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An analytical assessment of NAFO roughhead grenadier Subareas 2 and 3 stock.

by

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ABSTRACT

Catch and research survey data from 1992-2005 on the roughhead grenadier stock in NAFO Subareas 2 and 3 are fitted to the eXtended Survivors Analysis (XSA) model.
The model results indicated that the stock biomass has been increasing from 1996 to 2005. The biomass estimated for the beginning of 2005 was around 70.000 tonnes, the highest in the time series. Fishing mortality has declined since 1999 and showed the lowest value in the time series in 2005. Over the last few years, there have been two years with very good recruitment at age 3, which may increase the exploitable biomass in the future. The assessment results showed that the current roughhead grenadier Subarea 2 and 3 stock status is healthy.
While the analysis indicated that there was a clear retrospective pattern in the model estimates (i.e., fishing mortality being underestimated and total biomass overestimated), the sensitivity analysis showed that the results were robust to the model set up.
Although the short time series available, in addition to the wide age composition of this species, the low fishing mortality level estimate by XSA and the lack of convergence in the retrospective analyses, the results showed that the XSA model adequately fitted the data and that the XSA estimated trends are similar to those observed by research surveys. Therefore, it could be concluded that this assessment model may be an appropriate tool to be used in the quantitative assessment of the roughhead grenadier stock in NAFO Subareas 2 and 3.

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) (Figure 1) 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. Catches of roughhead grenadier increased sharply from 1989 (333 MT) to 1990 (3,244 MT) and continued increasing up to 1992 (6,700

MT); since then, it fluctuated around 4,000 and 4,500 tonnes up to 1997, reaching the highest levels of the time series in 1998 and 1999 (7,700 and 7,200 MT, respectively). Since then, catches decreased to 3,118 MT in 2001, further increasing to around 4,000 tonnes in 2003 and decreasing to 3,000 and 1,500 tonnes in 2004 and 2005, respectively.

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. Savvatimsky (1989, 1994) and Jorgensen (1996) investigated the age structure and growth of macrourids in the North-West Atlantic, based on age readings from scales. 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). Those studies concluded that the growth trajectories of males and females are different, males growing slower than females from 9 – 10 years old. Calibration of age estimates, derived from otolith readings, has been given by Rodríguez- Marín et al. (2002). Various authors have described the reproductive biology of M. berglax. For example, Yanulov (1962), Geistdoerfer (1979), Eliassen & Falk-Petersen (1985), Savvatimsky (1989), Murua & Motos (2000), Fossen et al. (2003), and Murua (2003) carried out studies on the timing of spawning, egg diameter, egg and ovary development and the fecundity of this species.

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 (Figure 1), 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). The current assessment of Subareas 2 and 3 of roughhead grenadier stock can be considered as a qualitative assessment mainly based on survey observations rather than a quantitative analytical assessment.

However, the importance of gathering reliable information on biological characteristics and the fishery of this species is even more essential as the catches in this unregulated deep water species are considerable. Proper monitoring and assessment of the status of this "new" resource is even more important as many traditional groundfish fisheries are collapsed or in poor condition. 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 for the first time the status of this stock based on an age disaggregate analytical assessment using all the available information.

Input Data

Catches

It has been acknowledged that a substantial part of the recent grenadier catches in Subarea 3, previously reported as roundnose grenadier, currently was roughhead grenadier. The misreporting has not yet been solved in the official statistics. However, Power and Maddock Parsons (MS 1998) revised the roughhead grenadier catch statistics since 1987 for assessment purpose. Nevertheless, only the revised catches since 1992 (Figure 2) are used in this assessment because the length compositions, and thus, age compositions, were not available before 1992.

Length Distributions

Due to the growth differences between sexes, length and age data have been analysed by sex.

The length frequencies by sex from the Spanish, Portuguese and Russian trawl catches in Div. 3LMNO were available for different years (Table 1) (González and Murua, 2005). According to the Spanish and Portuguese sampling protocol, grenadiers are measured by preanal fin lengths (AFL) whereas the Russians measure the total length. Total length is converted to AFL using the total length/AFL relationship estimated by Murua and Motos (2000).

Length frequencies by sex and Division were raised to the catches of the Divisions and then all length distributions by Divisions were added to obtain the length distribution of total catches by sex and year for each country.

Catch-at-Age

Ageing was based on otoliths from specimens caught in NAFO Divisions 3LMN. Validation of age estimates derived from otolith reading was presented by Rodríguez Marín et al. (2002). In Rodríguez Marín et al. document, three validation methods were applied: back –calculation of length-at-age, length-frequency analysis, and analyses of the progression of the length mode of an exceptionally large year class. The results of the latter two methods were internally consistent, but estimates by back-calculation were different and produced unrealistic growth curves.

The catch-at-age presented by González and Murua (2005) has been updated with the 2004 and 2005 data. Table 1 presents the data available to create the catch-at-age matrix.

The method used by González and Murua (2005) was as follows: the length distribution of total catches by sex for each country was converted to age distribution by sex and country using the Spanish ALK. For the years where ALK information was not available, a combined ALK (1999, 2000, 2002, 2003) by sex was applied. Then both sexes were added together to have the age distributions by country and year. In this process mean weight and mean length by age, year and country was also calculated. Subsequently, different country age distributions were summed up and, finally, raised to the NAFO total catch estimate of that year in order to obtain the total catch numbers by age and year as well as the associated mean weights and length by age.

Survey Indices

Biomass indices for the roughhead grenadier Subareas 2 and 3 stock are available from various research surveys, with different depth and area coverage (Table 2), (NAFO 2005, NAFO 2006). None of them cover the total area and depth distribution of this stock. But however, the Canadian fall survey series (Divisions 2J and 3K) and the Spanish research survey in Divisions 3NO are considered to provide the best information in order to monitor trends in resource status (NAFO 2005) 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).

With regard to the tuning indices used in this assessment, only the European Union (EU) Flemish Cap research survey in NAFO Division 3M and the Spanish research survey in Divisions 3NO were used since these were the only two surveys that provided the length distributions data necessary for estimating catch-at-age. Catch-at-age in numbers is given as mean number at age per tow (MNPT).

The European Union (EU) Flemish Cap research survey in NAFO Division 3M covers depths down to 750 metres. This survey was carried out with the R/V Cornide de Saavedra till 2003 and from then on, with the R/V Vizconde de Eza. However, parallel fishing operations were conducted in 2003 and 2004 in order to calibrate the two survey series to make them comparable. The transformed survey series (1994-2005) by age were presented by Murua and González (2006).

The Spanish research survey in Divisions 3NO covers the depth distribution to 1,400 metres. The length abundance indices between 1997 and 2005 (González-Troncoso et al., 2006) were transformed to age abundances indices by the method presented by González and Murua (2005).

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 assessment (1992-2005).

Data Screening

Catch-at-age

In order to analyse the consistency of the catch-at-age matrix, the Separable Virtual Population Analysis stock assessment model (Pope and Shepherd, 1982) was fitted to the NAFO roughhead grenadier Subareas 2 and 3 catch data. The model was fitted, in an initial step, to the whole catch-at-age data, i.e. catches from 1992 to 2005 and ages 1 to 24 to analyse the consistence of the catch-at-age matrix.

The residuals of the Separable VPA (Figure 3) show the difference of the observed catch ratios (LN (Catch (year+1,age+1) / Catch (year, age))) and the model catch ratios (LN (Catch (year+1,age+1) /Catch (year, age))). The largest errors were seen at ages less than 3 years and older than 20 years.

The consistency of different cohorts present in the catches can be tracked in Figure 4. It is seen that the younger and older ages of every cohort are difficult to track. The difficulty in tracking the younger ages are probably due to the selectivity of the gear, i.e. they are not fully recruited to the trawl. For the older ages, this can be due to the difficulty in age determination. Figure 4 shows that the individuals older than 20 years old are more difficult to track in the cohort.

Figure 5 show the catch proportion by age and year. It can be observed that ages more than 20 year old and less than 3 have a very small proportion. Age 8 or 9 is the first age to be fully recruited to the trawl gear and it seems tha there is not a big changes in the exploitation patter.

Therefore, the assessment will be carried out using an age range between 3 and 19 years, due to the selectivity of the young ages while age 19 is a plus group, in order to avoid the difficulties associated with the age determination of the older individuals.

Survey Data
The research survey data was screened using the methods described in Beare et al. (2003), who suggested that simple tests are useful for evaluating the ability of research surveys to track cohort strength. The tests are grouped into three categories using simple correlation analyses in order to analyse:

1. Within survey consistency: correlation between log-transformed indices at age (a) and year (y) with log-transformed indices at age (a+1) and year (y+1) from the same survey.
2. Between survey consistency: correlation between log-transformed indices at each age from different surveys.
3. Consistency between survey indices and the output from an analytical assessment: correlation between log-transformed indices surveys and estimated total number at age from the analytical model.

These tests were conducted on the two research surveys used as tuning fleet and for the age range used in the assessment.

The majority of the correlations analysed within and between survey indices measures systematic patterns, and most of the correlations analysed were not influenced by outliers values.

With regard to the analysis of internal survey consistency, Figure 6 shows that in the EU Flemish Cap survey the correlation for ages less than 6 years old was quite good (>0.5), the correlation between ages 6 and 8 years old being weak (0.5<x<0.3) and for ages older than 8 years, the most abundant age class in the catches, the correlation was good (>0.5), with the exception of ages 15-16 and 17-18 . For the Spanish 3NO research survey, the correlation by ages present the same pattern as in the EU Flemish Cap Survey, except for ages older than 14 years where the correlation was weaker than in EU Flemish Cap Survey (Figure 6).

Concerning the investigation in relation to between surveys consistency, Figure 7 and 8 shows that the agreement between surveys was quite good. The correlations were good (>0.6) for the most important ages in the catches (7 to 14) and only three ages (6, 15 and 18) showed very low correlation. This is very important because it shows that the different surveys used sampled the population consistently, in a similar manner, for the most important ages in the commercial catches. as it can be observed in Figure 8.

These analyses provided an initial step to detect the ability of survey indices to track cohort strength and provided a guide to qualify the survey information used as tuning in the analytical assessment. The results indicated that there were difficulties with two ages (6 and 15) and that they may introduce noise into the model, but all the other ages, including the most abundant in the catches, were suitable for tuning the analytical assessment.
The third analysis where the consistency between survey indices and the output from an analytical assessment is tested, will be included in the “Results” section.

Assessment method and model set-up

As an initial step, a preliminary Extended Survivors Analysis (XSA, Shepherd, 1999; Darby and Flatman, 1994) was carried out in order to analyse the quality of the survey information as tuning indices using commercial catch-at-age

from 1992-2005 and tuned with all disaggregated age index of the EU Flemish Cap (ages 3-18 and years 1994-2005) and Spanish 3NO (ages 3-18 and years 1997-2005) survey (XSA input data are available as Appendix I).
An XSA with the following specifications was carried out for each tuning survey to observe the individual quality of the data: all years of the tuning data series have the same weight in the calculations. Catchability independent of the stock size for all ages. Catchability constant since age 17. Final estimates not shrunk toward mean F to study only the tuning survey effects. A threshold value of 0.3 has been set for the log catchability standard errors.

The EU Flemish Cap survey only covered depths down to 750 metres, but however, roughhead grenadier is distributed down to depths of around 2,000 m (Murua and De Cárdenas, 2005) with the largest fish at greatest depth. Therefore, the information in relation to ages 17 and 18 was very limited in this survey.

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 log catchability residuals for each survey by year (Figure 9 and Figure 10) show that there were no strong trends in the residual time series and the large residuals occurred at younger and older ages; however, these ages are less frequent in the catches. The EU Flemish Cap survey log catchability residuals were greater than the Spanish 3NO survey, and this could be related to the differences in depth coverage in the two surveys. The inverse variance weighting used within XSA takes this into account in the estimation of parameters. Some year effects can be observed in the log catchability residuals, the most clear being 1998 in the Spanish 3NO survey data, which could be related to problems arising with trawling in the deepest strata in that particular year.

After the analysis of the log catchability residuals, a final XSA was carried out using the EU Flemish Cap survey series between 1994 and 2005 and restricted to ages 3 to 16, in order to avoid the scarce information provided by the oldest ages of this survey, and the Spanish 3NO research survey series between 1997 and 2005 and ages 3 to 18 as XSA tuning series with the following model specifications (Darby and Flatman, 1994). All XSA diagnostics are shown as Appendix II:

Input data
Catch-at-age data from 1992 to 2005 for ages 3 to 19, last age as plus group.
Tuning fleets: EU Flemish Cap indices from 1994 to 2005 for ages 3 to 16. Survey month: June. Spanish 3NO research survey indices from 1997 to 2005 for ages 3 to 18. Survey month May.
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 and this value has been applied in the assessment of roundnose grenadier with similar biology and inhabiting similar ecosystems (ICES, 2006).

Model specifications
All years in the tuning data series are given the same weight in the calculations.
Catchability analysis: A mean model is used to describe the relationship between catchability and abundance for all ages because the regression statistics are not significant to use the power model for younger ages.
The model (XSA) makes the assumption that catchability is independent of age (constant) above a specific, user-defined age. We have defined this age as 17 because older ages log q values decrease with the age for both surveys.
Terminal population estimation: For each age, a mean of the F values for the 4 years that precede the final year is calculated. This time period has been selected to avoid F trends and to estimate a robust mean F.
The survivors in years prior to the final year are shrunk to a terminal population derived from an average of the F values of the 3 ages that precede the oldest true age and the total catch value for the true age. The mean of these ages has been selected because the exploitation pattern for these ages is more or less constant.
A weight of 1.0 has been given for the F shrinkage means. In this case, the reason to use the shrinkage means was that the tuning series are shorter than the catch-at-age information and it is recommended to have an initial value to start the cohort analyses in the cohorts where there is no tuning information. This weight is the same for all years and ages and it allows the shrinkage values not to have a large influence in the parameter estimates in the period where there is tuning information.
A minimum value of 0.3 has been set for the log catchability standard errors used as weights estimating survivors. Fleet standard errors falling below that are replaced by this threshold value.
Prior weighting was not applied. All the estimates derived from all the different fleets are the same weight in the calculations.

Results and Discussion

Model converged after 118 iterations and the model fit is considered to be acceptable. The results are considered to be reliable in spite of 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 natural mortality level.

Total biomass, mean F between ages 11 to 16 (Fbar) and recruitment (Age 3) results are plotted in Figures 11, 12 and 13 and presented in Table 3. Fbar was considered the average fishing mortality for ages 11 to 16 because these ages are the most abundant in the catches and are completely recruited to the gear. All XSA output are available as Appendix III.

Model results indicated that the stock biomass increased from 1996 onwards 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 2005 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 2004.
Fishing mortality have declined since 1999 and it showed the lowest value of the time series in 2005. The current level of F is much smaller than the value of the assumed natural mortality
There are two very good recruitments at age three in recent years (2003 and 2004), which could increase the exploitable biomass in the future.

Sensitivity Analysis
In some cases, the model settings could have a considerable influence on the final results. Different values have been analyzed for some settings to study how sensitive the final biomass or fishing mortality are to these values. In the following discussion, only results and figures for biomass are presented; however, the results, figures and trends for fishing mortality agreed with the biomass results.

Natural Mortality: the natural mortality values assumed in similar species assessments are in the range from 0.1 to 0.2. Figure 14 presents the biomass results for three levels of M (0.1, 0.15, 0.2). Biomass results are sensitive to the chosen M value, the biomass increase with M, but only in the level since the trend is the same for the three M values.

Weight of the F shrinkage means: the different year range covered by the catch-at-age matrix and the surveys tuning indices (starting, respectively, in 1992 and 1994) was the main reason for applying F shrinkage means. Figure 15 shows the results for the biomass between the following three options: without shrinkage, with shrinkage with a similar SE (weight) of the tuning indices (0.5) and with shrinkage with a high SE (1.0). The first and third option results are very similar, except for the last two years where the biomass is larger when shrinkage is not applied. These results are normal because when the mean F shrinkage has a high standard error (SE) their influence on the final results in the years where there are survey information is very low. The option where the shrinkage has a similar SE to the tuning indices gave a lower biomass than the other two options. The cause of these results is that the survivors estimated by the shrinkage means are lower than those estimated by the survey indices.

Catchability independent of age: the log q values of the older ages decrease when the age increases, but from age 15 this decrease is smaller. There were some doubts as to which was the first age with a catchability constant. Figure 16 presents the biomass for catchability independent of age at age 15 and 17 and the results are very similar in both cases. It was decided that the model estimates the catchability for all ages rather than making the assumption that catchability is constant since a certain age.
Results seem to be not very sensitive to the values set. Only the choice of a Natural Mortality (M) value bears an important influence in the biomass results, but only in the level and not in the trend. For the others settings studied, the values selected have no considerable influence on the final biomass.

Consistency between research survey indices (used as tuning) and XSA abundance by age (Figure 17) shows that the correlation values and trends between the XSA estimates and the surveys indices were very high and similar; however, there were some inconsistencies for ages 5, 6, 7 and 15. These inconsistencies were mostly due to the poor quality of the survey information for those ages as it was observed in the within and between survey consistency analyses. This can mainly be due to ageing problems for older ages and catchability issues for younger ages, although they can also be affected by other factors such as immigration or emigration to/from the survey area, or a combination of all these factors.

Model and survey results are similar. The Canadian fall survey series (Divisions 2J and 3K) and the Spanish survey in Divisions 3NO are considered by the NAFO Scientific Council as the best survey information to monitor trends in resource status. The Canadian fall survey information is not included in the model and can be considered independent of the XSA results.
The trends in the Canadian survey biomass was very similar to the trend in the biomass estimated from the XSA (Figure 18). The EU Flemish Cap Survey trend was the one which most differed from the XSA results. This difference could be expected since this survey only covered a part of the depth distribution of the species and the survey information only represents the biomass less than 17 years old.

With regard to fishing mortality estimates from different surveys, it can be observed that the trend of the ratio total catch - total biomass in the Canadian fall survey (Divisions 2J+3K), the Spanish survey in Divisions 3NO and the Flemish Cap survey estimated by the swept area method, which can be considered as a proxy of Fishing mortality (F), and the trend of mean F (ages 3-18) estimated by the XSA, all values standardised to the 1997 value, were very similar (Figure 19).

Figure 20 shows the mean number per tow of age 3 in the Spanish survey in Divisions 3NO and the Flemish Cap survey and the number of recruits age 3 calculated by the XSA. In all series the trend was similar and it is noted that 2004 recruitment was the best of the series, being more than twice the average level of the time series. It is not possible to estimate the recruitment in the Canadian fall survey because there is no length or age information available from this survey.

In order to check the consistency of the assessment model, a retrospective analysis of the XSA was run using the same stock data, from which the time series of the estimated fishing mortality, the total biomass and the recruitment are plotted (Figure 21). Retrospective uncertainty is generally introduced into assessment model estimates as a result of model misspecification, usually an assumption of constancy in a parameter that in reality exhibits a trend or step to a new level (ICES, 1991; Mohn, 1999) and can be reduced by introducing changes to model setup or by removing sections of the data that do not conform to the model structure (ICES 1991, 1993).
The retrospective results (Figure 21) indicate that there was a clear retrospective pattern in the model estimates, 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, although they still are the best recruitments in the time series. The lack of convergence in the retrospective values could be due to the short time series analysed, low fishing mortality levels and the large number of the ages present in the catch-at-age matrix.

Conclusion

Although the short time series available in addition to the wide age composition of this species, the low fishing mortality level estimate by XSA and the lack of convergence in the retrospective analyses, the research survey indices and the XSA results give a similar picture of the state of the stock and the model (XSA) seems to fit the available data adequately. It could be considered that the model is appropriate to be used in the assessment of the NAFO roughhead grenadier Subarea 2 and 3.

The results of the XSA assessment showed that the current roughhead grenadier Subarea 2 and 3 stock status is healthy. Current estimates of biomass are the highest of the time series, current fishing mortality is the lowest of the series and 2003 and 2004 recruitments are the bests of the time series. The increase in total roughhead grenadier Subareas 2 and 3 biomass was double between 1992 and 2005, and this increase will probably continue in the coming years due to the growth of the last years good recruitments and the reduced fishing mortality expected as a result of the NAFO recovery plan for Greenland halibut (NAFO 2003); since roughhead grenadier is the most important species in the by-catch in the Greenland halibut fishery.

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Table 1 .- 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

Table 2 .- 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 - 2005	2GHJ 3MLNO	<1500 m
Canadian Spring Survey	1978 - 2005	3LNO	<730 m
Canadian deepwater	1991, 1994, 1995	3LMN	<1500 m
Spanish Surveys in Div. 3NO	1997 - 2005	3NO	<1500 m
EU Flemish Cap Surveys	1988 - 2005	3M	<730 m
Russian	2001 - 2002	3M	120 - 1280 m
EU Deepwater	1996	3LMN	700 - 3100m

Table 3 .- Results of the XSA model run for recruitment (age 3), total biomass, spawning stock biomass (SSB) and mean F between ages 11 and 16 (Fbar).

Year	Recruits age 3 (thousands)	Total Biomass (ton)	SSB (ton)	Fbar (11-16)
1992	15463	34156	3895	0.44
1993	22326	29512	3113	0.3446
1994	24342	30419	2998	0.3156
1995	22445	38624	2805	0.233
1996	20127	38954	2401	0.2095
1997	28220	43758	3131	0.2318
1998	32350	44985	3232	0.2501
1999	24032	54595	3952	0.3472
2000	21145	48072	5849	0.1917
2001	19558	46437	4491	0.1048
2002	27730	54798	5975	0.1063
2003	42418	64680	8122	0.0822
2004	54037	73377	6659	0.0603
2005	14380	70080	8564	0.0246

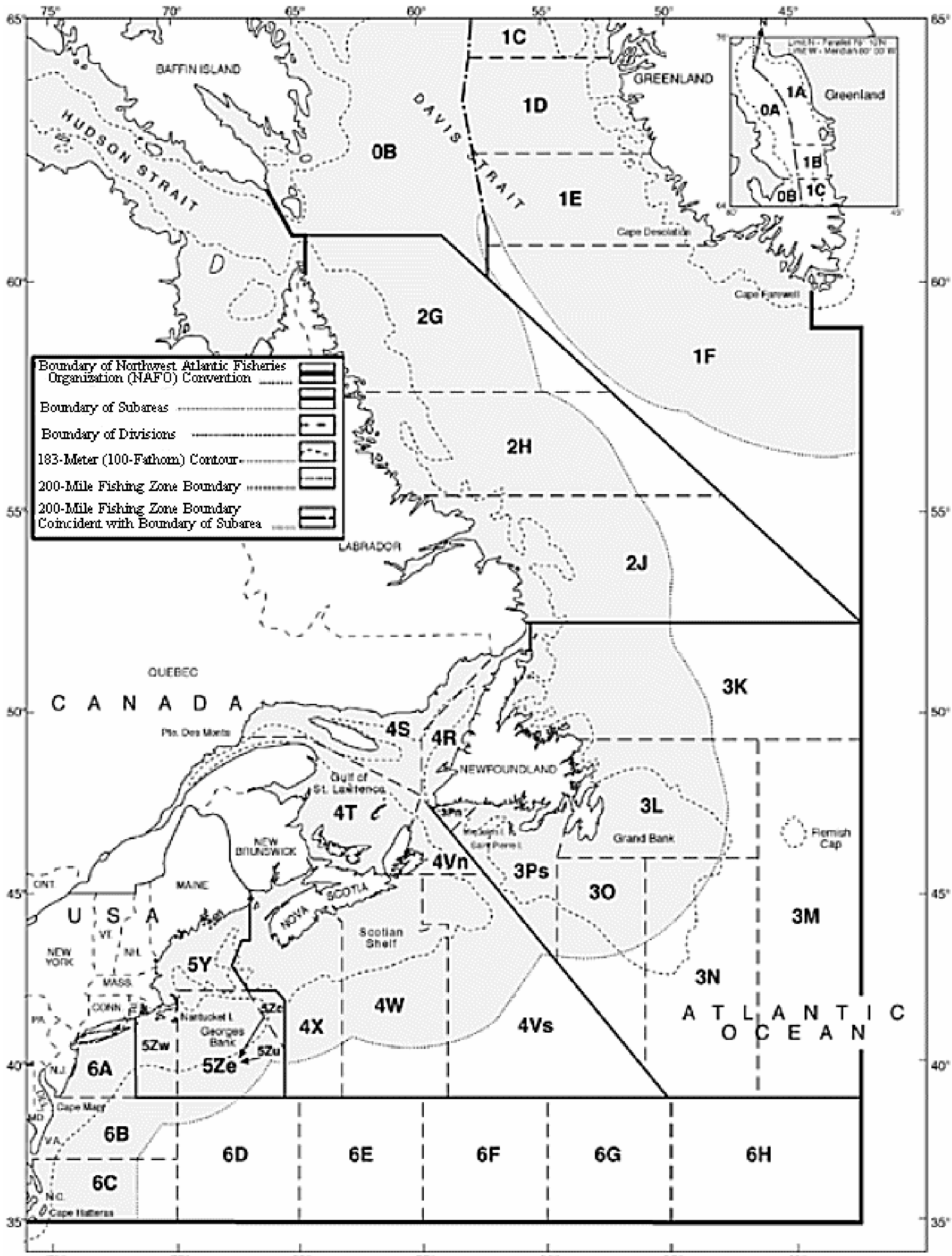

Figure 1 .- Map of NAFO area with Subareas and Division as well as the 200 miles Exclusive Economic Zone line.

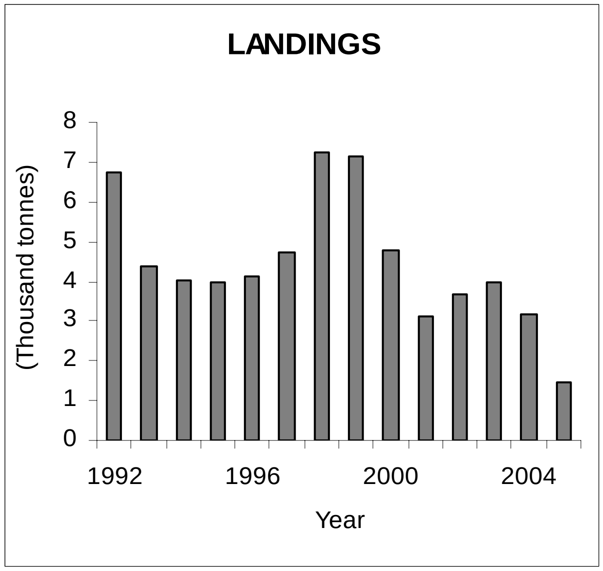

Figure 2 .- Roughhead grenadier NAFO Subarea 2 and 3 catches (ton) by year.

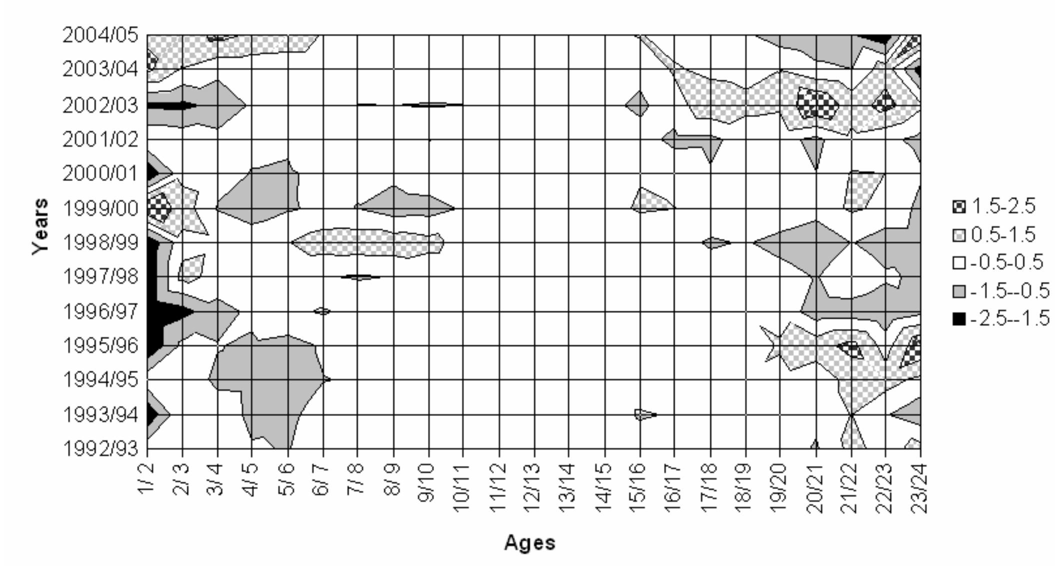

Figure 3 .- Difference of the catch ratios observed (LN (Catch $_{(year+1,age+1)}$ / Catch $_{(year, age)}$)) and the Separable Virtual Population Analysis model catch ratios (LN (Catch $_{(year+1,age+1)}$ / Catch $_{(year, age)}$)) of the roughhead grenadier NAFO Subarea 2 and 3 stock data.

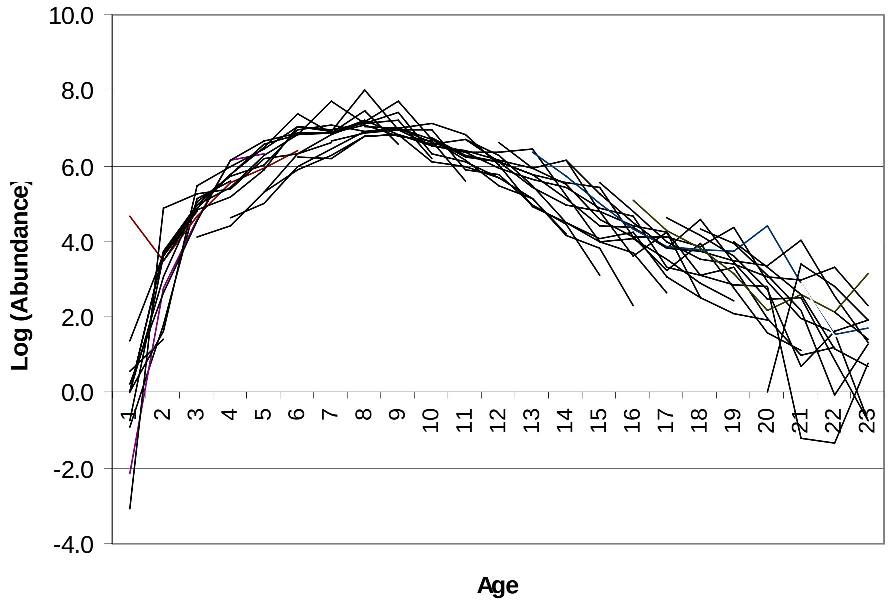

Figure 4 .- Roughhead grenadier NAFO Subarea 2 and 3 catches log abundance of the different cohorts present in the catches by age. Each line represents a cohort.

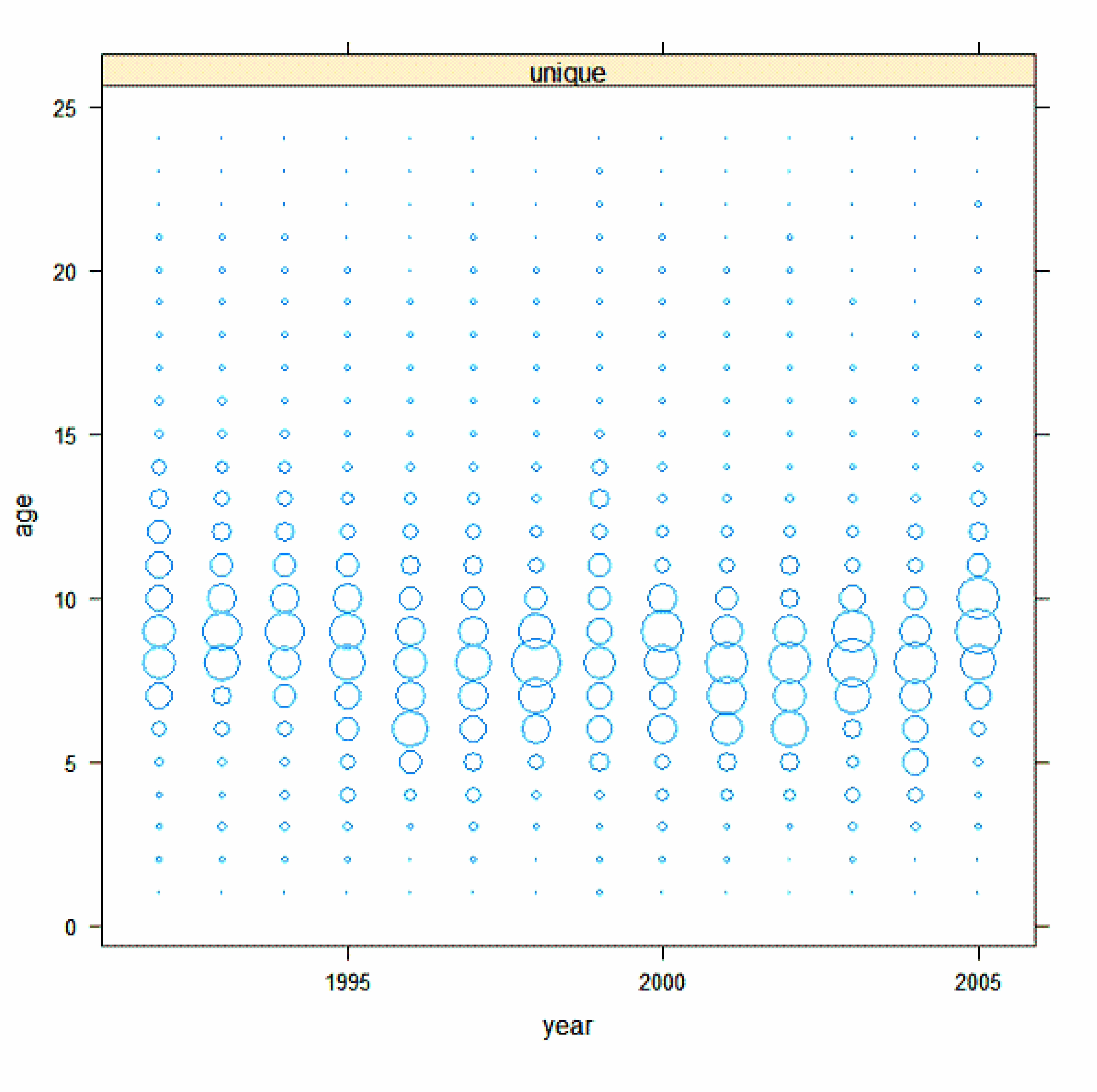

Figure 5 .- Roughhead grenadier NAFO Subarea 2 and 3 catch proportion at age by year.

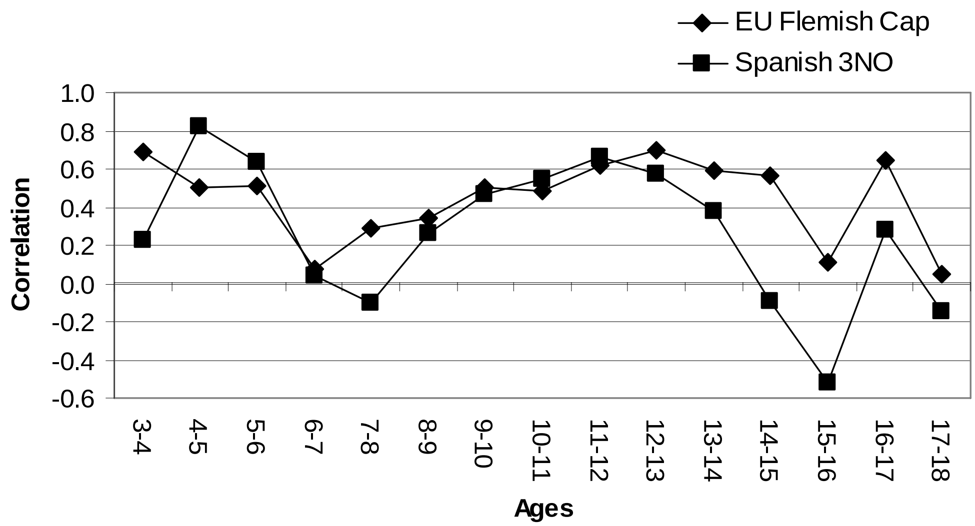

Figure 6 .- Correlation between log-transformed indices at age (a) and year (y) with log-transformed indices at age (a+1) and year (y+1) from EU Flemish Cap survey and Spanish 3NO survey.

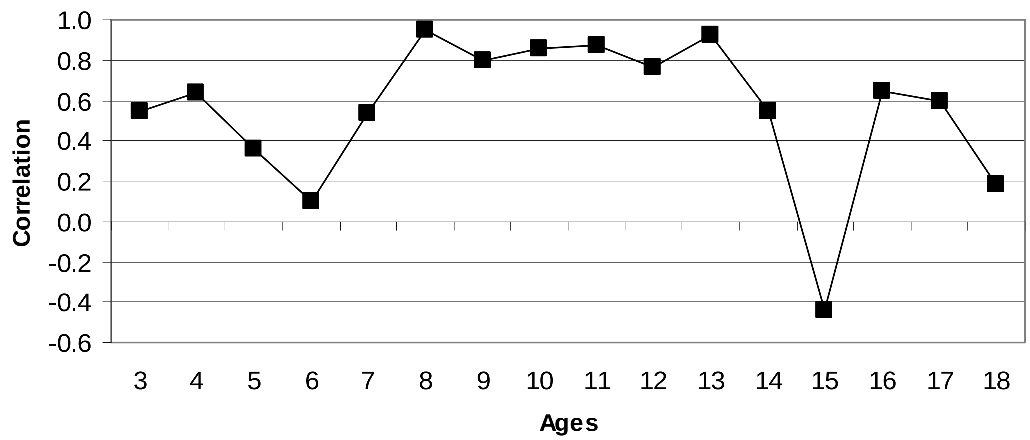

Figure 7 .- Correlation between log-transformed indices at each age from EU Flemish Cap survey and Spanish 3NO survey.

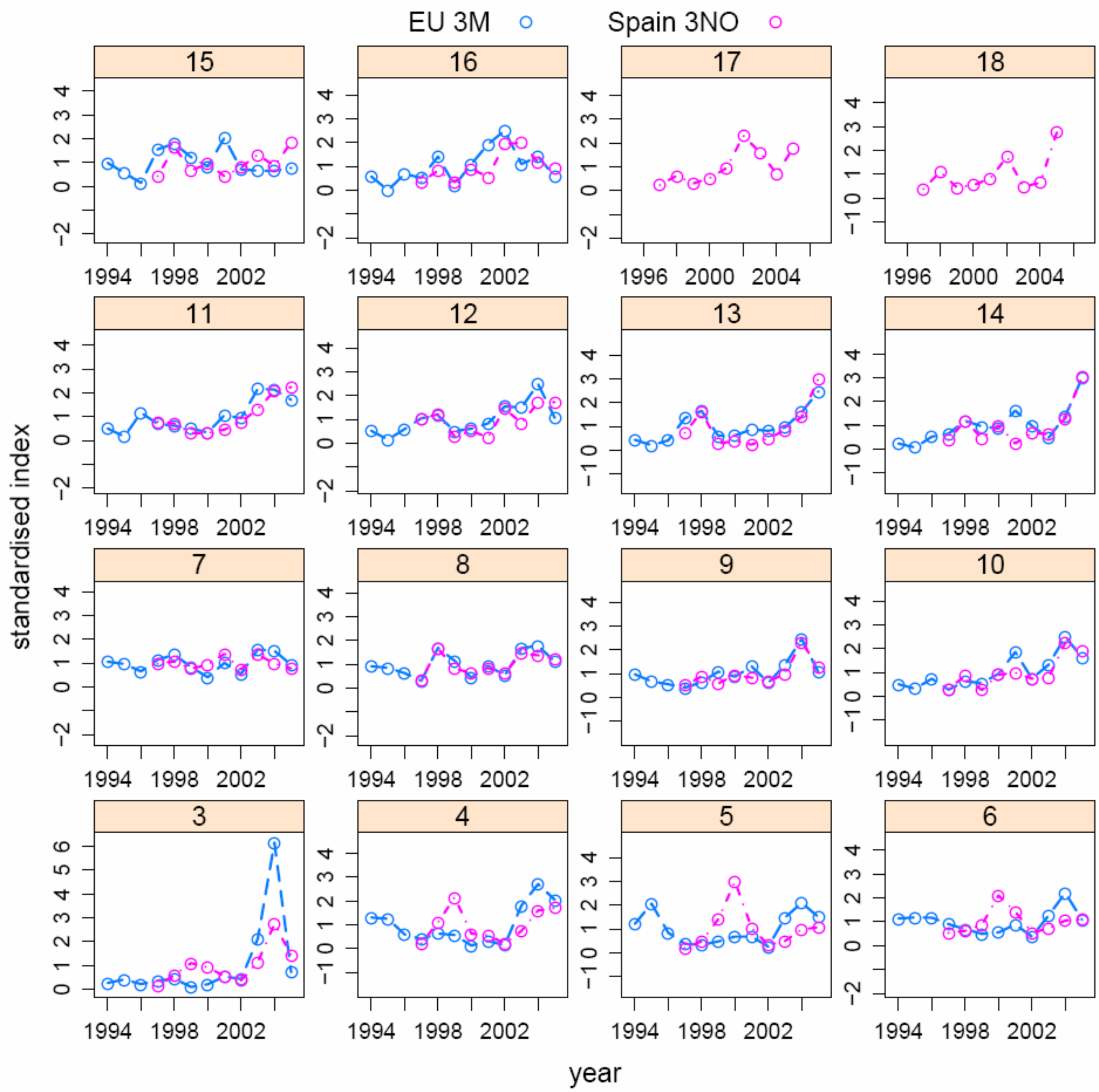

Figure 8 . EU Flemish Cap survey (EU 3M) and Spanish 3NO survey.1995 - 2005 indices by age.

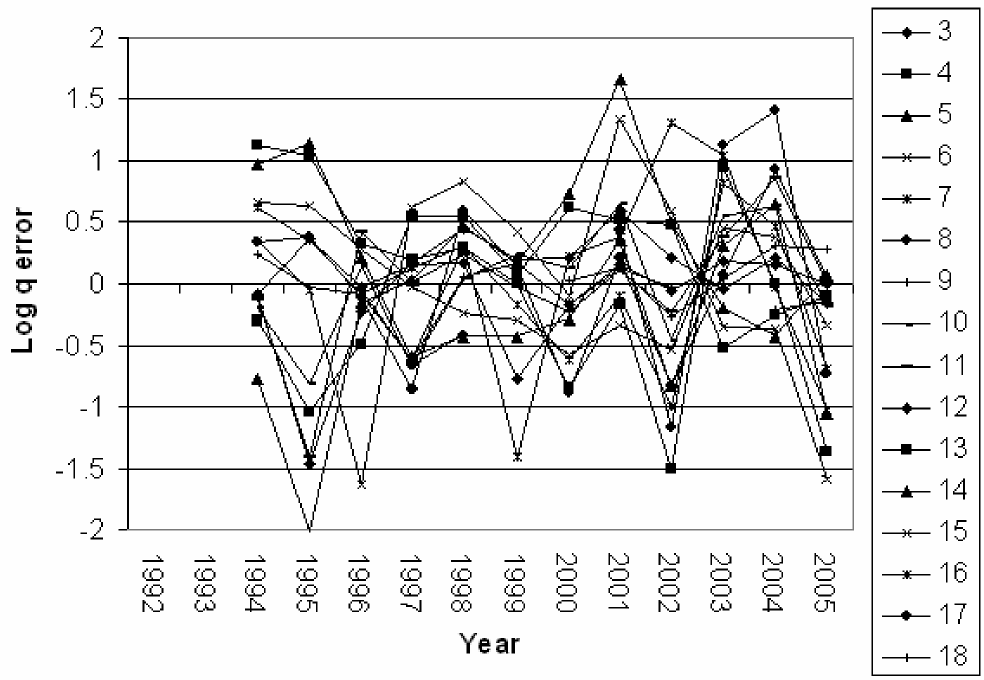

Figure 9 .- Extended Survivors Analysis log q errors of Flemish Cap survey by age and year. Each line present an age.

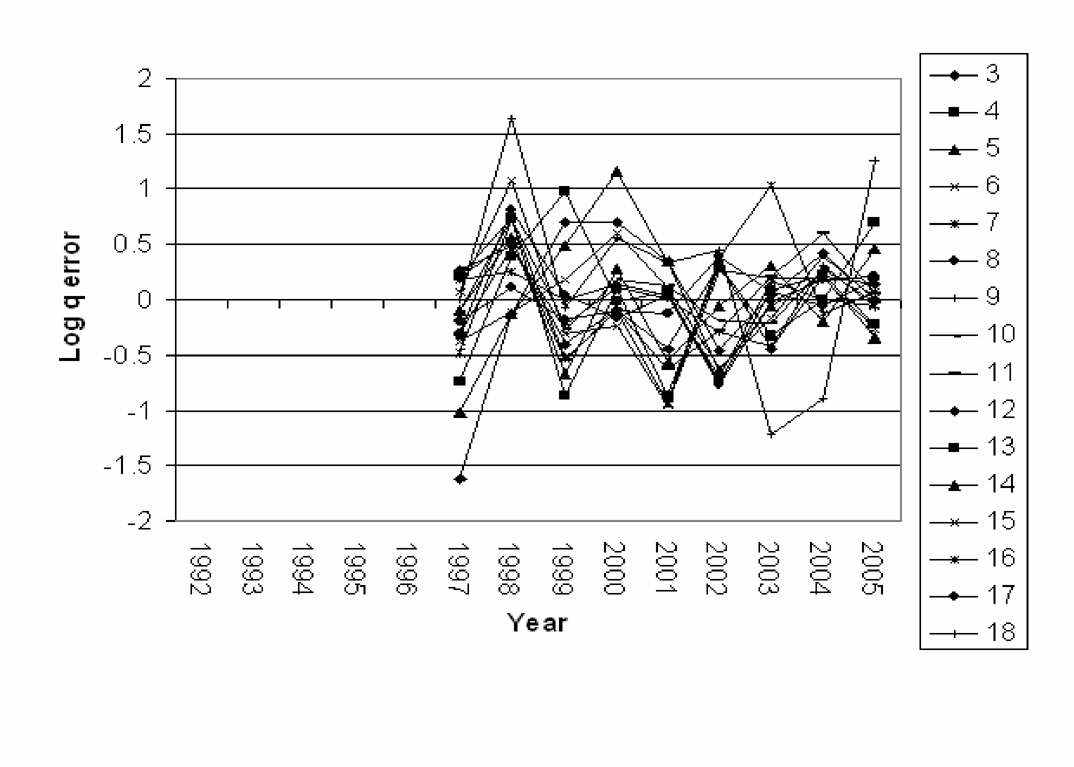

Figure 10 .- Extended Survivors Analysis log q errors of Spanish 3NO survey by age and year. Each line presents an age.

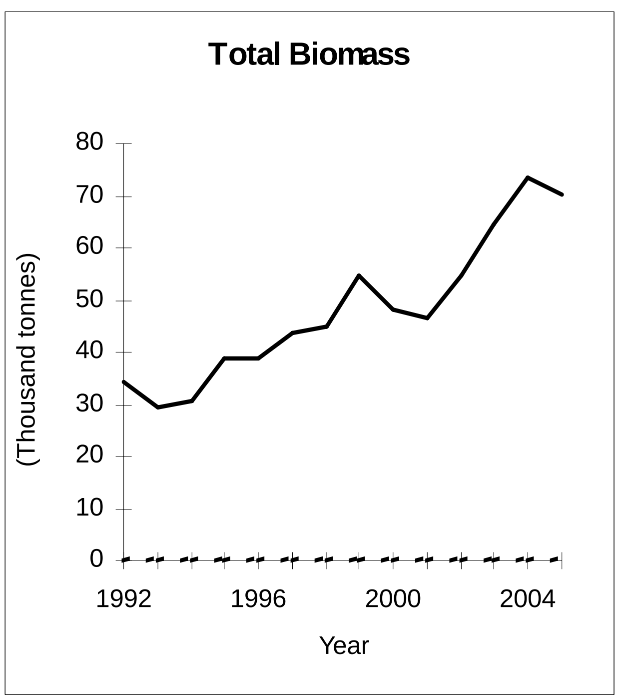

Figure 11 .- Total biomass (000 tonne) by year estimated by XSA

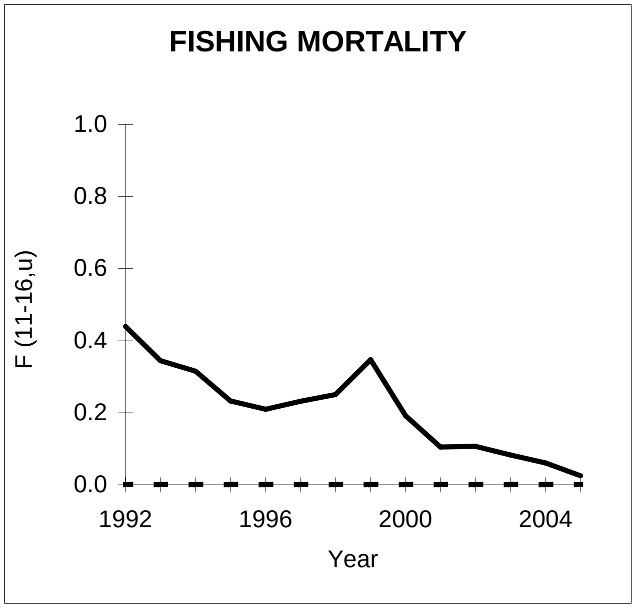

Figure 12 .- Mean *F* between ages 11 and 16 (*F*bar) by year estimated by XSA.

Figure 13 .- Number of recruits of age 3 (Thousands) by year estimated by XSA.

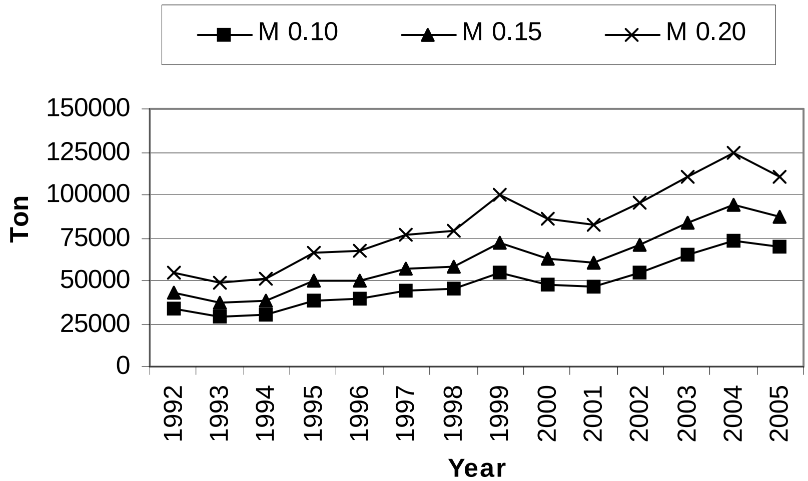

Figure 14 .- Total biomass by year estimated by XSA for three different values of Natural Mortality (*M*).

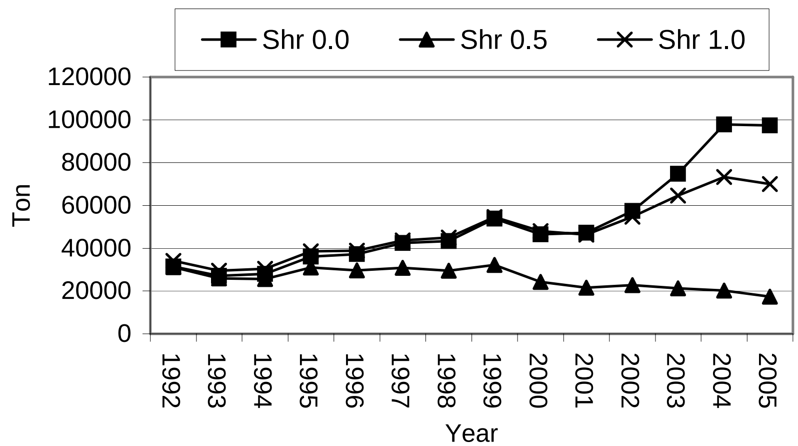

Figure 15 .- Total biomass by year estimated by XSA for three different values of the Standard Error (SE) of the *F* shrinkage.

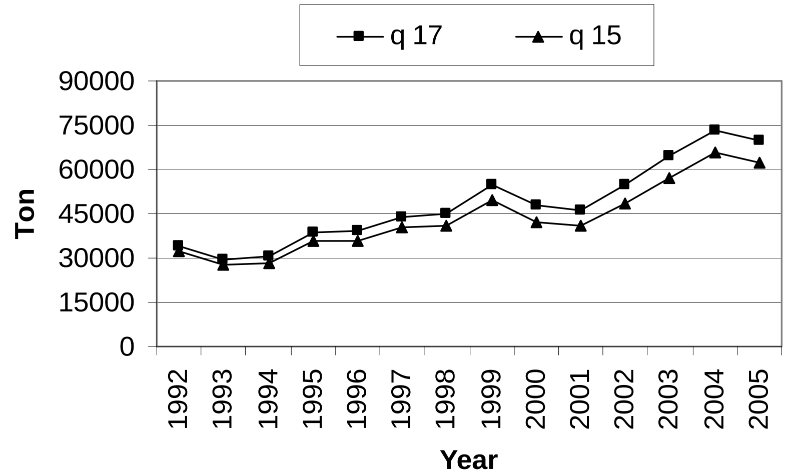

Figure 16 .- Total biomass by year estimated by XSA for two different ages from which catchability is independent of age (constant).

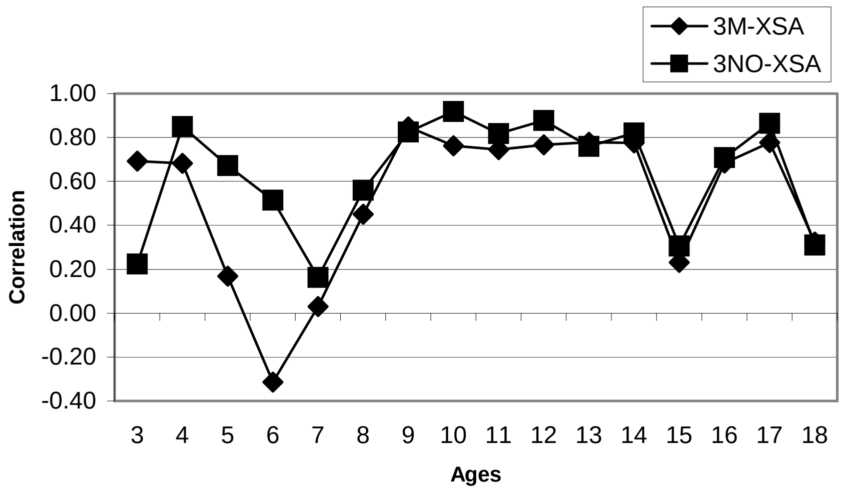

Figure 17 .- Correlation between log-transformed indices of the EU Flemish Cap survey and Spanish 3NO survey and the results of the XSA abundance by age.

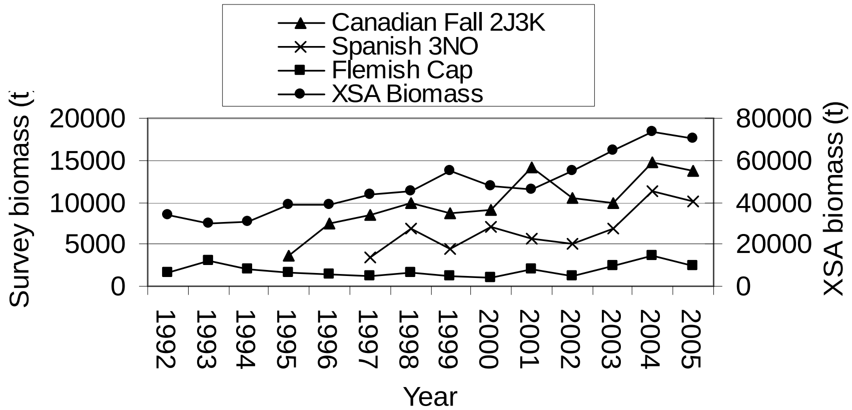

Figure 18 .- Total biomass of the Canadian 2J and 3K fall survey, EU Flemish Cap survey, Spanish 3NO survey and XSA by year.

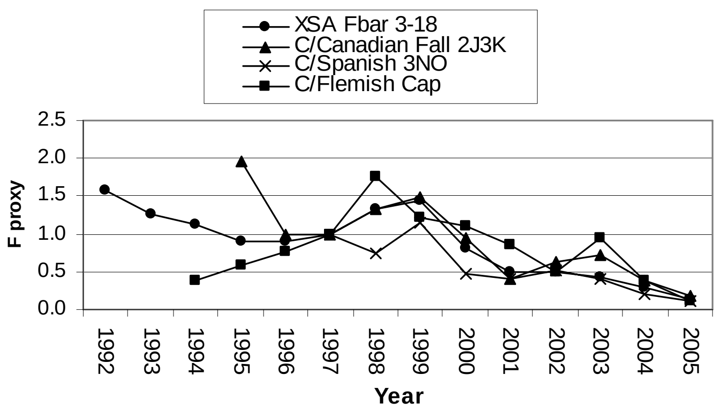

Figure 19.- Total catch / total biomass estimated by the swept area method ratio of the Canadian fall survey (Divisions 2J+3K), the Spanish survey in Divisions 3NO and Flemish Cap survey and XSA *F* mean (3-18) by year. All values standardised to 1997 value.

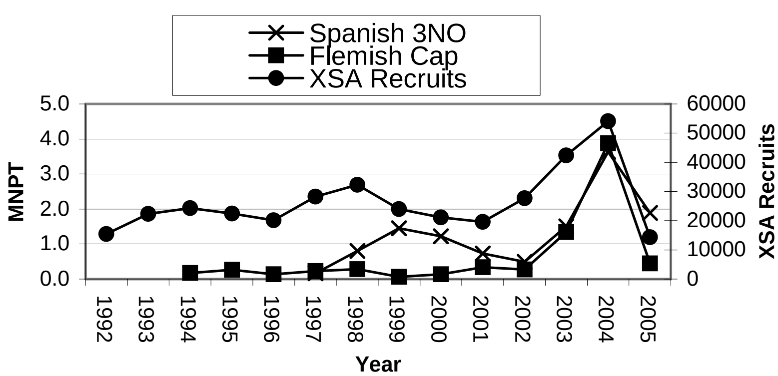

Figure 20.- Age 3 mean number per tow for the Spanish survey in Divisions 3NO and Flemish Cap survey and age 3 recruits (thousands) estimated by the XSA by year.

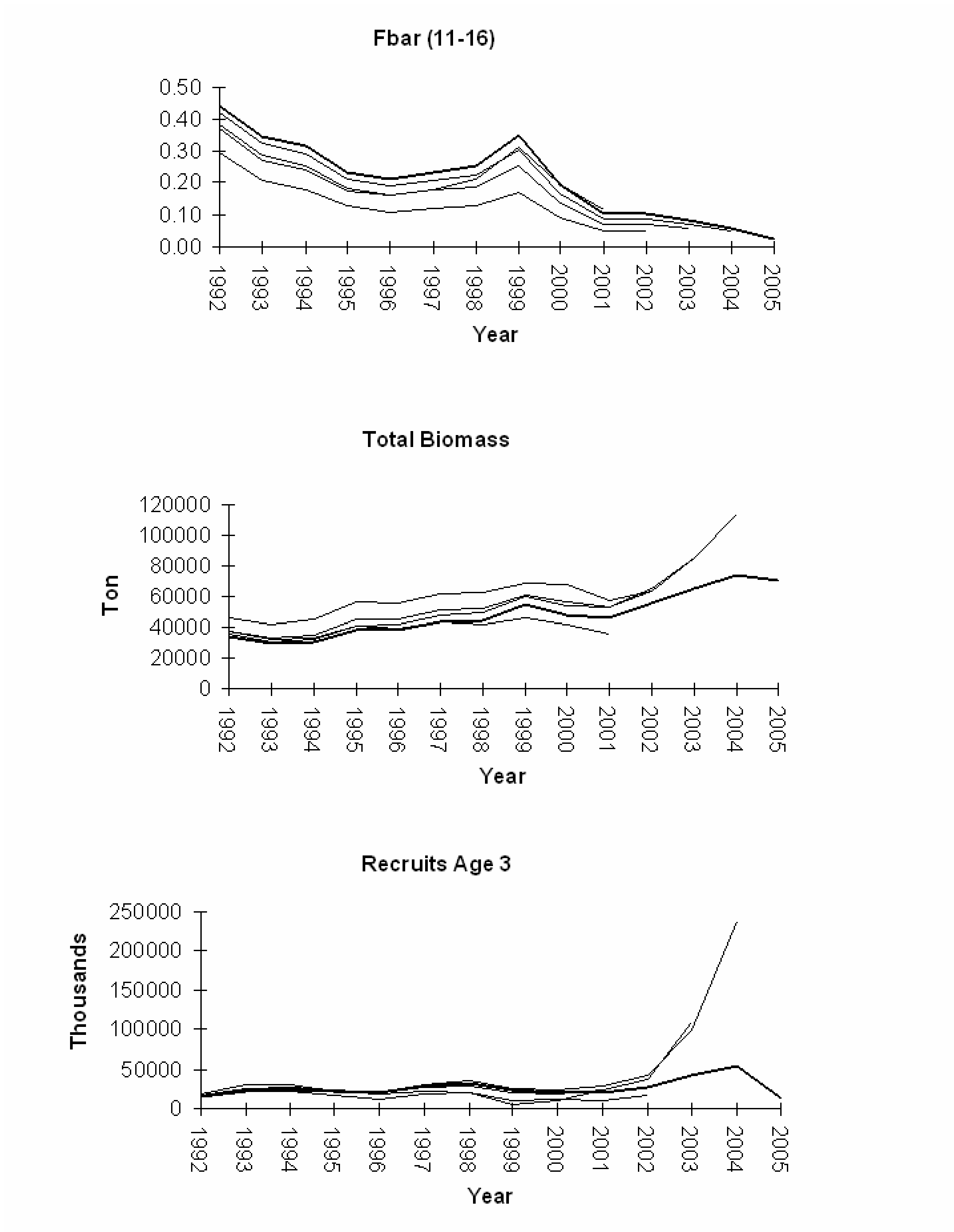

Figure 21 .- Retrospective time series of the XSA mean *F* between ages 11 and 16 (*F*bar), total biomass and number of recruits (age 3) XSA.

Appendix I

Run title : Roughhead grenadiers 05 (NAFO Subareas 2-3)

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE														
1	4	0	1	0	0	0	0	106	0	0	0	2	0	0
2	33	38	40	14	5	42	22	129	32	16	6	37	4	0
3	62	125	131	143	95	242	145	156	190	107	100	173	121	4
4	104	84	178	319	315	468	392	224	302	217	257	464	267	15
5	198	151	206	370	709	653	791	641	528	422	483	372	564	41
6	509	367	395	565	1162	926	1620	950	1118	916	1046	563	595	105
7	793	496	528	620	924	992	2213	962	983	1050	974	1190	736	222
8	1122	948	901	879	999	1271	3015	1238	1342	1170	1266	1709	1002	329
9	1080	1088	1062	912	922	1071	2226	1040	1693	913	874	1355	712	410
10	841	761	799	686	699	717	1216	808	1045	565	454	773	499	387
11	798	536	587	519	609	583	801	919	473	357	443	396	273	191
12	752	456	458	377	457	477	586	542	414	243	318	300	289	143
13	582	373	322	231	279	327	376	623	234	138	168	141	171	104
14	478	305	245	170	145	233	264	471	186	89	91	63	88	67
15	259	197	148	98	84	119	132	228	121	54	59	54	46	22
16	162	121	90	76	60	81	83	106	63	37	60	71	41	10
17	100	74	55	45	48	62	47	69	28	25	69	33	21	14
18	76	65	46	35	42	44	48	97	22	22	51	12	18	12
19	54	52	37	24	30	33	42	79	31	17	28	16	8	11
20	30	28	23	15	9	21	29	81	19	12	16	7	5	7
21	18	17	13	9	2	14	19	56	18	7	12	0	3	3
22	8	4	7	3	1	5	8	28	13	5	5	2	0	3
23	9	4	5	2	2	4	7	23	10	4	5	0	0	2
24	8	1	4	1	0	2	3	8	10	3	3	1	1	0
TOTALNUM	8080	6291	6281	6112	7598	8385	14085	9584	8875	6388	6790	7736	5467	2104
TONSLAND	6725	4395	4023	3982	4135	4740	7270	7160	4767	3117	3657	3984	3182	1456

Table 2 Catch weights at age (kg)

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE														
1	0.011	0	0.016	0	0	0	0.03	0.01	0.014	0.013	0.022	0.034	0.004	0.004
2	0.04	0.051	0.049	0.08	0.165	0.107	0.107	0.127	0.116	0.099	0.061	0.091	0.041	0.062
3	0.086	0.077	0.085	0.113	0.156	0.147	0.143	0.18	0.158	0.137	0.154	0.148	0.102	0.08
4	0.119	0.111	0.115	0.143	0.184	0.211	0.177	0.244	0.194	0.176	0.218	0.213	0.192	0.114
5	0.186	0.184	0.173	0.23	0.216	0.262	0.229	0.317	0.243	0.227	0.268	0.278	0.269	0.195
6	0.258	0.236	0.236	0.325	0.26	0.3	0.281	0.365	0.276	0.271	0.306	0.299	0.317	0.262
7	0.337	0.32	0.313	0.434	0.348	0.355	0.342	0.434	0.327	0.324	0.353	0.333	0.375	0.343
8	0.44	0.414	0.412	0.524	0.451	0.421	0.403	0.487	0.393	0.397	0.414	0.423	0.473	0.437
9	0.594	0.5	0.509	0.612	0.56	0.516	0.49	0.591	0.498	0.499	0.498	0.483	0.568	0.538
10	0.748	0.585	0.59	0.677	0.653	0.618	0.6	0.677	0.568	0.587	0.607	0.616	0.726	0.669
11	0.922	0.736	0.716	0.776	0.767	0.743	0.749	0.785	0.725	0.709	0.692	0.854	0.836	0.81
12	1.063	0.886	0.836	0.885	0.851	0.855	0.876	0.949	0.828	0.824	0.84	0.979	1.072	0.988
13	1.226	1.101	1.039	1.106	0.984	1.033	1.052	1.151	1.068	1.033	0.989	1.155	1.361	1.131
14	1.446	1.324	1.28	1.443	1.245	1.252	1.299	1.305	1.353	1.343	1.412	1.521	1.546	1.198
15	1.683	1.546	1.53	1.705	1.696	1.534	1.544	1.657	1.561	1.652	1.565	1.903	2.234	1.783
16	1.928	1.777	1.729	1.966	1.837	1.799	1.823	1.832	1.787	1.851	1.852	1.998	2.33	2.282
17	2.212	1.989	2.005	2.22	2.083	2.257	2.1	2.023	2.01	2.132	2.078	2.407	2.393	2.578
18	2.478	2.326	2.333	2.459	2.197	2.421	2.466	2.358	2.441	2.429	2.44	3.056	2.496	2.948
19	2.669	2.508	2.553	2.643	2.283	2.534	2.707	2.474	2.716	2.662	2.822	2.954	2.675	3.426
20	3.052	2.777	2.889	2.887	2.643	2.87	2.942	2.887	3.207	3	3.14	2.899	2.719	3.199
21	3.363	2.898	3.076	3.029	3.105	3.198	3.063	3.036	3.739	3.263	2.939	4.177	3.773	3.411

22	3.993	3.422	3.637	3.487	3.192	3.471	3.663	3.584	3.851	3.754	3.807	3.682	4.384	4.287
23	4.092	3.299	3.525	3.556	2.514	3.485	3.592	3.699	4.289	3.787	3.24	4.206	4.534	3.476
24	4.998	4.172	4.453	4.067	0	4.541	4.108	4.442	4.67	4.493	4.206	4.22	4.82	0
SOP	1.0001	1	0.9998	1.0013	1	0.9999	0.9998	0.9999	1.0002	0.9994	1.0002	1	1.0013	0.998

Table 3 Stock weights at age (kg)

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE														
1	0.011	0	0.016	0	0	0	0.03	0.01	0.014	0.013	0.022	0.034	0.004	0.004
2	0.04	0.051	0.049	0.08	0.165	0.107	0.107	0.127	0.116	0.099	0.061	0.091	0.041	0.062
3	0.086	0.077	0.085	0.113	0.156	0.147	0.143	0.18	0.158	0.137	0.154	0.148	0.102	0.08
4	0.119	0.111	0.115	0.143	0.184	0.211	0.177	0.244	0.194	0.176	0.218	0.213	0.192	0.114
5	0.186	0.184	0.173	0.23	0.216	0.262	0.229	0.317	0.243	0.227	0.268	0.278	0.269	0.195
6	0.258	0.236	0.236	0.325	0.26	0.3	0.281	0.365	0.276	0.271	0.306	0.299	0.317	0.262
7	0.337	0.32	0.313	0.434	0.348	0.355	0.342	0.434	0.327	0.324	0.353	0.333	0.375	0.343
8	0.44	0.414	0.412	0.524	0.451	0.421	0.403	0.487	0.393	0.397	0.414	0.423	0.473	0.437
9	0.594	0.5	0.509	0.612	0.56	0.516	0.49	0.591	0.498	0.499	0.498	0.483	0.568	0.538
10	0.748	0.585	0.59	0.677	0.653	0.618	0.6	0.677	0.568	0.587	0.607	0.616	0.726	0.669
11	0.922	0.736	0.716	0.776	0.767	0.743	0.749	0.785	0.725	0.709	0.692	0.854	0.836	0.81
12	1.063	0.886	0.836	0.885	0.851	0.855	0.876	0.949	0.828	0.824	0.84	0.979	1.072	0.988
13	1.226	1.101	1.039	1.106	0.984	1.033	1.052	1.151	1.068	1.033	0.989	1.155	1.361	1.131
14	1.446	1.324	1.28	1.443	1.245	1.252	1.299	1.305	1.353	1.343	1.412	1.521	1.546	1.198
15	1.683	1.546	1.53	1.705	1.696	1.534	1.544	1.657	1.561	1.652	1.565	1.903	2.234	1.783
16	1.928	1.777	1.729	1.966	1.837	1.799	1.823	1.832	1.787	1.851	1.852	1.998	2.33	2.282
17	2.212	1.989	2.005	2.22	2.083	2.257	2.1	2.023	2.01	2.132	2.078	2.407	2.393	2.578
18	2.478	2.326	2.333	2.459	2.197	2.421	2.466	2.358	2.441	2.429	2.44	3.056	2.496	2.948
19	2.669	2.508	2.553	2.643	2.283	2.534	2.707	2.474	2.716	2.662	2.822	2.954	2.675	3.426
20	3.052	2.777	2.889	2.887	2.643	2.87	2.942	2.887	3.207	3	3.14	2.899	2.719	3.199
21	3.363	2.898	3.076	3.029	3.105	3.198	3.063	3.036	3.739	3.263	2.939	4.177	3.773	3.411
22	3.993	3.422	3.637	3.487	3.192	3.471	3.663	3.584	3.851	3.754	3.807	3.682	4.384	4.287
23	4.092	3.299	3.525	3.556	2.514	3.485	3.592	3.699	4.289	3.787	3.24	4.206	4.534	3.476
24	4.998	4.172	4.453	4.067	0	4.541	4.108	4.442	4.67	4.493	4.206	4.22	4.82	0

Table 4 Natural Mortality (M) at age

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE														
1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
11	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
12	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
13	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
17	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
18	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
19	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
21	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
22	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
23	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

24	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 5 Proportion mature at age

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE														
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
13	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
15	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
16	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
17	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
18	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
19	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 6 Proportion of M before Spawning

Constant for all ages and years = 0

Table 7 Proportion of F before Spawning

Constant for all ages and years = 0

Table 8 Mean Numbers per Tow (MNPT) by age of the Flemish Cap Survey

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE														
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
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
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
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
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
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
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
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
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
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
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
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
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
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

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
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
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
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
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
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
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
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
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
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

Table 9 Mean Numbers per Tow (MNPT) by age of the Spanish 3NO Survey

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE														
1						0.000	0.041	0.005	0.023	0.112	0.287	0.396	0.494	0.286
2						0.051	0.084	0.921	0.868	0.536	0.661	2.087	0.615	0.699
3						0.166	0.801	1.451	1.220	0.729	0.497	1.506	3.632	1.890
4						0.327	1.554	3.040	0.895	0.810	0.308	1.053	2.263	2.430
5						0.453	1.129	3.310	7.042	2.460	0.772	1.166	2.307	2.509
6						1.388	1.629	2.294	5.508	3.730	1.445	1.884	2.766	2.901
7						2.628	2.892	2.061	2.505	3.744	2.011	3.650	2.641	2.098
8						0.881	4.208	2.084	1.612	2.134	1.591	3.706	3.487	3.111
9						0.850	1.461	0.973	1.565	1.373	1.104	1.656	3.855	2.077
10						0.451	1.277	0.391	1.339	1.451	1.089	1.151	3.341	2.815
11						0.587	0.533	0.229	0.229	0.343	0.577	0.987	1.555	1.672
12						0.550	0.644	0.147	0.272	0.131	0.771	0.449	0.907	0.916
13						0.271	0.605	0.105	0.145	0.088	0.188	0.309	0.524	1.124
14						0.088	0.264	0.102	0.221	0.054	0.150	0.140	0.283	0.673
15						0.053	0.204	0.082	0.117	0.053	0.099	0.164	0.106	0.227
16						0.028	0.066	0.028	0.072	0.045	0.156	0.160	0.095	0.074
17						0.014	0.038	0.018	0.032	0.058	0.141	0.098	0.043	0.110
18						0.020	0.056	0.023	0.028	0.042	0.088	0.025	0.033	0.141
19						0.015	0.046	0.015	0.036	0.026	0.067	0.031	0.008	0.017
20						0.009	0.032	0.014	0.018	0.012	0.020	0.014	0.003	0.025
21						0.007	0.017	0.009	0.012	0.010	0.018	0.000	0.003	0.013
22						0.004	0.009	0.003	0.005	0.003	0.009	0.006	0.003	0.000
23						0.004	0.009	0.002	0.005	0.004	0.007	0.000	0.000	0.000
24						0.000	0.001	0.001	0.001	0.003	0.004	0.000	0.000	0.000

Appendix II

Lowestoft VPA Version 3.1

11/10/2006 12:33

Extended Survivors Analysis

Roughhead grenadiers 05 (NAFO Subareas 2-3)

CPUE data from file Tun.txt

Catch data for 14 years. 1992 to 2005. Ages 3 to 19.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU 3M	1994	2005	3	16	.500	.600
Spain 3NO	1997	2005	3	18	.400	.500

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 17

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 4 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.000

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning converged after 109 iterations

Regression weights
, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000

Fishing mortalities

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Age										
3	.005	.009	.005	.007	.010	.006	.004	.004	.002	.000
4	.017	.028	.016	.008	.015	.012	.015	.020	.007	.000
5	.039	.039	.054	.030	.021	.023	.030	.025	.027	.001
6	.080	.059	.115	.076	.061	.042	.067	.041	.046	.006
7	.107	.082	.175	.084	.094	.068	.052	.091	.062	.020
8	.141	.189	.336	.126	.145	.139	.098	.110	.093	.032
9	.194	.197	.516	.165	.227	.124	.132	.130	.055	.045
10	.157	.203	.320	.316	.222	.099	.076	.148	.058	.035
11	.186	.171	.326	.378	.275	.099	.094	.079	.064	.026
12	.209	.195	.232	.340	.260	.198	.108	.077	.068	.039
13	.265	.203	.207	.367	.215	.116	.183	.058	.052	.029
14	.209	.330	.224	.384	.158	.107	.094	.087	.042	.023
15	.192	.236	.282	.274	.143	.056	.085	.066	.076	.012
16	.196	.256	.229	.340	.100	.053	.074	.127	.059	.019
17	.187	.279	.206	.271	.123	.048	.119	.048	.046	.024
18	.231	.232	.328	.748	.117	.123	.118	.025	.031	.030

1

XSA population numbers (Thousands)

AGE	3	4	5	6	7	8	9	10	11	12
YEAR										
1996	2.01E+04	2.02E+04	1.95E+04	1.59E+04	9.54E+03	8.00E+03	5.50E+03	5.04E+03	3.77E+03	2.55E+03
1997	2.82E+04	1.81E+04	1.80E+04	1.70E+04	1.33E+04	7.75E+03	6.29E+03	4.10E+03	3.90E+03	2.84E+03
1998	3.23E+04	2.53E+04	1.60E+04	1.56E+04	1.45E+04	1.11E+04	5.81E+03	4.67E+03	3.03E+03	2.97E+03
1999	2.40E+04	2.91E+04	2.25E+04	1.37E+04	1.26E+04	1.10E+04	7.18E+03	3.14E+03	3.07E+03	1.98E+03
2000	2.11E+04	2.16E+04	2.61E+04	1.98E+04	1.15E+04	1.05E+04	8.78E+03	5.51E+03	2.07E+03	1.90E+03
2001	1.96E+04	1.90E+04	1.93E+04	2.32E+04	1.68E+04	9.45E+03	8.21E+03	6.33E+03	3.99E+03	1.42E+03
2002	2.77E+04	1.76E+04	1.69E+04	1.70E+04	2.01E+04	1.42E+04	7.44E+03	6.56E+03	5.19E+03	3.27E+03
2003	4.24E+04	2.50E+04	1.57E+04	1.49E+04	1.44E+04	1.72E+04	1.17E+04	5.90E+03	5.50E+03	4.28E+03
2004	5.40E+04	3.82E+04	2.22E+04	1.38E+04	1.29E+04	1.19E+04	1.40E+04	9.27E+03	4.60E+03	4.60E+03
2005	1.44E+04	4.88E+04	3.43E+04	1.95E+04	1.19E+04	1.10E+04	9.82E+03	1.20E+04	7.91E+03	3.90E+03
Estimated population abundance at 1st Jan 2006	0.00E+00	1.30E+04	4.41E+04	3.10E+04	1.76E+04	1.06E+04	9.63E+03	8.50E+03	1.05E+04	6.98E+03
Taper weighted geometric mean of the VPA populations:	2.47E+04	2.23E+04	1.80E+04	1.48E+04	1.21E+04	9.93E+03	7.47E+03	5.29E+03	3.64E+03	2.49E+03
Standard error of the weighted Log(VPA populations) :	.3576	.3526	.3094	.2584	.2482	.2566	.2903	.3653	.3608	.3733

AGE						
YEAR	13	14	15	16	17	18
1996	1.26E+03	8.08E+02	5.03E+02	3.57E+02	2.97E+02	2.12E+02
1997	1.87E+03	8.72E+02	5.93E+02	3.76E+02	2.65E+02	2.23E+02
1998	2.11E+03	1.38E+03	5.67E+02	4.24E+02	2.63E+02	1.82E+02
1999	2.13E+03	1.55E+03	1.00E+03	3.87E+02	3.05E+02	1.94E+02
2000	1.27E+03	1.34E+03	9.57E+02	6.88E+02	2.49E+02	2.10E+02
2001	1.33E+03	9.29E+02	1.03E+03	7.51E+02	5.63E+02	2.00E+02
2002	1.06E+03	1.07E+03	7.56E+02	8.84E+02	6.44E+02	4.86E+02
2003	2.66E+03	7.96E+02	8.82E+02	6.28E+02	7.43E+02	5.18E+02
2004	3.58E+03	2.27E+03	6.60E+02	7.47E+02	5.00E+02	6.40E+02
2005	3.89E+03	3.08E+03	1.97E+03	5.54E+02	6.37E+02	4.33E+02
Estimated population abundance at 1st Jan 2006	3.40E+03	3.42E+03	2.72E+03	1.76E+03	4.92E+02	5.63E+02
Taper weighted geometric mean of the VPA populations:	1.72E+03	1.16E+03	7.60E+02	5.15E+02	3.76E+02	2.70E+02
Standard error of the weighted Log(VPA populations) :	.4298	.4221	.3660	.3042	.3956	.4369

1

Log catchability residuals.

Fleet : EU 3M

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
3	-0.53	-0.02	-0.55	-0.37	-0.3	-1.54	-0.62	0.37	-0.19	0.98	1.8	0.97
4	0.84	0.71	0.06	-0.21	-0.11	-0.35	-1.5	-0.51	-1.17	0.94	0.92	0.39
5	0.85	1.02	0.05	-0.67	-0.67	-0.67	-0.46	-0.16	-0.99	0.83	0.83	0.05
6	0.59	0.62	0.26	-0.08	-0.23	-0.45	-0.71	-0.41	-0.94	0.39	1.02	-0.05
7	0.54	0.31	-0.06	0.15	0.29	-0.11	-0.73	-0.22	-1.02	0.4	0.45	0.02
8	0.27	0.36	-0.08	-0.76	0.69	0.19	-0.73	0.15	-0.86	0.11	0.54	0.11
9	0.27	-0.11	-0.11	-0.56	0.16	0.27	-0.11	0.3	-0.34	0	0.37	-0.13
10	-0.24	-0.81	0.01	-0.74	0.02	0.28	0.21	0.68	-0.29	0.44	0.57	-0.13
11	0	-1.44	0.42	-0.14	0.09	-0.11	-0.19	0.22	-0.17	0.6	0.76	-0.03
12	0.02	-1.3	-0.3	0.16	0.23	-0.13	0.05	0.62	0.36	0.04	0.47	-0.23
13	-0.11	-0.89	-0.3	0.45	0.54	-0.39	0.07	0.31	0.51	-0.31	-0.11	0.23
14	-0.63	-1.74	0.07	0.27	0.36	0.11	0.03	1	0.34	-0.08	-0.08	0.36
15	0.48	0.09	-1.28	0.92	1.13	0.18	-0.23	0.54	-0.18	-0.43	-0.13	-1.09
16	-0.1	99.99	0.16	-0.12	0.73	-1.02	-0.07	0.38	0.49	0.03	0.07	-0.55
17	No data for this fleet at this age											
18	No data for this fleet at this age											

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10	11	12
Mean Log q	-11.2860	-11.1839	-10.6823	-10.1552	-9.8187	-9.6415	-9.6491	-9.5109	-9.6501	-9.5324
S.E(Log q)	.8991	.8064	.7207	.5888	.4758	.5119	.2845	.4731	.5516	.4929

Age	13	14	15	16
Mean Log q	-9.6906	-9.7641	-10.0789	-10.2144
S.E(Log q)	.4329	.6676	.7269	.4831

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	.49	1.406	10.72	.44	12	.43	-11.29
4	.48	1.436	10.62	.44	12	.37	-11.18
5	2.14	-.626	11.60	.03	12	1.59	-10.68
6	-1.48	-2.619	8.93	.10	12	.70	-10.16
7	23.44	-1.838	18.32	.00	12	10.11	-9.82
8	1.09	-.128	9.68	.18	12	.58	-9.64
9	.77	.990	9.49	.65	12	.22	-9.65
10	.75	.814	9.29	.52	12	.36	-9.51
11	.71	.882	9.24	.48	12	.40	-9.65
12	.79	.696	9.17	.51	12	.40	-9.53
13	.92	.280	9.52	.57	12	.42	-9.69
14	.68	1.095	8.89	.53	12	.45	-9.76
15	2.79	-1.175	16.21	.04	12	1.99	-10.08
16	.67	1.069	8.92	.54	11	.32	-10.21

Fleet : Spain 3NO

Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
3	99.99	-1.81	-.38	.51	.47	.03	-.70	-.02	.62	1.29
4	99.99	-.85	.37	.90	-.02	.01	-.88	.00	.33	.15
5	99.99	-1.21	-.17	.55	1.15	.40	-.62	-.14	.20	-.16
6	99.99	-.54	-.27	.19	.69	.13	-.49	-.11	.35	.04
7	99.99	.05	.11	-.13	.16	.17	-.64	.31	.08	-.09
8	99.99	-.55	.72	-.07	-.27	.11	-.61	.05	.35	.29
9	99.99	-.26	.50	-.27	.03	-.08	-.20	-.24	.39	.12
10	99.99	-.59	.37	-.42	.21	.09	-.24	-.04	.53	.09
11	99.99	.05	.27	-.56	-.22	-.55	-.29	.18	.81	.32
12	99.99	.25	.37	-.65	-.03	-.50	.40	-.42	.21	.37
13	99.99	.10	.79	-.90	-.13	-.72	.30	-.18	.04	.71
14	99.99	-.15	.44	-.55	.27	-.80	.07	.30	-.07	.49
15	99.99	-.29	1.12	-.36	-.02	-.93	.02	.37	.22	-.14
16	99.99	-.40	.33	-.39	-.13	-.71	.38	.77	.05	.08
17	99.99	-.68	.30	-.57	.14	-.11	.67	.14	-.29	.39
18	99.99	-.17	1.11	.35	.18	.64	.48	-.88	-.81	1.03

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	3	4	5	6	7	8	9	10	11	12
Mean Log q	-10.1796	-10.0166	-9.3147	-8.8041	-8.5009	-8.3980	-8.5159	-8.3858	-8.7245	-8.6617
S.E(Log q)	.8984	.5678	.6850	.3989	.2743	.4319	.2884	.3643	.4485	.4158

Age	13	14	15	16	17	18
Mean Log q	-8.8051	-8.8598	-8.8809	-8.9478	-9.0033	-9.0033
S.E(Log q)	.5717	.4430	.5629	.4593	.4495	.7543

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
3	2.35	-.703	10.13	.04	9	2.18	-10.18
4	.50	2.052	10.08	.71	9	.24	-10.02
5	.47	1.231	9.64	.44	9	.31	-9.31
6	.77	.348	9.02	.25	9	.33	-8.80
7	4.89	-1.583	4.42	.02	9	1.23	-8.50
8	.82	.298	8.56	.29	9	.38	-8.40
9	.87	.391	8.58	.57	9	.27	-8.52
10	.66	1.799	8.49	.80	9	.21	-8.39
11	.70	1.068	8.60	.65	9	.31	-8.72
12	.65	1.650	8.41	.76	9	.24	-8.66
13	.74	.784	8.49	.56	9	.43	-8.81
14	.77	.846	8.48	.66	9	.35	-8.86
15	2.88	-1.297	12.86	.06	9	1.56	-8.88
16	.76	.595	8.32	.46	9	.36	-8.95
17	.69	1.337	8.08	.72	9	.30	-9.00
18	3.66	-1.580	16.94	.05	9	2.41	-8.79

1

Terminal year survivor and F summaries :

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2002

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
EU 3M	34356.	.936	.000	.00	1	.351	.000
Spain 3NO	47145.	.947	.000	.00	1	.342	.000
F shrinkage mean	1022.	1.00				307	.004

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
13009.	.55	1.44	3	2.602	.000

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2001

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	122116.	.625	.700	1.12	2	.343	.000
Spain 3NO	58770.	.506	.209	.41	2	.523	.000
F shrinkage mean	1068.	1.00				.134	.014

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
44129.	.37	.83	5	2.277	.000

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	55159.	.480	.313	.65	3	.388	.001
Spain 3NO	34294.	.414	.160	.39	3	.521	.001
F shrinkage mean	1455.	1.00				.090	.027

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
31024.	.30	.44	7	1.477	.001

Age 6 Catchability constant w.r.t. time and dependent on age

Year class = 1999

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	24849.	.378	.282	.75	4	.358	.004
Spain 3NO	17305.	.295	.134	.45	4	.589	.006

F shrinkage mean	1984.	1.00				.053	.049

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
17574.	.23	.23	9	1.018	.006

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 1998

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
EU 3M	13919.	.301	.340	1.13	5	.317	.015
Spain 3NO	9853.	.211	.175	.83	5	.653	.021
F shrinkage mean	2993.	1.00				.030	.068

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
10601.	.17	.17	11	1.026	.020

Age 8 Catchability constant w.r.t. time and dependent on age

Year class = 1997

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
EU 3M	9808.	.262	.224	.86	6	.338	.031
Spain 3NO	10049.	.191	.103	.54	6	.636	.031
F shrinkage mean	2685.	1.00				.026	.110

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
9633.	.15	.12	13	.763	.032

Age 9 Catchability constant w.r.t. time and dependent on age

Year class = 1996

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated

	Survivors	s.e	s.e	Ratio		Weights	F
EU 3M	7308.	.198	.231	1.17	7	.402	.052
Spain 3NO	9711.	.163	.112	.69	7	.580	.039
F shrinkage mean	3334.	1.00				.018	.111

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
8495.	.12	.12	15	.977	.045

Age 10 Catchability constant w.r.t. time and dependent on age

Year class = 1995

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
EU 3M	9768.	.184	.176	.96	8	.397	.037
Spain 3NO	11275.	.150	.181	1.21	8	.587	.032
F shrinkage mean	3687.	1.00				.016	.095

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
10466.	.12	.12	17	1.067	.035

Age 11 Catchability constant w.r.t. time and dependent on age

Year class = 1994

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
EU 3M	6194.	.176	.146	.83	9	.397	.029
Spain 3NO	7813.	.144	.166	1.15	9	.587	.023
F shrinkage mean	2068.	1.00				.016	.084

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
6979.	.11	.11	19	1.029	.026

Age 12 Catchability constant w.r.t. time and dependent on age

Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	3028.	.169	.150	.88	10	.404	.044
Spain 3NO	3798.	.140	.124	.88	9	.580	.035
F shrinkage mean	1137.	1.00				.016	.113

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3398.	.11	.10	20	.918	.039

Age 13 Catchability constant w.r.t. time and dependent on age

Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	3795.	.159	.119	.75	11	.438	.026
Spain 3NO	3263.	.140	.114	.81	9	.547	.030
F shrinkage mean	922.	1.00				.015	.102

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3421.	.10	.09	21	.831	.029

Age 14 Catchability constant w.r.t. time and dependent on age

Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	2945.	.159	.086	.54	12	.432	.022
Spain 3NO	2657.	.140	.101	.72	9	.552	.024
F shrinkage mean	747.	1.00				.016	.082

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2723.	.10	.07	22	.694	.023

Age 15 Catchability constant w.r.t. time and dependent on age

Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	1925.	.162	.131	.81	12	.439	.011
Spain 3NO	1737.	.147	.113	.77	9	.544	.012
F shrinkage mean	283.	1.00				.017	.071

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1761.	.11	.10	22	.904	.012

Age 16 Catchability constant w.r.t. time and dependent on age

Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	519.	.180	.132	.73	12	.451	.018
Spain 3NO	502.	.171	.121	.70	9	.526	.018
F shrinkage mean	114.	1.00				.024	.078

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
492.	.12	.10	22	.791	.019

Age 17 Catchability constant w.r.t. time and dependent on age

Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU 3M	1.	.000	.000	.00	0	.000	.000
Spain 3NO	1.	.000	.000	.00	0	.000	.000
F shrinkage mean	202.	1.00				.022	.065

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
563.	.12	.08	21	.671	.024

Age 18 Catchability constant w.r.t. time and age (fixed at the value for age) 17

Year class = 1987

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
	Survivors	s.e	s.e	Ratio		Weights	F
EU 3M	1.	.000	.000	.00	0	.000	.000
Spain 3NO	1.	.000	.000	.00	0	.000	.000
F shrinkage mean	631.	1.00				.027	.018

Weighted prediction :

Survivors	Int	Ext	N	Var	F
at end of year	s.e	s.e		Ratio	
380.	.13	.12	20	.928	.030

Appendix III

Run title : Roughhead grenadiers 05 (NAFO Subareas 2-3)

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGE														
3	0.004	0.006	0.006	0.007	0.005	0.009	0.005	0.007	0.010	0.006	0.004	0.004	0.002	0.000
4	0.008	0.006	0.009	0.015	0.017	0.028	0.016	0.008	0.015	0.012	0.016	0.020	0.007	0.000
5	0.020	0.013	0.017	0.022	0.039	0.039	0.054	0.030	0.022	0.023	0.030	0.025	0.027	0.001
6	0.050	0.041	0.039	0.055	0.080	0.059	0.115	0.076	0.061	0.043	0.067	0.041	0.046	0.006
7	0.088	0.056	0.069	0.071	0.107	0.082	0.175	0.084	0.094	0.068	0.052	0.091	0.062	0.020
8	0.159	0.130	0.123	0.142	0.141	0.189	0.336	0.126	0.145	0.139	0.098	0.110	0.093	0.032
9	0.247	0.205	0.188	0.159	0.194	0.197	0.516	0.165	0.227	0.124	0.132	0.130	0.055	0.045
10	0.279	0.246	0.204	0.160	0.157	0.203	0.320	0.316	0.222	0.099	0.076	0.148	0.058	0.035
11	0.360	0.257	0.272	0.177	0.186	0.171	0.326	0.378	0.275	0.099	0.094	0.079	0.064	0.026
12	0.443	0.320	0.325	0.251	0.209	0.195	0.232	0.340	0.260	0.198	0.108	0.077	0.068	0.039
13	0.444	0.365	0.348	0.240	0.265	0.203	0.208	0.367	0.215	0.116	0.183	0.058	0.052	0.029
14	0.526	0.391	0.384	0.279	0.209	0.330	0.224	0.384	0.158	0.107	0.094	0.087	0.042	0.023
15	0.459	0.379	0.297	0.232	0.192	0.236	0.282	0.274	0.143	0.056	0.085	0.066	0.077	0.012
16	0.409	0.357	0.267	0.219	0.196	0.256	0.229	0.340	0.100	0.053	0.074	0.127	0.059	0.019
17	0.340	0.295	0.244	0.184	0.187	0.280	0.206	0.271	0.123	0.048	0.119	0.049	0.046	0.024
18	0.404	0.345	0.270	0.212	0.231	0.232	0.328	0.748	0.117	0.123	0.118	0.025	0.031	0.030
+gp	0.404	0.345	0.270	0.212	0.231	0.232	0.328	0.748	0.117	0.123	0.118	0.025	0.031	0.030
FBAR 11-16	0.440	0.345	0.316	0.233	0.210	0.232	0.250	0.347	0.192	0.105	0.106	0.082	0.060	0.025

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AGE															
3	15463	22326	24342	22445	20127	28220	32350	24032	21145	19558	27730	42418	54037	14380	0
4	13607	13932	20082	21901	20173	18121	25305	29134	21597	18952	17595	24996	38217	48779	13009
5	10762	12213	12527	18002	19513	17953	15952	22524	26148	19254	16942	15677	22176	34326	44129
6	11086	9550	10907	11139	15936	16982	15624	13681	19771	23158	17021	14870	13831	19529	31024
7	9901	9547	8292	9494	9542	13314	14485	12596	11476	16826	20083	14406	12920	11948	17574
8	8010	8205	8167	7001	8001	7754	11103	11002	10482	9449	14226	17246	11903	10990	10601
9	5184	6181	6522	6532	5499	6290	5808	7179	8778	8208	7437	11668	13979	9817	9633
10	3628	3663	4557	4891	5043	4099	4672	3138	5506	6332	6559	5898	9269	11971	8495
11	2775	2482	2591	3364	3773	3899	3026	3070	2070	3988	5192	5502	4602	7912	10466
12	2209	1752	1737	1785	2550	2835	2973	1977	1904	1424	3269	4276	4602	3904	6979
13	1708	1284	1151	1135	1257	1873	2112	2132	1273	1329	1057	2656	3584	3889	3398
14	1227	992	807	735	808	872	1384	1553	1337	929	1071	796	2269	3080	3421
15	740	656	607	497	503	593	567	1001	957	1033	756	882	660	1969	2723
16	508	423	406	408	357	376	424	387	688	751	884	628	747	554	1761
17	366	305	268	282	297	265	263	305	249	563	644	743	500	637	492
18	241	236	206	190	212	223	182	194	210	200	486	518	640	433	563
+gp	402	379	390	294	224	397	407	545	967	432	661	1122	608	955	1218
TOTAL	87817	94127	103559	110096	113815	124065	136636	134450	134560	132387	141613	164302	194543	185072	165487

Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 11-16
	Age 3					
1992	15463	34156	3895	6725	1.7264	0.44
1993	22326	29512	3113	4395	1.4117	0.3446
1994	24342	30419	2998	4023	1.342	0.3156
1995	22445	38624	2805	3982	1.4198	0.233
1996	20127	38954	2401	4135	1.722	0.2095
1997	28220	43758	3131	4740	1.5139	0.2318
1998	32350	44985	3232	7270	2.2494	0.2501
1999	24032	54595	3952	7160	1.8118	0.3472
2000	21145	48072	5849	4767	0.8149	0.1917
2001	19558	46437	4491	3117	0.694	0.1048
2002	27730	54798	5975	3657	0.6121	0.1063
2003	42418	64680	8122	3984	0.4905	0.0822
2004	54037	73377	6659	3182	0.4779	0.0603
2005	14380	70080	8564	1456	0.17	0.0246
Arith.						
Mean	26327	48032	4656	4471	1.1755	0.2101
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		