	10.1
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	12.4	11.6	11.5	12.3	11.3
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	13.7	13.1	13.5	13.6	12.5
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	15.1	15.0	14.9	15.2	14.0
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	16.6	16.8	16.9	17.1	16.4
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	17.9	18.5	18.3	17.9	18.1
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	19.5	19.1	20.0	18.8	19.2
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	20.9	20.8	22.3	20.2	20.9
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	22.5	22.7	23.0	21.7	23.2
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	23.5	24.5	25.5	25.3	24.9
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	23.9	27.2	27.1	24.6	26.7
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	27.7	29.5	28.3	26.9	27.0
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	30.2	30.9	29.7	28.3	28.8
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	31.5	32.3	32.2	29.3	30.7
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	33.1	35.0	31.2	27.1	31.5
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	35.0	35.0	31.2	34.6	31.8
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	34.1	37.2	33.2	29.2	33.1
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	34.9	40.2	32.5	36.8	35.4
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	38.1		36.6	36.5	35.5
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	35.2		35.5		34.1
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			33.8		33.2

Table 5 .- Available surveys biomass indices for the roughhead grenadier Subareas 2 and 3 stock, with their depth and area coverage.

Survey	Time Series	NAFO Division	Depth Range
Canadian Fall Survey	1978 – 1994	2GHJ 3KLMNO	<730 m
	1995 – 2009	2GHJ 3KLMNO	<1500 m
Spanish Surveys in Div. 3NO	1997 - 2009	3NO	<1500 m
EU Flemish Cap Surveys	1988 – 2003	3M	<730 m
	2004– 2009	3M	<1500 m
Canadian Spring Survey	1978 - 2006	3LNO	<730 m
Canadian deepwater	1991, 1994, 1995	3LMN	<1500 m
Russian	2001 - 2002	3M	120 - 1280 m
EU Deepwater	1996	3LMN	700 - 3100m

Table 6.- Available roughhead grenadier surveys biomass indices series. Mean Weight Per Tow for all except the Canadian Spring survey and Canadian deepwater survey are measure as total biomass.

	Can Autumn 2J+3K	**Can spring 3LNO(up to 750 m.)**	**Canadian deepwater survey**	**Spanish 3NO**	**EU Flemish Cap (up to 750 m.)**	**EU Flemish Cap (up to 1400 m.)**
1991			16215		1.66	
1992					1.96	
1993					3.76	
1994			26588		2.46	
1995	0.65		46668		1.94	
1996	1.29	2883			1.69	
1997	1.48	3103		3.81	1.49	
1998	1.71	5078		7.05	2.10	
1999	1.50	4043		4.53	1.56	
2000	1.66	5095		7.08	1.31	
2001	2.45	4948		5.73	2.58	
2002	1.91	3116		5.46	1.50	
2003	1.73	4297		7.40	2.92	
2004	2.57	4361		12.09	4.47	14.52
2005	2.42	15608		11.10	2.97	10.26
2006	2.60			11.11	4.89	9.26
2007	3.02			6.93	1.7	5.94
2008	*			7.93	3.68	9.91
2009	3.41			9.15	0.96	5.97

* Not available

Table 7 .- Flemish Cap Survey till 700 m depth and Spanish 3NO survey Mean numbers Per Tow (MNPT) by age.

Flemish Cap Mean Numbers per Town (700 m)

Ages/Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.000	0.000	0.161	0.000	0.064	0.019	0.004	0.078	0.048	0.581	0.268	0.136	0.012	0.015	0.006	0.004
2	0.057	0.133	0.070	0.057	0.159	0.045	0.096	0.259	0.235	2.660	0.578	0.333	0.439	0.028	0.098	0.048
3	0.169	0.261	0.137	0.231	0.283	0.061	0.134	0.336	0.273	1.339	3.876	0.451	0.545	0.073	0.283	0.055
4	0.606	0.581	0.279	0.190	0.294	0.268	0.063	0.149	0.071	0.836	1.254	0.948	0.487	0.044	0.272	0.036
5	0.630	1.071	0.437	0.195	0.172	0.247	0.353	0.352	0.134	0.768	1.089	0.781	0.623	0.108	0.211	0.005
6	0.709	0.736	0.729	0.561	0.430	0.307	0.345	0.553	0.235	0.789	1.373	0.678	0.698	0.251	0.355	0.068
7	0.704	0.642	0.435	0.762	0.902	0.554	0.271	0.671	0.361	1.048	1.006	0.620	0.894	0.333	0.568	0.057
8	0.613	0.570	0.420	0.202	1.129	0.767	0.288	0.628	0.352	1.120	1.188	0.739	0.645	0.371	0.924	0.154
9	0.471	0.328	0.269	0.196	0.312	0.526	0.423	0.633	0.299	0.665	1.195	0.513	0.606	0.221	0.667	0.107
10	0.225	0.140	0.328	0.122	0.281	0.245	0.421	0.827	0.331	0.590	1.113	0.720	0.717	0.429	0.586	0.082
11	0.136	0.044	0.316	0.188	0.168	0.136	0.090	0.287	0.253	0.587	0.578	0.461	0.904	0.214	0.536	0.152
12	0.102	0.029	0.116	0.205	0.227	0.099	0.119	0.163	0.302	0.293	0.486	0.208	0.492	0.134	0.201	0.079
13	0.050	0.024	0.047	0.154	0.189	0.069	0.071	0.100	0.093	0.110	0.183	0.282	0.364	0.118	0.395	0.070
14	0.019	0.006	0.042	0.052	0.095	0.076	0.069	0.129	0.078	0.038	0.111	0.237	0.262	0.096	0.098	0.079
15	0.033	0.019	0.005	0.052	0.060	0.041	0.028	0.068	0.024	0.022	0.022	0.026	0.243	0.048	0.222	0.059
16	0.011	0.000	0.013	0.010	0.027	0.004	0.021	0.037	0.048	0.021	0.027	0.011	0.125	0.042	0.060	0.042
17	0.000	0.000	0.000	0.007	0.015	0.000	0.000	0.036	0.011	0.048	0.028	0.022	0.037	0.026	0.069	0.004
18	0.000	0.000	0.000	0.006	0.000	0.000	0.014	0.015	0.013	0.000	0.008	0.003	0.048	0.015	0.009	0.002
19	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.012	0.007	0.000	0.036	0.000	0.006	0.019
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.006	0.000	0.000	0.003	0.020	0.007	0.000	0.007
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.004	0.002	0.000	0.000	0.000	0.001
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Spanish 3NO survey Mean Numbers per Town

Ages/Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1				0.000	0.041	0.005	0.023	0.112	0.287	0.396	0.494	0.286	0.047	0.424	0.125	0.143
2				0.051	0.084	0.921	0.868	0.536	0.661	2.087	0.615	0.699	0.752	0.588	0.419	0.387
3				0.166	0.801	1.451	1.220	0.729	0.497	1.506	3.632	1.890	1.441	0.834	0.706	0.665
4				0.327	1.554	3.040	0.895	0.810	0.308	1.053	2.263	2.430	1.030	0.810	1.029	0.912
5				0.453	1.129	3.310	7.042	2.460	0.772	1.166	2.307	2.509	1.507	1.363	1.026	0.563
6				1.388	1.629	2.294	5.508	3.730	1.445	1.884	2.766	2.901	2.073	1.622	1.417	1.840
7				2.628	2.892	2.061	2.505	3.744	2.011	3.650	2.641	2.098	2.716	1.572	1.717	1.729
8				0.881	4.208	2.084	1.612	2.134	1.591	3.706	3.487	3.111	2.261	1.540	1.723	3.467
9				0.850	1.461	0.973	1.565	1.373	1.104	1.656	3.855	2.077	2.264	0.879	1.097	1.477
10				0.451	1.277	0.391	1.339	1.451	1.089	1.151	3.341	2.815	2.431	1.642	1.180	0.720
11				0.587	0.533	0.229	0.229	0.343	0.577	0.987	1.555	1.672	2.853	1.210	1.166	1.350
12				0.550	0.644	0.147	0.272	0.131	0.771	0.449	0.907	0.916	1.472	0.735	0.657	0.733
13				0.271	0.605	0.105	0.145	0.088	0.188	0.309	0.524	1.124	0.821	0.555	0.989	0.950
14				0.088	0.264	0.102	0.221	0.054	0.150	0.140	0.283	0.673	0.489	0.364	0.290	0.647
15				0.053	0.204	0.082	0.117	0.053	0.099	0.164	0.106	0.227	0.277	0.126	0.332	0.546
16				0.028	0.066	0.028	0.072	0.045	0.156	0.160	0.095	0.074	0.208	0.101	0.100	0.314
17				0.014	0.038	0.018	0.032	0.058	0.141	0.098	0.043	0.110	0.167	0.104	0.115	0.034
18				0.020	0.056	0.023	0.028	0.042	0.088	0.025	0.033	0.141	0.028	0.037	0.073	0.035
19				0.015	0.046	0.015	0.036	0.026	0.067	0.031	0.008	0.017	0.014	0.006	0.026	0.147
20				0.009	0.032	0.014	0.018	0.012	0.020	0.014	0.003	0.025	0.002	0.026	0.017	0.019
21				0.007	0.017	0.009	0.012	0.010	0.018	0.000	0.003	0.013	0.000	0.000	0.009	0.004
22				0.004	0.009	0.003	0.005	0.003	0.009	0.006	0.003	0.000	0.000	0.000	0.015	0.002
23				0.004	0.009	0.002	0.005	0.004	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.029
24				0.000	0.001	0.001	0.001	0.003	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 8 .- Aspic input files used in the different runs. In red parameters changed from run 1 (Ind1). Goodness of fit and calculates values for the parameters. In red parameters values close to the limits. Yellow shadows are fixed values for parameters.

	Ind1			Ind4			Ind5			Ind52		
MC Search	0	20000		1	50000		1	50000		1	50000	
Conver criteria	1.00E-08			1.00E-08			1.00E-08			1.00E-08		
Restars	3.00E-08	6		3.00E-08	15		3.00E-08	15		3.00E-08	15	
Gen Mode	1.00E-04	12		1.00E-04	12		1.00E-04	12		1.00E-04	12	
Max F	8			8			8			8		
Penalty B1>K	0			0			0			0		
N° Series	3			3			3			3		
Weight series	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
B1/K	0.5			0.5			0.5			0.5		
MSY	1.00E+04			1.00E+04			1.00E+04			1.00E+04		
K	2.00E+05			2.00E+05			2.00E+05			2.00E+05		
qi	6.00E-05	2.00E-04	9.00E-05	6.00E-05	2.00E-04	9.00E-05	6.00E-05	2.00E-04	9.00E-05	6.00E-05	2.00E-04	9.00E-06
Parameters	6			6			6			6		
MSY lim	1.00E+03	1.00E+05		1.00E+03	1.00E+05		1.00E+03	1.00E+06		1.00E+03	1.00E+06	
K lim	5.00E+04	5.00E+06		5.00E+04	5.00E+06		5.00E+04	5.00E+07		5.00E+04	5.00E+07	
Seed	1803285			1900285			1900285			1900285		
R2 q1			-0.033			-0.032			-0.03			-0.029
R2 q2			0.316			0.315			0.318			0.318
R2 q3			0.608			0.606			0.605			0.602
contrast index			0.1158			0.1127			0.0408			0.0355
nearness index			0.7257			0.7205			0.5798			0.5696
B1/K			0.110			0.108			0.039			0.034
MSY			67200			66810			392700			543500
K			5000000			5000000			35390000			50000000
q(1)			2.83E-06			2.90E-06			1.13E-06			9.13E-07
q(2)			8.37E-06			8.57E-06			3.33E-06			2.70E-06
q(3)			2.26E-06			2.31E-06			9.00E-07			7.29E-07

	Ind6			Ind7			Ind8			Ind13		
MC Search	1	50000		1	50000		1	50000		0	20000	
Conver criteria	1.00E-08			1.00E-08			1.00E-08			1.00E-08		
Restars	3.00E-08	15		3.00E-08	15		3.00E-08	15		3.00E-08	15	
Gen Mode	1.00E-04	12		1.00E-04	12		1.00E-04	12		1.00E-04	12	
Max F	8			8			8			8		
Penalty B1>K	0			0			0			0		
N° Series	3			3			3			3		
Weight series	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
B1/K	0.5			0.5			0.5			0.5		
MSY	1.00E+04			1.00E+04			1.00E+04			1.00E+04		
K	2.00E+05			2.00E+05			2.00E+05			5.00E+04		
qi	6.00E-05	2.00E-04	9.00E-05	6.00E-05	2.00E-04	9.00E-05	6.00E-05	2.00E-04	9.00E-05	6.00E-05	2.00E-04	9.00E-05
Parameters	5 (B1/K = 0.7)			5 (B1/K = 0.7)			5 (B1/K = 0.7)			5 (B1/K = 0.5)		
MSY lim	1.00E+03	1.00E+06		1.00E+03	1.00E+06		1.00E+03	1.00E+06		1.00E+03	1.00E+05	
K lim	5.00E+04	5.00E+07		5.00E+03	5.00E+07		5.00E+03	5.00E+07		5.00E+03	5.00E+06	
Seed	1900285			1900285			1803285			1803285		
R2 q1			-0.007			-0.006			0.037			-0.002
R2 q2			0.175			0.13			0.255			0.247
R2 q3			0.315			0.206			0.363			0.404
contrast index			0.273			0.2352			0.4128			0.3452
nearness index			0.8278			0.8			0.942			1
B1/K			0.700			0.700			0.700			0.500
MSY			6327			68170			6091			73040
K			50000			2430000			16700			2919000
q(1)			5.81E-05			1.09E-06			1.74E-04			1.12E-06
q(2)			1.85E-04			3.41E-06			5.51E-04			3.37E-06
q(3)			4.86E-05			9.00E-07			1.45E-04			9.00E-07

Table 9 .- XSA result for Recruitment (Age 3), Total biomass and mean F ages 6 to 13(Fbar) as well as Total catches by year.

	Recruit (age 3)	Total Bio	CATCHES	FBAR 6-13
1992	15211	32186	6725	0.2692
1993	21817	27985	4395	0.2153
1994	22439	28658	4023	0.2109
1995	19758	36726	3982	0.1609
1996	19764	36863	4135	0.1767
1997	23405	39947	4740	0.1704
1998	26740	42419	7270	0.2938
1999	20797	49670	7160	0.2466
2000	18347	42670	4767	0.2073
2001	14148	41678	3117	0.1251
2002	14457	47828	3657	0.1164
2003	14263	44751	3984	0.1097
2004	15869	50057	3182	0.0779
2005	11394	51790	1456	0.0366
2006	11236	69820	1420	0.032
2007	7667	73777	664	0.0108
2008	12402	54070	847	0.0247
2009	15993	75373	629	0.0206

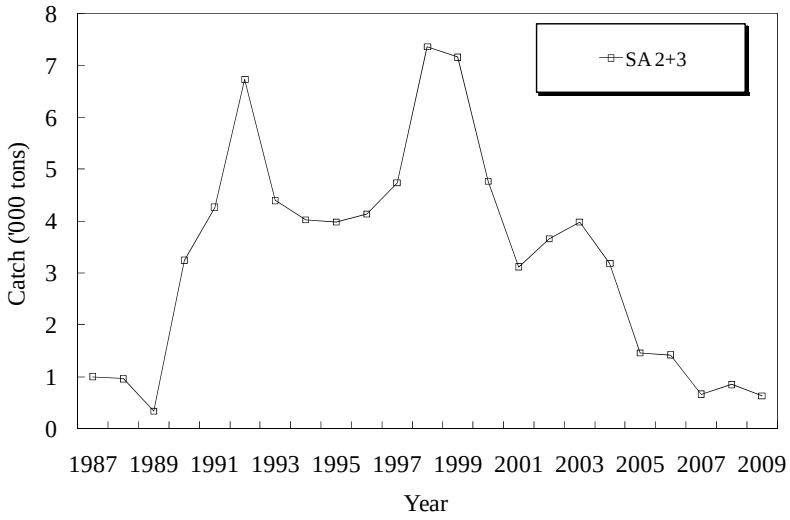

Fig. 1-. STACFIS roughhead grenadier NAFO Subarea 2 and 3 nominal catches (t).

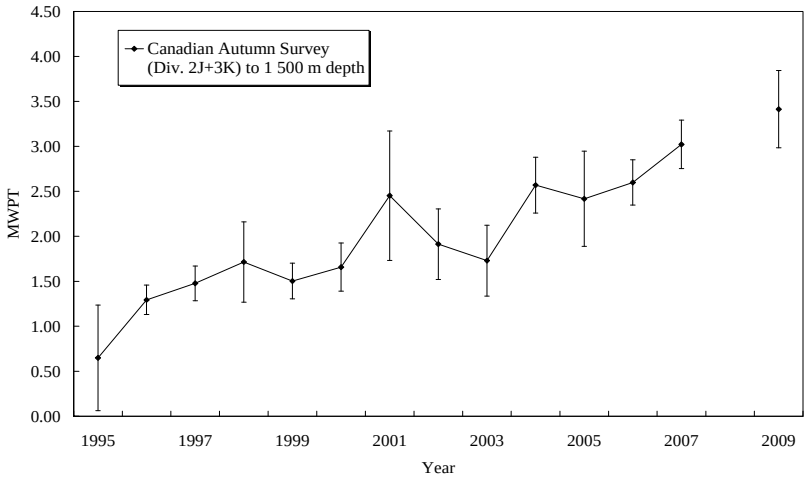

Fig. 2- Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the Canadian autumn (Div. 2J3K) survey

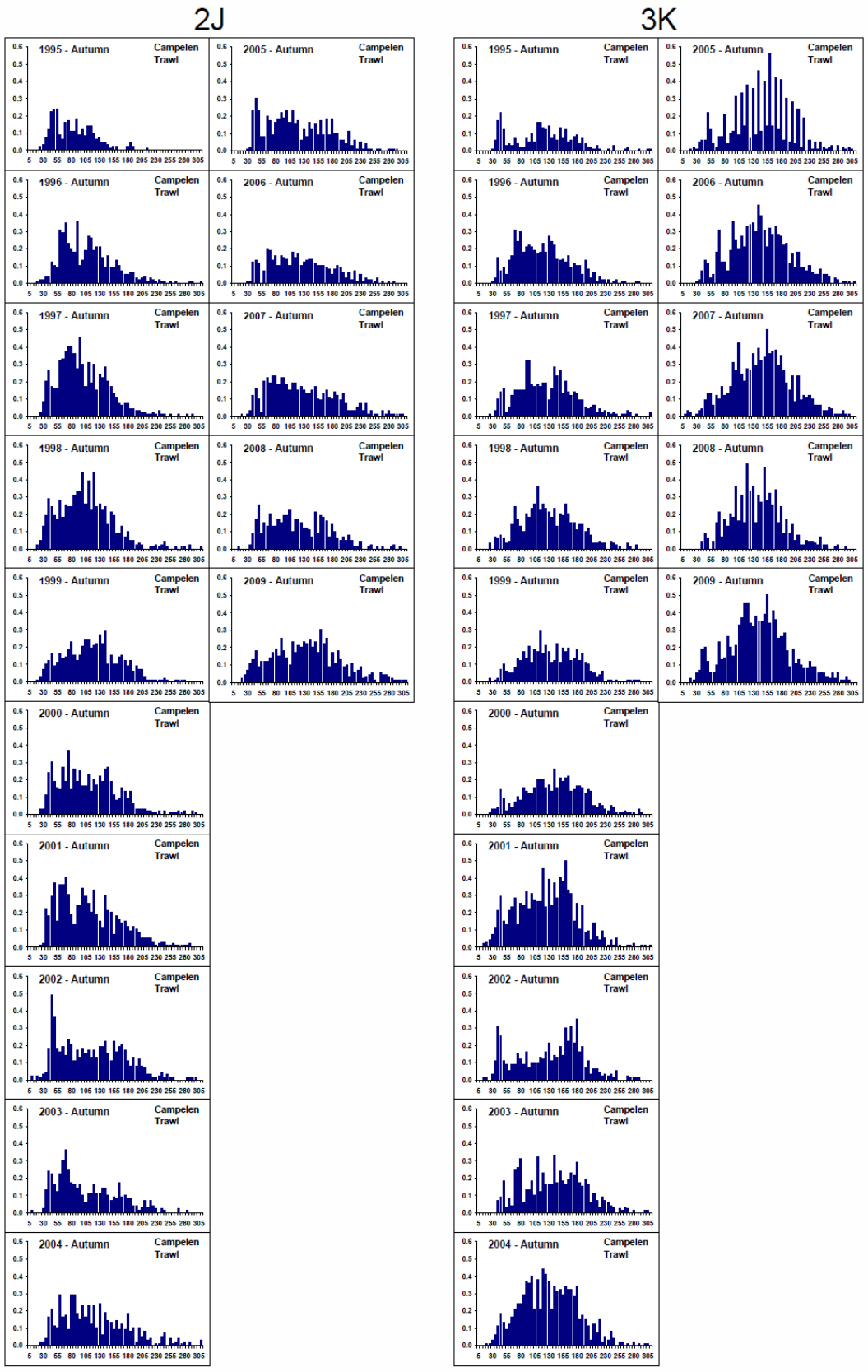

Fig. 3 -. Roughhead Grenadier length frequency distribution from Canadian Autumn surveys to Div. 2J3K. Mean Number Per Tow (MNPT). X-axis is AFL measure in mm.. (D. Power, DFO St. John's pers. comm.).

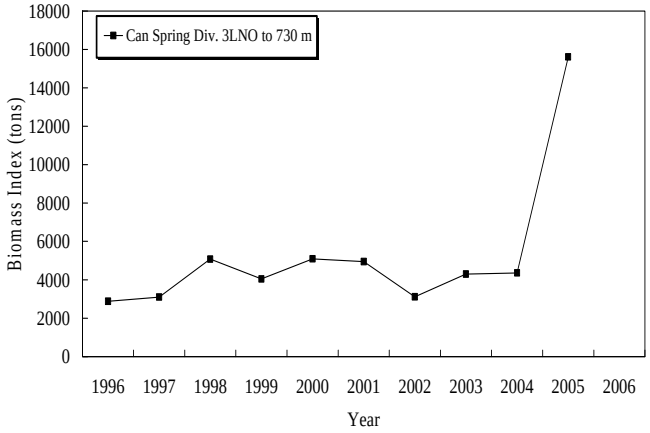

Fig 4.- Roughhead grenadier in Subareas 2+3: biomass indices from the Canadian spring surveys.

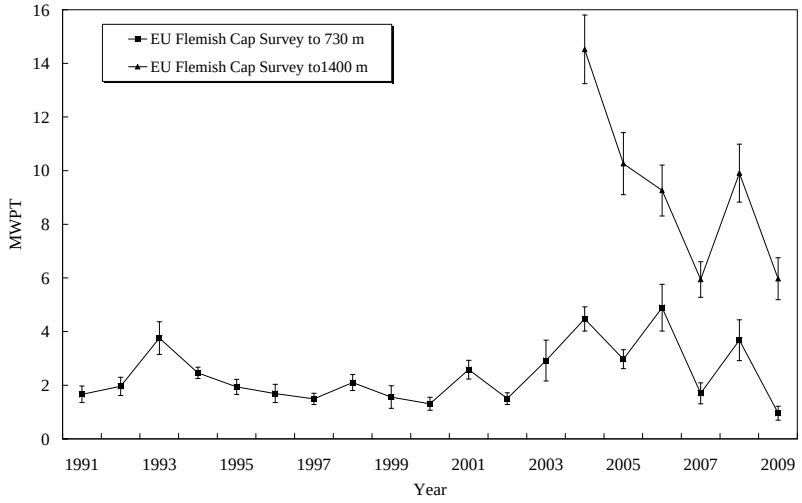

Fig. 5.-. Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the EU Flemish Cap survey.

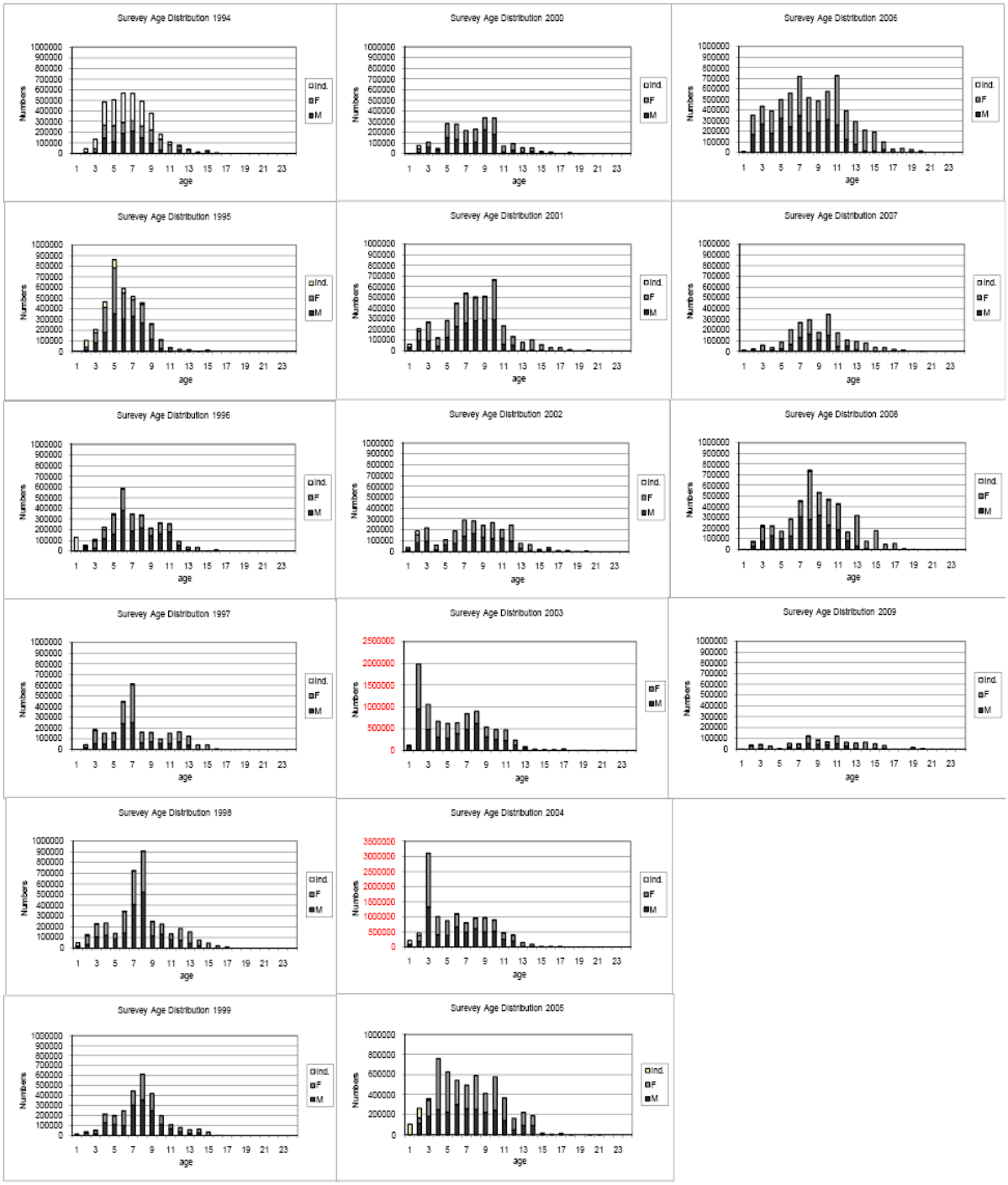

Fig. 6. – EU Flemish Cap survey age distribution, by sex till 700 m. In red different scale.

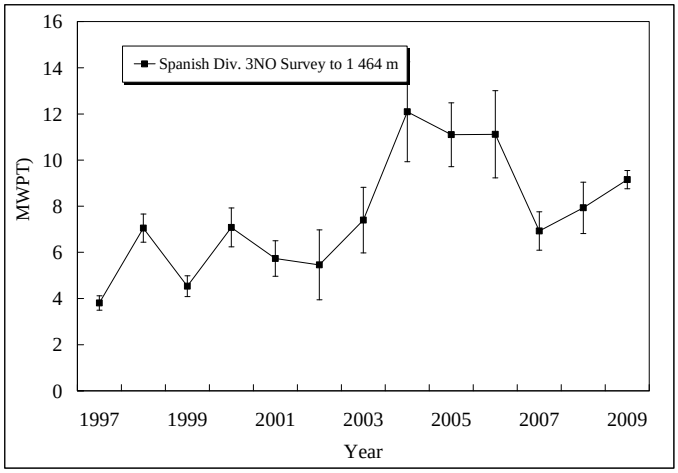

Fig. 7.- Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the Spanish Div. 3NO survey.

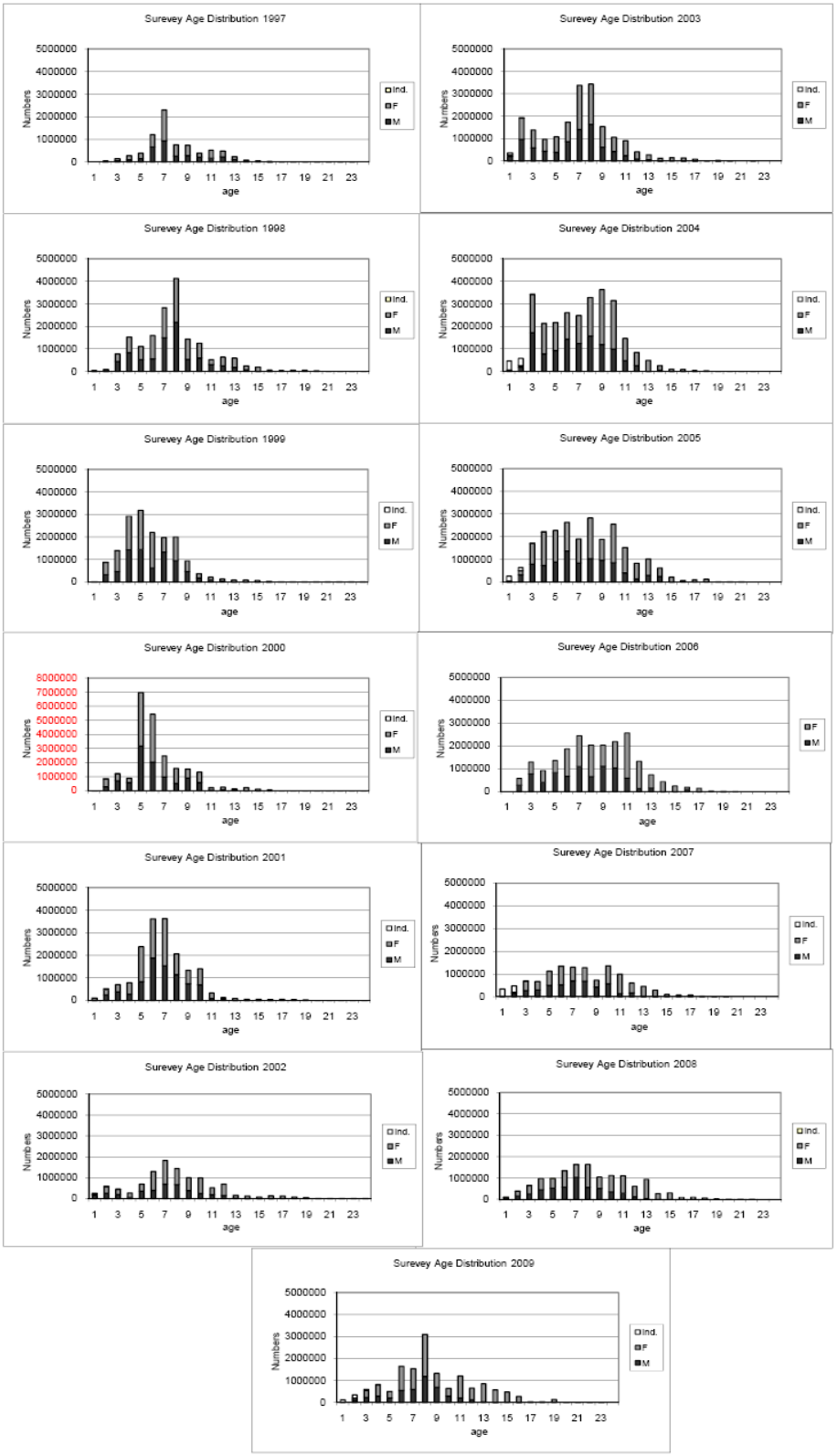

Fig. 8 . – Spanish 3NO survey age distribution, by sex . In red different scale.

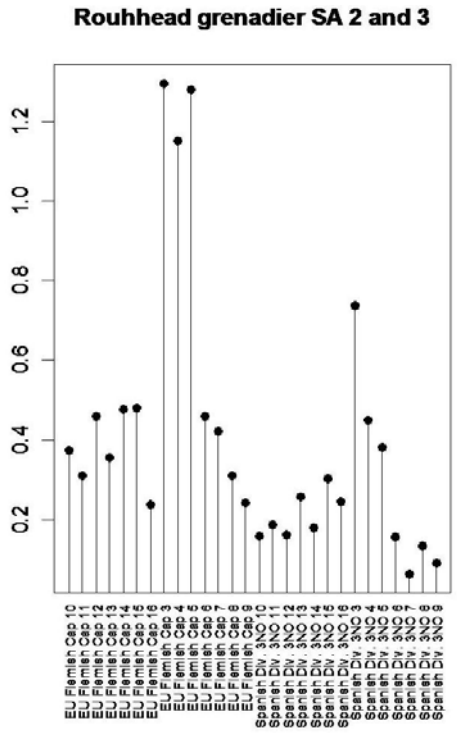

Fig. 9 – Standard Error (SE) of the log catchability residuals for EU Flemish Cap and Spanish 3NO surveys by year and age.

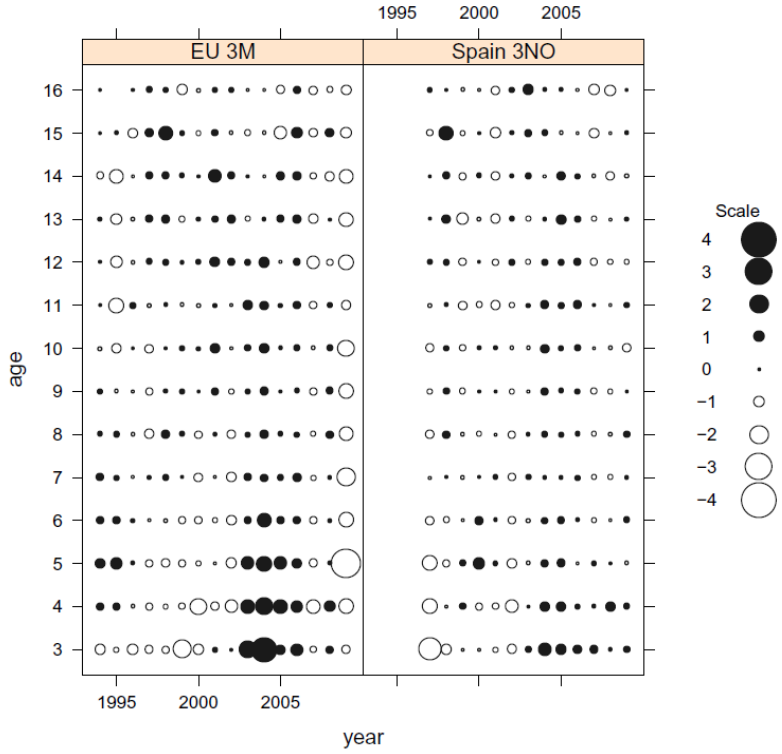

Fig. 10 – The log catchability residuals for Flemish Cap and Spanish 3NO surveys by year and age.

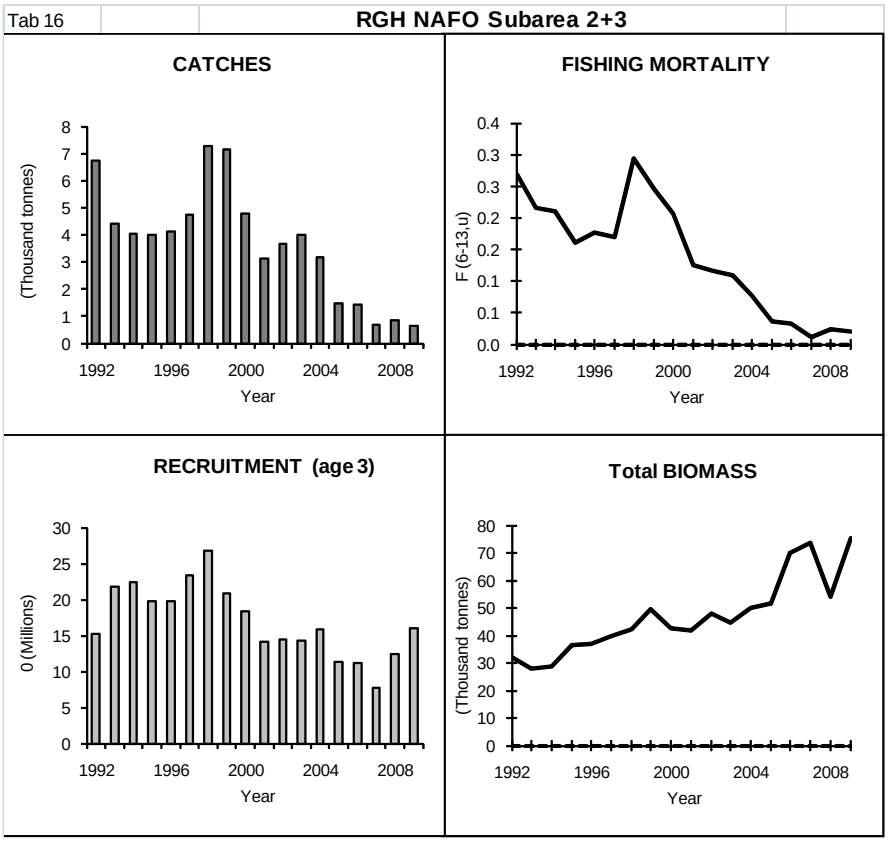

Fig. 11 – Total catches and XSA result for Total biomass, mean F ages 6 to 13 (Fbar) and recruitment (Age 3).

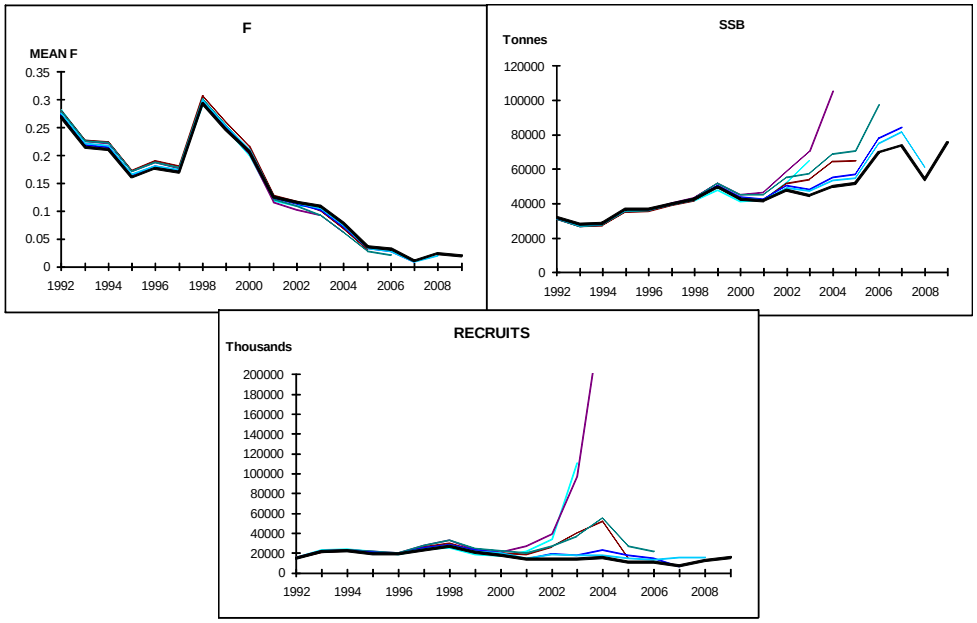

Fig. 12 – XSA retrospective results for Total biomass, mean F ages 6 to 13 (Fbar) and recruitment (Age 3).

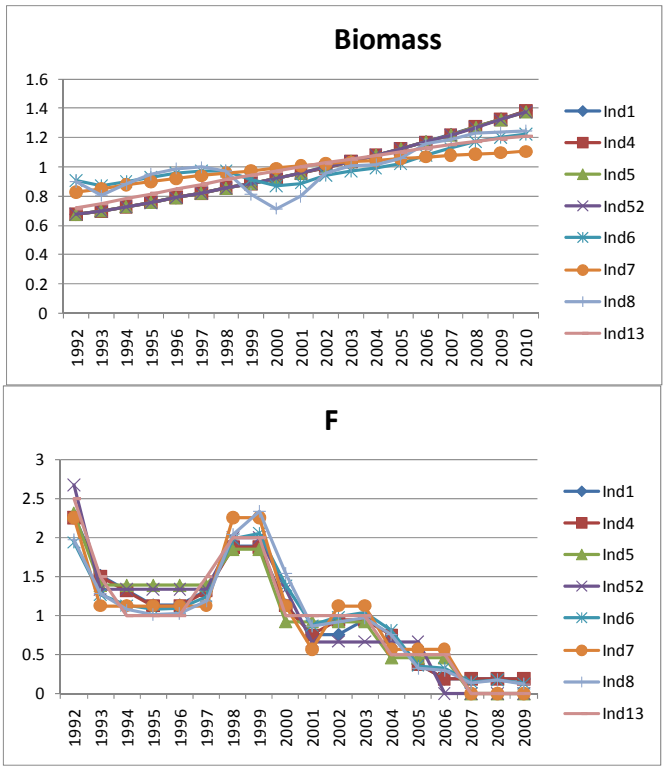

Fig. 13 – ASPIC results for total biomass and Fishing mortality obtained in the different runs. Total biomass and Fishing mortality were normalized to their mean for each run.

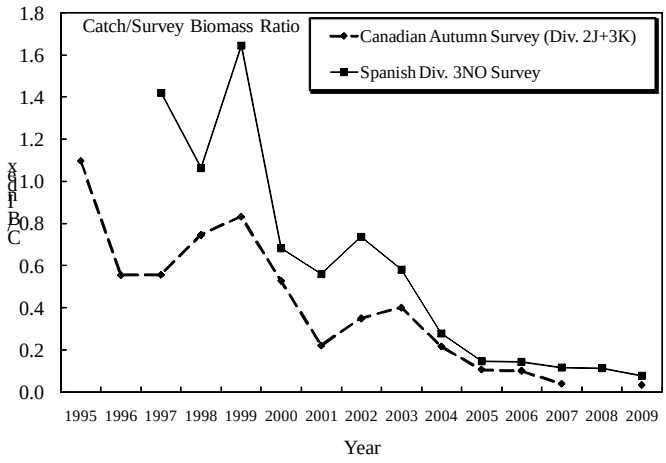

Fig. 14 – The catch / biomass (C/B) indexes obtained using the Canadian fall survey (2J+3K) and the Spanish 3NO biomass index in the period 1995-2009.

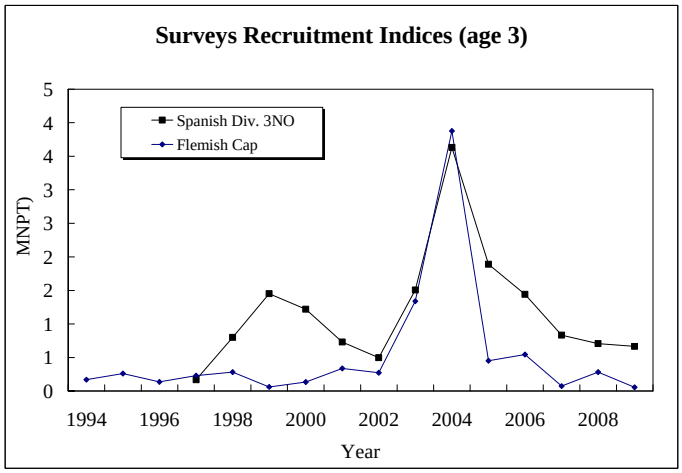

Fig. 15 – Roughhead grenadier in Subareas 2+3: Spanish Div. 3NO survey and EU Flemish Cap survey abundance (MNPT) at ages 3.

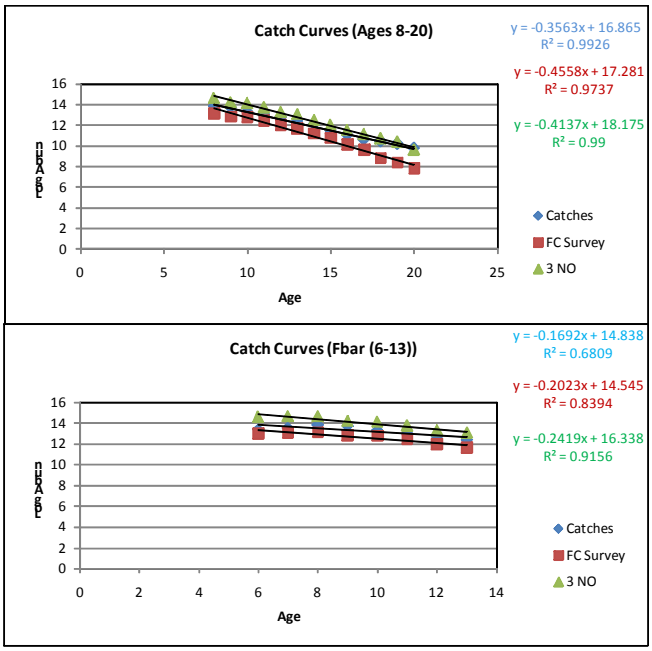

Fig. 16 – The catch curves for commercial catches (1992-2009), Flemish Cap survey (1994-2009) and Spanish 3NO survey (1997-2009) for ages 8 to 20 and 6 to 13.