Northwest Atlantic Fisheries Organization

Serial No. N6180 **NAFO SCR Doc. 13/027**

SCIENTIFIC COUNCIL MEETING – JUNE 2013

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

by

Fernando González-Costas

e-mail: fernando.gonzalez@vi.ieo.es
Instituto Español de Oceanografía, Vigo, Spain

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: Extended Survivors Analysis, a Stock-Production Model Incorporating Covariates (ASPIC) and a qualitative assessment based on survey and fishery information.

XSA results are considered uncertainties due to the low Fishing mortality estimated compare with the natural mortality level assumed and the high number of iterations needed to reach the convergence. ASPIC results make sense with historical data available for this stock despite the uncertainty in the B1/K parameter and the low contrast index value. 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 surveys information.

Biomass presents in all methods a general increased trend in the 1995-2006 period and between 2006 and 2009 is more or less stable at high levels. Between 2009-2012 presents a decreasing trend in the surveys indices and XSA results however remains stable at high levels in the ASPIC results. Trends of the different estimations of F were very similar. F presents a decreasing trend since 1998 till 2006 and since then is more or less stable at very low levels. All recruitment indices analysed show a clear recruitment pick around 2004 and the XSA and survey length abundance show other quite good recruitment in 2012 despite the difficult to follow cohorts strength.

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 (Gonzalez-Costas, 2012), 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). Before 1987 there is not Roughhead grenadier catch information available in the NAFO STATLANT data base. This could not mean that there should not have catches of this species before 1987. The reason for this doubt it is that before 1987 Roundnose grenadier was the only name that appeared in the STATLANT reporting forms. Since 1987, most of the Roughhead grenadier catches were taken as by-catch in the Greenland halibut fishery in Div. 3LMN by Spain, Portugal and Russia fleets. Catches of Roughhead grenadier increased sharply from 1989 (333 tons) to 1992 (6725 tons); since then until 1997 total catches have been about 4000 t. In 1998 and 1999 catches increased and were near the level of 7000 tons. Since then, catches decreased to 3000–4000 tons in 2001–2004 and to 600-800 t since 2007 to 2010. *In 2011, STACFIS only had STATLANT 21A available as estimates of catches. The inconsistency between the information available to produce catch figures used in the previous year's assessments and that available for the 2011 catches has made it impossible for STACFIS to provide the best assessments for some stocks* (NAFO, 2012). In the Roughhead grenadier case, the period from 2007 till 2011 the STATLANT and the STATFIS figures are quite similar at very small catch levels and it seems that for this stock it is not a mayor problem the use of the STATLANT 21A catch data in the assessment. In 2011 the STATLANT 21A catches for the Subarea 2+3 Roughhead grenadier were 1016 tons and 1303 tons in 2012.

Catches Length Distributions

Roughhead length frequencies from the Spanish, Portuguese and Russian trawl catches for 2010-2012 in Div. 3LMNO are available from Gonzalez-Costas et al. (2011, 2012, 2013), Vargas et al. (2011, 2012, 2013), Skryabin and Pochtar (2011) and Pochtar et al. (2012, 2013) respectively. Table 2 presents the availability of the length distribution in the series. Due to the growth differences between sex, length and age data have been analysed by sex. The Spanish and Portuguese lengths frequencies are measured as pre anal fin length (AFL), while the Russian ones as total lengths. The Russian length distributions were available grouped in 3 cm for 2010-2011 and one cm for 2012. 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). Due to this transformation and that some years were presented grouped in 3 cm there are some AFL length intervals without information in the Russian length distributions. Figure 2 shows the length distribution by year and country in the period 2010-2012. The Spanish and Russian length distributions are very similar and are different from the Portuguese ones. The Portuguese fleet catch individuals smaller than the Spanish and Russian fleets in this period. Base on this information and to solve the problems with the Russian length distribution for 2010-2011, the Spanish length distribution were applied to the Russian catches. The total catches length distributions for the stock were estimated raised the join Spanish, Portuguese and Russian catches length distribution to the total catches. Table 3 and Figure 3 present the total catches length distribution for the Roughhead grenadier Subarea 2+3 stock in the period 2010-2012. Figure 4 presents the sex ratio by length base on the Spanish and Portuguese length distributions for 2010-2012. The proportion of males

in the catches after 18 cm decreases progressively as length increases and is very difficult found males more than 30 cm. This patter is the same founded in previously studies (Murua and Gonzalez, 2007).

Catch-at-Age

Ageing was based on otoliths from specimens caught by Spanish commercial fleet and UE scientific surveys in NAFO Divisions 3LMN. The total catch-at-age numbers presented by González-Costas (2010) have been updated with the 2010-2012 data (Table 4 and Figure 3). Russian catches were transformed in ages applying the Spanish age compositions in the period 2010-2011 to avoid the problems with the Russian length distributions in that period. Table 2 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. In the period 2010-2012, most of annual catches are composed between ages 4 and 12, with a mode at age 6. This mode was slightly different in the years before: in 2009 was 8 and 7 in 2008.

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. 3MNO. Until 1995 an Engel trawl was used, changed since then to a Campelen 1800. Surveys depth is up to 1000 m 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 and Healy et al 2012). The estimates from 1995 onwards are not directly comparable with the previous time series due to the change in the survey gear. Taking into account the incomplete coverage of some strata in divisions 2GH and 3LMNO only the index of divisions 2J and 3K from both series (Engel and Campelen) are comparable. It was determined that the coverage deficiencies within Divs. 2J3K were such that the 2008 index from Divs. 2J3K could not be considered comparable to that of previous years (Healey and Mahé, 2009). The Roughhead biomass index (2J3K MWPT) from this survey since 1978 are presented in Table 6 and Figure 5. The Engel series (1978-1994) present a clear decreasing trend since 1978 till 1994. The Campelen series shows an opposite trend, the index increase from 1995 till 2011 with a slight decline in 2012. Figure 6 shows the length distributions for Division 2J and 3K since 1995. It can be observed a clear peak in 2002 with 5 cm (AFL) and in 2003 with 8 cm. in both Divisions but more clearly in Division 2J. This peak could indicate a good recruitment but it is difficult to track in later years.

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. Information is available in this survey for Roughhead grenadier since 1991. 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. Table 6 present the available biomass of this survey for Roughhead grenadier and Figure 7 shows the biomass index since 1996 till 2012. From 1996 to 2004, the biomass level does not present a clear trend. In 2005 and 2007, the biomass index had a big increase. After 2007 the biomass index is more or less stable at similar level than the period 1996-2004. 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 at depth more than 700 m., 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 transformed 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 (Casas and Gonzalez-Troncoso 2013) until 730 m from 1991 to 2012 and until 1400 m from 2004 to 2012 are presented in Table 6 and Figure 8. 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 2012. The 1400 indices show a clear decreased trend since the beginning of the series with its minimum in 2012. Figure 9 presents the age distributions of the EU Flemish Cap survey from 2003 to 2012 until 700 meters depth by sex, where it can be clearly appreciated a strong 2001 year class in 2003 and 2004 but since 2005 till 2009 this year class have been weaker than expected. In the period 2010-2012, a relative good signal of this cohort reappears.

EU-Spanish 3NO Survey: EU-Spain conduct a stratified random spring bottom trawl survey in the NAFO Regulatory Area Division 3NO since 1995. In 2001 the C/V Playa de Menduíña with a net trawl type Pedreira was replaced by the R/V Vizconde de Eza, using a trawl net type Campelen. The transformed entire series of mean catches, biomass and length distributions for Roughhead grenadier were presented by Gonzalez-Troncoso et al. (2013) since 1997, year in which the survey was extended to the depth strata. The roughhead grenadier biomass index from this survey series is presented in Table 6 and Figure 10. From 1997 to 2002 the biomass index of this survey did not show a clear trend. However, since then it has increased and in the period 2004-2006 reached the maximum level. In 2007 decreased to the 2003 level and since then till 2012 was more or less stable. The age distributions of the survey series (Figure 11) 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 has been weaker than expected**.** In 2009 a signal of this year class reappears again with 8 years old but it is difficult to track since then.

EU-Spanish 3L Survey (Flemish pass): The EU-Spanish surveys in Div. 3L of NAFO Regulatory Area (Flemish Pass) was initiated by Spain in 2003. The Research vessel "Vizconde de Eza" has carried out the entire surveys series following the same procedures and using the same bottom trawl gear Campelen 1800. To know more details about the technical specifications of the surveys, see Román et al., 2009. In 2003, the survey was carried out in spring (June) and it did not cover all strata adequately (69% of the total area prospected in 2006-2012). In 2004, the survey was carried out in August, for a period of nine days, and it covered only the 96%. In 2005, it was not possible to perform the survey due to problems with the winch of the ship; and in 2006, for the first time, an adequate prospecting survey was conducted in Division 3L with over 100 valid hauls (Roman et al. 2012). Due to these coverage and technical problems only the series since 2006 is analysed. The Roughhead grenadier biomass index from this survey series were presented by Roman et al. (2013) and show in Table 6 and Figure 10. From 2006 to 2008 the biomass index was stable and since them presents a clear decreasing trend, reaching the time series minimum in 2012.

Figure 12 presents the MWPT for the following series: Canadian fall 2J+3K (1978-2012), EU 3NO (1997-2012), EU 3L (2006-2012), EU Flemish Cap till 700 m.(1990-2012) and EU Flemish Cap till 1400 m.(2004-2012). It can be seen a increasing period since 1995 till 2004-2008 for all available indices and since them all the indices show a decreasing trend, except the Canadian fall 2J+3K index.

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 (1992-2012).

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 1992-2012 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 21 years (1992-2012). Ages 3 to 17 (Table 4).
- 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.
- 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).

Based on this model formulation, different runs were carried out changing the tuning series information. The base one was an update of the information used in 2010 by Gonzalez-Costas with the EU Flemish Cap survey series (700 m) between 1994 and 2012 and restricted to ages 3 to 16 and the EU-Spanish 3NO research survey series between 1997 and 2012 and ages 3 to 16. In 2012, there is now available 9 years information (2004-2012) of the UE Flemish Cap survey till 1400 meters depth. It was included this information in the XSA model and to avoid the overweight of the Flemish Cap survey information with two indices in the period 2004-2012 it was decided to used the UE Flemish Cap till 700 meters between 1994-2003 and to use the new Flemish Cap series till 1400 meters between 2004-2012 joint with EU-Spanish 3NO information for ages 3 to 16 as tuning series in a new run.
It was carried out other XSA run incorporating to the previous information the Canadian Fall 2J+3K for ages 3 to 16 from 1995 till 2012. This tuning series was created applying the UE-Flemish Cap ALK to the Canadian Fall 2J+3K MNPT length information. The tuning information of the different XSA runs for ages 3 to 16 was the following (Table 7):

- Run 1: EU Flemish Cap (700 m) (1994-2012) and EU-Spanish 3NO (1997-2012)
- Run 2: EU Flemish Cap till 700 m (1994-2003) and till 1400 m (2004-2012) and EU-Spanish 3NO (1997-2012)
- Run 3: EU Flemish Cap till 700 m (1994-2003) and till 1400 m (2004-2012), EU-Spanish 3NO (1997-2012) and Canadian Fall 2J+3K (1995-2012).
- Run 4: EU Flemish Cap till 700 m (1994-2003), EU-Spanish 3NO (1997-2012) and Canadian Fall 2J+3K (1995-2012).

All Extended Survivors Analysis (XSA) model configuration previous described converged after more than 180 iterations. This high iterations number needed to reach the convergence is a signal of the problems to fit the model with the available data. These problems can be due to different factors like a survey information difficulties to track the cohorts, age reading problems, etc.

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 all runs and surveys are presented in Figure 13. Values higher than 0.5 can be interpreted as fit problems. In Run 1, the major problems occurred at younger and old ages mainly in the EU Flemish Cap survey however, these ages are less frequent in the catches. This cachability problem could be related with the different depth coverage in the two surveys. In Run 2 it can be observed that the log catchability SE for the different surveys are quite good, most of them have values less than 0.5 but the highest values are found in younger and older ages. In Run 3, the Canadian 2J+3K and the EU 3NO surveys present quite good SE values for all ages and both EU Flemish Cap series present problems for younger ages. The log catchability residuals for each survey by year and run (Figure 14) show that there were no strong trends in the residual time series in the EU Spanish 3NO, Canadian fall 2J+3K and in the EU Flemish Cap survey between 1994 and 2003. The EU Flemish Cap indices since 2004, till 700 m and till 1400 m, present a clear decreasing trend in the residuals. This trend is a sign that the constant catchability assumption is not met. Basing on these results it was decided to remove the EU Flemish Cap survey information between 2004 and 2012 in the Run 4.

Total biomass, mean F between ages 6 to 13 (Fbar) and recruitment (Age 3) results are plotted in Figure 15 and presented in Table 9. Model results indicated that the stock biomass in all runs has an increase trend till 2006, between 2006-2010 remained stable, decreasing slightly in the last two years. The biomass trend is similar in all runs with higher level in the runs 3 and 4 where was used the Canadian 2J+3K information. The biomass estimated for the beginning of 2012 was around 70,000 tonnes in the runs without the Canadian 2J+3K information (runs 1 and 2) and 140,000 with this survey information (runs 3 and 4). Fishing mortality has declined since 1998 till 2007 and since then present a slight increase more evident in runs 1 and 2. The current level of F is much smaller than the value assumed for the natural mortality. The recruitment in runs 1 and 2 present a decreasing trend since 1998 till 2009 where reached its minimum and in the last years improved slightly. Recruitment picture in the Run 3 and 4 are different, present a decreasing trend between 2004 and 2009 and since then increase reaching in 2012 a value close to the maximum observed in the series. The results, at least quantitatively, are considered to be uncertain due to a number of factors that might influence the quality of the outcome, such as the high number of iterations required in all runs to reach convergence, the low Fishing mortality estimated in the last years compare with the assumed the natural mortality level, etc.

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 1987-2011 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.

Survey series indices input data: It was decided to exclude of this analysis the Canadian Spring survey because this survey only cover the Grand Banks till 700 m where the Roughhead grenadier is less abundant and it was exclude the EU 3L survey information due to the short time series available. The first step was to analyse the correlation between the different series (Table 10). The correlation between the Canadian Autumn index till 1400 m. is negative with the Flemish Cap survey indices and low with the UE 3NO survey index. Based on this information and that the Canadian Autumn index till 1400 trend in the last years is different from the other indices (Figure 12), it was decided to exclude this index from the analyse. The correlations between the other indices are quite good. To avoid the overweight of the UE Flemish Cap series in the period 2004-2012, it was decided to split the series: EU Flemish Cap survey till 700 m. from 1992 to 2003 only and EU Flemish Cap survey (Mean Weight per Tow) till 1400 m. from 2004 to 2011. The survey indices and catch series used in the production model were the following (Table 11):

- Nominal catches 1987-2012
- EU 3NO survey (Mean Weight per Tow) from 1997 to 2012.
- EU Flemish Cap survey (Mean Weight per Tow) till 1400 m. from 2004 to 2012.
- EU Flemish Cap survey (Mean Weight per Tow) till 700 m. from 1992 to 2003.
- Canadian Autumn survey 2J+3K (Mean Weight per Tow) till 1000 m. from 1987 to 1994 (Engel).

The survey data was treated in all model formulation as follow: EU 3NO survey index as CPUE type (CC) because this is the longer series cover till 1400 meters and cover the depth distribution of Roughhead grenadier fairly well (Murua and De Cardenas, 2005). The other three series as indices of biomass type (I). UE Flemish Cap indices as

annual average index (I1) because it is carried out in July and the Canadian Autumn survey as end of the year index (I2) because normally it is carried out between October and December.

With these data several runs were carried out in ASPIC version 5.33 to investigate the ASPIC model to various input specifications (starting values for B1/K, K, MSY and the random number seed). ASPIC RUN1with the default input specifications recommend by Prager (1994) is presented in Table 12. The parameters estimated by the model, especially the B1/K and MSY, have very big values with a non biological sense. Based on these results we run ASPIC with a bigger MSY bound (100000) and the penalty function for B1/K (RUN2) and with 4 different B1/K fixed values: 0.7 (RUN3) , 0.85 (RUN4), 1.15 (RUN5) and 1.3 (RUN6) to see the sensibility of the results to the B1/K value. Table 13 shows the values estimated by the model for the parameters in the different runs as well as same fit indices. The runs with fixed B1/K less than 1 had different problems: MSY were estimated very close to the defined bounds and K was estimated at very high biomass values with difficult biological explanation. All the runs with the parameter B1/K between 1 and 1.3 were quite consistent in the results and the parameters estimated by the model make sense with historical data available for this stock, despite the low contrast index value. We chose the run with the penalty function (RUN2) as the more appropriated with the available data because at the start of the series (1987) the stock biomass should be not higher than K. Before 1987 there is not Roughhead grenadier catch information available in the NAFO STATLANT data base. This could not mean that there should not have catches of this species before 1987 as it was pointed out before. There is not much information to assume a good value for B1/K less than 1. To test the stability of the results of the RUN2 we change the random number seed (RUN7 and RUN8) and the results were exactly the same. The absolute values of the parameters are presented in Table 13, emphasize the high value of Fmsy, production models tend to estimate some quantities more precisely than others as pointed out by Prager (2004). Among the quantities more precisely estimated are MSY, optimum effort and relative levels of stock biomass (B/Bmsy) and fishing mortalities (F/Fmsy). Table 14 shows the values for F, biomass ans yield as well as the B/Bmsy ans F/Fmsy ratios by year estimated by ASPIC RUN. Figure 16 presents the B/Bmsy and the F/Fmsy trajectory of the RUN2. The results show that since 2007 the biomass is the double of Bmsy and the relative F (F/Fmsy) is at very low level. Figure 17 shows the observed and the model estimated CPUE for the different surveys series used in the analysis. It can be observed that there is not index that well cover all the series and most of the indices only have increase or decrease information. This is could be the reason for the low contrast index value.

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.

Canadian Divisions 2J and 3K fall index and the Spanish research survey in Divisions 3NO have been considered in the last full assessment as the best information in order to monitor trends in resource status (NAFO 2010) 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). Now there are available more surveys series cover depths down to 1,500 metres. Figure 12 presents the relative mean weight per tow for all the series available cover down to 1,500 meters depth. It can be observed a clear increasing trend in the period 1995-2004 and since them all available indices show a clear downward trend except the Canadian Fall (2J+3K) index. This index presents an increasing trend since 1995 till 2012. Figure 18 presents the catch / biomass (C/B) indices obtained using all the available survey biomass indices cover till 1400 m depth. The Canadian fall survey and the Spanish 3NO biomass (C/B) indices in the period 1995-2012 show a clear decrease trend from 1995 to 2005 and since then are more or less stable at low level. The other (C/B) indices (EU Flemish Cap, and EU 3L) started in the middle of the twenties and they show a stable situation and similar level to the Canadian fall and the EU Spanish 3NO surveys in this period. Figure 19 presents the abundance series (MNPT) for ages 3 of the Canadian fall (2J+3K), the UE Div. 3NO survey, the EU Flemish Cap survey till 700 m. and the EU Flemish Cap survey till 1400 m. The transformations of the lengths in ages were made applying the EU Flemish Cap survey ALK to the length indices for all series. A strong 2001 year class can be clearly seen in 2004 in the UE Flemish Cap and UE 3NO series and less clearly in the Canadian Fall survey. The strong 2001 year class have been weaker than expected since 2005 in many years for all survey indices. This is an indication of the problems to track the cohort signal in older ages. This problem can be due to different factors like ages reading problems for this species, partial coverage of the different surveys, etc. Since 2004 the level of the recruitment was more or less constant in all series at low level. In 2012 a slight increase in the recruitment level can be observed in the Canadian fall (2J+3K) and the UE Div. 3NO survey. In 2010 STACFIS (NAFO 2010)

recommended that further investigation on recruitment indices for Roughhead grenadier in Subarea 2 and 3 will be carried out. It was analysed the surveys length distribution and it was decided establish as recruitment index the abundance of length less than 9 cm (AFL). This length is equivalent to individuals less than four years old (1-3) and should be equivalent to the recruitment indices for age 3 based on ages. Figure 20 presents the indices of abundance for the individuals less than 9 cm. For the Canadian Fall 2J+3K, the EU 3NO and the EU Flemish Cap (700 m) indices. The length recruitment picture is similar to the age picture; there is a recruitment pick in ages in 2004 that in lengths can be observed in 2003 and 2004 due to that the individuals less than 9 cm are a mix of ages 1, 2 and 3. This pick is observed in the Canadian Fall 2J+3K index two years before. In lengths can be observed a quite good recruitment in 2012 in the Canadian Fall 2J+3K and the EU 3NO series that is less evident in the recruitment indices (ages). This is could be due to that part of the signal in the length index can be due to length for ages less than 3 years old as we can observer the Canadian fall length distributions (Figure 6). All recruitment indices analysed (Surveys indices ages 3, Survey indices less than 9 cm and XSA abundance age 3) show a clear recruitment pick around 2004 and the XSA and survey length abundance show other quite good recruitment in 2012.

The Z values estimated from catch curves based on different information are presented in Figure 21. The Z estimate from the catch curve based upon commercial catch at age data (1992-2012) was 0.359 for ages 8 to 20 (R^2=0.99) and 0.188 for ages 6 to 13 (R^2=77). The value estimate from the catch curve for ages 8 to 20 of the UE Flemish Cap survey till 700 m (1994-2012) was 0.398 and 0.411 for the catch curve of the Spanish 3NO survey data (1997-2012) and 0.192 and 0.224 for ages 6 to 13 respectively. And for the UE Flemish Cap survey till 1400 m (2004-2012) were 0.236 for ages 8-20 and 0.215 for ages 6-13. The values estimated with different data sources are quite similar.

SUMMARY

XSA results are considered uncertainties due to the low Fishing mortality estimated compare with the natural mortality level assumed and to the high number of iterations needed to reach the convergence. In the ASPIC case, results make sense with historical data available for this stock, despite the uncertainty in the B1/K parameter and the low contrast index value. 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 surveys indices with depth coverage till 1400 meters that there are considered as the best survey information to monitor trends in resource status because they cover the depth distribution of Roughhead grenadier fairly well.

Biomass presents in all methods a general increased trend in the 1995-2006 period and between 2006 and 2009 is more or less stable at high levels. Between 2009-2012 presents a decreasing trend in the surveys indices and XSA results however remains stable at high levels in the ASPIC results. 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. F presents a decreasing trend since 1998 till 2006 and since then is more or less stable at very low levels. All recruitment indices analysed (Surveys indices ages 3, Survey indices less than 9 cm and XSA abundance age 3) despite the difficult to follow cohorts strength show a clear recruitment pick around 2004 and the XSA and survey length abundance show other quite good recruitment in 2012.

REFERENCES

Atkinson, D.B., and D. Power.MS 1987. Distribution of roughhead and roundnose grenadiers in the Northwest Atlantic. NAFO CR oc ., No.94,Serial No. N1398,28 p.

Atkinson, D.B., D. Power and J. Morgan (1994). Roundnose grenadier (Coryphaenoides rupestris) and Roughhead grenadier (Macrourus berglax) in NAFO Subareas 2+3. NAFO SCR Doc. 94/48.

Atkinson, D. B. (1995). The biology and fishery of roundnose grenadier (Coryphaenoides rupestris Gunnerus, 1765) in the North West Atlantic. In Deep Water Fisheries of the North Atlantic Ocean Slope (Hopper, A. G., ed.), pp. 51-112. Dordrecht: Kluwer.

Bowering, W. R., D. Power and M. J. Morgan (1995). Distribution and abundance of five major groundfish species at the continental slope of Divisions 3KLMN based upon Canadian deepwater surveys in 1991, 1994 and 1995. NAFO SCR Doc. 95/51.

Brodie W. (2005). A Description of the Fall Multispecies Survey in SA2+Divisions 3KLMNO from 1995-2004. NAFO SCR Doc. 05/8.

Casas JM and D. González-Troncoso. 2013. Results from Bottom Trawl Survey on Flemish Cap of June-July 2012. Serial No. N6163NAFO SCR Doc. 13/013

Darby, C.D., and S. Flatman. 1994. Virtual Population Analysis: Version 3.1 (Windows/Dos) user guide. Info. Tech. Ser., MAFF Direct. Fish. Res., Lowestoft, (1): 85pp.

D'Onghia G. D., Basanisi, M. & Tursi, A. (2000). Population structure, age and growth of macrourid fish from the upper slope of the Eastern-Central Mediterranean. Journal of Fish Biology 56, 1217-1238. doi: 10.1006/jfbi.2000.1243.

González-Costas, F. and H. Murua (2007). An analytical assessment of NAFO roughhead grenadier Subareas 2 and 3 stock. NAFO SCR Doc. 07/34.

González-Costas, F. (2009). Roughhead Grenadier subarea 2 and 3 XSA model configuration. Serial No. N5655 NAFO SCR Doc. 09/021.

González-Costas F., D. González-Troncoso, G. Ramilo, E. Román, J. Lorenzo, M. Casas, C. Gonzalez, A. Vázquez , and M. Sacau. Spanish Research Report for 2010. Serial Serial No. N5884 NAFO SCS Doc. 11/07

González-Costas F., D. González-Troncoso, G. Ramilo, E. Román, J. Lorenzo, M. Casas, C. Gonzalez, A. Vázquez, and M. Sacau1. Spanish Research Report for 2011. Serial No. N6023 NAFO SCS Doc. 12/09

González-Costas F., D. González-Troncoso, G. Ramilo, E. Román, J. Lorenzo, M. Casas, C. Gonzalez, A. Vázquez, and M. Sacau. Spanish Research Report for 2012. Serial No. N6150 NAFO SCS Doc. 13/07

González-Costas F. An assessment of NAFO roughhead grenadier Subarea 2 and 3 stock. Serial No. N5790 NAFO SCR Doc. 10/32.

González-Costas F. (2012). Spanish fisheries in NAFO Subarea 3. Serial No. N6045 NAFO SCR Doc. 12/021

Gonzalez-Troncoso, D. And J. M. Casas. Calculation of the Calibration Factors from the Comparative Experience between the R/V *Cornide de Saavedra* and the R/V *Vizconde de Eza* in Flemish Cap in 2003 and 2004. NAFO SCR Doc. 05/29

Gonzalez-Troncoso, Elena Guijarro and Xabier Paz. Biomass and length distribution for roughhead grenadier, thorny skate and white hake from the surveys conducted by Spain in NAFO 3NO. Serial No. N6162 NAFO SCR Doc. 13/012.

Gordon,. J. D. M. (1979). Lifestyle and phonology in deep sea anacanthine teleosts. Symposium of Zoological Society of London. 44: 327-359.

Healey, B. P. and Dwyer, K.S. (2005). A Simple Examination of Canadian Autumn Survey Trends in NAFO Divisions 3LNO for Greenland Halibut and American Plaice: The Impact of Incomplete Coverage of this Survey in 2004. NAFO SCR Doc. 05/34.

Healey, B. P. 2009. Greenland halibut (Reinhardtius hippoglossoides) in NAFO Subarea 2 and Divisions 3KLMNO: Stock Trends based on annual Canadian Research Vessel survey results during 1978-2008. Serial No. N5669 NAFO SCR Doc. 09-033.

Healey, B. P. and Jean-Claude Mahé. 2009. An Assessment of Greenland Halibut (Reinhardtius hippoglossoides) in NAFO Subarea 2 and Divisions 3KLMNO. Serial No. N5675 NAFO SCR Doc. 09/39.

Healey, B. P, W.B. Brodie, D.W. Ings, and D.J. Power. 2012. Performance and description of Canadian multi-species surveys in NAFO subarea 2 + Divisions 3KLMNO, with emphasis on 2009-2011. Serial No. N6043 NAFO SCR Doc. 12-019.

ICES ACFM 2006. Report of the working group on the biology and assessment of deep-sea fisheries resources (WGDEEP). ICES CM 2006/ACFM : 28.

McCallum, B. R. and S. J. Walsh (1996). Groundfish survey trawls used at the Northwest Atlantic Fisheries Centre, 1971-present. NAFO SCR Doc. 96/50.

Middleton, R. W. & Musick, J. A. (1986). The abundance and distribution of the family Macrouridae (Pisces: Gadiformes) in the Norfolk Canyon area. Fishery Bulletin U.S. 84: 35-62.

Murua, H. and L. Motos (1997). Reproductive biology of roughhead grenadier, Macrourus berglax in NAFO Divisions 3MNL. NAFO SCR Doc. 97/20.

Murua, H. 2003. "Population structure, growth and reproduction of roughhead grenadier on the Flemish Cap and Flemish Pass." Journal of Fish Biology (2003)63, 356 –373.

Murua H. and E. de Cárdenas. 2005. Depth distribution of deep water species in Flemish Pass. Journal of Northwest Atlantic Fishery Science 37.

Murua H., F. González and D. Power. 2005. A review of the Fishery and the Investigations of Roughhead grenadier (Macrourus berglax) in Flemish Cap and Flemish Pass. Journal of Northwest Atlantic Fishery Science 37.

Murua, H. and F. González (2006). A Review on Roughhead Grenadier (Macrourus berglax) Biology and Population Structure on Flemish Cap (NAFO Division 3M) 1991-2005 Based Upon EU Flemish Cap Bottom Survey Data. NAFO SCR Doc. 06/07.

Murua, H. and F. González (2007). A review on roughhead grenadier (*Macrourus berglax*) biology and population structure on Flemish Cap (NAFO Division 3M) 1991-2006 based upon EU Flemish Cap bottom survey data. Serial No. N5376 NAFO SCR Doc. 07/25.

NAFO. 2005. SCIENTIFIC COUNCIL MEETING, 2-16 June 2005. NAFO SCS Doc. 05/10.

NAFO. 2010. SCIENTIFIC COUNCIL MEETING – 3-16 June 2010. NAFO SCS Doc. 10/18.

NAFO. 2012. Report of Scientific Council Meeting, 1-14 JUNE 2012. Serial No. N6072 NAFO SCS Doc. 12/19.

Pochtar M. And K. Fomin. Russian Research Report for 2011. Serial No. N6018 NAFO SCS Doc. 12/05.

Pochtar M., K. Fomin and V. Zabavnikov. Russian Research Report for 2012. Serial No. N6159 NAFO SCS Doc. 13/09.

Power,D.,and D.Maddock Parsons.MS 1998. An assessment of roundnose grenadier (Coryphaenoides rupestris) in NAFO Subareas 2+3 and catch information on roughhead grenadier (Macrourus berglax). NAFO SCR Doc ., No.57,Serial No.N3049,11 p.

Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fishery Bulletin 92: 374-389.

Prager, M. H. 2004. User's Manual for ASPIC: A Stock-Production Model Incorporating Covariates 8ver. 5) and Auxiliary Programs. National Marine Fisheries Service.

Román, E., C. González, A. Armesto, and D. González-Troncoso. 2009. Results for the Spanish Survey in the NAFO Regulatory Area of Division 3L for the period 2003-2008. Serial No N5658, NAFO SCR Doc., No. 23, 26 p.

Roman E., C. González-Iglesias and D. González-Troncoso. 2012. Results for the Atlantic cod, Roughhead grenadier, redfish, thorny skate and black dogfish of the Spanish Survey in the NAFO Div. 3L for the period 2003-2011. Serial No. N6034 NAFO SCR Doc. 12/010.

Roman E., Ángeles Armesto and Diana González-Troncoso. 2013. Results for the Atlantic cod, roughhead grenadier, redfish, thorny skate and black dogfish of the Spanish Survey in the NAFO Div. 3L for the period 2003-2012. Serial No. N6168 NAFO SCR Doc. 13/017.

Saborido-Rey, F and A. Vazquez (2003). Results from the bottom trawl survey of Flemish Cap in July 2002. NAFO SCR Doc. 03/

Savvatimsky P.I. 1994. Age Structure of of Roughhead Grenadier (Macrourus berglax) in the Northwest Atlantic, 1985. NAFO Sci. Coun. Studies, 20: 53-64.

Schaefer, M. B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bulletin of the Inter-American Tropical Tuna Commission 1(2):27-56.

Schaefer, M. B. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific ocean. Bulletin of the Inter-American Tropical Tuna Commission 2: 247-268.

Scott, W. B., and M. G. Scott. 1988. Atlantic fishes of Canada. Can Bull. Fish. Aquat. Sci. 219, 731 pp.

Shepherd, J. G. 1999. Extended survivors analysis: An improved method for the analysis of catch-at-age data and abundance indices ICES Journal of Marine Science Vol. 56, No. 5, October 1999, pp. 584-591.

Skryabin, I.A. and M.V. Pochtar. Russian Research Report for 2010. Serial No. N5902 NAFO SCS Doc. 11/11.

Snelgrove, P.V.R. and R.L. Haedrich. 1985. Structure of the deep demersal fish-fauna off Newfoundland. Mar. Ecol. Prog. Ser. 27: 99-107.

Vargas J., R. Alpoim, E. Santos and A. M. Ávila de Melo. 2011. PORTUGUESE RESEARCH REPORT FOR 2010. Serial No. N5881 NAFO SCS Doc. 11/05.

Vargas J., R. Alpoim, E. Santos and A. M. Ávila de Melo. 2012. PORTUGUESE RESEARCH REPORT FOR 2011. Serial No. N6022 NAFO SCS Doc. 12/08.

Vargas J., R. Alpoim, E. Santos and A. M. Ávila de Melo. 2013. PORTUGUESE RESEARCH REPORT FOR 2012. Serial No. N6145 NAFO SCS Doc. 13/05.

Wheeler, A. 1969. The fishes of the British Isles and Northwest Europe: Anacanthini (p. 255.259). MacMillan and Co. Ltd., London England, 613 p.

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
2010			7	22	652	168	94			943
2011[c]			1	62	431	298	223	1		1016
2012[c]			3	13	652	511	119	5		1303

[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.
[C] Years with only STATLANT 21A Information

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
2010	X	X	X	X
2011	X	X	X	X
2012	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 total catches length distributions (‘000) by year measure as pre anal fin length (AFL), samples and catches.

LENGTH Length (cm)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	0	0	0	0	0	0	0	1	0	0	0	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	0	0	0
2	0	0	0	0	0	0	0	20	0	0	0	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	0	0	0
4	1	0	0	0	0	0	0	30	0	0	0	1	2	0	0	0	0	0	0	0	0
5	4	0	3	0	0	0	0	15	0	0	0	1	1	0	1	0	0	0	0	0	0
6	12	7	5	0	0	0	0	8	0	1	1	4	3	0	0	0	0	0	0	1	1
7	12	12	16	4	0	10	7	12	4	3	5	22	24	1	2	0	1	2	4	3	6
8	11	29	33	8	3	63	21	45	32	16	16	44	39	3	8	4	3	12	21	25	37
9	39	115	67	43	17	121	57	126	112	59	59	102	70	6	19	10	10	42	68	38	80
10	69	51	159	308	212	287	221	157	224	150	162	233	168	12	56	21	22	84	166	99	177
11	101	65	132	231	328	518	448	278	327	210	238	333	256	20	99	32	56	178	284	220	354
12	146	100	150	306	647	529	687	517	474	343	378	444	350	41	157	48	137	243	552	532	740
13	223	255	212	314	771	515	835	651	714	519	492	456	399	93	147	51	138	166	312	336	458
14	531	288	370	412	796	654	1290	591	810	853	727	761	497	133	156	49	169	121	232	181	266
15	742	368	418	529	705	811	2241	698	863	912	950	951	552	167	187	58	201	119	208	172	192
16	755	623	517	515	569	943	2287	719	1038	719	967	1134	621	214	233	49	212	97	191	159	229
17	710	850	774	612	615	752	1777	807	1185	657	782	1005	632	277	234	47	216	64	127	141	155
18	678	802	813	681	653	642	1093	660	891	589	600	769	541	268	276	46	128	72	107	106	141
19	720	560	690	671	504	572	902	725	680	456	389	557	371	219	197	46	91	50	79	79	90
20	571	421	471	418	503	528	561	709	417	279	253	356	263	172	114	40	72	28	54	64	74
21	551	245	299	282	511	333	402	580	241	155	158	244	191	121	60	43	29	16	49	50	63
22	494	203	211	185	189	228	281	358	171	95	117	154	154	82	51	34	29	18	31	36	40
23	350	219	174	97	155	210	216	380	139	66	75	117	90	59	37	31	17	12	24	35	48
24	395	231	149	91	63	154	213	276	84	53	61	94	93	55	30	27	17	14	21	25	34
25	198	204	150	60	60	128	115	258	99	46	57	71	66	36	31	26	8	17	15	31	37
26	176	188	113	66	62	79	96	167	96	41	50	49	43	22	18	23	11	16	19	29	28
27	121	109	88	73	14	47	49	166	65	32	40	45	41	23	16	20	19	10	15	28	26
28	131	74	64	59	50	45	74	125	44	29	43	36	29	14	21	18	6	10	7	21	20
29	117	75	47	48	60	54	29	87	37	24	42	26	27	12	12	15	2	7	2	13	18
30	64	52	49	17	85	41	30	69	14	19	31	39	22	8	9	10	1	6	3	11	19
31	46	50	28	31	17	35	38	70	21	18	25	21	20	7	6	8	1	4	3	3	11

32	38	55	28	25	0	23	57	60	18	8	21	13	17	9	7	4	5	6	2	3	5
33	22	11	15	15	0	27	12	73	9	9	16	7	7	8	4	3	1	2	2	2	3
34	17	13	15	9	10	18	14	35	10	9	12	8	7	4	7	3	0	2	1	1	2
35	8	9	9	1	0	6	13	21	9	7	10	9	5	5	5	2	1	3	0	0	0
36	8	4	3	0	0	5	11	21	18	3	8	6	2	4	1	1	1	0	0	0	0
37	1	1	4	4	0	0	7	9	15	2	2	2	2	5	1	1	0	1	0	1	1
38	0	0	3	0	0	1	2	9	0	1	1	1	1	2	0	1	0	0	0	0	0
39	1	0	0	0	0	2	0	2	0	2	1	0	0	2	0	0	1	0	0	0	0
40	14	0	2	0	0	2	0	0	12	1	1	0	1	0	1	0	0	0	0	0	0
TOTAL	8080	6291	6281	6114	7598	8385	14085	9584	8875	6386	6789	8114	5609	2104	2208	770	1606	1423	2598	2446	3356
Samples	219	48	288	234	229	225	34	164	214	299	276	150	188	106	152	97	61	133	104	45	56
Catch (ton)	6725	4395	4023	3982	4135	4740	7270	7160	4767	3117	3657	4179	3290	1456	1420	664	847	629	943	1016	1303

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	2007	2008	2008	2009	2010	2011	2012
1	4	0	1	0	0	0	0	106	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
2	33	38	40	14	5	42	22	129	32	16	6	37	4	0	1	0	0	0	0	1	0	1	1
3	62	125	131	143	95	242	145	156	190	107	100	173	121	4	4	1	1	2	3	13	0	16	22
4	104	84	178	319	315	468	392	224	302	217	257	464	267	15	17	11	14	20	27	80	113	111	235
5	198	151	206	370	709	653	791	641	528	422	483	372	564	41	122	99	65	71	103	109	497	393	477
6	509	367	395	565	1162	926	1620	950	1118	916	1046	563	595	105	212	64	88	285	267	429	741	672	948
7	793	496	528	620	924	992	2213	962	983	1050	974	1190	736	222	323	116	106	410	371	238	348	447	514
8	1122	948	901	879	999	1271	3015	1238	1342	1170	1266	1709	1002	329	325	71	83	227	266	240	405	339	408
9	1080	1088	1062	912	922	1071	2226	1040	1693	913	874	1355	712	410	358	58	56	194	207	90	232	229	233
10	841	761	799	686	699	717	1216	808	1045	565	454	773	499	387	251	74	82	159	149	46	102	194	182
11	798	536	587	519	609	583	801	919	473	357	443	396	273	191	191	91	83	75	83	50	50	82	99
12	752	456	458	377	457	477	586	542	414	243	318	300	289	143	76	54	56	54	44	30	46	70	66
13	582	373	322	231	279	327	376	623	234	138	168	141	171	104	56	37	40	32	36	30	30	55	61
14	478	305	245	170	145	233	264	471	186	89	91	63	88	67	49	27	33	23	17	22	21	48	44
15	259	197	148	98	84	119	132	228	121	54	59	54	46	22	23	18	18	25	12	10	5	32	33
16	162	121	90	76	60	81	83	106	63	37	60	71	41	10	9	11	15	11	8	8	3	18	13
17	100	74	55	45	48	62	47	69	28	25	69	33	21	14	17	3	9	9	6	7	4	6	13
18	76	65	46	35	42	44	48	97	22	22	51	12	18	12	8	20	9	5	4	3	2	5	4
19	54	52	37	24	30	33	42	79	31	17	28	16	8	11	3	8	5	1	1	6	1	2	1
20	30	28	23	15	9	21	29	81	19	12	16	7	5	7	2	2	5	4	2	3	0	3	3
21	18	17	13	9	2	14	19	56	18	7	12	0	3	3	2	1	2	0	0	3	0	0	1
22	8	4	7	3	1	5	8	28	13	5	5	2	0	3	0	0	0	0	0	0	0	1	0
23	9	4	5	2	2	4	7	23	10	4	5	0	0	2	0	4	1	0	0	2	1	0	0
24	8	1	4	1	0	2	3	8	10	3	3	1	1	0	0	0	0	0	0	1	0	0	0
Total	8080	6291	6281	6112	7598	8385	14085	9584	8875	6388	6790	7736	5467	2104	2047	770	770	1606	1606	1423	2601	2723	3356

Mean Weight (gr)

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007	2008	2008	2009	2010	2011	2012
1	11		16				30	10	14	13	22	34	4	4		68							
2	40	51	49	80	165	107	107	127	116	99	61	91	41	62	16	93	68			90		31	35
3	86	77	85	113	156	147	143	180	158	137	154	148	102	80	109	105	102	52	56	118	38	53	57
4	119	111	115	143	184	211	177	244	194	176	218	213	192	114	161	161	167	90	97	164	98	90	105
5	186	184	173	230	216	262	229	317	243	227	268	278	269	195	212	256	245	147	162	212	165	138	137
6	258	236	236	325	260	300	281	365	276	271	306	299	317	262	265	383	342	213	227	262	220	179	182
7	337	320	313	434	348	355	342	434	327	324	353	333	375	343	343	410	397	305	302	321	297	239	260
8	440	414	412	524	451	421	403	487	393	397	414	423	473	437	434	516	503	423	426	444	396	364	378
9	594	500	509	612	560	516	490	591	498	499	498	483	568	538	561	619	602	494	486	556	549	479	516
10	748	585	590	677	653	618	600	677	568	587	607	616	726	669	609	848	807	527	566	648	744	638	656
11	922	736	716	776	767	743	749	785	725	709	692	854	836	810	788	1095	1116	665	686	817	887	849	898
12	1063	886	836	885	851	855	876	949	828	824	840	979	1072	988	1023	1199	1203	832	853	1067	1135	1103	1120
13	1226	1101	1039	1106	984	1033	1052	1151	1068	1033	989	1155	1361	1131	1282	1655	1589	1308	1325	1287	1416	1341	1332
14	1446	1324	1280	1443	1245	1252	1299	1305	1353	1343	1412	1521	1546	1198	1709	1876	1829	1209	1268	1544	1689	1561	1640
15	1683	1546	1530	1705	1696	1534	1544	1657	1561	1652	1565	1903	2234	1783	2160	1957	2119	816	1590	1617	1808	1752	1962
16	1928	1777	1729	1966	1837	1799	1823	1832	1787	1851	1852	1998	2330	2282	2457	2374	2375	1703	1909	1914	2266	1974	2219
17	2212	1989	2005	2220	2083	2257	2100	2023	2010	2132	2078	2407	2393	2578	2808	3715	2903	1853	2026	2301	2509	2316	2428
18	2478	2326	2333	2459	2197	2421	2466	2358	2441	2429	2440	3056	2496	2948	3377	2527	2786	1586	1788	2459	2655	2384	2669
19	2669	2508	2553	2643	2283	2534	2707	2474	2716	2662	2822	2954	2675	3426	3502	3065	2741	3220	3241	2562	2923	2575	2820
20	3052	2777	2889	2887	2643	2870	2942	2887	3207	3000	3140	2899	2719	3199	4089	3251	3269	1995	2037	2843	2997	2779	2855
21	3363	2898	3076	3029	3105	3198	3063	3036	3739	3263	2939	4177	3773	3411	5186	4213	3031	3639	3837	3465	3192	2971	3806
22	3993	3422	3637	3487	3192	3471	3663	3584	3851	3754	3807	3682	4384	4287		3830	4255	4255	3757	3477	3841	2868	
23	4092	3299	3525	3556	2514	3485	3592	3699	4289	3787	3240	4206	4534	3476		3369	3830			3126	3549	4169	
24	4998	4172	4453	4067		4541	4108	4442	4670	4493	4206	4220	4820							2873	4384	4062	4648

Mean Length (cm)

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007	2008	2008	2009	2010	2011	2012
1	4.7		5.5				5.1	3.6	4.7	4.1	4.0	4.8	2.2	3.5		6.5							
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	7.4	6.5			7.4		7.0	6.5
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	8.1	8.0	8.3	8.4	8.8	7.5	8.4	8.2
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	9.5	9.7	10.0	10.2	10.1	9.4	10.1	10.5
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	11.8	11.5	11.9	12.3	11.3	11.5	11.7	11.5
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	14.2	13.5	13.4	13.6	12.5	12.8	12.8	12.8
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	15.1	14.9	15.2	15.2	14.0	14.6	14.0	14.4
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	17.1	16.9	17.1	17.1	16.4	16.3	16.2	16.3
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	18.5	18.3	18.0	17.9	18.1	18.4	17.8	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	19.5	19.1	20.3	20.0	18.3	18.8	19.2	20.5	19.7	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	20.9	20.8	22.2	22.3	19.9	20.2	20.9	21.9	21.6	22.1
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	23.0	21.5	21.7	23.2	23.9	23.7	23.9
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	26.1	25.5	25.2	25.3	24.9	25.9	25.4	25.5
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	27.4	27.1	24.2	24.6	26.7	27.6	26.7	27.5
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	27.4	28.3	20.6	26.9	27.0	28.2	27.9	29.3
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	29.7	27.3	28.3	28.8	30.6	29.1	30.6
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	34.9	32.2	28.4	29.3	30.7	31.6	30.7	31.3
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	30.3	31.2	26.0	27.1	31.5	32.3	31.1	32.8
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	32.3	31.2	34.5	34.6	31.8	33.4	31.8	33.7
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	33.0	33.2	28.8	29.2	33.1	33.8	32.6	33.9
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	36.6	32.5	36.1	36.8	35.4	34.5	33.6	37.7
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		35.5	36.6	38.0	36.5	35.5	36.7	33.0	
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		34.0	35.5			34.1	35.8	37.3	
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	38.5	37.5	40.5

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 – 2012	2GHJ 3KLMNO	<1500 m
EU-Spanish Surveys in Div. 3NO	1997 - 2012	3NO	<1500 m
EU-Spanish Surveys in Div. 3L (Flemish pass)	2003-2004; 2006-2012	3L	100-1500 m.
EU Flemish Cap Surveys	1988 – 2012	3M	<730 m
	2004– 2012	3M	<1500 m
Canadian Spring Survey	1991 - 2012	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.

Year	EU-Spa 3NO	EU-Spa 3L	EU FC (>700)	EU FC (>1400)	Can Fall (2J+3K)	Can Spring	Can Deepwater
1978					7.00		
1979					5.88		
1980					7.29		
1981					4.66		
1982					5.67		
1983					5.22		
1984					4.82		
1985					2.49		
1986					2.49		
1987					2.12		
1988					1.91		
1989					1.20		
1990			1.06		2.36		
1991			1.66		1.60	270	
1992			1.96		0.59	1141	16215
1993			3.76		0.48	561	
1994			2.46		0.31	675	
1995	0.10		1.94		0.65	358	26588
1996	0.94		1.69		1.29	2883	46668
1997	3.81		1.49		1.48	3103	
1998	7.05		2.10		1.71	5078	
1999	4.53		1.55		1.50	4043	
2000	7.08		1.30		1.66	5095	
2001	5.73		2.59		2.45	4948	
2002	5.46		1.51		1.91	3116	
2003	7.40	21.16	2.92		1.73	4297	
2004	12.09	29.38	4.47	14.04	2.57	4361	
2005	11.10	*	2.97	10.26	2.42	15608	
2006	11.11	30.52	4.89	9.26	2.60	5415	
2007	6.93	29.77	1.70	5.94	3.02	13475	
2008	7.93	34.18	3.68	9.91	2.06	4977	
2009	9.15	27.17	0.97	5.96	3.41	4300	
2010	6.97	23.70	1.74	7.43	3.62	5722	
2011	6.82	18.57	0.86	7.19	4.34	4577	
2012	8.59	16.50	0.76	4.47	3.36	6713	

* Not available
In yellow, series with Engel 145 gear and in the case of the Can 2J+3K till 1000 meters depth coverage.
Years with coverage problems in red.

Table 7 .- EU Flemish Cap Survey till 700 m depth, EU Spanish 3NO survey, EU Flemish Cap till 1400 and Canadian Fall 2J+3K Mean Numbers Per Tow (MNPT) by age and year.

EU Flemish Cap till 700

Year\Ages	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1994	0.169	0.606	0.630	0.709	0.704	0.613	0.471	0.225	0.136	0.102	0.050	0.019	0.033	0.011
1995	0.261	0.581	1.071	0.736	0.642	0.570	0.328	0.140	0.044	0.029	0.024	0.006	0.019	0.000
1996	0.137	0.279	0.437	0.729	0.435	0.420	0.269	0.328	0.316	0.116	0.047	0.042	0.005	0.013
1997	0.231	0.190	0.195	0.561	0.762	0.202	0.196	0.122	0.188	0.205	0.154	0.052	0.052	0.010
1998	0.283	0.294	0.172	0.430	0.902	1.129	0.312	0.281	0.168	0.227	0.189	0.095	0.060	0.027
1999	0.061	0.268	0.247	0.307	0.554	0.767	0.526	0.245	0.136	0.099	0.069	0.076	0.041	0.004
2000	0.134	0.063	0.353	0.345	0.271	0.288	0.423	0.421	0.090	0.119	0.071	0.069	0.028	0.021
2001	0.336	0.149	0.352	0.553	0.671	0.628	0.633	0.827	0.287	0.163	0.100	0.129	0.068	0.037
2002	0.273	0.071	0.134	0.235	0.361	0.352	0.299	0.331	0.253	0.302	0.093	0.078	0.024	0.048
2003	1.339	0.836	0.768	0.789	1.048	1.120	0.665	0.590	0.587	0.293	0.110	0.038	0.022	0.021
2004	3.876	1.254	1.089	1.373	1.006	1.188	1.195	1.113	0.578	0.486	0.183	0.111	0.022	0.027
2005	0.451	0.948	0.781	0.678	0.620	0.739	0.513	0.720	0.461	0.208	0.282	0.237	0.026	0.011
2006	0.545	0.487	0.623	0.698	0.894	0.645	0.606	0.717	0.904	0.492	0.364	0.262	0.243	0.125
2007	0.073	0.044	0.108	0.251	0.333	0.371	0.221	0.429	0.214	0.134	0.118	0.096	0.048	0.042
2008	0.283	0.272	0.211	0.355	0.568	0.924	0.667	0.586	0.536	0.201	0.395	0.098	0.222	0.060
2009	0.055	0.036	0.005	0.068	0.057	0.154	0.107	0.082	0.152	0.079	0.070	0.079	0.059	0.042
2010	0.289	0.133	0.101	0.082	0.159	0.554	0.608	0.426	0.287	0.139	0.076	0.079	0.026	0.014
2011	0.092	0.083	0.046	0.062	0.073	0.141	0.241	0.307	0.148	0.084	0.051	0.038	0.020	0.016
2012	0.098	0.017	0.031	0.030	0.050	0.122	0.154	0.161	0.191	0.104	0.054	0.028	0.017	0.001

EU Spain 3NO

Year\Ages	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1997	0.166	0.327	0.453	1.388	2.628	0.881	0.850	0.451	0.587	0.550	0.271	0.088	0.053	0.028
1998	0.801	1.554	1.129	1.629	2.892	4.208	1.461	1.277	0.533	0.644	0.605	0.264	0.204	0.066
1999	1.451	3.040	3.310	2.294	2.061	2.084	0.973	0.391	0.229	0.147	0.105	0.102	0.082	0.028
2000	1.220	0.895	7.042	5.508	2.505	1.612	1.565	1.339	0.229	0.272	0.145	0.221	0.117	0.072
2001	0.729	0.810	2.460	3.730	3.744	2.134	1.373	1.451	0.343	0.131	0.088	0.054	0.053	0.045
2002	0.497	0.308	0.772	1.445	2.011	1.591	1.104	1.089	0.577	0.771	0.188	0.150	0.099	0.156
2003	1.506	1.053	1.166	1.884	3.650	3.706	1.656	1.151	0.987	0.449	0.309	0.140	0.164	0.160
2004	3.632	2.263	2.307	2.766	2.641	3.487	3.855	3.341	1.555	0.907	0.524	0.283	0.106	0.095
2005	1.890	2.430	2.509	2.901	2.098	3.111	2.077	2.815	1.672	0.916	1.124	0.673	0.227	0.074
2006	1.441	1.030	1.507	2.073	2.716	2.261	2.264	2.431	2.853	1.472	0.821	0.489	0.277	0.208
2007	0.834	0.810	1.363	1.622	1.572	1.540	0.879	1.642	1.210	0.735	0.555	0.364	0.126	0.101
2008	0.706	1.029	1.026	1.417	1.717	1.723	1.097	1.180	1.166	0.657	0.989	0.290	0.332	0.100
2009	0.665	0.912	0.563	1.840	1.729	3.467	1.477	0.720	1.350	0.733	0.950	0.647	0.546	0.314
2010	1.009	0.522	0.737	0.837	1.028	2.368	1.506	0.730	0.623	0.687	0.667	0.612	0.202	0.141
2011	0.335	0.447	0.351	0.632	1.035	1.809	1.677	1.613	0.625	0.625	0.428	0.410	0.300	0.197
2012	1.442	1.194	1.391	0.852	1.434	2.413	1.801	0.970	0.898	0.770	0.656	0.512	0.317	0.132

EU Flemish Cap till 1400

Year\Ages	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2004	5.766	2.603	2.499	2.933	2.347	2.822	2.515	2.475	1.315	1.247	0.584	0.539	0.179	0.296
2005	1.173	1.898	1.981	2.201	1.691	1.942	1.173	1.378	0.910	0.540	0.884	0.844	0.262	0.168
2006	0.827	1.105	1.368	1.564	1.767	1.229	1.224	1.281	1.300	0.673	0.629	0.478	0.467	0.324
2007	0.167	0.251	0.401	0.786	0.903	0.880	0.519	0.801	0.527	0.368	0.328	0.341	0.210	0.238
2008	0.887	1.036	1.036	1.288	1.595	1.641	1.347	1.187	1.088	0.511	0.960	0.286	0.590	0.203
2009	0.253	0.341	0.204	0.791	0.765	1.379	0.706	0.412	0.669	0.448	0.461	0.393	0.351	0.261
2010	0.508	0.503	0.615	0.884	0.863	1.956	1.177	0.735	0.573	0.459	0.372	0.425	0.208	0.211
2011	0.251	0.371	0.437	0.588	0.768	1.114	0.923	0.836	0.474	0.466	0.373	0.409	0.322	0.258

2012	0.330	0.285	0.334	0.284	0.467	0.859	0.751	0.422	0.531	0.401	0.350	0.251	0.176	0.090
Canadian Fall 2J+3K														
Year\Ages	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1995	0.330	0.355	0.517	0.354	0.173	0.104	0.057	0.028	0.013	0.009	0.006	0.003	0.015	0.000
1996	1.161	1.018	0.731	0.777	0.324	0.281	0.155	0.167	0.140	0.038	0.014	0.013	0.004	0.008
1997	1.302	0.922	0.527	0.844	0.822	0.241	0.234	0.126	0.107	0.108	0.069	0.025	0.021	0.010
1998	1.067	0.868	0.580	0.702	0.724	0.699	0.247	0.233	0.102	0.124	0.112	0.047	0.037	0.010
1999	0.757	0.679	0.588	0.515	0.529	0.525	0.382	0.214	0.133	0.068	0.044	0.038	0.025	0.008
2000	0.870	0.262	1.052	0.710	0.418	0.328	0.397	0.414	0.087	0.117	0.052	0.085	0.034	0.026
2001	1.637	0.767	0.977	0.817	0.806	0.597	0.442	0.506	0.188	0.099	0.061	0.051	0.027	0.023
2002	0.686	0.333	0.612	0.504	0.452	0.548	0.424	0.431	0.209	0.245	0.076	0.043	0.024	0.035
2003	0.981	0.447	0.505	0.592	0.587	0.511	0.323	0.316	0.332	0.177	0.096	0.041	0.029	0.027
2004	1.631	0.938	0.915	0.958	0.634	0.658	0.549	0.516	0.247	0.162	0.087	0.038	0.013	0.012
2005	0.545	0.630	0.635	0.743	0.662	0.792	0.411	0.494	0.306	0.169	0.175	0.123	0.048	0.009
2006	0.669	0.657	0.806	0.802	0.953	0.614	0.521	0.498	0.451	0.204	0.171	0.093	0.041	0.034
2007	0.717	0.683	1.029	0.947	1.017	1.011	0.483	0.697	0.408	0.226	0.135	0.098	0.031	0.027
2008	0.643	0.851	0.783	0.891	0.830	0.668	0.477	0.304	0.247	0.075	0.082	0.029	0.020	0.009
2009	0.599	0.702	0.394	1.364	0.900	1.517	0.782	0.388	0.574	0.232	0.183	0.124	0.103	0.051
2010	0.716	0.561	0.548	0.814	0.814	1.493	1.104	0.592	0.343	0.233	0.185	0.139	0.044	0.034
2011	0.710	0.617	0.559	0.566	0.658	0.932	0.922	0.956	0.506	0.502	0.279	0.214	0.146	0.082
2012	0.942	0.720	0.640	0.449	0.594	1.006	0.906	0.494	0.503	0.285	0.160	0.119	0.094	0.041

Table 9 .- XSA result for Recruitment (Age 3), Total biomass and mean F ages 6 to 13(Fbar) for the different runs..

	Biomass (tons)				**Fbar (6-13)**			
Year	**Run 1**	**Run2**	**Run 3**	**Run 4**	**Run 1**	**Run2**	**Run 3**	**Run 4**
1992	37445	32645	40093	37310	0.224	0.268	0.214	0.230
1993	33642	28759	37098	33931	0.174	0.213	0.165	0.180
1994	35351	29935	39903	36000	0.166	0.207	0.157	0.173
1995	45693	39293	53191	47522	0.124	0.157	0.112	0.125
1996	46349	40334	54997	48735	0.136	0.173	0.117	0.132
1997	50497	44452	60274	53198	0.135	0.157	0.110	0.125
1998	54944	47357	66696	58084	0.233	0.259	0.182	0.208
1999	67799	55058	84573	72656	0.184	0.213	0.136	0.161
2000	58276	48856	77713	65851	0.149	0.169	0.106	0.127
2001	57550	49346	80400	67782	0.088	0.096	0.063	0.076
2002	64007	56137	92090	77879	0.083	0.090	0.059	0.070
2003	58064	52438	87245	74651	0.083	0.092	0.060	0.071
2004	66445	60224	102512	87179	0.061	0.066	0.041	0.049
2005	72236	66559	117663	98413	0.029	0.032	0.020	0.023
2006	96707	88946	157745	133632	0.028	0.030	0.017	0.019
2007	97668	90542	159278	137207	0.010	0.010	0.006	0.006
2008	68598	63487	111975	98433	0.022	0.023	0.011	0.012
2009	94258	85318	154509	135800	0.019	0.019	0.008	0.009
2010	97244	86460	158519	142772	0.038	0.037	0.015	0.015
2011	71287	66253	129658	118971	0.047	0.046	0.019	0.019

2012	73935	69999	144586	134287	0.074	0.072	0.025	0.025

Recruitment age 3 (Thousands)

Year	Run 1	Run2	Run 3	Run 4
1992	16772	16540	19500	18067
1993	25488	24673	31880	28741
1994	26939	26396	33850	29895
1995	24258	23829	29586	26058
1996	24387	22717	29637	25842
1997	28418	25338	33327	30048
1998	29568	27331	37465	33212
1999	22806	21865	31396	27961
2000	19766	19025	30673	27639
2001	15804	14929	27094	25182
2002	15635	14980	28505	26768
2003	14620	13844	29794	28848
2004	17661	16125	36318	35325
2005	13871	13727	30797	30322
2006	11339	11853	28805	29526
2007	9034	9979	23464	23941
2008	9299	9160	21593	21805
2009	6770	6770	18558	18775
2010	10153	8715	23954	24213
2011	8281	8044	23668	25409
2012	16270	14420	33892	35855

Table 10 .- Correlation between the Canadian fall 2J+3K (1995-2012), EU Spanish 3NO (1997-2012), EU Flemish Cap till 700 (1992-2012) and 1400 meters (2004-2012) surveys series.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

1 Canadian 2J3K, Yield	1.000 17				
2 Spanish 3NO (1400 m)	0.318 15	1.000 16			
3 Spanish Flemish Cap (1400 m)	-0.581 8	0.690 9	1.000 9		
4 3M Flemish Cap (700 m)	-0.133 17	0.608 16	0.824 9	1.000 21	
5 Canadian 2J3K, 1000	0.000 0	0.000 0	0.000 0	0.115 3	1.000 8
	1	2	3	4	5

Table 11 .- Catch series and survey indices (Canadian fall 2J+3K (1987-1994), EU Spanish 3NO (1997-2012), EU Flemish Cap till 700 (1992-2003) and 1400 meters (2004-2012)) used in the ASPIC production model.

Year	Catches	EU 3NO (CC)	EU FC 1400 (I1)	EU FC 700 (I1)	Can 2J+3K Engel (I2)
1987	1001	-1.00	-1.00	-1.00	7.00
1988	960	-1.00	-1.00	-1.00	5.88
1989	333	-1.00	-1.00	-1.00	7.29
1990	3294	-1.00	-1.00	-1.00	4.66
1991	4268	-1.00	-1.00	-1.00	5.67
1992	6730	-1.00	-1.00	1.96	5.22
1993	4400	-1.00	-1.00	3.76	4.82
1994	4020	-1.00	-1.00	2.46	2.49
1995	3980	-1.00	-1.00	1.94	-1.00
1996	4140	-1.00	-1.00	1.69	-1.00
1997	4740	3.81	-1.00	1.49	-1.00
1998	7270	7.05	-1.00	2.10	-1.00
1999	7160	4.53	-1.00	1.56	-1.00
2000	4770	7.08	-1.00	1.31	-1.00
2001	3120	5.73	-1.00	2.58	-1.00
2002	3660	5.46	-1.00	1.50	-1.00
2003	3980	7.40	-1.00	2.92	-1.00
2004	3180	12.09	14.52	-1.00	-1.00
2005	1460	11.10	10.26	-1.00	-1.00
2006	1420	11.11	9.26	-1.00	-1.00
2007	664	6.93	5.94	-1.00	-1.00
2008	847	7.93	9.91	-1.00	-1.00
2009	629	9.15	5.97	-1.00	-1.00
2010	941	6.97	7.42	-1.00	-1.00
2011	1016	6.82	7.19	-1.00	-1.00
2012	1303	8.59	4.47	-1.00	-1.00

Table 12 .- ASPIC input file with the default specifications recommend by Prager (1994) and used in Run 1.

```
FIT                                          ## Run type (FIT, BOT, or IRF)
"NAFO Subareas 2+3 RHG 2011"
LOGISTIC  YLD    SSE
112                                           ## Verbosity
500  50                                       ## Number of bootstrap trials, <= 1000
0  20000                                      ## 0=no MC search, 1=search, 2=repeated srch; N trials
1.0000E-08                                   ## Convergence crit. for simplex
3.0000E-08  6                                ## Convergence crit. for restarts, N restarts
1.0000E-04  12                               ## Conv. crit. for F; N steps/yr for gen. model
8.0000                                       ## Maximum F when cond. on yield
0.0                                          ## Stat weight for B1>K as residual (usually 0 or 1)
4                                            ## Number of fisheries (data series)
1.0000E+00  1.0000E+00  1.0000E+00  1.0000E+00    ## Statistical weights for data series
0.5000                                       ## B1/K (starting guess, usually 0 to 1)
5.0000E+03                                    ## MSY (starting guess)
1.0000E+05                                   ## K (carrying capacity) (starting guess)
2.0000E-04  9.0000E-05  6.0000E-05  6.0000E-05    ## q (starting guesses -- 1 per data series)
1  1  1  1  1  1  1                          ## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
```

5.0000E+02 5.0000E+04 ## Min and max constraints -- MSY
1.0000E+04 5.0000E+06 ## Min and max constraints -- K

Table 13 .- Values estimated by the ASPIC model for the parameters in the different runs as well as same fit indices. . In red parameters values close to the limits.

	RUN1	RUN2	RUN3	RUN4	RUN5	RUN6	RUN7	RUN8
Iter	5	203	10	17	11	11	32	35
TOTAL OBJECTIVE FUNCTION:	4.12	3.99	4.39	4.39	4.00	4.04	3.99	3.99
Estimated contrast index (ideal = 1.0):	0.57	0.43	0.02	0.03	0.53	0.68	0.43	0.43
Estimated nearness index (ideal = 1.0):	0.53	0.89	0.82	0.68	0.88	0.88	0.89	0.89
MODEL PARAMETER ESTIMATES								
----------	----------							
Parameter	Estimate							
B1/K Starting relative biomass (in 1987)	1.55	1.04	0.70	0.85	1.15	1.30	1.04	1.04
MSY Maximum sustainable yield	50000	6728	500	500	6704	6710	6728	6727
K Maximum population size	566600	16150	2947000	2588000	17240	18360	16140	16160
phi Shape of production curve (Bmsy/K)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Survey Indices	----------				---------			----------
q(1) Spanish 3NO (1400 m)	0.000013	0.000532	0.000004	0.000003	0.000499	0.000469	0.000533	0.000532
q(2) Spanish Flemish Cap (1400 m)	0.000014	0.000520	0.000004	0.000004	0.000487	0.000458	0.000520	0.000520
q(3) 3M Flemish Cap (700 m)	0.000004	0.000164	0.000001	0.000001	0.000154	0.000144	0.000164	0.000164
q(4) Canadian 2J3K, 1000	0.000008	0.000371	0.000003	0.000002	0.000346	0.000322	0.000371	0.000371
----------	----------							
Parameter	Estimate							
MSY Maximum sustainable yield	50000	6728	500	500	6704	6710	6728	6727
Bmsy Stock biomass giving MSY	283300	8076	1473000	1294000	8622	9179	8070	8079
Fmsy Fishing mortality rate at MSY	0.177	0.833	0.00034	0.000	0.778	0.731	0.834	0.833
n Exponent in production function	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
g Fletcher's gamma	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.000
B./Bmsy Ratio: B(2012)/Bmsy	1.99	1.90	1.35	1.64	1.90	1.91	1.90	1.90
F./Fmsy Ratio: F(2011)/Fmsy	0.013	0.101	1.925	1.585	0.102	0.102	0.101	0.101
Fmsy/F. Ratio: Fmsy/F(2011)	76.28	9.87	0.52	0.63	9.83	9.85	9.87	9.87
Y.(Fmsy) Approx. yield available at Fmsy in	92000	10060	677	822	10130	10240	10060	10060
...as proportion of MSY	1.84	1.50	1.35	1.64	1.51	1.53	1.50	1.50
Ye. Equilibrium yield available in 2012	1223.00	1233.00	437.40	292.50	1227.00	1216.00	1229.00	1233.00
...as proportion of MSY	0.02	0.18	0.87	0.58	0.18	0.18	0.18	0.18

Table 14 .- Values estimated by the ASPIC model for F, Biomass and yield and the correspondent F/Fmsy and B/Bmsy ratios

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1987	0.062	1.680E+04	1.615E+04	1.001E+03	1.001E+03	-8.452E+00	7.439E-02	2.080E+00
2	1988	0.061	1.579E+04	1.567E+04	9.600E+02	9.600E+02	7.771E+02	7.353E-02	1.955E+00
3	1989	0.021	1.560E+04	1.578E+04	3.330E+02	3.330E+02	6.094E+02	2.534E-02	1.932E+00
4	1990	0.220	1.588E+04	1.495E+04	3.294E+03	3.294E+03	1.829E+03	2.644E-01	1.966E+00
5	1991	0.309	1.441E+04	1.382E+04	4.268E+03	4.268E+03	3.314E+03	3.706E-01	1.785E+00
6	1992	0.547	1.346E+04	1.231E+04	6.730E+03	6.730E+03	4.853E+03	6.565E-01	1.667E+00
7	1993	0.366	1.158E+04	1.201E+04	4.400E+03	4.400E+03	5.123E+03	4.396E-01	1.434E+00
8	1994	0.318	1.231E+04	1.264E+04	4.020E+03	4.020E+03	4.575E+03	3.817E-01	1.524E+00
9	1995	0.306	1.286E+04	1.301E+04	3.980E+03	3.980E+03	4.219E+03	3.673E-01	1.593E+00
10	1996	0.316	1.310E+04	1.309E+04	4.140E+03	4.140E+03	4.130E+03	3.795E-01	1.622E+00
11	1997	0.369	1.309E+04	1.286E+04	4.740E+03	4.740E+03	4.364E+03	4.424E-01	1.621E+00
12	1998	0.627	1.271E+04	1.159E+04	7.270E+03	7.270E+03	5.426E+03	7.529E-01	1.574E+00
13	1999	0.695	1.087E+04	1.030E+04	7.160E+03	7.160E+03	6.208E+03	8.340E-01	1.346E+00
14	2000	0.448	9.919E+03	1.065E+04	4.770E+03	4.770E+03	6.031E+03	5.376E-01	1.228E+00
15	2001	0.255	1.118E+04	1.224E+04	3.120E+03	3.120E+03	4.913E+03	3.060E-01	1.384E+00
16	2002	0.277	1.297E+04	1.319E+04	3.660E+03	3.660E+03	4.024E+03	3.330E-01	1.606E+00
17	2003	0.299	1.334E+04	1.330E+04	3.980E+03	3.980E+03	3.915E+03	3.593E-01	1.651E+00
18	2004	0.235	1.327E+04	1.355E+04	3.180E+03	3.180E+03	3.635E+03	2.817E-01	1.643E+00
19	2005	0.101	1.373E+04	1.441E+04	1.460E+03	1.460E+03	2.576E+03	1.216E-01	1.700E+00
20	2006	0.094	1.484E+04	1.504E+04	1.420E+03	1.420E+03	1.729E+03	1.134E-01	1.838E+00
21	2007	0.043	1.515E+04	1.544E+04	6.640E+02	6.640E+02	1.128E+03	5.161E-02	1.876E+00
22	2008	0.054	1.562E+04	1.562E+04	8.470E+02	8.470E+02	8.546E+02	6.508E-02	1.934E+00
23	2009	0.040	1.562E+04	1.569E+04	6.290E+02	6.290E+02	7.405E+02	4.811E-02	1.935E+00
24	2010	0.060	1.574E+04	1.565E+04	9.410E+02	9.410E+02	8.074E+02	7.217E-02	1.948E+00
25	2011	0.065	1.560E+04	1.556E+04	1.016E+03	1.016E+03	9.494E+02	7.838E-02	1.932E+00
26	2012	0.084	1.554E+04	1.543E+04	1.303E+03	1.303E+03	1.142E+03	1.013E-01	1.924E+00
27	2013		1.537E+04						1.904E+00

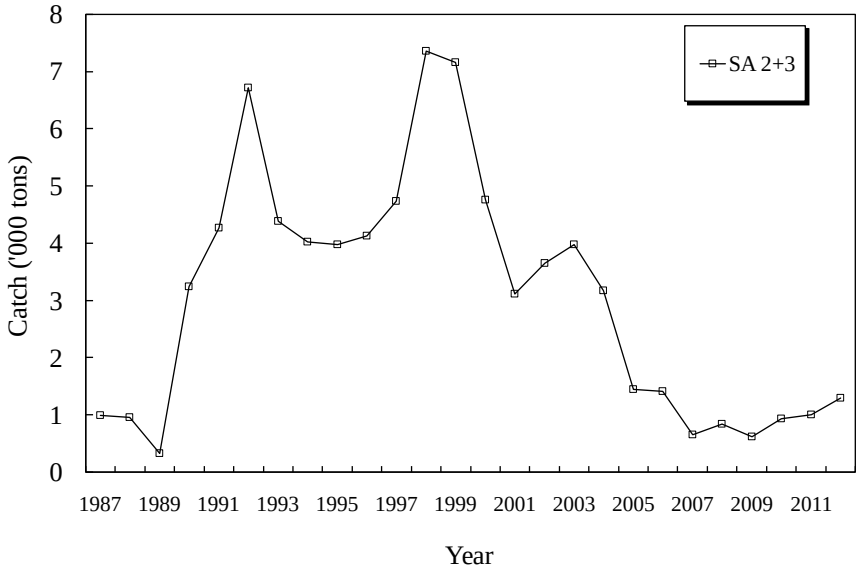

Fig. 1-. STACFIS Roughhead grenadier NAFO Subarea 2 and 3 nominal catches (t).

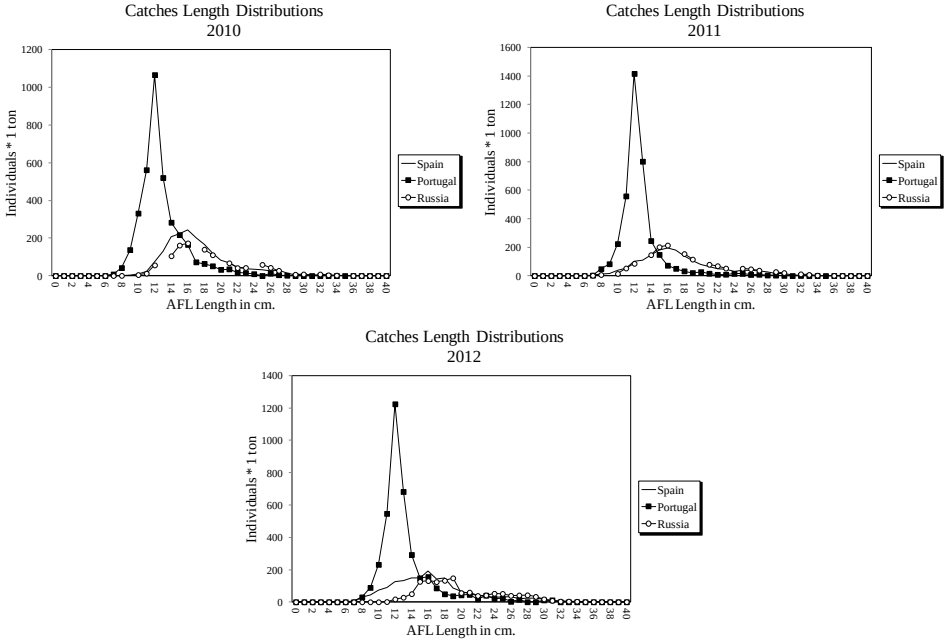

Fig. 2-. Suabarea 2+3 Roughhead grenadier Spanish, Portuguese and Russian catches length distributions (individuals per ton) for 2010-2012.

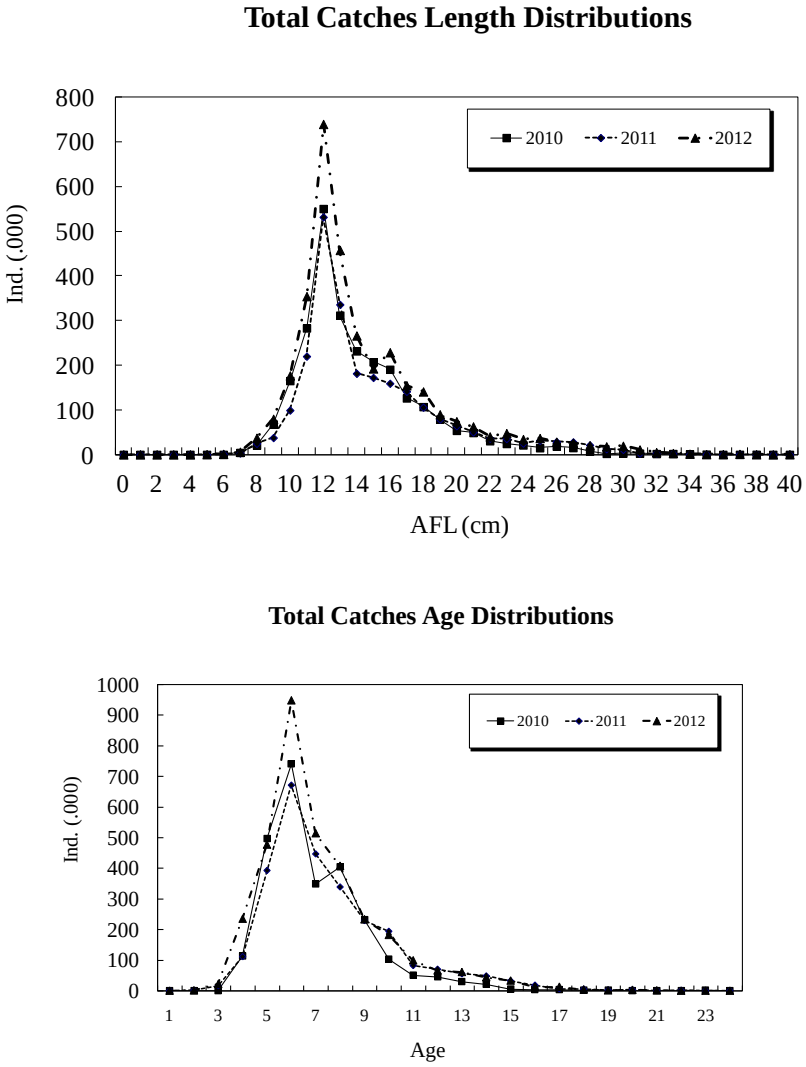

Fig. 3-. Suabarea 2+3 Roughhead grenadier total catches length and Age distributions for 2010-2012.

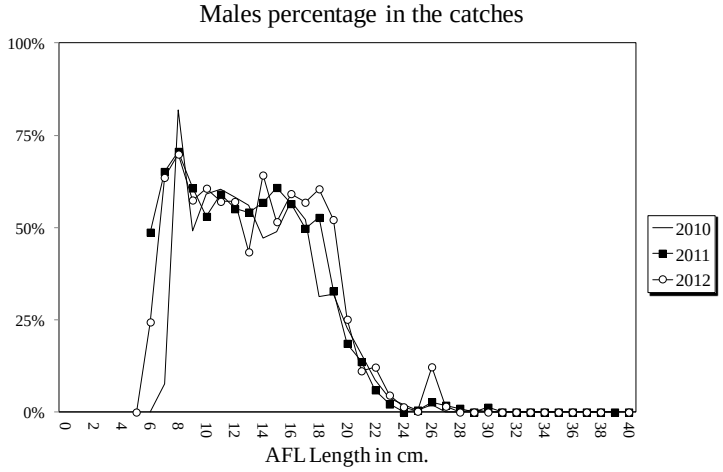

Fig. 4-. Suabarea 2+3 Roughhead grenadier sex ratio by length for 2010-2012. Based on the Spanish and Portuguese commercial length samples.

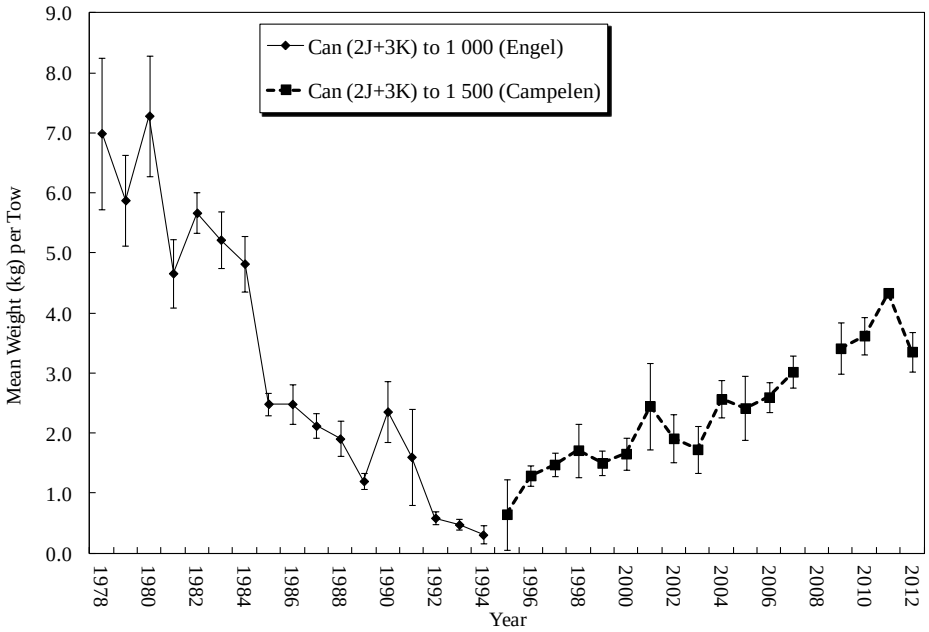

Fig. 5- Roughhead grenadier in Subareas 2+3: biomass index (+/- SE) from the Canadian autumn (Div. 2J3K) survey

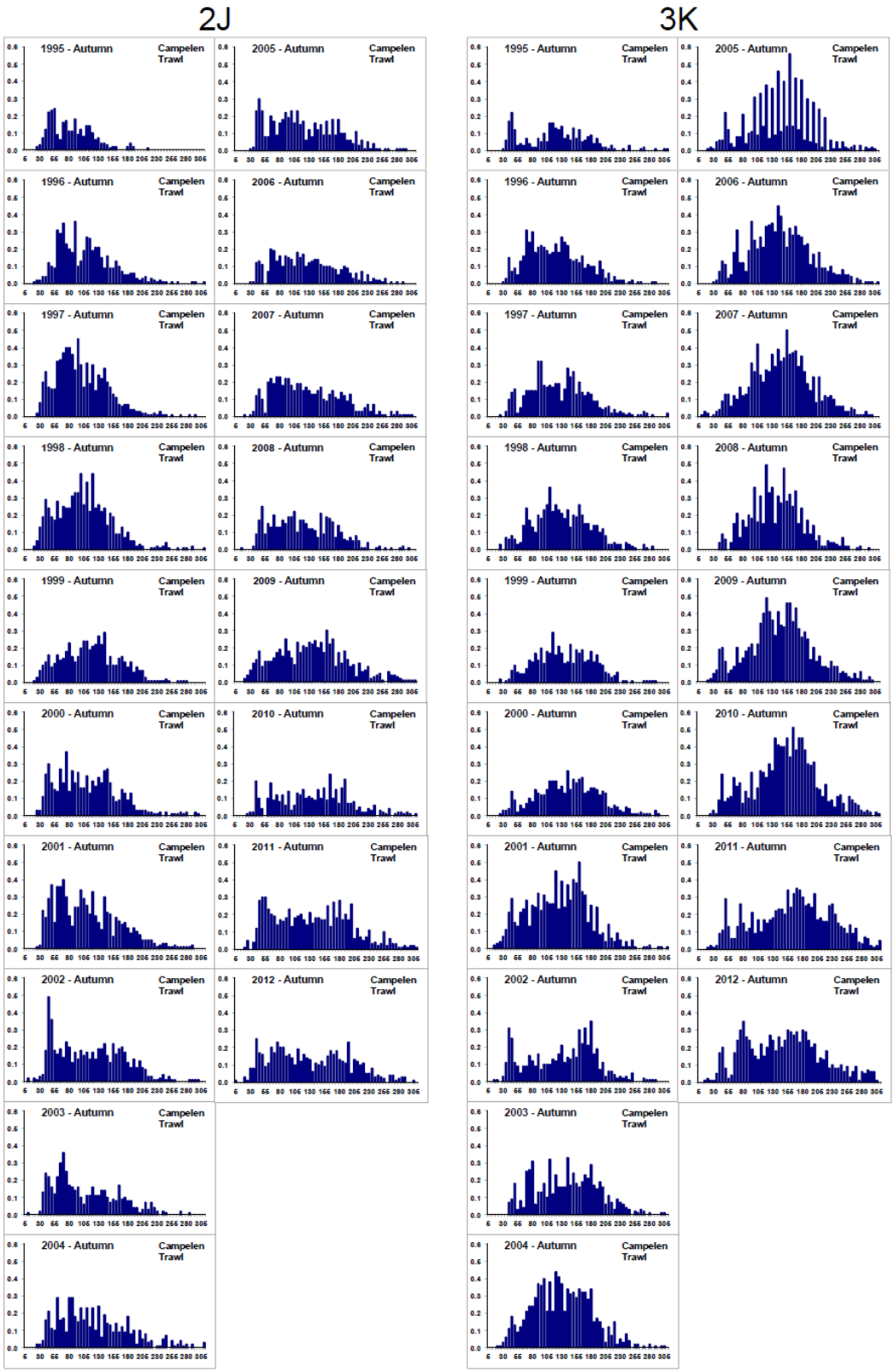

Fig. 6 -. Roughhead Grenadier length frequency distribution from Canadian Autumn surveys to Div. 2J3K. Mean Number Per Tow (MNPT). X-axis is AFL measure in mm.. (D. Power, DFO St. John's pers. comm.).

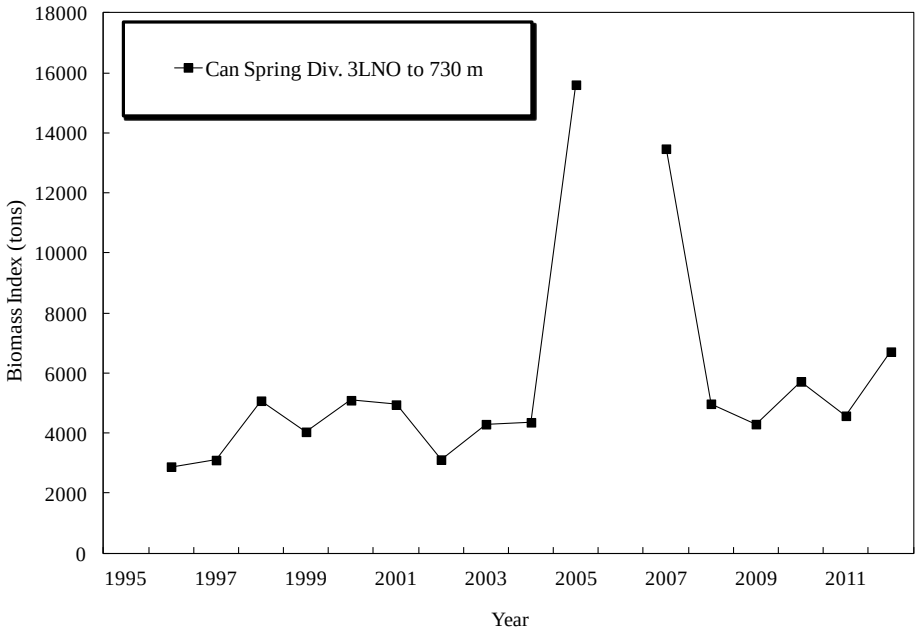

Fig 7.- Roughhead grenadier in Subareas 2+3: biomass index from the Canadian spring surveys.

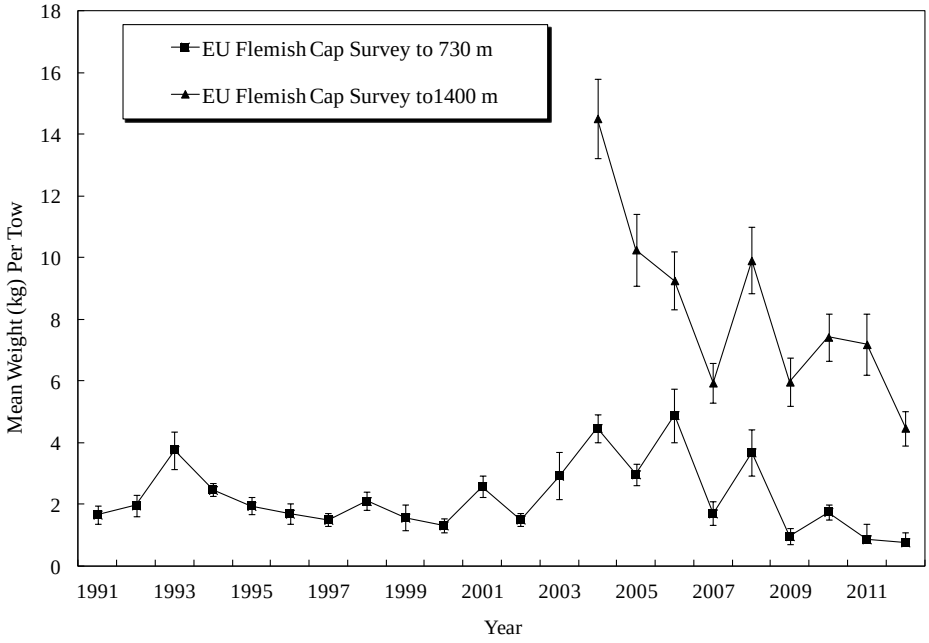

Fig. 8.-. Roughhead grenadier in Subareas 2+3: biomass index (+/- SE) from the EU Flemish Cap survey.

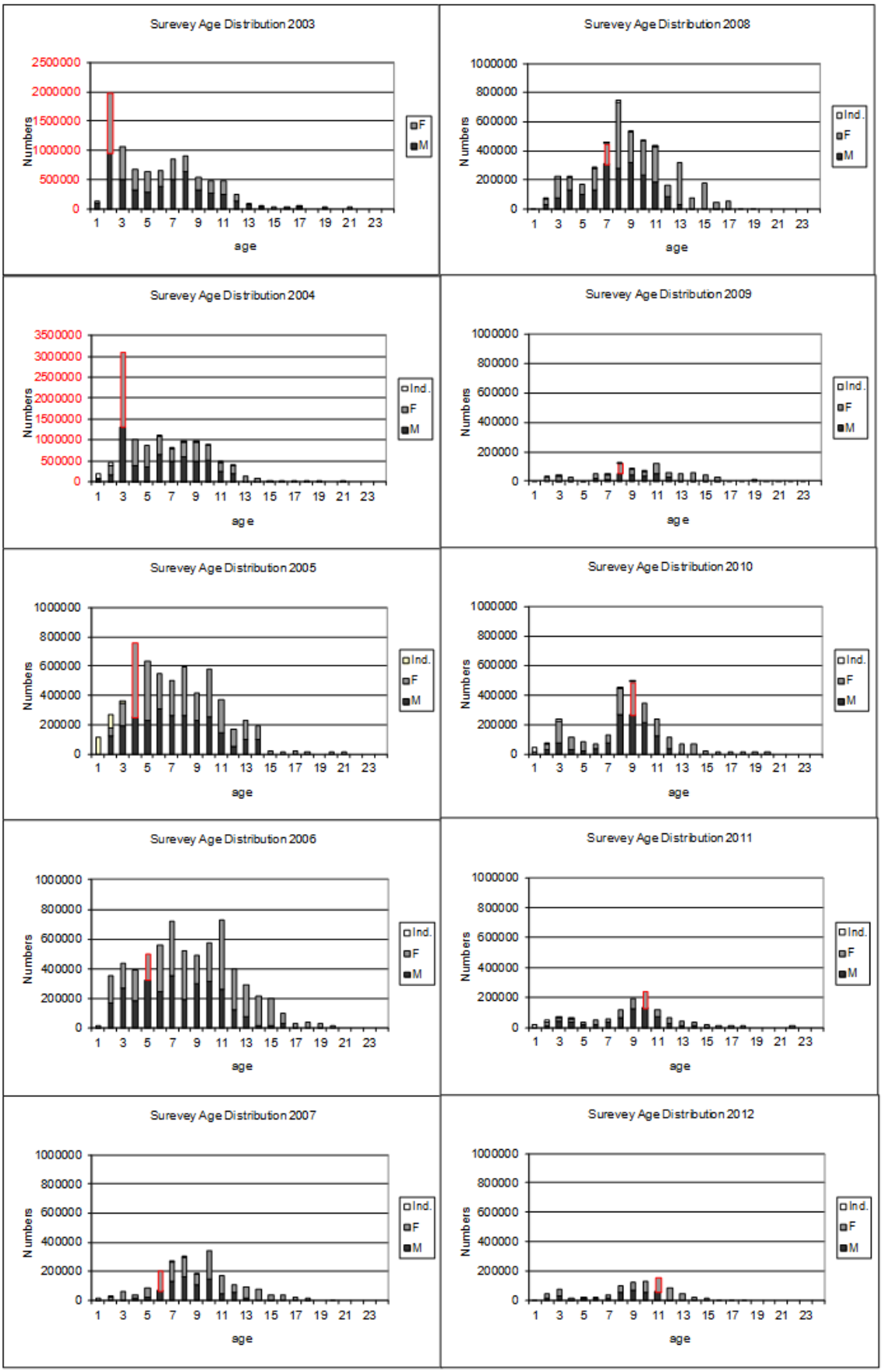

Fig. 9. – EU Flemish Cap survey age distribution, by sex till 700 m. Axis y in red different scale. Females 2001 cohort in red.

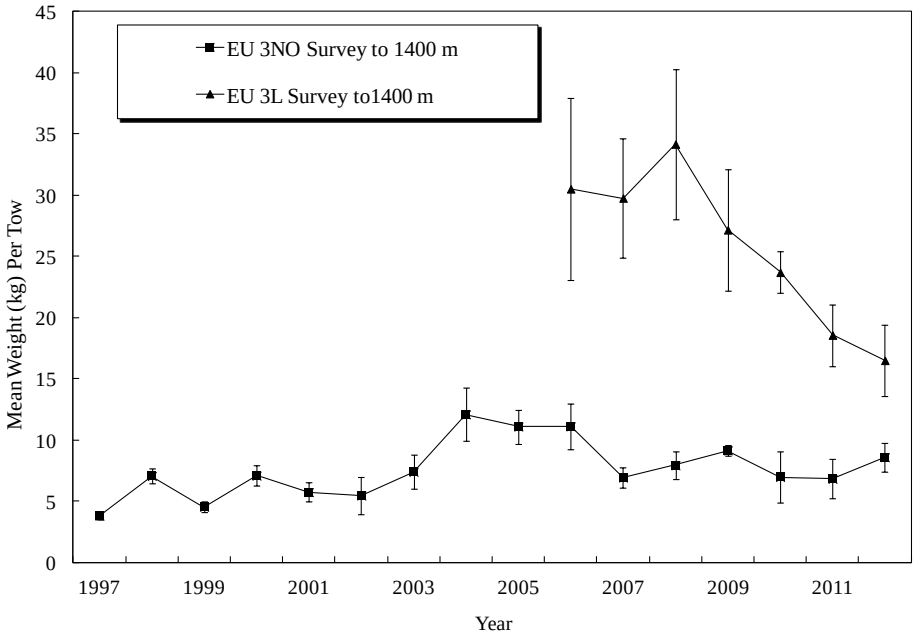

Fig. 10.- Roughhead grenadier in Subareas 2+3: biomass index (+/- SE) from the EU Spanish Div. 3NO and 3L surveys.

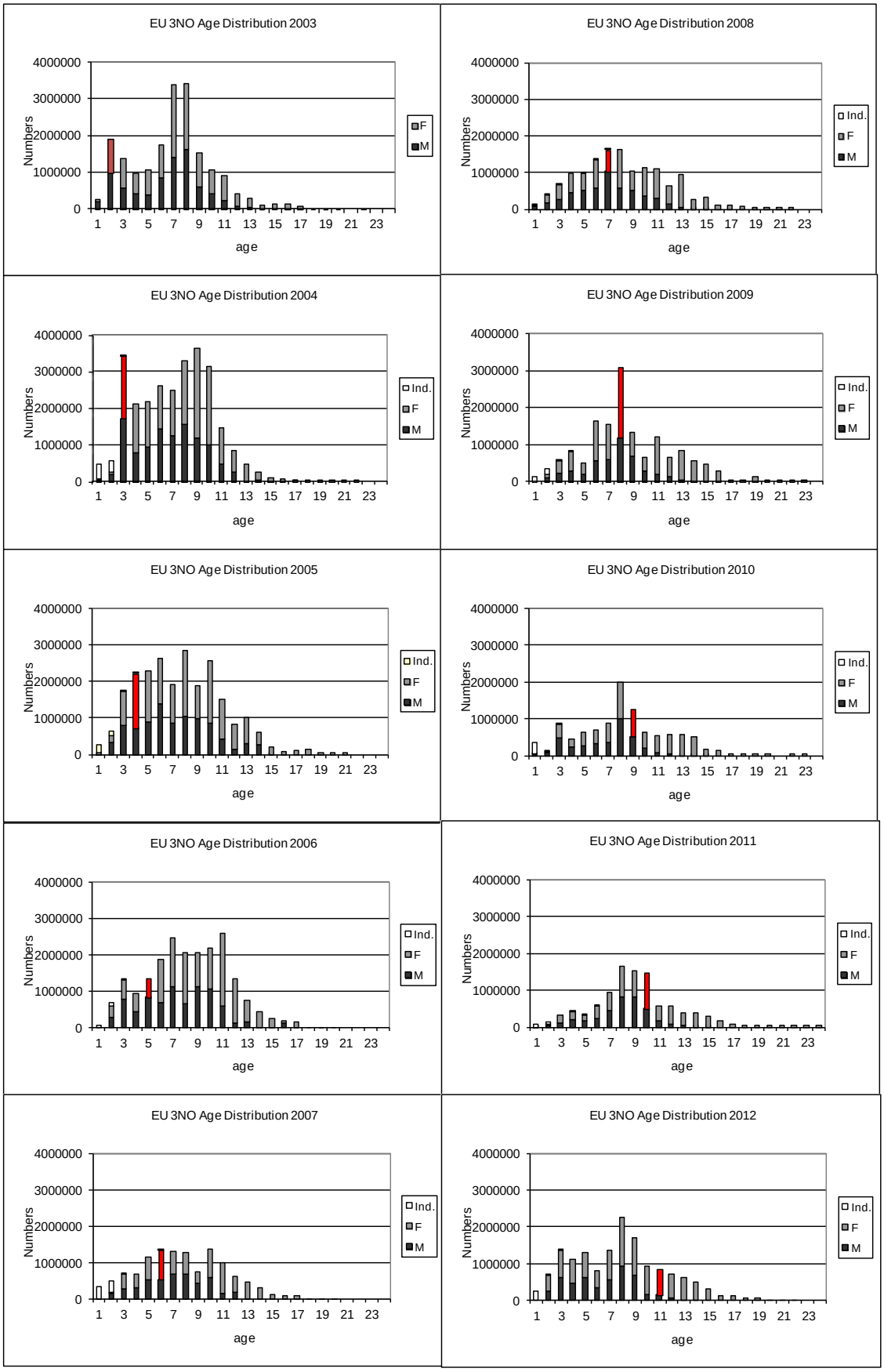

Fig. 11 . – EU 3NO survey age distribution, by sex. Females 2001 cohort in red.

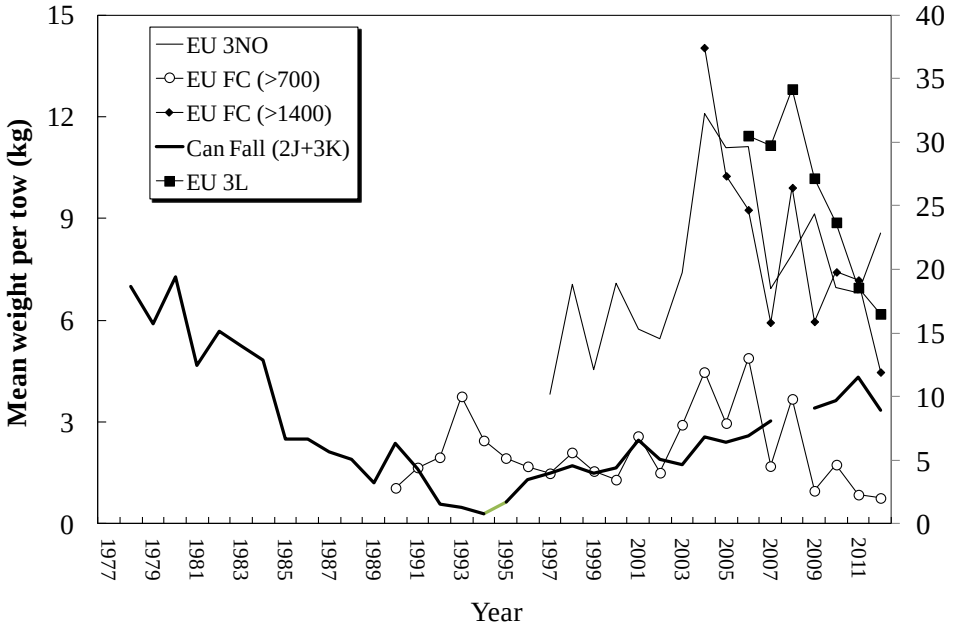

Fig. 12- Roughhead grenadier in Subareas 2+3: MWPT biomass indices from Canadian fall 2J+3K (1978-2012), EU 3NO (1997-2012), EU 3L (2006-2012), EU Flemish Cap till 700 m. (1990-2012) and EU Flemish Cap till 1400 m.(2004-2012) surveys.

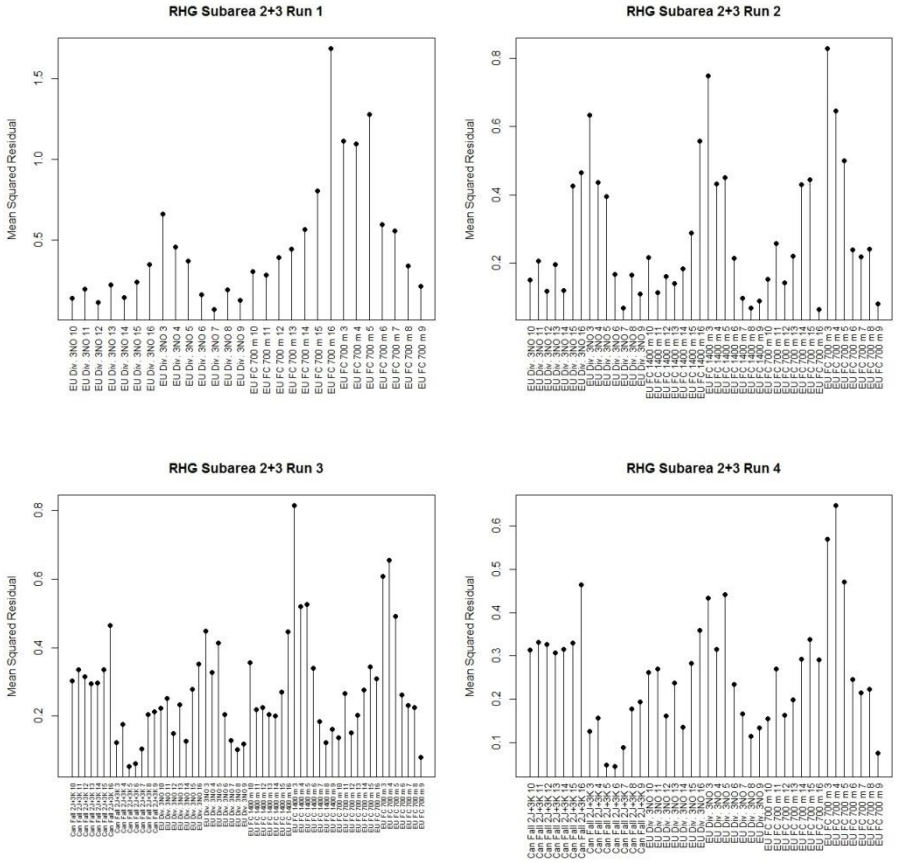

Fig. 13 – Standard Error (SE) of the log catchability for EU Flemish Cap till 700 and 1400 meters, EU Spanish 3NO surveys and the Canadian fall 2J+3K by and age.

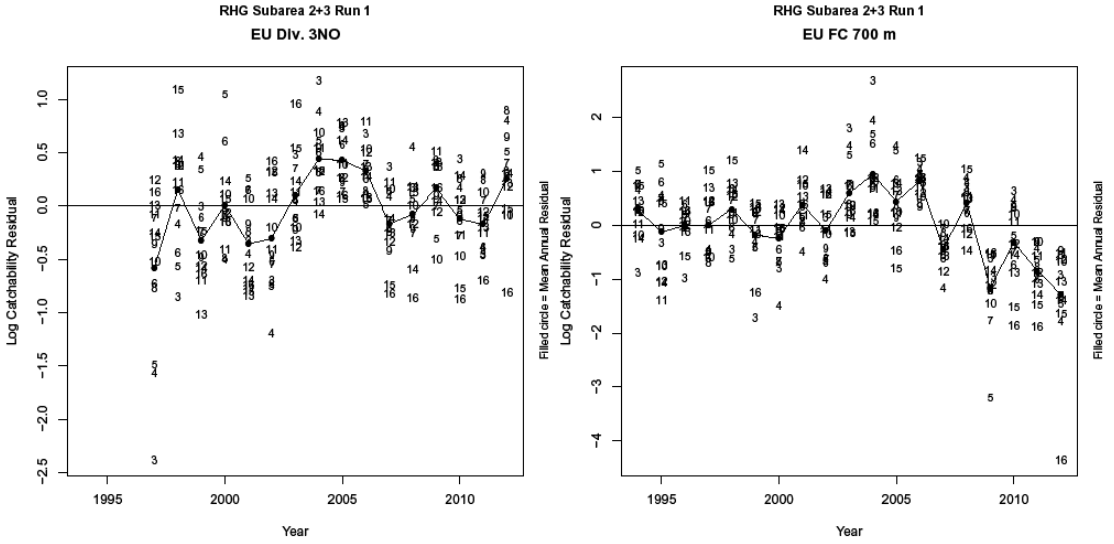

Fig. 14 – Log catchability residuals for Run 1 (EU Flemish Cap till 700 and UE Spanish 3NO surveys) by year and age.

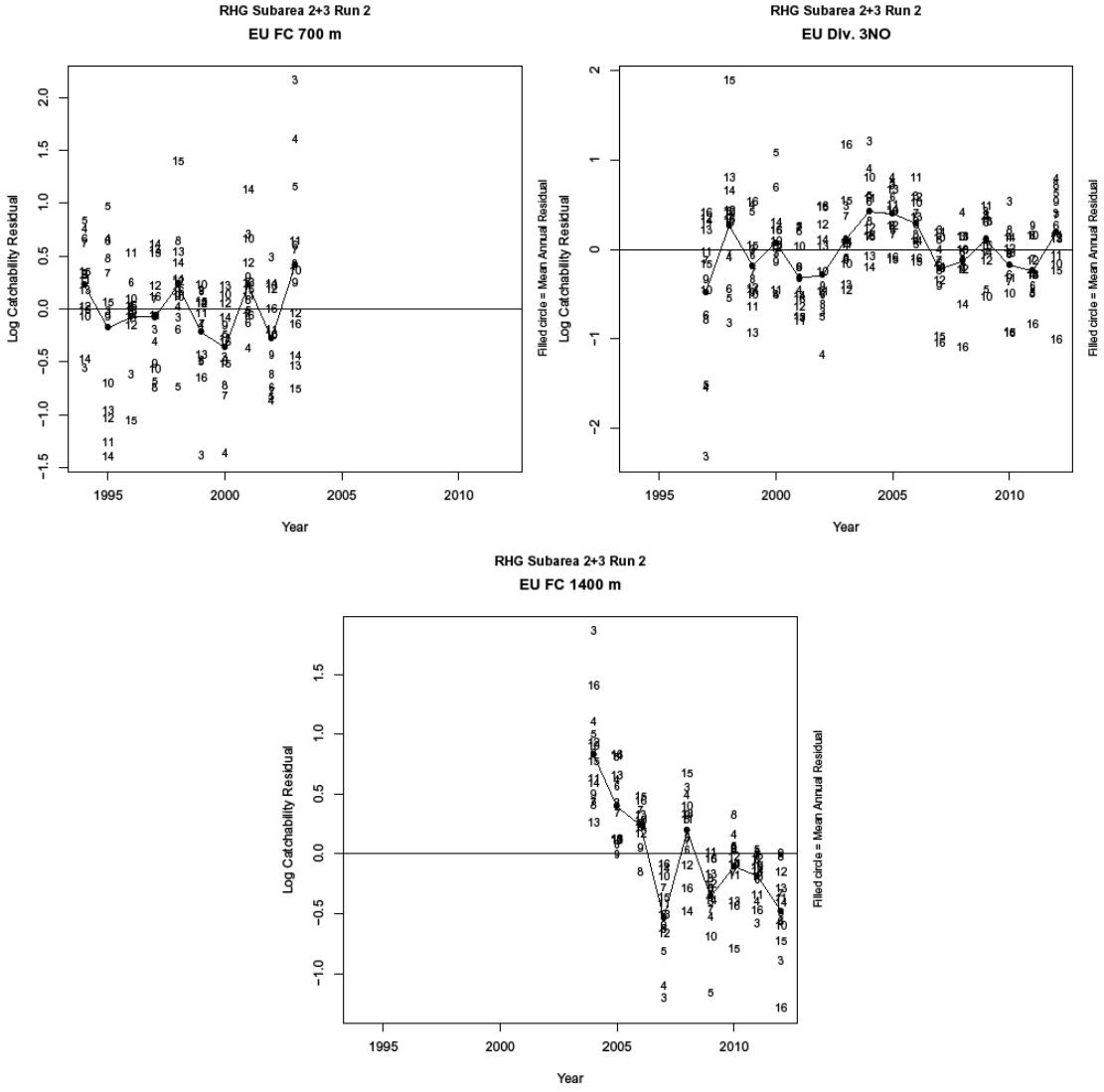

Fig. 14 Con– Log catchability residuals for Run 2 (EU Flemish Cap till 700 and 1400 meters and EU Spanish 3NO surveys) by year and age.

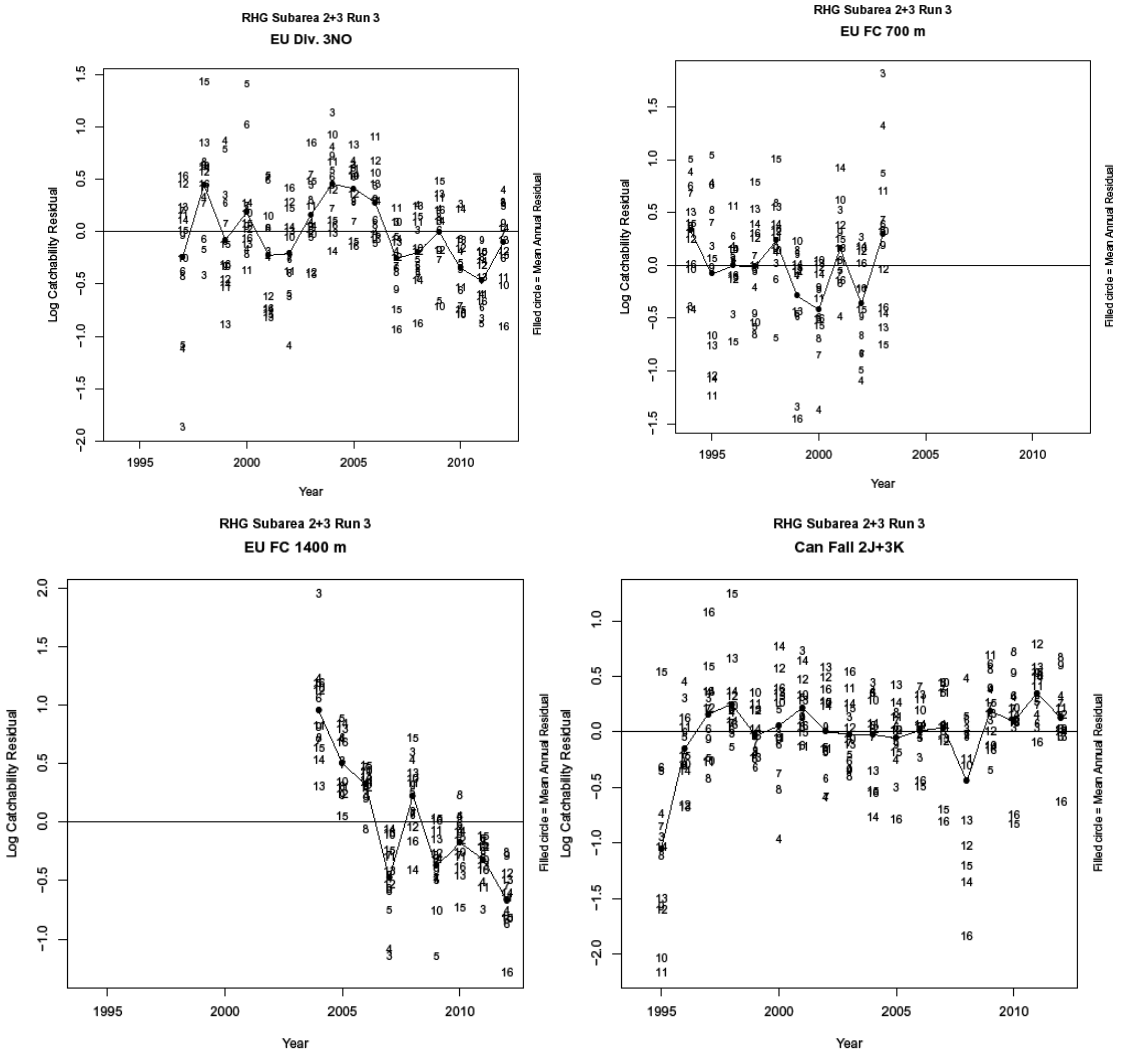

Fig. 14 Con. – Log catchability residuals for Run 3 (EU Flemish Cap till 700 and 1400 meters, EU Spanish 3NO and Canadian 2J+3K surveys) by year and age.

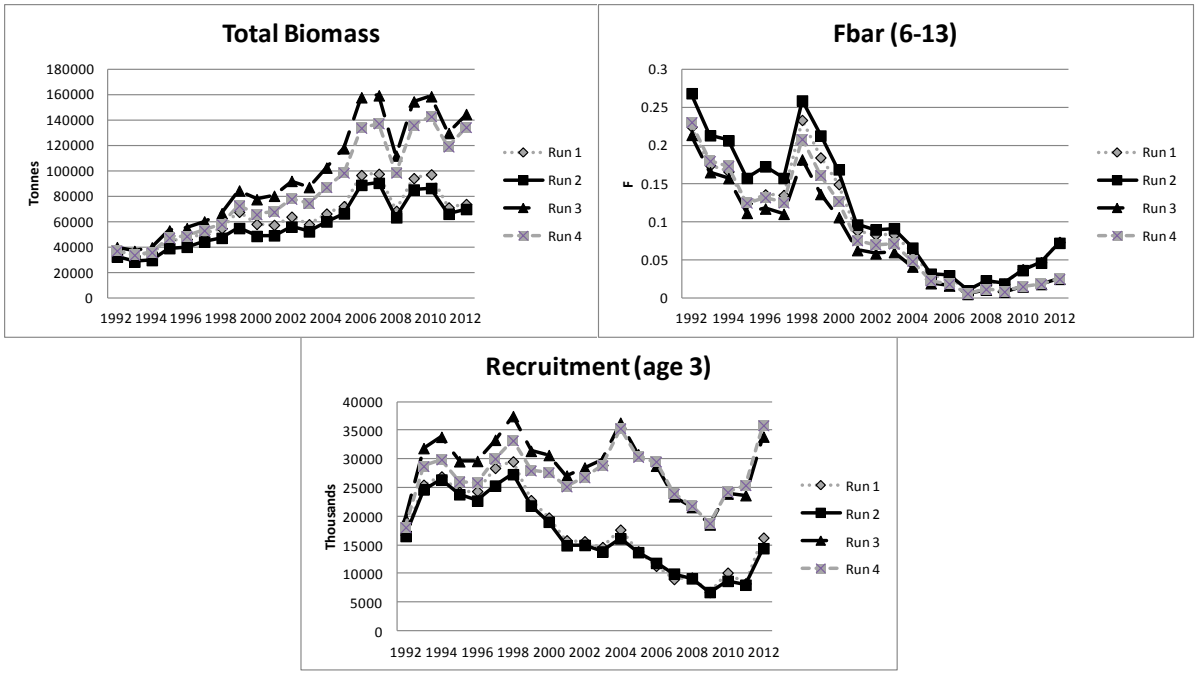

Fig. 15 –XSA result for Total biomass, mean F ages 6 to 13 (Fbar) and recruitment (Age 3) for the different runs.

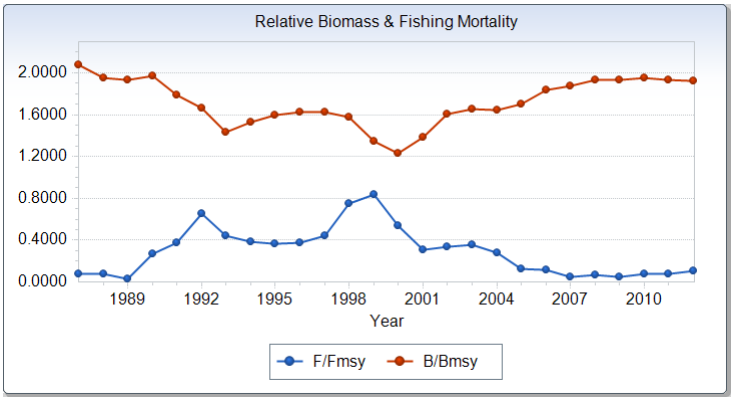

Fig. 16 – B/Bmsy and the F/Fmsy trajectory of the ASPIC Run 2

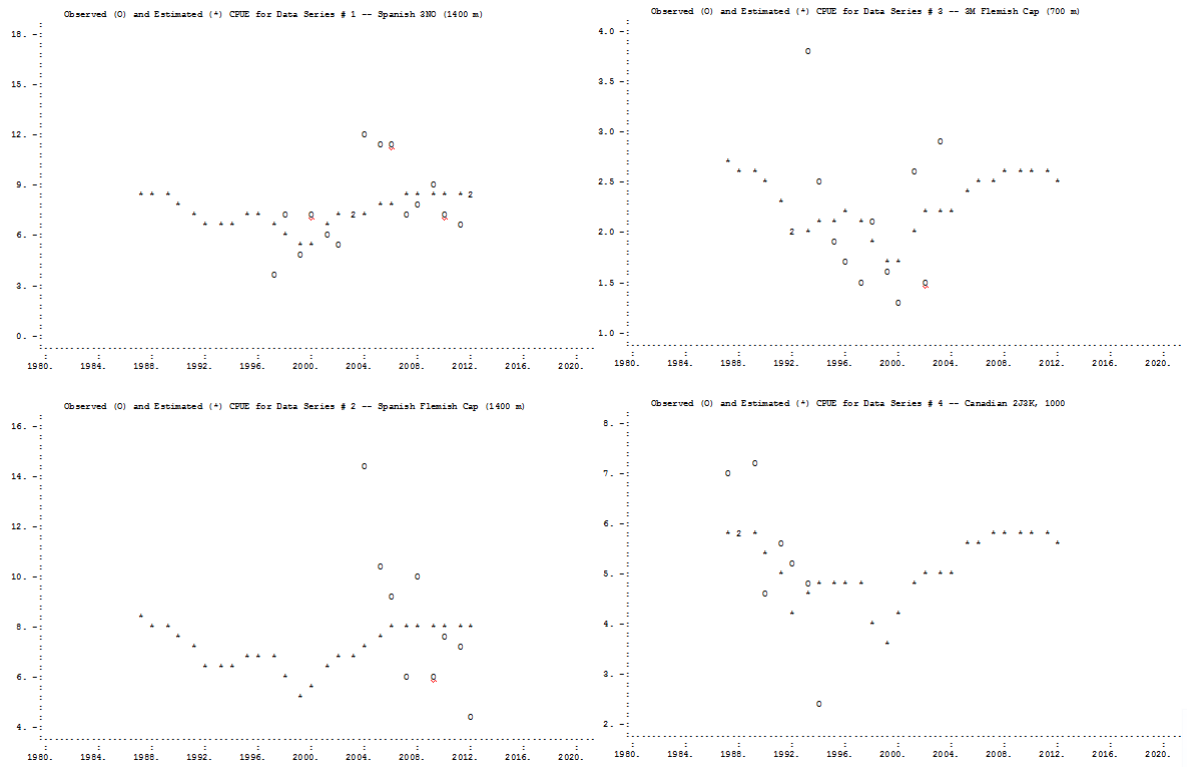

Fig. 17 –The observed and model estimated CPUE for the different surveys series used in the ASPIC RUN2

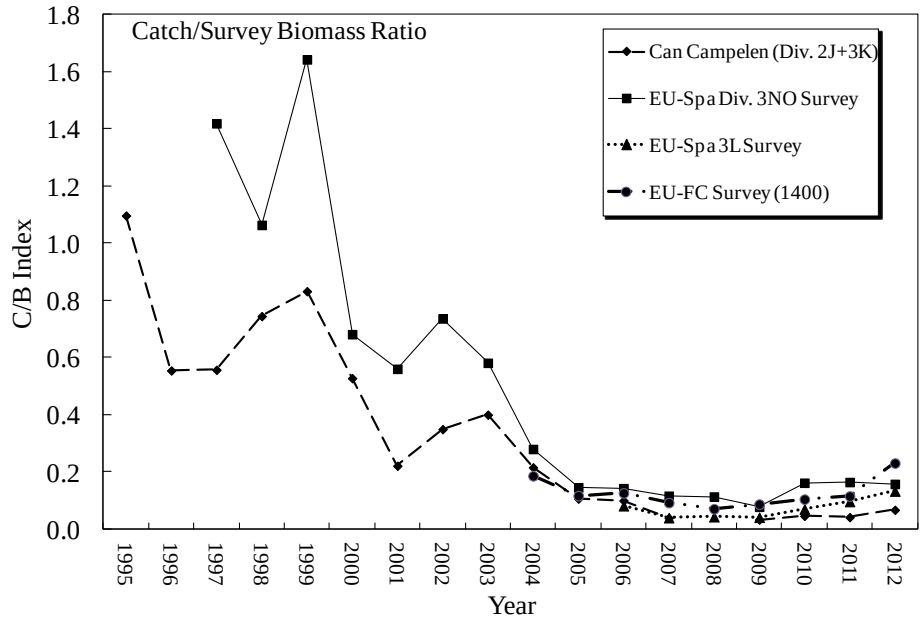

Fig. 18 – The catch / biomass (C/B) indexes obtained using the Canadian fall survey (2J+3K), the EU Spanish 3NO, EU Spanish 3L and the EU Flemish Cap (till 1400 m) biomass indices in the period 1995-2012.

Surveys Recruitment Indices (age 3)

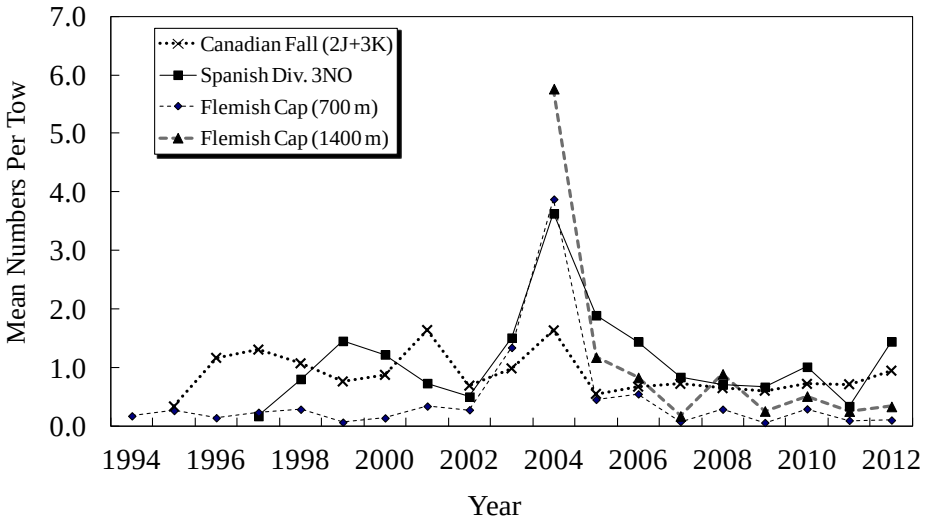

Fig. 19 – Roughhead grenadier in Subareas 2+3: Canadian Fall (2J+3K), EU Spanish Div. 3NO survey, EU Flemish Cap (700 m) and EU Flemish Cap (1400 m) survey abundance (MNPT) at ages 3.

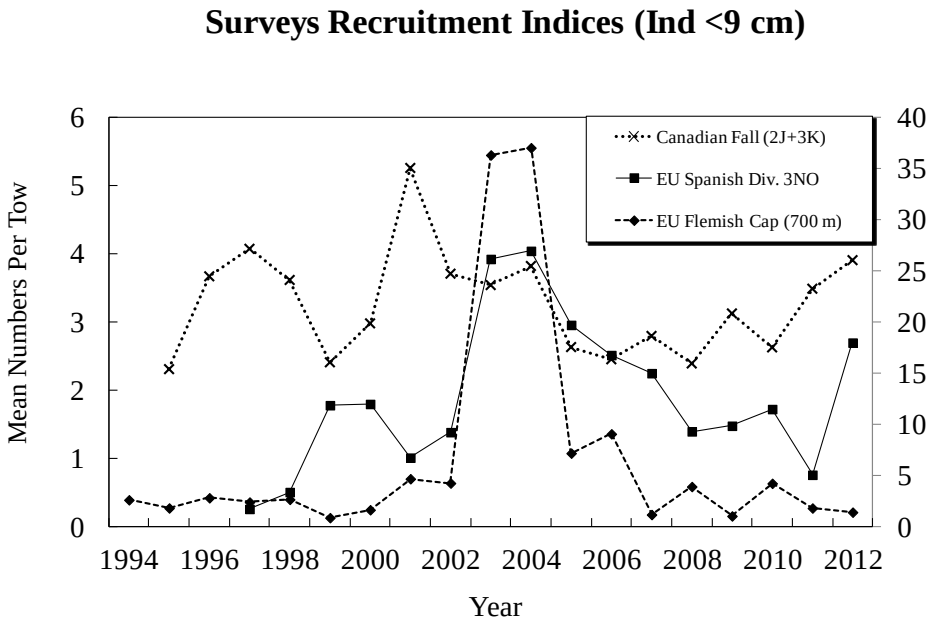

Fig. 20 – Roughhead grenadier in Subareas 2+3: Canadian Fall (2J+3K), EU Spanish Div. 3NO survey and EU Flemish Cap (700 m) survey abundance for individuals less than 9 cm.

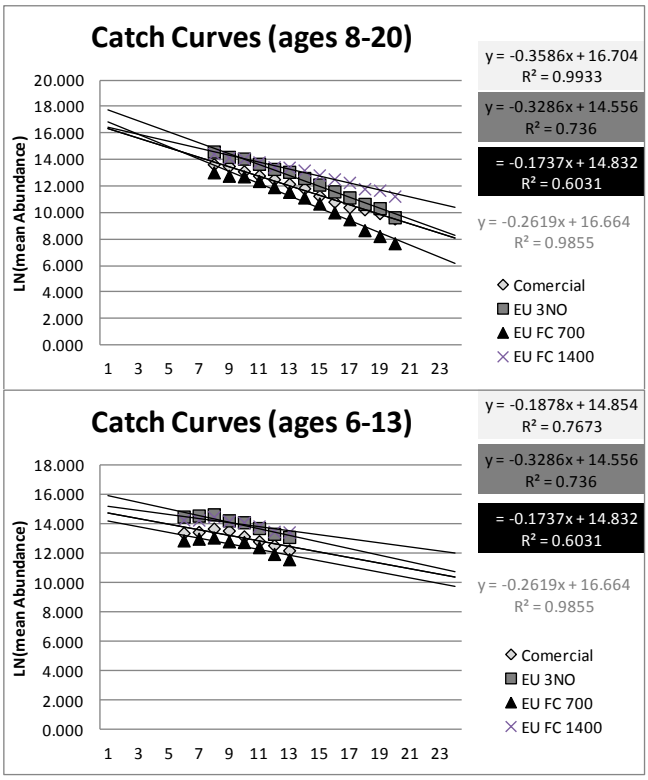

Fig. 21 – The catch curves for commercial catches (1992-2012), EU Spanish 3NO survey (1997-2012), EU Flemish Cap survey till 700 m (1994-2012) and Flemish Cap survey till 1400 m (2004-2012) for ages 8 to 20 and 6 to 13.