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An Assessment of Beaked Redfish (*S. mentella* and *S. fasciatus*) in NAFO Division 3M (With an Approach to the Likely Impact of Recent 3M Cod Growth on Redfish Natural Mortality)

By

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**Abstract**

The 3M redfish assessment is focused on the beaked redfish, regarded as a management unit composed of two populations from two very similar species: the Flemish Cap *S. mentella* and *S. fasciatus*. The reason for this approach is the historical dominance of this group in the 3M redfish commercial catch until 2005. However a new golden redfish fishery (*S. marinus*) started on September 2005 on shallower depths of the Flemish Cap bank above 300m. This new reality implied a revision of catch estimates, in order to split recent redfish commercial catch from the major fleets on Div. 3M into golden (*S. marinus*) and beaked (*S. mentella* and *S. fasciatus*) redfish catches.

An Extended Survivor Analysis (Shepherd, 1999) was used with the same framework of previous assessments and with the tuning of the 1989-2010 EU survey. Recent survey results suggest that the beaked redfish stock has not been able to hold its growth and sustain an above average level, suffering instead a severe decline on the second half of the 2000's. For several reasons, the most likely hypothesis to justify this unexpected downward trend on stock size is an increase in mortality other than fishing mortality. From the sensitive analysis, carried out for a set of natural mortality options, a natural mortality of 0.4 (fixed for ages 4-6 through 2006-2010, and ages 7+ on 2009 and 2011) was adopted. This is the lowest possible level of natural mortality giving assessment results in line with the recent survey declines and at the same time with key diagnostics very close to the best ones, obtained with a higher natural mortality of 0.55. A 2011-2007 retrospective XSA was also carried out. When compared to previous assessments, these retrospective present more consistent trends namely as regards female spawning biomass and average fishing mortality, coupled with a non systematic bias signal.

Very high fishing mortalities until 1996 forced a rapid decline of abundance, biomass and female spawning biomass. With lower fishing mortalities since then, the stock decline was halted. The weak 1991-1997 year classes kept the stock size at a low level till 2003, basically sustained by the survival and growth of the existing cohorts. Recruitment at age 4 increased from 2002 till 2006, when the 2002 year class was at an historical high, and from 2006 to 2008 fell as fast as it went up, still continuing to decrease on most recent years and being on 2010 just below average. Above average year classes coupled with fishing mortalities in the vicinity of  $F_{0.1}$  or even lower allowed a rapid growth of biomass and abundance since 2003 and sustained the stock at a high level on 2007-2008. However the stock decreased on the last couple of years despite low catch and, being still above average level, there are no signs that the present decline rate is slowing down. Female spawning stock component experienced a similar decline.

Short and medium term stochastic projections were obtained for female spawning stock biomass (SSB) under  $F_{statusquo}$  (average 2008-2010 fishing mortality), together with SSB and yield medium term probability profiles. Keeping fishing mortality at its present low level well below  $F_{0.1}$  will sustain on the short term the female spawning stock biomass above the SSB interval from where all the abundant year classes from the past decade were generated. But on the long term it will be natural mortality to determine the future of beaked redfish as a fishery resource. The average 2012-2013  $F_{statusquo}$  catch for beaked redfish will be

of 3,200 tons. According to 2008-2010 observed catch data from the Portuguese, Spanish and Russian National Sampling Programmes on board, a beaked redfish annual catch of 3,200 tons would correspond to an overall 3M redfish catch (including the shallower golden redfish catches) near 7,000 tons (6,840 tons).

### Introduction

There are three stocks of redfish in NAFO Division 3M: deep-sea redfish (*Sebastes mentella*) with a maximum abundance at depths greater than 300m, golden redfish (*Sebastes marinus*) and Acadian redfish (*Sebastes fasciatus*) preferring shallower waters of less than 400m. Due to their external resemblance *S. mentella* and *S. fasciatus* are commonly designated as beaked redfish. The identity of the Flemish Cap redfish populations is supported by morphometric studies (Saborido Rey, 1998).

The 3M redfish assessment is focused on beaked redfish, regarded as a management unit composed of two populations from two very similar species: the Flemish Cap *S. mentella* and *S. fasciatus*. The reason for this approach is the dominance of this group in the 3M redfish commercial catch. During the entire series of EU Flemish Cap surveys (1988-2010) beaked redfish also represents the majority of redfish survey biomass (71%).

Flemish Cap beaked redfish are long living species presenting slow growth, slow maturation and a long recruitment process to the bottom, extending to lengths up to 30-32cm. The *S. mentella* and *S. fasciatus* populations have similar length growth, namely females, up to 20 years old (Saborido Rey, 2001). Redfish are viviparous with the larvae eclosion occurring right before or after birth. Mean length of female first maturation varies from 26,5cm (at age 8) for Acadian redfish to 30.1cm (at age 10) for deep-sea redfish (Saborido Rey, *pers. comm.* 2000). Spawning on Flemish Cap occurs through February till the first half of April for deep-sea redfish while for Acadian redfish spawning reach its maximum in July – August (Saborido Rey, 1994).

### Description of the fishery

The 3M redfish stocks have been exploited both by pelagic and bottom trawl. Due to the similarity of their external morphology the commercial catches of 3M redfish are reported together. Historically the majority of pelagic and bottom commercial catches from the 3M redfish fisheries are a mixture of *S.mentella* and *S.fasciatus*. The redfish by-catch from the 3M Greenland halibut fishery is 100% *S. mentella*.

The redfish fishery on Division 3M increased from 20,000 tons in 1985 to 81,000 tons in 1990, falling continuously since then till 1998-1999, when a minimum catch around 1,000 tons has been recorded most as by-catch of the Greenland halibut fishery (Table 1a, Fig. 1a). This drop of the 3M redfish catches was related with the quick decline of the stock biomass followed by an abrupt decline of fishing effort deployed in this fishery.

The relative increase of the catch on 2000-2002 (to a level between 3,700 and 2,900 tons) reflected an increase of the fishing effort directed to 3M redfish, pursued by the Portuguese and Russian fleets. However, in 2003, catch from Russia fall by 90% and the overall catch didn't reach 2,000 tons. In 2004 catch increased again to almost 3,000 tons and Portugal consolidated its major role in the fishery with 2,500 tons (Table 1a).

From July 2004 to July 2006 Flemish Cap EU survey showed a 3.5 fold increase in bottom biomass of both golden and beaked redfish (Casas *et al.*, 2007). Redfish catches followed that increase and, despite posterior stock declines, were kept at a relative high level of 7,000-11,000 tons between 2006 and 2010. The rapid increase of golden redfish biomass allowed a new golden redfish fishery from September 2005 onwards on shallower waters above 300m. So over the most recent years we have at the same time two redfish fisheries occurring at depths above (golden redfish) and below (beaked redfish) 300m, basically pursued by Portuguese bottom trawl and Russian pelagic trawl.

Furthermore the high levels of both golden and beaked redfish biomass match with an important increase of cod biomass since 2006, with increasing cod by-catches and finally the reopening of the Flemish Cap cod fishery in 2010 with a TAC of 5,500 tons. This would necessarily imply another contribution to the maintenance of a relatively high level of redfish catches, in this case associated with increasing fishing effort directed to cod.

These new realities forced a revision of redfish catch estimates, in order to split recent commercial catch of the major fleets on the Flemish Cap bank (Portugal, Russia and Spain) into golden and beaked redfish and to have for each of the main fleets the available length sampling separated as well.

In order to estimate a proxy of the beaked redfish catch by fleet, a 2005-2010 revision of the logbooks from the monitored vessels has been carried by the national sampling programmes of Portugal, Spain and Russia. For each fleet the observed hauls were assembled by depth intervals (<300m; 300-400m; 400-700m and >700m). The proportion of beaked redfish found in the EU survey redfish catch (excluding juveniles) at each of these intervals was applied to the correspondent commercial redfish observed catch taken from the same depth interval in order to get a beaked redfish catch estimate. The ratio between estimated beaked redfish catch and observed redfish catch for the monitored vessels was then applied to the fleet annual catch in order to get a beaked redfish catch estimate for that fleet. This exercise was performed for the Portuguese bottom trawl (2005-201), Spanish bottom trawl (2005-2009) and Russian pelagic trawl (2005-2010).

The 2005-2008 3M redfish catches of Japan were assigned to beaked redfish. The 2005-2009 3M beaked redfish catches of the Baltic States were estimated with an average beaked redfish proportion found on the redfish catches of Portugal and Spain on each of those years. For 2010, the European Union catch, given in the NAFO Circ. Letter with the "Recording of Provisional Catches for December 2010" (11<sup>th</sup> February 2011, Ref. No.: GFS/11-056), is not yet disaggregated by country. So the Portuguese beaked redfish proportion for 2010 was applied to the whole EU provisional redfish catch of last year.

The 1989-2010 redfish nominal catch is presented on Table 1a, STACFIS redfish catch on Table 1b and the beaked redfish landings used in this assessment on Table 1c and Fig. 1a. Finally on Table 1d are tabulated the golden and beaked redfish proportions by depth found in the 2005-2010 EU surveys (Gonzalez, *pers. comm.*, 2009-2011), that were used to get the beaked redfish commercial catch estimates by fleet.

The boom in 1993 and further settlement of a shrimp fishery in Flemish Cap lead to high levels of redfish by-catch in 1993-1994. From 1995 onwards by-catch in weight fell to apparent low levels but since 2001 increased again, reaching 1006 tons in 2003. That increase does not reflect any expansion of the 3M shrimp fishery and was supported by above average year classes occurring on 2001-2003. From Canadian observer data (Kulka and Firth, *pers. comm.*, 1999-2005) the redfish by-catch on the 3M shrimp fishery declined to 471 ton in 2004 and again to 80 ton in 2005 (Table 1e), reflecting an important reduction of the 3M shrimp catch observed in recent years (Skúladóttir and Pétursson, 2006). The overall level of the 2006-2010 redfish by-catch remains unknown.

In 2001-2003 the redfish by-catch in numbers from the Flemish Cap shrimp fishery justified 78% of the total 3M redfish catch. In 2004 represented 44%, and just 15% of the total catch in 2005 (Table 1f, Fig. 1b). On most recent years (2006-2010) the beaked redfish catch in the assessment is assumed to be the commercial catch.

### **Length composition of the commercial catch and by-catch**

The 1998-2006 3M beaked redfish commercial length weight relationships from the Portuguese commercial catch (Alpoim and Vargas, 2004; Vargas *et al.*, 2005 and 2007-2011) were used to compute the mean weights of all commercial catches and correspondent catch numbers at length (Table 2a). The 1993-2004 beaked redfish length weight relationships from the EU survey (Table 2b: Troncoso and Casas, *pers. comm.* 2005) were used to compute the mean weights of the by-catch and correspondent by-catch numbers at length.

Length sampling from the Portuguese bottom trawl and from the Russian pelagic trawl are the major input to the length composition of the 3M beaked redfish commercial catch. The Russian beaked redfish length sampling from pelagic trawl is just applied to the Russian beaked redfish pelagic catches. The pelagic catch is near 100% of the Russian catch but for 1996, 1998-1999 and 2003-004. The Portuguese beaked redfish length sampling is applied to the beaked redfish catch of bottom trawl fleets with the exception of the Spanish and Japanese fleets for the years where respective length sampling data are available (Table 3a). In order to overcome the lack of the length sampling of the Portuguese catches on 1993-1994 and of the Russian catches on 1992-1994, for each year and fleet an expected length composition of the commercial catch was derived from the permille length composition of the

correspondent EU survey catch, using a “exploitation pattern at length” calculated previously for each commercial trawl gear (Ávila de Melo et al., 2009).

Length structure of the commercial catch show relative stability between 1989 and 2001, with most of the annual mean lengths falling within 27-31cm. Small sizes increase their presence in the commercial catch afterwards, being responsible of annual mean lengths bellow 28cm and wide oscillations in the catch structure at length. Until very recently this presence of small redfish in the commercial catch was the outcome of several recruitment processes from a sequence of abundant year classes. However the severe decline of the commercial mean length between 2009 and 2010 may also reflect a decline on the size of the exploitable stock, as suggested by the EU survey results (Table 3b, Fig. 2).

Redfish by-catch proportion in weight of the shrimp catch and redfish by-catch in numbers at length for the 3M shrimp fishery were available from 1993 till 2004, based on data collected on board of Norwegian (1993-1998) and Canadian (1993-1997; 1999-2004) vessels (Kulka, 1999 and *pers. comm.*, 2000-2005; Firth, *pers. comm.* 2004-2005). The sum of the absolute length compositions of the 1989-2010 commercial catch with the absolute length compositions of the 1993-2004 by-catch is the 3M redfish catch at length input of this assessment (Table 3c).

### **Age composition of the catch**

Age composition of the total catch was obtained using the *S.mentella* age length keys from the 1990-2007 and 2009-2010 EU surveys. No *S.mentella* age length key was available for 2008: a synthetic *S.mentella* age length key was applied both to commercial and survey length compositions (Fran Saborido-Rey, *pers. comm.* 2009). Before 1993 age group 8 was the most abundant in the commercial catch and consecutive 1981-1984 cohorts were the most important when passing through this age. The lack of sorting grades on shrimp trawl at the beginning of the 3M shrimp fishery justified that the most abundant age group in the catch (including redfish by-catch) moved back to age 4 and 5 in 1993-1995, targeting prematurely the above average 1989 and 1990 cohorts. The expansion of the shrimp fishery with sorting grade escape device and the decline of the redfish fishery lead to even younger modal age groups between 1996 and 2004, when age 2 was the most abundant on the redfish catch most of the years (nevertheless 1990 year class dominated again the commercial catch in 2000). The 1999-2005 cohorts dominated sequentially the overall catch through most years of the past decade (with the exception of 2005), some of them on several years, first still in the shrimp by-catch and later on in the commercial fishery (Table 3d).

The length weight relationships from the Portuguese commercial catch (Table 2a) were used to calculate mean weights at age in the redfish catch (commercial plus by-catch) (Table 3e).

## **Research surveys**

There are two survey series providing bottom biomass indices as well as length and age structure of the Flemish Cap redfish stocks: one series from Russia (1983-1993; 1995-1996 and 2001-2002) and the other one from the European Union/Spain and Portugal (1988-2010). An earlier bottom trawl survey series has been carried out by Canada from 1979 till 1985. This series was discontinued since then, despite an isolated Canadian bottom trawl survey conducted again on 1996.

For reasons explained in previously (Ávila de Melo *et al.*, 2003) the EU survey series is the only source of survey data used in the assessment.

### **EU survey**

The EU survey has been conducted annually in June-July since 1988 as a bottom trawl survey, down to the 731m-depth contour till 2002, extending to 1400m depth since 2003. Swept area is divided according to the Flemish Cap bank stratification proposed by Doubleday (1981) and revised and extended by Bishop (1994). The survey series used in the assessment is the original one, covering the nineteen strata of the bank till 731m. Half an hour valid hauls were kept around 120 each year, with the number of hauls in each stratum proportional to the respective swept area. Each haul swept the bottom at a constant speed about 3.3-3.5 knots, with the gear performance controlled during most of the tows with SCANMAR equipment.

On the 1988 and 1989 surveys only golden redfish has been separated from the rest of the redfish catches. Since 1990, juvenile redfish (less than 21cm) has also been separated as an independent category, and 1992 forward all the 3 species and juveniles were separated in each haul catch prior to sampling procedures. However, with the continuation of these surveys, the skill to identify redfish smaller than 21 cm increased. The juvenile redfish that has been identified is directly allocated in its species catch, contributing to the decreasing of the proportion of small redfish classified as juvenile over the most recent years. At present most of the juvenile category is composed of unidentified redfish less than 16cm.

In June 2003 a new Spanish research vessel, the *RV Vizconde de Eza* (VE) replaced the *RV Cornide de Saavedra* (CS) that had carried out so far the EU survey series with the exception of the years of 1989 and 1990. In order to preserve the full use of the 1988-2002 survey indices available for beaked redfish, the original time series were converted to the new RV units. The conversion of the original EU survey indices to the new RV units as regards the four different categories of redfish considered in the EU survey (Acadian, deep-sea, golden and juvenile redfish) and their further assemblage in order to get the converted survey time series for beaked redfish (Acadian and deep-sea redfish including the respective juveniles) is fully described in the 2005 EU survey report (Troncoso and Casas, 2005) and is summarized in the 2005 assessment (Ávila de Melo *et al.*, 2005).

### **Length weight relationships for the stock**

Annual length weight relationships for *S. mentella* and *S. fasciatus* (1992-2010) and for the two species combined (1988-2010) were available from survey data (Troncoso and Casas *pers. comm.*, 2005-2011) (Table 2b). *S. mentella* and *S. fasciatus* length weight relationships were used to get 1992-2011 *SOP* survey biomasses and *SSB* for each redfish species. The *Sebastes sp.* length weight relationships were used to get the 1988-1991 *SOP* survey biomass and *SSB* for beaked redfish.

### **Beaked redfish survey abundance and mature female abundance at length**

Each of the redfish categories included in the beaked redfish unit (beaked redfish including juveniles, 1988-1989; beaked redfish, 1990-1991; *S. mentella*, 1992-2002; *S. fasciatus*, 1992-2002 and juveniles, 1990-2002) had their own survey abundance at length original series converted to the new RV units using the conversion framework described in the 2005 assessment (Ávila de Melo *et al.*, 2005). The transformed *S. mentella*, *S. fasciatus* and juvenile survey abundance at length series were then linked to with the 2003-2010 *RV Vizconde de Eza* length distributions. For each year and redfish category, abundance at length is re-scaled in order to fit the correspondent swept area survey biomass estimate. Finally the matrices of length distributions from all redfish categories were assembled into a single survey abundance at length series for beaked redfish (Table 4a).

A similar process is carried out in order to get a mature female abundance at length series, were the original female abundance at length series of each of the above mentioned redfish categories is transformed into a mature female at length series using the adequate maturity ogive available (Saborido-Rey, 1994 and Saborido-Rey, *pers. comm.* 2000). Details of the process can be found in the 2003 assessment (Ávila de Melo *et al.*, 2003).

### **Age composition of the survey stock and mature female component**

The survey abundance at age for the 1989-2010 3M beaked redfish stock and mature female component (Table 4b and 4c) were obtained using the *S.mentella* age length keys from the 1990-2010 surveys. Due to the scarcity of redfish larger than 40cm either in the survey and commercial catch, a plus group was considered at age 19.

Fran Saborido-Rey (Instituto de Investigaciones Marinas,Vigo, Spain) has carried out age reading of 3M redfish otoliths since 1990 (Saborido-Rey, 1994). Due to the fact that the 1989 *S.mentella* age length key was based on scale readings, the 1990 *S. mentella* age length key was also used in 1989. The ageing criteria of 3M redfish otoliths have been first revised in 1995 (Saborido-Rey, 1995) and 1998 (Saborido Rey *pers. comm.*, 1998) and survey age length keys were then standardized accordingly. The purpose of these revisions was to get a clearer consistence on the tracking of the most abundant cohorts. Details regarding the building of the synthetic 2008 age length key are available on last assessment (Ávila de Melo *et al.*, 2009).

The annual beaked redfish length weight relationships from the survey (Table 2b) were used to calculate the mean weights at age in the 3M beaked redfish stock and female spawning stock 3M (Table 4e and 4f).

### **Maturity ogives**

Annual maturity ogives for 3M beaked redfish were available as the proportion of mature females in the survey stock abundance at age (Table 4d). This matrix was included in the Extended Survival Analysis to get annual female spawning biomass.

### **Survey biomass and abundance, 1988-2010**

The 1989-2010 survey mean catch per tow for beaked redfish is presented on Table 5a and Fig. 3a. Details on the computation of this combined index can be found in 2003 assessment (Ávila de Melo *et al.*, 2003). Survey year class strength at age 4, abundance and biomass for the total stock unit, exploitable and female spawning stock can be found on Table 5b. Trends of the respective standardized series are at Fig.'s 3b to 3e.

The survey biomass and abundance declined on the first years of the interval till 1990-1991, and fluctuate at low level until 2001-2003. A sequence of increasingly strong year classes (2000-2002) lead rapidly the stock to a maximum in 2006. The size of the most recent year classes recruiting at age 4 (2003-2006) declined as fast as their predecessors went up, and the 2006 cohort in 2010 returned to the average level. Both overall and exploitable stocks follow very similar trends to recruitment since 2006 and are in the vicinity of their respective average levels on the terminal year. As for the survey indices related to female spawning stock component their increase observed since 2002 was halted with a drop from 2009 to 2010, but still keeping its size well above average.

Despite a sequence of relatively abundant and abundant year classes (2001-2005) and a low to very low exploitation regime over the last fifteen years, survey results suggest that the beaked redfish stock has not been able to hold its growth and sustain an above average level, suffering instead a severe decline on the second half of the 2000's. Migration to the neighbouring waters of northern Grand Bank is an unlikely hypothesis, taking into account the Flemish Pass barrier. Being so, this unexpected downward trend on stock size can only be attributed to mortality other than fishing mortality.

The strong possibility of an important increase on natural mortality can be associated to cod growth on Flemish Cap: not only in terms of abundance but also in terms of individual growth, leading to a consistent increase of cod biomass from 2006 onwards (Gonzalez *et al.*, 2010). The likely increase of redfish natural mortality, due to an increase of redfish on the Flemish Cap cod diet, is analysed next in the sensitivity analysis of the present assessment.

### **XSA Assessment**

Wide inter-annual variability can be observed on bottom trawl survey indices for redfish, caused by the scattered occurrence of large schools and changes in redfish availability as regards the vertical opening of the bottom net. These fluctuations originate year patterns in the catchabilities that relate survey indices with stock size at age that in turn will print retrospective patterns on the assessment results. Nevertheless, the long EU survey series seems to reflect well the overall dynamic of the stock, rich of contrasting trends over the last 22 years, and so is considered by the authors a valid tool to frame an Extended Survivors Analysis (XSA, Shepherd 1999) despite the above mentioned caveats.

The model runs with an XSA algorithm included in the Lowestoft VPA Suite (Darby and Flatman, 1994). An XSA summary and formulation to this case study can be found in the 2003 assessment (Ávila de Melo *et al.*, 2003).

### **Input files**

The input files for XSA analysis are presented in Table 6. As on previous assessments natural mortality was assumed constant at 0.1 on a first standard run, but allowed to vary over age and time afterwards in order to select a magnitude of  $M$  in line with the most recent stock trends given by the survey. The proportion of mature females at age is the one observed through the 1989-2010 period, though on an annual basis (Table 4d). The month with a peak

of spawning for 3M *Sebastes mentella*, February (Saborido-Rey, 1994), was the one chosen to estimate the proportion of  $F$  and  $M$  before spawning. The first age group considered was age 4 (the first age in the catch at age matrix with catches assigned every year) and age 18 was the last true age (from age 19 onwards both survey and commercial sampling data are scarce and so the plus group was set at age 19). Landings were given by the *SOP* of the 4+ catch at age and commercial weight at age matrices.

The present Extended Survivor Analysis used as tuning file the 1989-2010 EU survey abundance at age matrix, with the 1989-2002 indices converted into the new *RV Vizconde de Eza* units (Casas *et al.*, 2011).

## The framework

The model runs free of any of the available *softener* tools:

- No tapered time weighting, in order to give a full use and equal importance to the twenty two years of input data, namely the former ones till 1993 when a full-scale redfish fishery occurred on Flemish Cap.
- No shrinkage of fishing mortalities at age on the terminal year (catches and stock size indices have not been stable on recent years).
- Fishing mortalities at oldest true age were not shrunk either.
- Survivors at age were not shrunk to a mean of previous age abundances at the beginning of the last years of the assessment.

A run with catchability independent of year-class strength on all ages till the penultimate true age (17) showed the  $t$  values for the slopes that linearly relate the log abundance with the log survey index for the recruiting ages (4 and 5) not differing significantly from 1 (*Student's t* test with 20 degrees of freedom = No. points - 2, significance level of 0.05). This lack of a significant trend on the regression slopes for the youngest ages led us to accept catchability independent with respect to year class strength. Catchability was set constant with respect to age only at age 17: after declining between age 4 and 10, catchability is relatively stable on older ages (11-17) but assuming a constant  $q$  will lead to poorer diagnostics. In order to avoid overweight of the cohort's terminal population estimate by the last true age, the minimum allowable standard error of the *log* catchability on the last true age (18) of was set at 0.5.

In summary, apart the input of annual maturity ogives and the possibility of a  $M$  higher than 0.1 on recent years, the principles underlying the 2011 XSA framework remained unchanged from previous assessments (Ávila de Melo *et al.*, 2009): no recruiting ages with catchability dependent of year-class strength, constant catchability just at the penultimate age and a minimum standard error of the *log* catchability for the last true age of 0.5.

## Sensitivity Analysis and XSA diagnostics: adjusting the model to recent survey trends.

Going back to the survey trends for year class strength at age 4 (Fig. 3b), exploitable stock (Fig. 3d) and female spawning stock (Fig. 3e) it is obvious that the first two components started their decline earlier, on 2006, while the third component started later, on 2009. Over recent years (2006-2010) the major contribution to the survey exploitable biomass came from ages 4 to 6 (55-85%) while for female spawning stock biomass (SSB) the major contribution came from ages 7 and older (75-98%). So, when considering a set of runs for a range of  $M$ 's higher than the standard value for redfish species (0.1), these facts determined the definition of two time/age boxes where natural mortality increased: (1) 2006-2010 for ages 4 to 6, and (2) 2009-2010 for ages 7 and older. For years before 2006  $M$  was kept at 0.1.

The interval of magnitude for natural mortality to be considered on the sensitivity runs was set from 0.1 to 1.0, with 0.1 increments. For reasons explained below, a 0.5 increment was after included between 0.4 and 0.6. On each of these runs natural mortality was kept constant within the boxes predefined above. Finally other two runs were performed with *annual* natural mortality increasing in the boxes at the same rate of the Flemish Cap 1) cod abundance and 2) cod biomass. The conversion of *annual* to *instant* natural mortality ( $M$ ) is presented in Table 7a. Values of  $M > 1.0$  were rejected and  $M$  was set at 1.0 in those cases.

The goodness of fit of the model for each of the  $M$  options is given by the sum of squared  $\log q_{age}$  residuals for 2006-2010, the most recent period where the survey indices declined and is assumed that  $M$  increased. These results have a minimum  $SS$  plateau, for  $M$  between 0.4 and 0.6 (Table 7b, Fig. 4a). Continuing at a finer scale, with  $M = 0.45$  and  $0.55$ , allowed to locate the objective function in the vicinity of  $M = 0.55$ .

The set of exploitable and female spawning biomass trends given by the  $M$  's within the minimum plateau is plotted on Fig.'s 4b and 4c against the trends given by the survey and the standard  $M$  , with all series standardized to the respective mean and unit standard deviation. All trends from the best  $M$  's were in line with the survey story, while the standard run simply ignores what is going on.

Obviously the lower  $M = 0.4$  of this selection gave the less pessimistic results. Nevertheless a four fold increase on natural mortality puts a tremendous pressure on long living and slow growing fish: it means that even without exploitation a cohort will suffer a 99% reduction from age 4 to age 15 when under the standard  $M = 0.1$  that same reduction would be of 67%. That is why choosing the "best" fit with  $M = 0.55$  would be an unrealistic heavy option leaving little room to recovery, that could only be justified by a clear improvement on the model performance leading to much more robust results. When looking at the key diagnostics of the five XSA runs with  $M$  ranging from 0.40 to 0.60 (Table 7c. Fig's 5a to 5d) that seems not to be the case:  $M$  going up from 0.4 to 0.6 turns on a minimal improvement on the diagnostics of the assessment.

On this redfish age based assessment, mean  $\log$  catchabilities present a pattern of year effects that mark all  $\log q_{age}$  residuals bubble plots from the several XSA runs considered in the sensitivity analysis (the plots for the most important runs for this analysis are assembled on Fig. 6). Positive  $\log q$  residuals dominate during the intermediate years of 1994-2002, while the on the first years, 1989-1993, there is a clear negative pattern, sometimes with very large residuals as it is the case of the 1983-1985 cohorts between 1989 and 1991. From 2004 onwards residuals are generally of a much smaller size and the marked negative/positive pattern of the past is lost. An improvement on the last year pattern is observed when XSA increase  $M$  from standard 0.1 to 0.4, but that is not so obvious on further increases between 0.4 and higher natural mortalities.

As it was concluded for other diagnostics, choosing the best  $M$  based on a strict statistical criterion has little impact on the goodness of fit. This evidence is also illustrated on Fig. 6 by the similarity of the residual patterns of  $\log q_{age}$  residuals when the model runs with  $M$  ranging between 0.4 and 0.6.

Taking into account the results of the sensitivity analysis natural mortality level at 0.4 was fixed in the present XSA assessment for ages 4-6 through 2006-2010, and ages 7+ on 2009 and 2011. The full diagnostics output for the chosen  $M$  option are presented on Table 8.

### Retrospective Analysis

A 2011-2007 retrospective XSA was carried out in order to check the bias on the main results of the recent assessments back in time (Table 9a and 9b, Fig. 7). This retrospective analysis covers a period of rapid and profound contrast on the dynamics of the stock and is a useful check to measure how good the model fit to new natural mortality levels assumed recently. When compared to previous assessments (Ávila de Melo *et al*, 2007 and 2009) this retrospective XSA present more consistent trends, namely as regards female spawning biomass (SSB) and average fishing mortality, coupled with a non systematic bias signal (for instance the XSA 2009 biomass lies between the ones given by the 2010 and 2011 assessments, the same occurring to the XSA 2011 SSB, staying between the ones from the 2009 and 2010 XSA's). On comparison the bias magnitude for the last retrospective assessments, 2011 XSA presents the best results for one and three year revisions (Table 9b).

From the possible causes of retrospective patterns – patterns of catch misreporting, patterns in catchability or misspecification of natural mortality (Sinclair *et al.*, 1990) – the last two causes seem to be the most likely causes of



bias in this redfish assessment. However, the assumption of a higher level of  $M$  over most recent year seems to attenuate both the magnitude and the typical pattern of this type of bias.

### Final considerations on the diagnostics

An “erratic” pelagic-demersal distribution, associated with schooling and longevity will always doom bottom survey dependent redfish analytical assessments to relatively poor diagnostics and more or less severe retrospective biases. Nevertheless, if the stock unit shows a consistent dynamics, as it is the case for 3M beaked redfish over the 2000’s, the correspondent signals can generate consistent results over time without the help of the XSA statistical facilities commonly used to smooth ugly retrospective patterns. Despite year to year biases, this assessment results are able to initialize similar projections from consecutive assessments, namely as regards short term yield (*see retroprojections from last assessment*, António Ávila de Melo *et al*, 2009). Being so, the final outcome of the 3M beaked redfish assessment turns out to be a sound alternative to the usual Scientific Council rule of thumb recommendation around catch averages or to no recommendation at all.

### 2011 XSA Results

Very high fishing mortalities until 1996 forced a rapid decline of abundance, biomass and female spawning biomass (Table 10, Fig. 8a:  $4+$  Biomass vs  $4+$  Abundance and SSB vs  $FBar$ ). With lower fishing mortalities since then the stock decline was halted. But the weak 1991-1997 year classes kept the stock size at a low level till 2003, basically sustained by the survival and growth of the existing cohorts. The recruitment at age 4 increased from 2002 till 2006, when the 2002 year class was at an historical high, and from 2006 to 2008 fell as fast as it went up, still continuing to decrease on most recent years and being on 2010 just bellow average (Table 10, Fig. 8b). Above average year classes coupled with fishing mortalities in the vicinity of  $F_{0.1}$  or even lower allowed a rapid growth of

biomass and abundance since 2003 and sustained the stock at a high level on 2007-2008. However the stock decreased on the last couple of years for causes other than fishing and, despite the stock size being still above average level, there are no signs that the present decline rate is slowing down. These stock trends have been followed by the female spawning stock component (Table 10, Fig. 8a).

The reproductive potential of the stock increased steadily on the late 1990’s-early 2000’s but fell from 2002 to 2004 and record a further decline on 2006 (Fig. 8a, R/SSB plot). The stock seems to have returned recently to the low productivity regime observed until 1998. But in 2010 the SSB was still well above average (see summary table on the bottom of Table 10) and above the level where the highest recruitments have occurred (Fig. 8a, SR plot). Furthermore, this apparent decline on reproductive potential may reflect higher natural mortalities at pre-recruited ages, rather than the return to a low productivity regime.

Regardless no apparent relationship between the size of the year classes at age 4 and the parental female stock biomass (Fig. 9a, SR plot), and the possible negative impact of high  $M$ ’s prior the entry of young redfish in the exploitable stock, keeping female spawning stock biomass within or above the range of SSB’s that generated the good year classes of the 2000’s is in the short term the main concern as regards the management of this stock.

### Stock projections

Short and medium term stochastic projections of female spawning stock biomass (SSB) under a gradient of  $F$  *status quo* percentages, together with SSB and yield medium term probability profiles under  $F$  *status quo*, were obtained with a program of the CEFAS laboratory (Lowestoft/UK), first applied to a NAFO stock in 2000 (Mahe and Darby, 2000). This *Mterm* algorithm use initial abundance for ages 5 and older, at the beginning of the first year of the projection interval (2011, given by the XSA survivors by the end of 2010) abide to a measure of uncertainty. It bootstraps recruitment (age 4) from the third to the tenth year of the projection (on the first two years of the projection, 2011 and 2012, recruitment is set at the 1989-2008 geomean). The program has been upgraded to allow projections for long living stocks with a large number of ages included in the analytical assessment (Smith and Darby, *pers. comm.* 2001). The input data were aggregated in two categories of files:

- a. *.srr* file (Table 11a), assuming no stock recruitment relationship and with a random recruitment around the geo-mean of the 1989-2008 recruitments (numbers at age 4, from the XSA). The first age at the beginning of each year is given by the re-sampling of the *log* residuals of the 1989-2008 recruitments. The 2009 and 2010 recruitments were excluded from the average due to the greater uncertainty of their estimate by the present XSA.
- b. *.sen* sensitivity file (Table 11b), including the usual vectors needed to forward projections, with uncertainty associated to all vectors but natural mortality, which was fixed at 0.4 for all ages and years. Maturity ogive, as well as stock and catch weights at age are the 2008-2010 averages with associated errors. The XSA survivors at age 5+ coupled with the geomean recruitment at age 4, are the basis to get the starting population at the beginning of 2011 (the same level of recruitment is assumed for 2012). Being the internal and external standard errors from XSA diagnostics (Table 8/ Terminal year survivor and F estimates) two measures of the uncertainty around the survivor estimate for each age, their average was adopted as the coefficients of variation associated with the starting population at age. Fishing mortality was kept constant through projections at  $F_{statusquo}$ , corresponding to the 2008-2010  $\bar{F}_{age}$ .

The reason for keeping fishing mortality at  $F_{statusquo}$  is that the assessment is based on the assumption that natural mortality is at present well above the usual level considered on redfish stocks, being the major force driving the actual stock decline. With  $M$  at 0.4, average 2008-2010 fishing mortality represents just 15% of total mortality and is kept at a level well below  $F_{0,1}$  (Ávila de Melo *et al*, 2003) over the projection interval.

The results of the *Mterm* projections (Table 12a and 12b, Figures 9a and 9b, 10a and 10b) showed that, on the short term (2012-2013), with an average  $F_{statusquo}$  catch of 3,200 tons the probability of keeping SSB at a safe level above 20,000 tons is high. However, and despite all the uncertainty related with the recent level of  $M$ , that turn medium term projections meaningless, if high natural mortalities of the order of magnitude assumed in this assessment persist the stock will continue to decline even under low/very low fishing mortalities.

According to 2008-2010 observed catch data from the Portuguese, Spanish and Russian National Sampling Programmes on board, a beaked redfish annual catch of 3,200 tons would correspond to an overall 3M redfish catch (including the shallower golden redfish catches) near 7,000 tons (6,840 tons).

### Conclusions

The results of the present Extended Survivors Analysis are not in line with previous assessments: the declines on survey stock abundance and biomass first observed in 2007-2008 were confirmed in 2009-2010 and extended to the survey female spawning component. These new declines could not be explained by a commercial catch that has been chronically small for more than a decade and a half. The new assessment results can only reflect the declines foreseen by the survey if natural mortality is allowed to suffer an important increase since 2006, first just over the younger ages and later on covering the full age spectrum. The most likely cause of such sudden shift downwards on the beaked redfish stock size would be depletion by cod. Individual cod from consecutive good year classes have been growing at a much faster rate on the Flemish Cap bank, pushing the cod stock recovery from severe depletion and finally allowing its reopening to direct fishing last year. Keeping fishing mortality at its present low level will sustain on the short term the female spawning stock biomass above the SSB interval from where all the abundant year classes from the past decade were generated. But on the long term it will be natural mortality to determine the future of beaked redfish as a fishery resource.

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Table 1a: 3M Redfish nominal catches (ton) by country, 1989-2010.

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010 <sup>1</sup>	
CAN			2		10							5											
CUB	1765	4195	1772	2303	945						2												875
DDR		4025																					
GRL				1		26	4	2		2		11											
JPN	885	2082	1432	1424	967	488	553	678	212	439	320	31	80	67	98	209	483	383	613	603			
SUN/RUS	13937	34581	24661	2937	2035	2980	3560	52		7	108	1864	1281	1155	115	6	1023	849	780	1212	1184	961	
UKR															5	3		1					
E-LVA				7441	5099	94	304					13	11				2	48	250			58	
E-LTU					2128									10	1		522	397	542				
E-EST						47	863	13				631	158	5	23	60	1093	1249	728	950	1643		
E-SP	213	2007	6324	3647	100	610	165	113	129	262	268	348	272	220	633	266	542	596	533	1225	745		
E PRT	13012	11665	3787	3198	4781	5630	1284	281	83	259	97	925	1590	1513	1113	2574	2696	2594	2357	3707	5027		
EU																							6096
FR-STP										2							10				8		
KOR-S	17885	8332	2936	8350	2962																		
FAROE IS.			16				15	1						6		6				215	1	42	
NORWAY						8																	
Total	47697	66887	40914	29317	19027	9883	6748	1140	423.8	970.7	795	3828	3392	2976	1988	3126	6417	6319	5553	7920	8658	7974	

Table 1b: STACFIS Estimates of 3M redfish commercial catches from various sources.

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010 <sup>1</sup>
Total	58100	81000	48500	43300	29000	11300	13500	5789	1300	971	1068	3658	3224	2934	1881	2923	6550	7156	6662	8465	11317	7974

Table 1c: STACFIS Estimates of 3M beaked redfish commercial catches from various sources. From 2005 onwards also using information on distribution by depth of the EU survey catch (D. Gonzalez pers. comm.) and of the commercial catch of Portugal, Russia (M. Pochtar pers.comm.) and Spain (F. Gonzalez pers. comm.)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total	58100	81000	48500	43300	29000	11300	13500	5789	1300	971	1068	3658	3224	2934	1881	2923	4148	5997	5149	4277	3656	5056

Table 1d: Percentage of beaked redfish found in the EU survey redfish catch (excluding juveniles; redfish beyond 700m depth is 100% *S. mentella*) (Diana González pers. comm.).

	2005	2006	2007	2008	2009	2010		2005	2006	2007	2008	2009	2010
<b>&lt;200m</b>							<b>200-300m</b>						
golden	36.1	51.1	97.9	100.0	100.0	100.0	golden	54.5	50.7	32.4	68.3	84.9	68.3
beaked	63.9	48.9	2.1	0.0	0.0	0.0	beaked	45.5	49.3	67.6	31.7	15.1	31.7
<b>300-400m</b>							<b>400-700m</b>						
golden	18.8	5.9	12.0	28.5	22.0	28.5	golden	2.1	5.0	1.3	8.8	0.9	8.8
beaked	81.2	94.1	88.0	71.5	78.0	71.5	beaked	97.9	95.0	98.7	91.2	99.1	91.2

Table 1e: Redfish by-catch in weight (ton) from the 3M shrimp fishery, 1993-2005 (Kulka, D. and J. Firth pers. comm.)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
By-catch in weight (ton) <sup>2</sup>	11970	5903	374	550	157	191	96	106	738	767	1006	471	80

Table 1f: 3M Redfish catch in numbers(millions), 1989-2008.

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Comm.	125.3	196.3	104.2	94.1	49.2	24.6	34.9	15.5	3.0	2.2	2.3	9.6	8.5	9.1	4.6	12.5	12.5	28.2	16.1	15.3	11.6	22.7
By-catch					124.5	62.9	4.0	15.2	3.2	5.2	3.8	3.2	29.1	19.8	21.9	9.9	1.8					
Total	125.3	196.3	104.2	94.1	173.7	87.5	39.0	30.7	6.2	7.4	6.1	12.8	37.6	28.9	26.4	22.4	14.4	28.2	16.1	15.3	11.6	22.7

Table 2a: Length weight relationships  
for 3M beaked redfish from commercial catch  
(Alpoim,2004; Vargas, 2005, 2007-2011)

Year	a	b
1998	0.0390	2.7401
1999	0.0466	2.6807
2000	0.0095	3.1110
2001	0.0243	2.8695
2002	0.0433	2.7031
2003	0.0202	2.9025
2004	0.0133	3.0312
2006	0.0096	3.1176
2007	0.0100	3.1018
2008	0.0407	2.6452
2009	0.0120	3.0635
2010	0.0145	2.9911

Table 2b: Length weight relationships for 3M beaked redfish from EU survey (Troncoso and Casas, *pers. comm.* 2005-2011)

Year	<i>S. mentella</i>		<i>S. fasciatus</i>		<i>Sebastes sp.</i>	
	a	b	a	b	a	b
1988					0.058	2.593
1989					0.022	2.867
1990					0.018	2.928
1991					0.027	2.814
1992	0.019	2.911	0.027	2.841	0.030	2.788
1993	0.013	3.021	0.028	2.824	0.017	2.965
1994	0.017	2.960	0.020	2.927	0.021	2.896
1995	0.011	3.073	0.016	3.001	0.013	3.034
1996	0.017	2.948	0.023	2.876	0.021	2.890
1997	0.014	2.999	0.019	2.960	0.015	3.001
1998	0.013	3.025	0.019	2.944	0.014	3.019
1999	0.014	2.994	0.020	2.910	0.018	2.928
2000	0.018	2.938	0.025	2.853	0.022	2.874
2001	0.012	3.043	0.017	2.978	0.015	3.008
2002	0.012	3.054	0.018	2.967	0.014	3.026
2003	0.011	3.069	0.009	3.151	0.012	3.055
2004	0.014	2.999	0.017	2.977	0.012	3.074
2005	0.015	2.974	0.012	3.061	0.011	3.088
2006	0.011	3.069	0.012	3.066	0.011	3.088
2007	0.010	3.119	0.016	2.996	0.014	3.026
2008	0.019	2.921	0.016	2.983	0.020	2.902
2009	0.012	3.067	0.016	2.983	0.015	3.004
2010	0.013	3.021	0.024	2.850	0.018	2.925

Table 3a: Availability of length data for commercial catches and by-catch of

	3M beaked redfish, 1989-2010				
	Portugal	Spain	Japan	Russia	Canada (by-catch)
1989					
1990					
1991					
1992					
1993					
1994					
1995					
1996					
1997					
1998					
1999					
2000					
2001					
2002					
2003					
2004					
2005					
2006					
2007					
2008					
2009					
2010					
	available length data				
	derived from the length composition of the 1993-1994 beaked redfish EU survey abundance (Portugal)				
	or				
	derived from the length composition of the 1992-1994 beaked redfish EU survey abundance (Russia)				
	assumed as by-catch of Russian Greenland halibut fishery with the same length composition of EU commercial bottom trawl.				

Table 3b: Length composition (absolute frequencies in'000s) of the 3M redfish commercial catch, 1989-2010.

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
10	3													10			3	16	12				
11				1	3									48		1	18	40	41			3	
12	3			1	7							5		220		3	108	86	133		1	9	
13	11				5							11		723		5	381	70	172		5	28	
14	25	4			40	4						1		590		12	509	91	88		5	99	
15	8	73		1	120	15				2		6	4	175		43	474	112	23	6	37	248	
16	30	190		4	167	66		20				1	4	70		203	516	313	18	14	68	341	
17	59	724		3	55	244		20	1	2		6	20	53	6	352	423	436	31	12	102	481	
18	30	2489	156	6	39	607	118	20	20	1		17	57	84	6	464	285	635	138	47	121	669	
19	11	5774	647	97	54	922	265	66	6	8		27	41	144		666	183	1296	433	166	147	912	
20	111	6179	1331	418	71	491	1142	360	8	13	1	50	43	187		1165	157	2168	371	381	226	1559	
21	383	2904	1234	1987	125	427	2874	964	14	28	1	48	63	173	2	1513	132	3104	658	622	308	2254	
22	1149	1205	1179	3834	337	408	5895	2215	41	52	2	103	117	166	4	1512	159	3939	490	1032	535	3696	
23	3766	1927	945	3016	668	457	5715	1641	104	94	1	112	197	175	30	961	216	3658	720	794	869	3261	
24	8408	5526	1697	1690	1116	701	1691	1324	263	116	9	206	277	284	89	845	287	3179	760	1198	981	1671	
25	14733	11932	3737	2468	1159	870	1157	785	325	222	118	317	451	414	262	720	555	2261	947	787	1257	1151	
26	14793	19979	6292	7519	1577	1020	793	513	310	223	112	717	891	511	363	571	724	1427	1471	1760	1266	848	
27	11148	25638	10368	11599	1701	986	953	740	198	207	220	1322	1241	672	516	596	927	1181	1876	2050	1145	775	
28	7059	26047	12852	11899	2456	1688	1185	758	169	173	303	1654	1450	854	535	553	1057	1058	1405	2306	1086	886	
29	5773	20113	15100	8677	2448	2039	1476	855	210	168	301	1467	1193	841	588	426	1111	779	1348	1244	877	870	
30	7424	15200	13056	7505	3277	1987	1506	899	248	162	191	1036	996	814	475	384	779	619	1350	692	590	838	
31	6972	10134	7456	5452	3846	2327	1257	954	223	172	204	677	537	625	390	269	770	444	998	437	596	627	
32	7383	8308	7054	4705	3974	2611	1304	891	248	157	242	451	339	463	359	304	525	353	850	272	434	500	
33	7030	6551	3519	4150	4831	1963	1219	689	268	112	169	321	210	366	331	319	543	262	639	311	300	398	
34	6927	6397	3891	4309	4283	1347	1008	672	107	74	75	300	146	221	258	204	527	193	463	208	216	234	
35	6520	5486	3101	4286	3737	1154	1035	281	76	54	136	187	77	111	200	111	536	169	312	59	156	181	
36	4920	4398	2620	3104	3474	776	1041	198	43	47	72	151	38	70	94	76	412	124	162	230	88	101	
37	4080	3047	2394	2336	2914	404	915	220	24	46	65	150	31	26	47	53	105	47	33	105	64	57	
38	2441	2206	1672	1582	1753	366	749	103	27	33	7	113	37	18	16	50	25	36	28	158	44	34	
39	1566	1557	1748	1343	2453	328	488	125	11	29	30	56	17	14	8	31	25	15	34	59	14	2	
40	946	769	1024	917	1151	191	469	45	3	16	2	34	10	7	2	33	7	14	5	137	5	4	
41	504	581	640	522	517	105	346	38	12	11	4	26	5	1		41	34	17	16	65	4		
42	341	345	201	214	476	37	164	46	5	8		19	6	2		14		11	6	61	2		
43	289	264	283	237	118	10	69	18	1	3	1	25	3		2	18		11	3	52	1		
44	135	130	19	172	170	9	50	3	6	2		14	2			12		4	8	26	2		
45	143	73	14	39	26	9	34	2	1		2	3	1		1	6		3	3	5	2		
46	75	32	8	9	17		7	4	1			10	1			5		4	5	20			
47	46	16			17		19	1	1			6						1		7	1		
48	28	12	8	17			4						1			1		1		10			
49	4	12																1		3			
50	11	4						27											8				
51	4	12																					
52	4																						
53	7	16																1		2			
54		8																					
55		4																					
56																							
57																							
58		4																					
59																							
60																							
61									11														
mean weight (g)	464	413	465	460	590	460	386	374	438	435	471	379	379	321	410	250	331	213	321	279	316	222	28.2934
mean length (cm)	30.1	28.8	30.2	30.0	32.9	29.8	27.6	27.6	29.5	29.4	30.9	29.6	28.6	25.6	30.2	24.6	26.6	24.0	27.5	27.6	27.1	24.3	28.2934



Table 3c: Length composition (absolute frequencies in'000s) of the 3M redfish total annual catch, 1989-2010 (including redfish by-catch in the 3M shrimp fishery, 1993-2004).

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5												3	9	10	55	14						
6								147	1	3	15	5	200	60	246	95						
7							5	4306	105	109	115	59	534	381	601	182						
8							7	2412	127	248	550	123	1486	668	1131	242						
9							5	211	71	40	812	55	4218	538	1432	355						
10	3						3	416	258	45	845	193	6537	888	1454	593	3	16	12			
11				1	3		15	1056	569	391	390	593	6275	1655	913	1055	18	40	41			3
12	3			1	9	19	36	841	512	1830	313	1011	4996	3205	1368	1498	108	86	133		1	9
13	11			0	29	338	34	459	164	1721	286	761	2126	5809	2741	1229	381	70	172		5	28
14	25	4		0	257	979	64	488	120	340	97	182	746	4660	2546	1093	509	91	88		5	99
15	8	73		1	1998	2232	247	731	119	63	90	90	531	1946	1886	1022	474	112	23	6	37	248
16	30	190		4	7682	7312	430	1713	647	116	86	50	522	865	1994	999	516	313	18	14	68	341
17	59	724		3	29380	17576	758	1182	184	85	62	22	453	430	2513	987	423	436	31	12	102	481
18	30	2489	156	6	47422	21654	1105	758	61	32	41	27	339	339	1751	815	285	635	138	47	121	669
19	11	5774	647	97	30110	11939	1086	444	68	34	39	35	146	297	657	927	183	1296	433	166	147	912
20	111	6179	1331	418	6815	2807	1569	428	85	19	14	60	89	265	224	1398	157	2168	371	381	226	1559
21	383	2904	1234	1987	1117	745	3001	1058	75	39	7	52	91	209	183	1690	132	3104	658	622	308	2254
22	1149	1205	1179	3834	697	521	5922	2220	82	65	9	105	142	186	93	1588	159	3939	490	1032	535	3696
23	3766	1927	945	3016	669	457	5722	1641	126	102	6	114	210	187	80	988	216	3658	720	794	869	3261
24	8408	5526	1697	1690	1116	701	1694	1324	273	135	11	208	288	290	108	857	287	3179	760	1198	981	1671
25	14733	11932	3737	2468	1159	870	1162	785	328	237	122	317	455	417	272	727	555	2261	947	787	1257	1151
26	14793	19979	6292	7519	1577	1020	798	513	311	243	112	719	893	513	364	574	724	1427	1471	1760	1266	848
27	11148	25688	10368	11599	1701	986	957	740	198	217	223	1322	1242	672	517	597	927	1181	1876	2050	1145	775
28	7059	26047	12852	11899	2456	1688	1192	758	169	174	303	1654	1451	855	536	553	1057	1058	1405	2306	1086	886
29	5773	20113	15100	8677	2448	2039	1483	855	210	169	301	1467	1194	841	589	426	1111	779	1348	1244	877	870
30	7424	15200	13056	7505	3277	1987	1509	899	248	162	191	1036	996	815	475	384	779	619	1350	692	590	838
31	6972	10134	7456	5452	3846	2327	1258	954	223	172	204	677	537	626	390	270	770	444	998	437	596	627
32	7393	8308	7054	4705	3974	2611	1304	891	248	158	242	451	339	464	359	304	525	353	850	272	434	500
33	7030	6551	3519	4150	4831	1963	1219	689	268	112	169	321	210	366	331	319	543	262	639	311	300	398
34	6927	6397	3891	4309	4283	1347	1008	672	107	75	75	300	146	221	258	204	527	193	463	208	216	234
35	6520	5486	3101	4286	3737	1154	1035	281	76	54	136	187	77	111	200	111	536	169	312	59	156	181
36	4920	4398	2620	3104	3474	776	1041	198	43	47	72	151	38	70	94	76	412	124	162	230	88	101
37	4080	3047	2394	2336	2914	404	915	220	24	46	65	150	31	26	47	53	105	47	33	105	64	57
38	2441	2206	1672	1582	1753	366	749	103	27	33	7	113	37	18	16	50	25	36	28	158	44	34
39	1566	1557	1748	1343	2453	328	488	125	11	29	30	56	17	14	8	31	25	15	34	59	14	2
40	946	769	1024	917	1151	191	469	45	3	16	2	34	10	7	2	33	7	14	5	137	5	4
41	504	581	640	522	517	105	346	38	12	11	4	26	5	1	41	34	17	16	65	4		
42	341	345	201	214	476	37	164	46	5	8		19	6	2		14		11	6	61	2	
43	289	264	283	237	118	10	69	18	1	3	1	25	3	5	2	18		11	3	52	1	
44	135	130	19	172	170	9	50	3	6	2		14	2			12		4	8	26	2	
45	143	73	14	39	26	9	34	2	1		2	3	1		1	6		3	3	5	2	
46	75	32	8	9	17		7	4	1			10	1			5		4	5	20		
47	46	16			17		19	1	1			6						1		7	1	
48	28	12	8	17			4						1		1			1		10		
49	4	12																1		3		
50	11	4																		8		
51	4	12																				
52	4	0																				
53	7	16																				
54		8																	1	2		
55		4																				
56																						
57																						
58		4																				
59																						
60																						
61									11													
number ('000)	125310	196321	104246	94117	173677	87505	38979	30697	6180	7385	6051	12800	37620	28932	26441	22436	12515	28179	16062	15333	11556	22735
weight (ton)	58100	81000	48500	43300	40970	17203	13874	6339	1457	1162	1164	3764	3962	3701	2887	3612	4148	5997	5149	4277	3656	5056

Table 3d: Catch in numbers at age (' 000) of 3M redfish, 1989-2010, including redfish by-catch in the shrimp fishery (1993-2004).

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+	Total	Most abundant year class
1989	0	16	136	444	1057	7890	22978	24054	14508	9716	8792	6213	6366	5883	5199	2965	2122	1969	5003	125310	1981
1990	0	0	5996	10382	2773	5860	28741	47007	32291	18415	11643	6614	5940	5430	4449	2543	1888	1788	4562	196321	1982
1991	0	0	0	1229	3592	6929	18141	22725	16867	8491	6503	4808	3967	2888	1102	1648	1270	780	3305	104246	1983
1992	0	0	0	237	5234	7018	16988	18149	11681	7422	5608	4455	4286	3302	2952	1953	1189	746	1730	92949	1984
1993	0	274	3805	110773	10414	3064	3409	4557	2101	3936	5178	5512	4547	4665	3554	2092	1666	2614	1514	173677	1989
1994	0	755	5135	53804	6411	1630	2399	2522	2550	2819	2521	1956	1459	856	969	460	320	390	551	87505	1990
1995	16	84	979	2770	13324	5399	1889	2423	1554	1471	1869	1137	966	927	1070	833	482	548	1239	38979	1990
1996	7075	2966	2288	1632	3546	4635	1402	1399	1431	983	767	733	393	404	283	202	135	133	289	30697	1995
1997	563	1216	490	692	144	595	800	272	285	322	219	194	98	119	27	28	30	10	76	6180	1995
1998	445	3678	810	109	59	109	285	706	422	69	76	355	45	50	12	33	66	4	52	7385	1996
1999	2337	998	228	151	43	16	70	258	593	367	81	114	263	39	78	79	69	105	147	6037	1998
2000	438	2400	254	89	130	204	387	1018	1436	4211	657	170	71	608	64	38	34	38	558	12804	1990
2001	12984	13397	1805	828	337	386	842	1303	869	856	3229	381	117	62	65	60	19	29	61	37630	1999
2002	2545	11722	6220	1435	350	478	554	854	1009	530	642	1819	337	109	157	57	50	9	54	28932	2000
2003	4920	6570	6494	1712	1946	281	391	546	565	423	365	311	1222	214	22	102	69	23	266	26441	2001
2004	1482	4520	2996	1013	4104	2581	1564	999	611	379	268	203	254	953	19	83	46	19	342	22436	2002
2005	3	1228	891	611	311	683	875	1264	1462	1122	820	860	423	418	1240	126	75	21	84	12515	2003
2006	16	407	617	2031	4853	8382	5584	2388	1250	521	395	242	191	179	198	725	80	9	112	28179	2000
2007	12	345	161	442	782	824	4237	2165	2063	630	784	763	347	322	246	1106	505	32	296	16062	2000
2008	0	5	31	246	723	2619	2553	2934	2426	1095	592	380	226	221	128	120	130	436	467	15333	2000
2009	0	66	163	434	468	1419	1613	1645	1455	1452	741	453	136	304	53	110	35	147	862	11556	2001
2010	0	1035	1015	2532	5020	3894	3321	916	670	959	1308	527	478	234	66	113	63	40	545	22735	2005

Table 3e: Weights at age in the catch and by-catch (Kg) of 3M redfish, 1989-2010.

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989		0.043	0.099	0.174	0.208	0.251	0.293	0.344	0.401	0.453	0.535	0.597	0.644	0.668	0.712	0.729	0.783	0.794	1.005
1990			0.130	0.144	0.183	0.258	0.318	0.364	0.401	0.434	0.508	0.579	0.639	0.658	0.709	0.726	0.773	0.768	1.006
1991				0.147	0.182	0.287	0.347	0.401	0.439	0.511	0.558	0.616	0.672	0.721	0.772	0.853	0.833	0.867	0.964
1992				0.157	0.197	0.269	0.337	0.389	0.437	0.503	0.584	0.626	0.693	0.732	0.750	0.850	0.803	0.933	1.017
1993		0.065	0.094	0.114	0.152	0.248	0.325	0.406	0.444	0.480	0.556	0.595	0.652	0.710	0.737	0.901	0.868	0.885	1.096
1994		0.057	0.098	0.109	0.145	0.267	0.316	0.393	0.436	0.509	0.543	0.583	0.609	0.702	0.691	0.745	0.844	0.868	0.902
1995	0.014	0.041	0.086	0.164	0.184	0.239	0.327	0.397	0.442	0.495	0.552	0.583	0.665	0.725	0.751	0.829	0.835	0.873	1.050
1996	0.011	0.037	0.078	0.093	0.184	0.209	0.316	0.378	0.441	0.498	0.532	0.590	0.635	0.650	0.705	0.747	0.806	0.845	1.075
1997	0.019	0.037	0.074	0.092	0.153	0.266	0.284	0.394	0.442	0.507	0.548	0.595	0.621	0.626	0.672	0.761	0.793	0.741	1.291
1998	0.014	0.043	0.058	0.107	0.165	0.213	0.318	0.295	0.427	0.480	0.519	0.572	0.639	0.712	0.728	0.827	0.839	0.745	1.026
1999	0.020	0.040	0.072	0.101	0.140	0.201	0.325	0.364	0.351	0.433	0.509	0.597	0.553	0.580	0.568	0.583	0.671	0.612	0.737
2000	0.010	0.025	0.045	0.069	0.124	0.167	0.237	0.284	0.349	0.332	0.439	0.518	0.659	0.557	0.492	0.662	0.720	0.761	0.817
2001	0.017	0.032	0.063	0.097	0.148	0.211	0.269	0.322	0.361	0.411	0.404	0.537	0.611	0.674	0.674	0.617	0.797	0.860	0.989
2002	0.018	0.045	0.066	0.115	0.165	0.227	0.265	0.328	0.359	0.423	0.491	0.450	0.577	0.601	0.623	0.703	0.643	0.866	0.877
2003	0.013	0.038	0.066	0.085	0.107	0.190	0.253	0.288	0.341	0.384	0.454	0.500	0.409	0.584	0.587	0.633	0.550	0.692	0.664
2004	0.012	0.032	0.062	0.091	0.131	0.174	0.223	0.274	0.338	0.377	0.456	0.513	0.558	0.445	0.610	0.681	0.586	0.724	0.897
2005	0.017	0.042	0.065	0.088	0.114	0.184	0.252	0.294	0.349	0.384	0.476	0.508	0.519	0.638	0.598	0.692	0.693	0.878	0.932
2006	0.015	0.037	0.073	0.102	0.137	0.172	0.215	0.279	0.349	0.400	0.443	0.447	0.537	0.573	0.626	0.460	0.625	0.842	1.024
2007	0.015	0.028	0.050	0.107	0.130	0.146	0.251	0.277	0.354	0.392	0.453	0.493	0.515	0.527	0.538	0.441	0.547	0.701	0.757
2008	0.000	0.058	0.082	0.113	0.135	0.172	0.219	0.260	0.289	0.316	0.360	0.381	0.402	0.489	0.514	0.540	0.563	0.457	0.786
2009	0.000	0.059	0.078	0.155	0.140	0.212	0.233	0.267	0.326	0.351	0.450	0.370	0.538	0.475	0.531	0.506	0.708	0.626	0.566
2010	0.000	0.064	0.094	0.122	0.155	0.180	0.221	0.276	0.310	0.358	0.392	0.442	0.492	0.501	0.530	0.575	0.497	0.529	0.589

Table 4a: 3M beaked redfish abundance at length ('000s) from EU bottom trawl survey series (1988-2002 by RV Cornide Saavedra (CS), 2003-2010 by RV Vizconde de Eza (VE)); former period converted to new RV units).

Length (cm)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5											2868												
6		73	239	1042				144			956			455	1091	779					136	54	61
7	1203	160	1952	39644	4931	1102		31	2453		695	291		1240	9720	6940	286	499	304	1547	573	477	544
8	8538	1890	15439	194701	117561	3160		594	12310	1359	3390	2417	1883	18643	14581	10410	12530	5985	94129	26849	5315	2640	3263
9	8327	2007	11861	90135	75875	1764		1816	6548	2887	6048	12420	6848	152327	44733	31940	69454	8679	410980	214426	4271	5731	6535
10	7082	2894	846	9088	57005	7812	274	1889	867	1615	1573	8840	5242	246451	53017	37818	181225	11172	569937	471628	5446	3386	3861
11	20338	8434	412	17232	332037	36153	1573	3397	1762	4312	2626	3052	4412	29300	52317	37322	178289	47283	83653	269398	21536	5348	6099
12	39345	20228	390	18876	381332	46734	2665	9269	5827	12810	13751	2976	15579	9424	115720	82575	306313	109207	93826	255837	62810	7229	8244
13	27472	21581	1062	5790	90012	29392	5209	4666	5993	14318	22307	4851	30605	16454	247642	176520	217455	305354	168066	460809	135178	7342	7478
14	4000	46259	1865	1174	16174	79964	25338	4768	8609	7064	11124	4639	18860	19286	292527	206474	109487	563721	368890	359968	146220	14300	13152
15	802	87282	2527	1706	27540	165019	58046	9835	16820	13161	14504	19442	6447	31061	99677	63031	59669	496389	570816	235990	109149	37040	23025
16	1034	71271	6765	8180	41045	138724	130198	24357	14379	23773	29969	39114	4277	71951	73453	45579	93021	321931	705419	132602	150419	74563	31410
17	1499	22119	15552	25997	9939	29763	219435	64809	23877	29710	20988	26097	8270	56570	59348	29838	130177	216267	1022160	204730	200256	106859	35142
18	1140	3665	17573	47123	7593	9245	230202	110934	54208	30013	13414	32861	19781	22594	72239	31830	155247	199060	785217	363584	236520	147862	63068
19	4032	2167	10349	74331	14615	4970	121884	144384	108902	36047	14029	29489	27898	12501	74283	37393	179357	182684	502051	489233	195040	182429	88904
20	7430	3097	2514	83897	24467	3328	33879	100682	153048	68928	13962	20335	29190	18149	55461	32007	156658	169721	357550	396759	241170	274446	108084
21	16559	4479	1078	40486	46504	3306	16450	38742	135158	101923	18530	14731	24042	24890	28013	24617	86575	163284	189221	256720	256356	244424	138243
22	33994	9816	3011	10581	70167	5125	8472	9863	83283	98256	33310	17528	21181	25754	23745	16788	48011	179265	120687	144663	241869	209744	150168
23	68369	18570	10028	3744	51568	7222	7632	3978	37902	62655	56319	29378	18209	17298	19916	14445	29273	132897	99934	101176	141913	137275	112686
24	102943	33229	13236	3855	23847	8078	9824	3261	17322	24171	57007	61585	29389	15498	21186	26716	18368	81899	76563	71205	106627	138138	74872
25	108959	50665	28825	7720	10049	5812	11309	3704	7875	9733	33609	75417	54137	14734	16263	52455	11706	41610	57756	42237	61464	93215	61323
26	79514	60423	42888	9638	12417	5431	9941	4600	4102	5921	14895	57490	76085	18293	14695	74506	11260	32227	25060	38613	45511	49136	37645
27	33899	49923	41939	9642	16819	4256	6971	4265	5830	4280	5807	20106	78418	17465	13793	77547	8280	18476	13669	25283	31512	37652	24648
28	13963	31600	28902	8402	18154	4326	8135	4642	4150	3998	2710	6614	54137	13151	12150	53878	7280	12570	8322	13766	20128	19937	16266
29	6818	17451	16287	5836	12743	3066	6925	4694	4325	2790	1258	2472	21494	7232	9235	20825	5204	8890	5071	8331	10536	19353	10922
30	9150	10747	9819	4833	11009	2882	4765	4493	2995	3195	828	804	4582	5003	5643	4343	3753	7874	5648	9541	3737	6364	6414
31	7567	8245	7209	3513	7557	2362	3995	3479	2489	1977	959	701	1715	1439	2210	1384	2651	3273	2393	3284	5765	4025	2468
32	8886	9234	6686	3034	4866	1882	3611	2792	2280	1514	762	652	890	782	818	510	1835	2954	1722	2100	1171	2631	1586
33	8570	6908	5710	3287	4450	2012	2463	2304	2050	1291	619	470	1120	337	572	1097	1132	1085	1340	3374	1034	2360	1450
34	7451	6529	6333	3279	4276	1660	1613	1897	1410	981	517	401	578	405	286	630	762	736	479	909	371	175	572
35	5646	6544	4312	2567	3486	1536	1468	1591	948	590	293	347	382	199	122	305	323	310	383	238	312	1587	151
36	4929	5410	3975	2295	2635	1518	1039	1441	757	544	310	221	388	161	113	363	166	174	192	71	29	563	60
37	3631	3912	3065	1811	2014	1425	590	1205	568	305	194	134	357	67	68	320	108	29		20	29	249	50
38	3166	2501	2223	1488	1620	904	549	717	402	212	142	81	67	80	54	58	98	29	96	10	39	46	30
39	3092	4145	2425	1739	2156	1392	520	932	471	212	168	78	131	67	27	131		19			29	46	101
40	2090	2908	1634	1079	1410	831	379	493	266	143	65	39	87	27	14	87			95	10	20	1657	
41	1499	1192	842	471	586	378	225	433	243	124	77	26	44	54	14	44	10				10		37
42	665	742	421	367	426	362	84	313	162	37	26	26		13	14								
43	253	291	253	179	165	103	28	156	69	0	65	13	29	40	14								10
44	84	87	51	53	165	168	28	36	23	25	26			15			15						
45	84	87	67	53	45	26	28	36	23		13	26											
46		58	17	53	30	26		36			13									10			
47			34	11		26		12															
48						39			12														
total	664025	638823	330614	748931	1509292	623284	935746	581692	730719	570876	400725	496163	566768	869393	1434771	1201521	2085973	3325555	6341632	4604910	2442512	1838324	1038539

Table 4b: 3M beaked redfish abundance at age ('000s) from EU bottom trawl survey series, 1989-2010.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+	Total	Most abundant year class	
1988	18068	94236	10657	19600	28673	105880	172047	106189	37983	18147	11580	7031	6836	6017	5102	2919	2365	2162	8533	541062	1981	
1989	4130	53137	219406	19357	8071	35188	89946	89433	43605	21698	12392	7202	6537	5939	5301	3013	2467	2189	9812	638823	1986	
1990	29489	2710	33397	24565	2605	17585	56217	67444	36082	18378	10186	5630	5333	4816	4009	2318	1851	1730	6269	330614	1982	
1991	325523	51145	5421	154995	127962	17655	20481	13300	8086	4187	3884	3393	3014	2479	952	1514	1139	653	3155	748938	1990	
1992	198367	866124	59802	58014	144968	71881	30456	26346	16857	9630	6011	4452	4062	3082	2852	2072	1258	1028	2031	1509292	1990	
1993	6025	151086	90620	306049	10455	21648	10476	6426	2189	2996	2596	2453	1910	2000	1589	859	874	1414	1619	623284	1989	
1994	0	20065	76102	677611	79504	22080	22594	11375	7515	4950	3935	2808	2105	1122	1257	7515	657	482	616	968	935746	1990
1995	2585	18672	63686	114762	332114	8381	8942	8765	4706	3963	4073	2322	1642	1441	1536	1045	605	732	1721	581692	1990	
1996	21311	18163	34710	25262	190134	402615	11731	8653	5698	2783	2035	1950	991	1117	886	659	453	436	1132	730719	1990	
1997	5861	28568	34939	86326	96940	78135	222658	4967	3731	2768	1494	1269	689	837	236	298	368	124	667	570876	1990	
1998	15530	38427	62957	35093	32524	52330	30121	125511	3903	486	396	1990	257	249	77	156	343	28	347	400725	1990	
1999	23967	12166	50006	79605	45976	38126	46333	39046	151887	5871	257	337	858	110	246	253	201	435	381	496163	1990	
2000	13974	54195	27539	32860	61731	46285	47381	71096	35736	169492	2949	463	158	1548	152	81	83	52	992	566768	1990	
2001	419116	55177	121788	86078	52309	42284	29268	20323	8954	5122	26935	853	304	174	198	156	57	64	234	869393	2000	
2002	123142	480414	394558	235867	61369	46106	30279	22076	17766	4899	3033	13969	580	164	241	81	60	23	143	1434771	2000	
2003	87887	395055	335930	65241	84103	24769	14624	10827	6967	3974	2233	1323	11068	465	53	248	274	52	669	1045762	2001	
2004	263495	762656	301339	144934	430153	104119	34399	17197	8318	4654	2365	1301	1182	8772	72	232	250	42	492	2085973	2002	
2005	26335	1244660	652407	425205	292846	467795	123484	47163	20489	10868	4939	3849	1663	655	3050	64	45	21	16	3325555	2003	
2006	1075350	1210339	1202363	1528343	752862	373958	133664	38139	11992	3707	2477	1591	980	656	592	4168	212	24	215	6341632	2000	
2007	714451	986044	933290	537850	652131	384716	283236	66498	25067	3799	3834	2379	1241	1147	576	6720	1515	14	402	4604910	2005	
2008	15741	426790	292064	441539	414437	559582	177908	65953	27153	9725	4177	2316	1392	800	258	157	132	2278	111	2442512	2002	
2009	14963	89897	180844	353754	396975	290371	250188	127865	59244	37189	9903	10772	1017	3811	480	752	300	1352	8645	1838324	2004	
2010	14325	111084	88995	187503	250123	157413	138615	34940	18552	15351	12900	4018	1728	910	286	310	209	145	1189	1038598	2005	

Table 4c: 3M beaked redfish mature female abundance at age ('000s) from EU bottom trawl survey series, 1989-2010.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+	Total	Most abundant year class
1988				124	456	3852	11667	11447	6085	3947	3723	2798	3047	2824	2606	1536	1405	1278	6465	63260	1981
1989				43	156	1545	7734	11709	7329	4218	3366	2593	2910	2829	2722	1561	1440	1231	7823	59210	1981
1990				13	59	840	5392	9830	6743	3922	2988	2245	2655	2529	2300	1346	1110	1020	4432	47425	1982
1991				55	493	820	2102	2501	2086	1443	1634	1658	1619	1448	596	1054	769	446	2437	21161	1983
1992				18	1610	1817	2280	4334	4320	3147	2222	1829	1981	1668	1644	1413	818	811	1614	31525	1984
1993				0	121	995	925	1009	463	779	778	761	707	834	676	942	598	983	1068	11638	1985
1994				19	247	1006	1912	1682	1508	1510	1247	900	674	478	515	344	302	405	665	13413	1987
1995				86	418	360	910	1343	1005	1105	1269	720	525	523	568	498	296	425	1344	11394	1987
1996				0	1297	2557	1505	1754	1528	980	852	893	521	593	492	394	291	283	793	14731	1990
1997				0	147	2720	6144	2287	1841	1263	705	605	333	403	113	157	201	67	428	17415	1990
1998				0	133	924	1560	5282	785	120	119	647	86	96	26	61	155	9	231	10234	1990
1999				0	155	1129	3118	4737	15007	1341	102	153	340	41	101	99	103	199	307	26931	1990
2000				0	335	1052	3056	10012	9198	29716	1352	162	97	638	83	55	60	34	615	56465	1990
2001				0	554	1329	2140	2777	1922	1815	6695	335	108	65	71	57	20	24	175	18089	1990
2002				230	463	1547	1933	2574	3161	1826	1136	5364	308	82	113	28	26	9	62	18864	1990
2003				155	1043	1945	5179	7552	6024	3076	1340	684	7277	277	36	295	124	69	716	35793	1990
2004				41	1431	2676	3028	2990	2112	1528	1100	749	785	3754	57	161	165	31	333	20942	1990
2005				1628	2581	13745	11962	11076	7139	4410	2717	2266	921	469	1840	33	26	12	9	60834	1999
2006				4246	5755	11696	12617	8104	4431	1675	1265	750	554	394	430	2012	131	23	187	54269	1999
2007				2236	4799	4890	29711	14750	11948	2989	3319	2194	1166	1072	519	5111	1297	9	353	86362	2000
2008				1138	3490	20273	23927	21308	13256	5989	2827	1638	986	590	144	69	53	1667	50	97404	2001
2009				5054	4452	16405	18890	18985	16470	16945	6487	5358	838	2691	321	591	280	1205	6647	121620	2001
2010				2012	4546	8402	21248	11573	8155	8378	8127	2652	1301	678	249	263	154	127	912	78778	2003

Table 4d: annual maturity ogives for 3M beaked redfish as the relative abundance of mature females at each age, from the EU survey abundance at age 1988-2010.

YearAge	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1988				0.006	0.016	0.036	0.068	0.108	0.160	0.218	0.322	0.398	0.446	0.469	0.511	0.526	0.594	0.591	0.758
1989				0.002	0.019	0.044	0.086	0.131	0.168	0.194	0.272	0.360	0.445	0.476	0.513	0.518	0.584	0.562	0.797
1990				0.001	0.023	0.048	0.096	0.146	0.187	0.213	0.293	0.399	0.498	0.525	0.574	0.581	0.599	0.590	0.707
1991				0.000	0.004	0.046	0.103	0.188	0.258	0.345	0.421	0.489	0.537	0.584	0.626	0.696	0.675	0.683	0.772
1992				0.000	0.011	0.025	0.075	0.164	0.256	0.327	0.370	0.411	0.488	0.541	0.576	0.682	0.650	0.789	0.795
1993				0.000	0.012	0.046	0.088	0.157	0.212	0.260	0.300	0.310	0.370	0.417	0.425	1.096	0.684	0.696	0.659
1994				0.000	0.003	0.046	0.085	0.148	0.201	0.305	0.317	0.320	0.320	0.426	0.409	0.523	0.628	0.656	0.687
1995				0.001	0.001	0.043	0.102	0.153	0.213	0.279	0.312	0.310	0.320	0.363	0.370	0.477	0.490	0.580	0.781
1996				0.000	0.007	0.006	0.128	0.203	0.268	0.352	0.418	0.458	0.525	0.531	0.555	0.598	0.642	0.649	0.700
1997				0.000	0.002	0.035	0.028	0.460	0.493	0.456	0.472	0.477	0.483	0.482	0.478	0.525	0.546	0.545	0.643
1998				0.000	0.004	0.018	0.052	0.042	0.201	0.247	0.301	0.325	0.334	0.386	0.332	0.392	0.451	0.318	0.665
1999				0.000	0.003	0.030	0.067	0.121	0.099	0.228	0.399	0.454	0.396	0.372	0.411	0.391	0.510	0.457	0.639
2000				0.000	0.005	0.023	0.065	0.141	0.257	0.175	0.458	0.350	0.614	0.412	0.546	0.682	0.720	0.647	0.619
2001				0.000	0.011	0.031	0.073	0.137	0.215	0.354	0.249	0.392	0.355	0.376	0.360	0.365	0.361	0.369	0.749
2002				0.001	0.008	0.034	0.064	0.117	0.178	0.373	0.374	0.384	0.531	0.503	0.468	0.345	0.433	0.417	0.436
2003				0.002	0.012	0.079	0.354	0.698	0.865	0.774	0.600	0.517	0.657	0.596	0.677	1.187	0.453	1.330	1.071
2004				0.000	0.003	0.026	0.088	0.174	0.254	0.328	0.465	0.576	0.664	0.428	0.784	0.695	0.660	0.758	0.676
2005				0.004	0.009	0.029	0.097	0.235	0.348	0.406	0.550	0.589	0.554	0.716	0.603	0.514	0.568	0.592	0.571
2006				0.003	0.008	0.031	0.094	0.212	0.369	0.452	0.511	0.471	0.565	0.601	0.725	0.483	0.615	0.959	0.871
2007				0.004	0.007	0.013	0.105	0.222	0.477	0.787	0.866	0.922	0.939	0.934	0.902	0.761	0.856	0.656	0.877
2008				0.003	0.008	0.036	0.134	0.323	0.488	0.616	0.677	0.707	0.709	0.737	0.557	0.438	0.406	0.732	0.454
2009				0.014	0.011	0.056	0.076	0.148	0.278	0.456	0.655	0.497	0.824	0.706	0.668	0.785	0.933	0.892	0.769
2010				0.011	0.018	0.053	0.153	0.331	0.440	0.546	0.630	0.660	0.753	0.745	0.871	0.847	0.739	0.874	0.767

Table 4e: Weights at age of the 3M beaked redfish stock (Kg) from EU surveys, 1988-2010.

YearAge	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1988	0.017	0.040	0.093	0.158	0.185	0.220	0.252	0.282	0.317	0.362	0.456	0.523	0.563	0.583	0.623	0.638	0.696	0.697	0.847
1989	0.012	0.032	0.060	0.100	0.164	0.205	0.248	0.284	0.317	0.349	0.431	0.511	0.563	0.586	0.631	0.643	0.706	0.703	0.880
1990	0.011	0.028	0.082	0.097	0.171	0.212	0.261	0.299	0.331	0.361	0.443	0.524	0.582	0.602	0.652	0.668	0.731	0.727	0.920
1991	0.012	0.029	0.067	0.109	0.135	0.214	0.276	0.337	0.385	0.465	0.515	0.569	0.616	0.649	0.700	0.779	0.764	0.794	0.892
1992	0.013	0.032	0.070	0.096	0.171	0.208	0.292	0.354	0.396	0.452	0.525	0.571	0.635	0.680	0.704	0.807	0.769	0.879	0.933
1993	0.010	0.034	0.051	0.066	0.156	0.212	0.287	0.365	0.395	0.434	0.513	0.554	0.624	0.687	0.714	0.871	0.853	0.867	1.101
1994	0.000	0.045	0.076	0.090	0.130	0.226	0.276	0.348	0.395	0.464	0.493	0.530	0.549	0.673	0.659	0.719	0.816	0.852	0.912
1995	0.011	0.027	0.071	0.102	0.113	0.217	0.288	0.357	0.405	0.456	0.514	0.546	0.632	0.702	0.726	0.812	0.822	0.869	1.067
1996	0.011	0.036	0.062	0.079	0.138	0.141	0.270	0.328	0.384	0.443	0.480	0.533	0.580	0.600	0.649	0.697	0.756	0.794	0.956
1997	0.013	0.031	0.059	0.090	0.127	0.190	0.174	0.355	0.406	0.466	0.505	0.573	0.609	0.621	0.682	0.746	0.787	0.759	0.933
1998	0.010	0.034	0.062	0.089	0.138	0.181	0.229	0.222	0.371	0.422	0.490	0.550	0.624	0.687	0.714	0.809	0.832	0.729	1.103
1999	0.014	0.033	0.064	0.087	0.121	0.176	0.223	0.260	0.246	0.323	0.473	0.564	0.513	0.552	0.541	0.552	0.642	0.615	0.766
2000	0.016	0.037	0.060	0.097	0.132	0.174	0.234	0.285	0.329	0.297	0.418	0.528	0.668	0.564	0.497	0.673	0.718	0.718	0.750
2001	0.015	0.028	0.062	0.085	0.140	0.179	0.238	0.297	0.328	0.384	0.340	0.516	0.598	0.663	0.668	0.616	0.771	0.853	1.010
2002	0.013	0.034	0.052	0.101	0.132	0.184	0.227	0.282	0.323	0.390	0.408	0.398	0.561	0.595	0.629	0.719	0.644	0.894	0.952
2003	0.012	0.034	0.054	0.076	0.109	0.161	0.217	0.264	0.321	0.355	0.413	0.462	0.351	0.558	0.584	0.638	0.509	0.694	0.754
2004	0.015	0.030	0.066	0.094	0.120	0.163	0.221	0.278	0.343	0.378	0.444	0.498	0.553	0.426	0.635	0.685	0.543	0.756	0.755
2005	0.013	0.041	0.061	0.092	0.119	0.166	0.214	0.273	0.339	0.379	0.459	0.481	0.462	0.591	0.502	0.710	0.724	0.904	0.869
2006	0.014	0.044	0.071	0.088	0.114	0.157	0.215	0.265	0.337	0.401	0.431	0.429	0.492	0.533	0.588	0.422	0.551	0.839	0.773
2007	0.015	0.030	0.058	0.109	0.120	0.137	0.205	0.250	0.314	0.397	0.457	0.520	0.542	0.539	0.523	0.399	0.489	0.730	0.553
2008	0.014	0.043	0.074	0.101	0.130	0.168	0.218	0.275	0.325	0.369	0.415	0.438	0.442	0.492	0.567	0.605	0.591	0.448	0.769
2009	0.015	0.056	0.081	0.117	0.133	0.177	0.190	0.227	0.260	0.319	0.396	0.326	0.543	0.436	0.476	0.501	0.676	0.817	0.532
2010	0.013	0.058	0.095	0.118	0.151	0.182	0.219	0.263	0.290	0.325	0.364	0.387	0.457	0.451	0.622	0.527	0.473	0.518	0.517

Table 4f: Weights at age of the 3M mature female beaked redfish stock (Kg) from EU surveys, 1988-2010.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1988				0.180	0.198	0.235	0.268	0.307	0.354	0.403	0.480	0.537	0.572	0.593	0.631	0.645	0.711	0.711	0.853
1989				0.157	0.174	0.220	0.267	0.306	0.337	0.376	0.461	0.541	0.575	0.596	0.636	0.647	0.728	0.725	0.886
1990				0.160	0.181	0.228	0.283	0.323	0.352	0.390	0.474	0.553	0.594	0.615	0.658	0.671	0.749	0.746	0.886
1991				0.151	0.163	0.251	0.304	0.354	0.406	0.473	0.528	0.585	0.629	0.661	0.712	0.791	0.778	0.809	0.908
1992				0.157	0.185	0.225	0.310	0.372	0.412	0.459	0.534	0.593	0.656	0.706	0.732	0.828	0.800	0.889	0.947
1993				0.000	0.183	0.226	0.288	0.375	0.411	0.438	0.518	0.558	0.645	0.705	0.728	0.929	0.865	0.875	1.156
1994				0.153	0.169	0.244	0.286	0.357	0.402	0.470	0.502	0.539	0.569	0.702	0.684	0.750	0.824	0.874	0.952
1995				0.153	0.157	0.226	0.296	0.366	0.412	0.459	0.516	0.546	0.638	0.723	0.740	0.837	0.854	0.889	1.079
1996				0.000	0.176	0.187	0.281	0.337	0.389	0.449	0.483	0.536	0.583	0.606	0.658	0.702	0.757	0.799	0.959
1997				0.000	0.188	0.226	0.240	0.358	0.410	0.465	0.503	0.576	0.612	0.625	0.684	0.747	0.790	0.768	0.957
1998				0.000	0.159	0.195	0.266	0.243	0.384	0.436	0.493	0.554	0.626	0.707	0.712	0.815	0.844	0.729	1.128
1999				0.000	0.152	0.193	0.238	0.277	0.264	0.341	0.464	0.572	0.514	0.542	0.534	0.544	0.673	0.643	0.778
2000				0.000	0.162	0.192	0.270	0.304	0.344	0.327	0.424	0.519	0.681	0.574	0.494	0.695	0.724	0.728	0.770
2001				0.000	0.165	0.191	0.246	0.306	0.344	0.390	0.374	0.514	0.602	0.665	0.667	0.622	0.776	0.853	1.035
2002				0.151	0.174	0.209	0.238	0.305	0.340	0.399	0.453	0.408	0.557	0.587	0.616	0.715	0.643	0.888	0.968
2003				0.098	0.127	0.208	0.244	0.272	0.320	0.344	0.396	0.456	0.344	0.576	0.584	0.675	0.590	0.694	0.782
2004				0.149	0.160	0.195	0.243	0.288	0.352	0.399	0.466	0.518	0.566	0.460	0.635	0.675	0.550	0.756	0.718
2005				0.108	0.131	0.189	0.244	0.286	0.345	0.385	0.472	0.493	0.481	0.585	0.514	0.705	0.719	0.900	0.861
2006				0.098	0.138	0.198	0.239	0.288	0.352	0.406	0.447	0.440	0.511	0.540	0.595	0.441	0.545	0.839	0.804
2007				0.118	0.143	0.163	0.265	0.290	0.367	0.400	0.461	0.522	0.543	0.539	0.524	0.408	0.490	0.730	0.554
2008				0.115	0.156	0.204	0.247	0.292	0.333	0.376	0.425	0.442	0.438	0.475	0.539	0.565	0.539	0.442	0.624
2009				0.168	0.139	0.219	0.236	0.270	0.317	0.331	0.401	0.336	0.552	0.448	0.494	0.506	0.676	0.852	0.565
2010				0.123	0.159	0.205	0.244	0.274	0.297	0.331	0.368	0.397	0.461	0.456	0.638	0.523	0.479	0.518	0.519

Table 5a: 3M beaked redfish survey mean catch per tow from EU bottom trawl survey series (1988-2002 by RV Cornide Saavedra (CS), 2003-2010 by RV Vizconde de Eza (VE); former period converted to new RV units).

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>mean weight per tow (Kg/tow)</b>	199	159	109	85	147	68	125	90	125	104	74	103	146	78	129	59	185	297	532	279	224	342	178
<b>SE</b>	32	21	13	10	17	24	38	10	17	18	12	30	57	12	17	7	26	53	79	43	45	92	34
<b>CV</b>	16%	13%	12%	12%	12%	36%	30%	11%	14%	18%	16%	29%	39%	16%	13%	12%	14%	18%	15%	15%	20%	27%	19%

Table 5b: 3M beaked redfish year class strength, total stock, exploitable stock and female spawning stock from EU bottom trawl survey series. 1988-2002 by RV Cornide Saavedra (CS), 2003-2010 by RV Vizconde de Eza (VE); former period converted to new RV units.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>year class strength at age 4 (millions)</b>	20	19	25	155	58	306	678	115	25	86	35	80	33	86	236	65	145	425	1528	538	442	354	188
<b>abundance (millions)</b>	664	639	331	749	1509	623	936	582	731	571	401	496	567	869	1435	1202	2086	3326	6342	4605	2443	1838	1039
<b>4+abundance (millions)</b>	541	362	265	367	385	376	840	497	657	502	284	410	471	273	437	227	759	1402	2854	1971	1708	1553	824
<b>biomass ('000 ton)</b>	160	128	89	72	119	78	105	73	100	84	60	82	118	64	107	132	157	302	485	386	308	286	162
<b>4+ biomass ('000 ton)</b>	155	113	86	67	92	45	100	71	101	82	56	81	116	51	69	34	106	209	333	279	264	266	147
<b>spawning biomass ('000 ton)</b>	28	28	23	12	16	8	7	6	6	6	3	8	18	6	7	11	8	17	14	27	28	38	23
<b>ssb proportion</b>	18%	22%	25%	16%	13%	10%	6%	9%	6%	8%	5%	9%	16%	9%	6%	8%	5%	6%	3%	7%	9%	13%	13%

Table 6: Input files for 2011 XSA assessment.

REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2011					
1					
red3mla.txt					
red3mcn.txt					
red3mcw.txt					
red3msw.txt					
red3mnm.txt					
red3mmo.txt					
red3mpf.txt					
red3mpm.txt					
red3mfo.txt					
red3mfn.txt					
red3mtun.txt					

REDFISH NAFO 3M LANDINGS tons		
1	1	
1989	2010	
4	19	
5		
58086		
80223		
48500		
43300		
43100		
17664		
13879		
6101		
1408		
1011		
1095		
3665		
3327		
2964		
2273		
3260		
4039		
5936		
5131		
4274		
3639		
4894		



REDFISH NAFO 3M CATCH NUMBERS thousands															
1	2														
1989	2010														
4	19														
1															
444	1057	7890	22978	24054	14508	9716	8792	6213	6366	5883	5199	2965	2122	1969	5003
10382	2773	5860	28741	47007	32291	18415	11643	6614	5940	5430	4449	2543	1888	1788	4562
1229	3592	6929	18141	22725	16867	8491	6503	4808	3967	2888	1102	1648	1270	780	3305
237	5234	7018	16988	18149	11681	7422	5608	4455	4286	3302	2952	1953	1189	746	1730
110773	10414	3064	3409	4557	2101	3936	5178	5512	4547	4665	3554	2092	1666	2614	1514
53804	6411	1630	2399	2522	2550	2819	2521	1956	1459	856	969	460	320	390	551
2770	13324	5399	1889	2423	1554	1471	1869	1137	966	927	1070	833	482	548	1239
1632	3546	4635	1402	1399	1431	983	767	733	393	404	283	202	135	133	289
692	144	595	800	272	285	322	219	194	98	119	27	28	30	10	76
109	59	109	285	706	422	69	76	355	45	50	12	33	66	4	52
151	43	16	70	258	593	367	81	114	263	39	78	79	69	105	147
89	130	204	387	1018	1436	4211	657	170	71	608	64	38	34	38	558
828	337	386	842	1303	869	856	3229	381	117	62	65	60	19	29	61
1435	350	478	554	854	1009	530	642	1819	337	109	157	57	50	9	54
1712	1946	281	391	546	565	423	365	311	1222	214	22	102	69	23	266
1013	4104	2581	1564	999	611	379	268	203	254	953	19	83	46	19	342
611	311	683	875	1264	1462	1122	820	860	423	418	1240	126	75	21	84
2031	4853	8382	5584	2388	1250	521	395	242	191	179	198	725	80	9	112
442	782	824	4237	2165	2063	630	784	763	347	322	246	1106	505	32	296
246	723	2619	2553	2934	2426	1095	592	380	226	221	128	120	130	436	467
434	468	1419	1613	1645	1455	1452	741	453	136	304	53	110	35	147	862
2532	5020	3894	3321	916	670	959	1308	527	478	234	66	113	63	40	545

REDFISH NAFO 3M CATCH WEIGHT AT AGE kg															
1	3														
1989	2010														
4	19														
1															
0.174	0.208	0.251	0.293	0.344	0.401	0.453	0.535	0.597	0.644	0.668	0.712	0.729	0.783	0.794	1.005
0.144	0.183	0.258	0.318	0.364	0.401	0.434	0.508	0.579	0.639	0.658	0.709	0.726	0.773	0.768	1.006
0.147	0.182	0.287	0.347	0.401	0.439	0.511	0.558	0.616	0.672	0.721	0.772	0.853	0.833	0.867	0.964
0.157	0.197	0.269	0.337	0.389	0.437	0.503	0.584	0.626	0.693	0.732	0.750	0.850	0.803	0.933	1.017
0.114	0.152	0.248	0.325	0.406	0.444	0.480	0.556	0.595	0.652	0.710	0.737	0.901	0.868	0.885	1.096
0.109	0.145	0.267	0.316	0.393	0.436	0.509	0.543	0.583	0.609	0.702	0.691	0.745	0.844	0.868	0.902
0.164	0.184	0.239	0.327	0.397	0.442	0.495	0.552	0.583	0.665	0.725	0.751	0.829	0.835	0.873	1.050
0.093	0.184	0.209	0.316	0.378	0.441	0.498	0.532	0.590	0.635	0.650	0.705	0.747	0.806	0.845	1.075
0.092	0.153	0.266	0.284	0.394	0.442	0.507	0.548	0.595	0.621	0.626	0.672	0.761	0.793	0.741	1.291
0.107	0.165	0.213	0.318	0.295	0.427	0.480	0.519	0.572	0.639	0.712	0.728	0.827	0.839	0.745	1.026
0.101	0.140	0.201	0.325	0.364	0.351	0.433	0.509	0.597	0.553	0.580	0.568	0.583	0.671	0.612	0.737
0.069	0.124	0.167	0.237	0.284	0.349	0.332	0.439	0.518	0.659	0.557	0.492	0.662	0.720	0.761	0.817
0.097	0.148	0.211	0.269	0.322	0.361	0.411	0.404	0.537	0.611	0.674	0.674	0.617	0.797	0.860	0.989
0.115	0.165	0.227	0.265	0.328	0.359	0.423	0.491	0.450	0.577	0.601	0.623	0.703	0.643	0.866	0.877
0.085	0.107	0.190	0.253	0.288	0.341	0.384	0.454	0.500	0.409	0.584	0.587	0.633	0.550	0.692	0.664
0.091	0.131	0.174	0.223	0.274	0.338	0.377	0.456	0.513	0.558	0.445	0.610	0.681	0.586	0.724	0.897
0.088	0.114	0.184	0.252	0.294	0.349	0.384	0.476	0.508	0.519	0.638	0.598	0.692	0.693	0.878	0.932
0.102	0.137	0.172	0.215	0.279	0.349	0.400	0.443	0.447	0.537	0.573	0.626	0.460	0.625	0.842	1.024
0.107	0.130	0.146	0.251	0.277	0.354	0.392	0.453	0.493	0.515	0.527	0.538	0.441	0.547	0.701	0.757
0.113	0.135	0.172	0.219	0.260	0.289	0.316	0.360	0.381	0.402	0.489	0.514	0.540	0.563	0.457	0.786
0.155	0.140	0.212	0.233	0.267	0.326	0.351	0.450	0.370	0.538	0.475	0.531	0.506	0.708	0.626	0.566
0.122	0.155	0.180	0.221	0.276	0.310	0.358	0.392	0.442	0.492	0.501	0.530	0.575	0.497	0.529	0.589

REDFISH NAFO 3M STOCK WEIGHT AT AGE kg															
1	4														
1989	2010														
4	19														
1															
0.100	0.164	0.205	0.248	0.284	0.317	0.349	0.431	0.511	0.563	0.586	0.631	0.643	0.706	0.703	0.880
0.097	0.171	0.212	0.261	0.299	0.331	0.361	0.443	0.524	0.582	0.602	0.652	0.668	0.731	0.727	0.920
0.109	0.135	0.214	0.276	0.337	0.385	0.465	0.515	0.569	0.616	0.649	0.700	0.779	0.764	0.794	0.892
0.096	0.171	0.208	0.292	0.354	0.396	0.452	0.525	0.571	0.635	0.680	0.704	0.807	0.769	0.879	0.933
0.066	0.156	0.212	0.287	0.365	0.395	0.434	0.513	0.554	0.624	0.687	0.714	0.871	0.853	0.867	1.101
0.090	0.130	0.226	0.276	0.348	0.395	0.464	0.493	0.530	0.549	0.673	0.659	0.719	0.816	0.852	0.912
0.102	0.113	0.217	0.288	0.357	0.405	0.456	0.514	0.546	0.632	0.702	0.726	0.812	0.822	0.869	1.067
0.079	0.138	0.141	0.270	0.328	0.384	0.443	0.480	0.533	0.580	0.600	0.649	0.697	0.756	0.794	0.956
0.090	0.127	0.190	0.174	0.355	0.406	0.466	0.505	0.573	0.609	0.621	0.682	0.746	0.787	0.759	0.933
0.089	0.138	0.181	0.229	0.222	0.371	0.422	0.490	0.550	0.624	0.687	0.714	0.809	0.832	0.729	1.103
0.087	0.121	0.176	0.223	0.260	0.246	0.323	0.473	0.564	0.513	0.552	0.541	0.552	0.642	0.615	0.766
0.097	0.132	0.174	0.234	0.285	0.329	0.297	0.418	0.528	0.668	0.564	0.497	0.673	0.718	0.718	0.750
0.085	0.140	0.179	0.238	0.297	0.328	0.384	0.340	0.516	0.598	0.663	0.668	0.616	0.771	0.853	1.010
0.101	0.132	0.184	0.227	0.282	0.323	0.390	0.408	0.398	0.561	0.595	0.629	0.719	0.644	0.894	0.952
0.076	0.109	0.161	0.217	0.264	0.321	0.355	0.413	0.462	0.351	0.558	0.584	0.638	0.509	0.694	0.754
0.094	0.120	0.163	0.221	0.278	0.343	0.378	0.444	0.498	0.553	0.426	0.635	0.685	0.543	0.756	0.755
0.092	0.119	0.166	0.214	0.273	0.339	0.379	0.459	0.481	0.462	0.591	0.502	0.710	0.724	0.904	0.869
0.088	0.114	0.157	0.215	0.265	0.337	0.401	0.431	0.429	0.492	0.533	0.588	0.422	0.551	0.839	0.773
0.109	0.120	0.137	0.205	0.250	0.314	0.397	0.457	0.520	0.542	0.539	0.523	0.399	0.489	0.730	0.553
0.101	0.130	0.168	0.218	0.275	0.325	0.369	0.415	0.438	0.442	0.492	0.567	0.605	0.591	0.448	0.769
0.117	0.133	0.177	0.190	0.227	0.260	0.319	0.396	0.326	0.543	0.436	0.476	0.501	0.676	0.817	0.532
0.118	0.151	0.182	0.219	0.263	0.290	0.325	0.364	0.387	0.457	0.451	0.622	0.527	0.473	0.518	0.517



REDFISH NAFO 3M PROPORTION MATURE AT AGE															
1	6														
1989	2010														
4	19														
1															
0.006	0.016	0.036	0.068	0.108	0.160	0.218	0.322	0.398	0.446	0.469	0.511	0.526	0.594	0.591	0.758
0.002	0.019	0.044	0.086	0.131	0.168	0.194	0.272	0.360	0.445	0.476	0.513	0.518	0.584	0.562	0.797
0.001	0.023	0.048	0.096	0.146	0.187	0.213	0.293	0.399	0.498	0.525	0.574	0.581	0.599	0.590	0.707
0.000	0.004	0.046	0.103	0.188	0.258	0.345	0.421	0.489	0.537	0.584	0.626	0.696	0.675	0.683	0.772
0.000	0.011	0.025	0.075	0.164	0.256	0.327	0.370	0.411	0.488	0.541	0.576	0.682	0.650	0.789	0.795
0.000	0.012	0.046	0.088	0.157	0.212	0.260	0.300	0.310	0.370	0.417	0.425	1.096	0.684	0.696	0.659
0.000	0.003	0.046	0.085	0.148	0.201	0.305	0.317	0.320	0.320	0.426	0.409	0.523	0.628	0.656	0.687
0.001	0.001	0.043	0.102	0.153	0.213	0.279	0.312	0.310	0.320	0.363	0.370	0.477	0.490	0.580	0.781
0.000	0.007	0.006	0.128	0.203	0.268	0.352	0.418	0.458	0.525	0.531	0.555	0.598	0.642	0.649	0.700
0.000	0.002	0.035	0.028	0.460	0.493	0.456	0.472	0.477	0.483	0.482	0.478	0.525	0.546	0.545	0.643
0.000	0.004	0.018	0.052	0.042	0.201	0.247	0.301	0.325	0.334	0.386	0.332	0.392	0.451	0.318	0.665
0.000	0.003	0.030	0.067	0.121	0.099	0.228	0.399	0.454	0.396	0.372	0.411	0.391	0.510	0.457	0.639
0.000	0.005	0.023	0.065	0.141	0.257	0.175	0.458	0.350	0.614	0.412	0.546	0.682	0.720	0.647	0.619
0.000	0.011	0.031	0.073	0.137	0.215	0.354	0.249	0.392	0.355	0.376	0.360	0.365	0.361	0.369	0.749
0.001	0.008	0.034	0.064	0.117	0.178	0.373	0.374	0.384	0.531	0.503	0.468	0.345	0.433	0.417	0.436
0.002	0.012	0.079	0.354	0.698	0.865	0.774	0.600	0.517	0.657	0.596	0.677	1.187	0.453	1.330	1.071
0.000	0.003	0.026	0.088	0.174	0.254	0.328	0.465	0.576	0.664	0.428	0.784	0.695	0.660	0.758	0.676
0.004	0.009	0.029	0.097	0.235	0.348	0.406	0.550	0.589	0.554	0.716	0.603	0.514	0.568	0.592	0.571
0.003	0.008	0.031	0.094	0.212	0.369	0.452	0.511	0.471	0.565	0.601	0.725	0.483	0.615	0.959	0.871
0.004	0.007	0.013	0.105	0.222	0.477	0.787	0.866	0.922	0.939	0.934	0.902	0.761	0.856	0.656	0.877
0.003	0.008	0.036	0.134	0.323	0.488	0.616	0.677	0.707	0.709	0.737	0.557	0.438	0.406	0.732	0.454
0.014	0.011	0.056	0.076	0.148	0.278	0.456	0.655	0.497	0.824	0.706	0.668	0.785	0.933	0.892	0.769
0.011	0.018	0.053	0.153	0.331	0.440	0.546	0.630	0.660	0.753	0.745	0.871	0.847	0.739	0.874	0.767

REDFISH NAFO 3M F ON OLDEST AGE GROUP BY YEAR					
1	9				
1989	2010				
4	19				
5					
0.844					
1.039					
1.106					
0.774					
2.267					
0.731					
0.996					
0.346					
0.069					
0.089					
0.253					
0.491					
0.364					
0.249					
0.426					
0.366					
0.593					
0.399					
1.856					
0.055					
0.770					
0.770					

REDFISH NAFO 3M PROPORTION OF F BEFORE SPAWNING					
1	7				
1989	2010				
4	19				
3					
0.08					

REDFISH NAFO 3M PROPORTION OF M BEFORE SPAWNING					
1	8				
1989	2010				
4	19				
3					
0.08					

REDFISH NAFO 3M F AT AGE IN LAST YEAR																
1	10															
1989	2010															
4	19															
2																
0.0033	0.0152	0.0421	0.0744	0.0656	0.1005	0.0766	0.1151	0.1299	0.1013	0.1358	0.1358	0.6667	0.5384	0.77	0.77	

REDFISH NAFO 3M SURVEY TUNNING DATA																
101																
EU BOTTOM TRAWL SURVEY																
1989	2010															
1	1	0.5	0.6													
4	19															
10555	19357	8071	35188	89946	89433	43605	21698	12392	7202	6537	5939	5301	3013	2467	2189	9812
10555	24565	2605	17585	56217	67444	36082	18378	10186	5630	5333	4816	4009	2318	1851	1730	6269
10555	154995	127962	17655	20481	13300	8086	4187	3884	3393	3014	2479	952	1514	1139	653	3155
10555	58014	144968	71881	30456	26346	16857	9630	6011	4452	4062	3082	2852	2072	1258	1028	2031
10555	306049	10455	21648	10476	6426	2189	2996	2596	2453	1910	2000	1589	859	874	1414	1619
10555	677611	79504	22080	22594	11375	7515	4950	3935	2808	2105	1122	1257	657	482	616	968
10555	114762	332114	8381	8942	8765	4706	3963	4073	2322	1642	1441	1536	1045	605	732	1721
10555	25262	190134	402615	11731	8653	5698	2783	2035	1950	991	1117	886	659	453	436	1132
10555	86326	96940	78135	222658	4967	3731	2768	1494	1269	689	837	236	298	368	124	667
10555	35093	32524	52330	30121	125511	3903	486	396	1990	257	249	77	156	343	28	347
10555	79605	45976	38126	46333	39046	151887	5871	257	337	858	110	246	253	201	435	481
10555	32860	61731	46285	47381	71096	35736	169492	2949	463	158	1548	152	81	83	52	992
10555	86078	52309	42284	29268	20323	8954	5122	26935	853	304	174	198	156	57	64	234
10555	235867	61369	46106	30279	22076	17766	4899	3033	13969	580	164	241	81	60	23	143
10555	65241	84103	24769	14624	10827	6967	3974	2233	1323	11068	465	53	248	274	52	669
10555	144934	430153	104119	34399	17197	8318	4654	2365	1301	1182	8772	72	232	250	42	492
10555	425205	292846	467795	123484	47163	20489	10868	4939	3849	1663	655	3050	64	45	21	16
10555	1528343	752862	373958	133664	38139	11992	3707	2477	1591	980	656	592	4168	212	24	215
10555	537850	652131	384716	283236	66498	25067	3799	3834	2379	1241	1147	576	6720	1515	14	402
10555	441539	414437	559582	177908	65953	27153	9725	4177	2316	1392	800	258	157	132	2278	111
10555	353754	396975	290371	250188	127865	59244	37189	9903	10772	1017	3811	480	752	300	1352	8645
10555	187503	250123	157413	138615	34940	18552	15351	12900	4018	1728	910	286	310	209	145	1189

Ages 4-6					Ages 4-6				
	Cod numbers*	Cod increase	M annual	<b>M</b>		Cod biomass*	Cod increase	M annual	<b>M</b>
2005	6404		0.095	<b>0.10</b>	2005	5004		0.095	<b>0.10</b>
2006	16558	2.586	0.246	<b>0.28</b>	2006	8383	1.675	0.159	<b>0.17</b>
2007	24788	1.497	0.368	<b>0.46</b>	2007	16755	1.999	0.319	<b>0.38</b>
2008	29065	1.173	0.432	<b>0.57</b>	2008	26711	1.594	0.508	<b>0.71</b>
2009	35165	1.210	0.523	<b>0.74</b>	2009	39702	1.486	0.755	<b>1.00</b>
2010	38044	1.082	0.565	<b>0.83</b>	2010	70256	1.770	1.336	<b>1.00</b>
Ages 7+					Ages 7+				
	Cod numbers*	Cod increase	M annual	<b>M</b>		Cod biomass*	Cod increase	M annual	<b>M</b>
2008	29065		0.0951626	<b>0.10</b>	2008	26711		0.0951626	<b>0.10</b>
2009	35165	1.209874419	0.1151348	<b>0.12</b>	2009	39702	1.486353937	0.1414453	<b>0.15</b>
2010	38044	1.081871179	0.124561	<b>0.13</b>	2010	70256	1.769583396	0.2502992	<b>0.29</b>

\* Gonzalez *et al.*, 2010

	0.1	0.2	0.3	0.4	0.45	0.5	0.55	0.6	0.7	0.8	M <sub>codBincrease</sub>	M <sub>codNincrease</sub>	0.9	1.0
M <sub>ages4-6,2006-2010;7+,2009-2010</sub>														
SS log q residuals <sub>2006-2010</sub>	29.89	27.37	25.56	24.27	23.89	23.69	23.68	23.84	24.57	25.94	26.39	26.73	28.00	30.80
no iterations	50	51	51	52	52	52	52	52	52	51	51	51	51	51



Table 7c: Key diagnostics of five XSA<sub>2010</sub> runs with M ranging from 0.40 to 0.60 for ages 4 - 6 through 2006 - 2010, and ages 7+ on 2009 and 2011.

Standard error of mean log catchability of ages with catchability independent of year class strength and constant w.r.t. time																	
MAges	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Av. se log q	
0.40	0.777	1.270	0.925	0.638	0.721	0.735	0.731	0.591	0.696	0.526	0.702	0.686	0.758	0.887	0.382	0.691	
0.45	0.778	1.266	0.920	0.635	0.714	0.731	0.731	0.591	0.695	0.526	0.704	0.685	0.758	0.888	0.383	0.689	
0.50	0.782	1.263	0.915	0.633	0.708	0.728	0.732	0.591	0.694	0.526	0.707	0.684	0.759	0.889	0.383	0.688	
0.55	0.787	1.260	0.910	0.631	0.702	0.725	0.732	0.592	0.694	0.527	0.710	0.683	0.760	0.890	0.383	0.688	
0.60	0.795	1.258	0.906	0.629	0.697	0.722	0.734	0.593	0.694	0.528	0.714	0.683	0.761	0.891	0.383	0.687	
Internal st errors of survivors at age																	
MAges	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Av. se <sub>int</sub> surv	
0.40	0.794	0.677	0.551	0.421	0.366	0.329	0.302	0.272	0.255	0.233	0.229	0.218	0.214	0.216	0.212	0.294	
0.45	0.796	0.678	0.550	0.420	0.364	0.327	0.301	0.271	0.254	0.232	0.228	0.217	0.213	0.215	0.211	0.293	
0.50	0.799	0.680	0.550	0.419	0.363	0.326	0.300	0.270	0.254	0.232	0.227	0.217	0.212	0.214	0.209	0.292	
0.55	0.805	0.683	0.550	0.419	0.362	0.325	0.299	0.269	0.253	0.231	0.227	0.216	0.212	0.214	0.208	0.291	
0.60	0.813	0.687	0.552	0.419	0.361	0.325	0.299	0.269	0.253	0.231	0.227	0.216	0.212	0.213	0.207	0.291	
External st errors of survivors at age																	
MAges	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Av. se <sub>ext</sub> surv	
0.40		0.030	0.101	0.050	0.327	0.218	0.215	0.216	0.128	0.172	0.102	0.161	0.105	0.141	0.157	0.161	
0.45		0.047	0.095	0.067	0.303	0.206	0.214	0.217	0.126	0.174	0.102	0.159	0.102	0.141	0.158	0.159	
0.50		0.065	0.094	0.091	0.280	0.197	0.213	0.219	0.126	0.176	0.102	0.157	0.101	0.141	0.159	0.158	
0.55		0.082	0.100	0.118	0.259	0.189	0.213	0.221	0.126	0.178	0.103	0.155	0.099	0.142	0.160	0.159	
0.60		0.100	0.112	0.145	0.240	0.184	0.214	0.223	0.126	0.181	0.105	0.154	0.098	0.142	0.162	0.160	
S difference between internal and external st errors of survivors at age																	
MAges	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	SS (se <sub>int</sub> -se <sub>ext</sub> )	
0.40		0.419	0.203	0.138	0.002	0.012	0.008	0.003	0.016	0.004	0.016	0.003	0.012	0.006	0.003	0.843	
0.45		0.398	0.207	0.125	0.004	0.015	0.008	0.003	0.016	0.003	0.016	0.003	0.012	0.005	0.003	0.818	
0.50		0.378	0.208	0.108	0.007	0.017	0.008	0.003	0.016	0.003	0.016	0.004	0.012	0.005	0.003	0.786	
0.55		0.361	0.203	0.091	0.011	0.018	0.007	0.002	0.016	0.003	0.015	0.004	0.013	0.005	0.002	0.751	
0.60		0.345	0.194	0.075	0.015	0.020	0.007	0.002	0.016	0.003	0.015	0.004	0.013	0.005	0.002	0.715	

Table 8: Extended Survivor Analysis summary of diagnostics for 2011 (Lowestoft VPA Version 3.1).						
single EU survey, 1989-2010						
M=0.1 all ages 1989-2005						
M=0.4 ages 4-6 2006-2010 and ages 7+ 2009-2010						
REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2011						
CPUE data from file red3mtun.txt						
Catch data for 22 years. 1989 to 2010. Ages 4 to 19.						
Fleet	Fi	Last	First	Last	Alpha	Beta
	year	year	age	age		
EU BOTTOM TRAWL SURV	1989	2010	4	18	0.5	0.6
Time series weights :						
Tapered time weighting not applied						
Catchability analysis :						
Catchability independent of stock size for all ages						
Catchability independent of age for ages $\geq 17$						
Terminal population estimation :						
Final estimates not shrunk towards mean F						
Minimum standard error for population						
estimates derived from each fleet = .500						
Prior weighting not applied						
Tuning converged after 52 iterations						

Log catchability residuals.  
Fleet : EU BOTTOM TRAWL SURV

Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4	-1.99	-1.34	0.95	0.02	0.81	0.86	0.57	-0.18	0.86	0.01	0.62	-0.27	0.24	0.59	-1.22	-0.87	-0.16	0.61	-0.1	0	-0.02	0
5	-3.15	-3.88	0.6	1.16	-1.16	0.57	0.55	1.32	1.32	-0.01	0.37	0.45	0.29	0	-0.32	0.79	-0.09	0.68	0.14	0.03	0.27	0.05
6	-1.93	-2.13	-1.66	0.49	-0.27	0.26	-1	1.05	0.71	0.89	0.33	0.56	0.27	0.37	-0.71	0.13	1.08	0.55	0.5	0.47	0.16	-0.14
7	-0.99	-0.95	-1.45	-0.32	-0.85	0.31	-0.06	-0.02	0.74	0.02	1.01	0.8	0.4	0.21	-0.5	-0.1	0.58	0.12	0.73	0.12	0.22	-0.02
8	-0.45	-0.42	-1.49	-0.09	-0.86	-0.1	0.15	0.78	-0.39	0.52	0.64	1.87	0.41	0.57	-0.42	0.08	0.65	-0.19	-0.16	-0.33	0.33	-1.09
9	-0.43	-0.4	-1.44	-0.12	-1.55	0.24	-0.22	0.75	0.75	-0.11	1.15	1.07	0.4	0.86	-0.06	-0.2	0.84	-0.2	-0.1	-0.58	0.2	-0.86
10	-0.49	-0.36	-1.54	-0.23	-0.73	0.18	0.66	0.07	0.94	-0.68	0.9	1.82	-0.27	0.43	-0.03	0.1	0.68	-0.25	-0.79	-0.49	0.43	-0.34
11	-0.46	-0.52	-1.07	-0.41	-0.5	0.54	1.09	1	0.01	-0.48	-0.88	0.83	0.48	-0.32	0.15	-0.1	0.69	-0.31	0.3	-0.25	0.12	0.11
12	-0.76	-0.82	-1.16	-0.42	-0.59	0.39	0.84	1.34	1.1	0.56	-0.42	-0.02	0.01	0.02	-0.98	-0.19	0.67	-0.2	-0.11	0.03	1.03	-0.33
13	-0.37	-0.42	-0.82	-0.31	-0.23	0.17	0.87	0.92	1.15	-0.01	0.23	-0.75	0.1	0.3	0.17	-0.73	0.53	-0.21	-0.03	-0.22	-0.24	-0.09
14	-0.54	-0.23	-0.86	-0.44	-0.29	-0.1	0.26	1.2	1.12	0.32	-0.78	1.42	-0.55	-0.26	0.5	-0.02	-1.26	-0.24	0.06	-0.36	1.04	0.04
15	0.29	-0.05	-1.04	0.17	0.13	0.45	1.61	0.61	0.47	-0.66	1.07	0.17	0.37	0.57	-0.74	-0.65	-0.53	-0.81	0.29	-0.83	-0.17	-0.7
16	-0.1	-0.28	-0.96	-0.2	-0.63	-0.4	0.8	1.61	-0.64	-0.12	0.43	0.03	0.18	-0.57	0.88	0.77	-0.68	-0.41	1.66	-1.09	0.23	-0.5
17	-0.27	0.17	-0.41	-0.78	-0.25	-0.64	0.02	0.76	1.69	-0.35	0.47	-0.36	0.02	-0.35	1.13	1.56	-0.02	1.4	-1.27	-1.88	-0.08	-0.56
18	0	0.05	-0.01	0.09	0.48	0.2	0.36	0.16	-0.22	-0.62	0.13	-0.45	-0.31	-0.6	-0.07	-0.3	-0.29	0.06	-0.12	-0.7	0.85	-0.3

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

Age	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mean Log q	-8.2484	-8.2281	-8.303	-8.4344	-8.6738	-8.9931	-9.3668	-9.632	-9.6264	-9.8234	-9.6962	-10.056	-9.6703	-9.6508	-9.6508
S.E(Log q)	0.7767	1.2698	0.9247	0.638	0.721	0.735	0.7313	0.5909	0.6956	0.526	0.7015	0.6862	0.7575	0.8869	0.3819

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
4	1.06	-0.338	8.1	0.64	22	0.84	-8.25
5	1.27	-0.768	7.58	0.29	22	1.63	-8.23
6	1.15	-0.65	7.99	0.48	22	1.08	-8.3
7	1.2	-1.259	8.09	0.66	22	0.76	-8.43
8	1.48	-2.381	8.11	0.56	22	0.96	-8.67
9	1.38	-1.948	8.81	0.57	22	0.95	-8.99
10	1.18	-1.017	9.41	0.63	22	0.86	-9.37
11	1.17	-1.236	9.78	0.73	22	0.68	-9.63
12	1.53	-3.055	10.29	0.62	22	0.9	-9.63
13	1.27	-2.557	10.32	0.82	22	0.59	-9.82
14	1.25	-1.772	10.2	0.72	22	0.83	-9.7
15	1.09	-0.754	10.3	0.78	22	0.76	-10.06
16	1.17	-1.257	10.14	0.72	22	0.88	-9.67
17	1.6	-3.634	11.54	0.65	22	1.13	-9.65
18	0.92	1.912	9.43	0.96	22	0.32	-9.73

Terminal year survivor and F summaries :

<b>Age 4</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 2006</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	55776	0.794	0	0	1	1	0.036
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
	55776	0.79	0	1	0	0.036	

<b>Age 5</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 2005</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	68801	0.677	0.03	0.04	2	1	0.058
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
	68801	0.68	0.03	2	0.044	0.058	

<b>Age 6</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 2004</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	56595	0.551	0.101	0.18	3	1	0.055
Weighted prediction :							
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
	56595	0.55	0.1	3	0.184	0.055	

<b>Age 7</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 2003</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	50113	0.421	0.05	0.12	4	1	0.053
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
	50113	0.42	0.05	4	0.119	0.053	

<b>Age 8</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 2002</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimated
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	47930	0.366	0.327	0.89	5	1	0.016
Survivors	Int	Ext	N	Var	F		
at end of year	s.e	s.e		Ratio			
	47930	0.37	0.33	5	0.894	0.016	

<b>Age 9</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 2001</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimatec
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	27546	0.329	0.218	0.66	6	1	0.02
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	27546	0.33	0.22	0.661	6	0.02	

<b>Age 10</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 2000</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimatec
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	19662	0.302	0.215	0.71	7	1	0.039
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	19662	0.3	0.22	0.712	7	0.039	

<b>Age 11</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 1999</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimatec
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	13509	0.272	0.216	0.79	8	1	0.076
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	13509	0.27	0.22	0.795	8	0.076	

<b>Age 12</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 1998</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimatec
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	6520	0.255	0.128	0.5	9	1	0.064
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	6520	0.26	0.13	0.5	9	0.064	

<b>Age 13</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 1997</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimatec
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	2587	0.233	0.172	0.74	10	1	0.141
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	2587	0.23	0.17	0.74	10	0.141	

<b>Age 14</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 1996</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimate
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	1043	0.229	0.102	0.45	11	1	0.169
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	1043	0.23	0.1	11	0.447	0.169	

<b>Age 15</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 1995</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimate
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	1039	0.218	0.161	0.74	12	1	0.051
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	1039	0.22	0.16	12	0.738	0.051	

<b>Age 16</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 1994</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimate
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	598	0.214	0.105	0.49	13	1	0.144
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	598	0.21	0.1	13	0.489	0.144	

<b>Age 17</b> Catchability constant w.r.t. time and dependent on age							
<b>Year class = 1993</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimate
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	427	0.216	0.141	0.65	14	1	0.114
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	427	0.22	0.14	14	0.652	0.114	

<b>Age 18</b> Catchability constant w.r.t. time and age (fixed at the value for age) 17							
<b>Year class = 1992</b>							
Fleet		Int	Ext	Var	N	Scaled	Estimate
		s.e	s.e	Ratio		Weights	F
EU BOTTOM TRAWL SURV	227	0.212	0.157	0.74	15	1	0.134
Survivors		Int	Ext	Var	N	F	
at end of year		s.e	s.e	Ratio			
	227	0.21	0.16	15	0.739	0.135	

Table 9a: XSA retrospective analysis, 2010-2006

Biomass						SSB					
Year	2011	2010	2009	2008	2007	Year	2011	2010	2009	2008	2007
1989	217	217	212	213	210	1989	51	51	48	48	47
1990	186	185	181	182	180	1990	44	44	42	42	41
1991	133	133	130	130	129	1991	37	37	35	35	35
1992	98	98	96	96	95	1992	36	36	34	34	33
1993	67	67	66	66	65	1993	21	21	20	20	20
1994	44	44	42	44	45	1994	9	9	9	9	8
1995	35	35	32	35	35	1995	7	7	7	7	6
1996	24	24	21	24	25	1996	4	4	3	4	3
1997	22	22	20	23	24	1997	5	5	4	4	4
1998	24	24	21	26	27	1998	8	8	7	8	9
1999	24	24	21	26	28	1999	4	4	3	4	4
2000	28	29	25	31	33	2000	5	5	5	5	6
2001	28	29	26	32	34	2001	7	7	6	8	9
2002	32	34	29	37	41	2002	6	7	6	8	8
2003	35	37	32	40	44	2003	7	7	6	8	9
2004	54	56	49	64	63	2004	17	18	15	19	21
2005	73	81	71	93	88	2005	12	12	10	15	17
2006	109	135	128	157	159	2006	13	14	12	16	17
2007	124	150	140	169		2007	16	17	15	20	
2008	142	170	155			2008	33	36	29		
2009	135	158				2009	31	36			
2010	121					2010	25				

FBAR						REC					
Year	2011	2010	2009	2008	2007	Year	2011	2010	2009	2008	2007
1989	0.32	0.32	0.33	0.33	0.34	1989	54	54	54	54	54
1990	0.49	0.49	0.50	0.50	0.51	1990	42	42	42	42	42
1991	0.37	0.37	0.38	0.38	0.38	1991	24	24	24	24	24
1992	0.57	0.58	0.59	0.58	0.59	1992	22	22	22	22	22
1993	0.67	0.67	0.69	0.69	0.70	1993	139	139	139	139	140
1994	0.47	0.47	0.49	0.48	0.49	1994	145	145	136	158	169
1995	0.71	0.72	0.76	0.75	0.77	1995	26	27	22	25	23
1996	0.55	0.55	0.60	0.59	0.61	1996	13	13	13	16	17
1997	0.15	0.15	0.17	0.16	0.17	1997	14	15	14	17	18
1998	0.09	0.09	0.10	0.10	0.10	1998	13	14	14	16	17
1999	0.13	0.13	0.15	0.15	0.16	1999	16	18	16	18	19
2000	0.25	0.25	0.27	0.26	0.27	2000	16	17	17	18	17
2001	0.17	0.17	0.19	0.17	0.17	2001	26	28	23	25	29
2002	0.20	0.20	0.22	0.20	0.20	2002	51	54	51	62	71
2003	0.16	0.16	0.17	0.16	0.15	2003	85	84	73	92	102
2004	0.12	0.11	0.13	0.11	0.11	2004	133	146	134	186	122
2005	0.19	0.18	0.21	0.17	0.16	2005	191	244	225	272	231
2006	0.09	0.09	0.10	0.08	0.08	2006	377	573	608	688	787
2007	0.17	0.15	0.26	0.15		2007	267	288	252	274	
2008	0.08	0.07	0.08			2008	200	229	200		
2009	0.06	0.05				2009	163	171			
2010	0.08					2010	86				





Table 10: XSA results for 2011 assessment

Run title : REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2011												
Terminal Fs derived using XSA (Without F shrinkage)												
(Table 8)	Fishing mortality (F) at age											
YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE												
4	0.0086	0.2988	0.0562	0.0114	1.8023	0.4959	0.117	0.1467	0.052	0.0087	0.0097	0.0057
5	0.0157	0.0616	0.1429	0.3173	0.8161	0.3914	0.1932	0.1931	0.0155	0.005	0.0038	0.0093
6	0.0847	0.102	0.1929	0.403	0.2765	0.2462	0.5902	0.0855	0.0403	0.0132	0.0015	0.0201
7	0.2129	0.4397	0.458	0.8594	0.3099	0.3224	0.4424	0.2625	0.0172	0.022	0.0095	0.0414
8	0.3012	0.7687	0.659	1.0282	0.517	0.3524	0.5529	0.6078	0.0665	0.017	0.0225	0.1658
9	0.2788	0.737	0.614	0.7548	0.2611	0.5424	0.3392	0.6576	0.2086	0.1255	0.0161	0.1509
10	0.2426	0.5997	0.3808	0.5315	0.5443	0.584	0.6145	0.3318	0.263	0.0641	0.1375	0.1361
11	0.3034	0.4518	0.3866	0.4129	0.7784	0.7176	0.8704	0.6716	0.1019	0.0817	0.0898	0.3449
12	0.2737	0.3491	0.302	0.4422	0.8102	0.6769	0.7405	0.9203	0.3115	0.2134	0.1522	0.2458
13	0.3726	0.4045	0.3242	0.4268	0.987	0.4545	0.7512	0.5431	0.2524	0.0984	0.2166	0.1201
14	0.3652	0.5546	0.3118	0.4343	1.0225	0.4311	0.5175	0.7286	0.2763	0.1766	0.1043	0.9622
15	0.5644	0.4595	0.1818	0.5332	1.041	0.5254	1.3643	0.2597	0.0825	0.0361	0.4051	0.2223
16	0.5664	0.5276	0.2729	0.4952	0.8023	0.3039	1.0689	0.9359	0.033	0.1235	0.3113	0.3133
17	0.4314	0.7683	0.4838	0.2879	0.9267	0.2333	0.5297	0.4193	0.2935	0.0913	0.362	0.1908
18	0.5826	0.6978	0.7504	0.5174	1.6637	0.5022	0.6876	0.2395	0.0436	0.0516	0.1841	0.3086
+gp	0.5826	0.6978	0.7504	0.5174	1.6637	0.5022	0.6876	0.2395	0.0436	0.0516	0.1841	0.3086
0 FBAR 6-16	0.3242	0.4904	0.3713	0.5747	0.6682	0.4688	0.7138	0.5459	0.1503	0.0883	0.1333	0.2475

(Table 8)	Fishing mortality (F) at age											
YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	FBAR **	**
AGE												
4	0.0335	0.0302	0.0213	0.008	0.0034	0.0066	0.002	0.0015	0.0033	0.0365	0.0138	
5	0.0242	0.016	0.047	0.0588	0.0027	0.035	0.0038	0.0049	0.0043	0.058	0.0224	
6	0.0311	0.0392	0.0144	0.0732	0.0112	0.0995	0.0091	0.0193	0.0146	0.0548	0.0296	
7	0.0974	0.0514	0.0368	0.0937	0.0289	0.1073	0.0703	0.0369	0.018	0.0528	0.0359	
8	0.1713	0.1218	0.0592	0.1118	0.0918	0.0925	0.0498	0.0573	0.0316	0.0155	0.0348	
9	0.1865	0.1743	0.0995	0.0784	0.2123	0.1111	0.0971	0.0653	0.0383	0.0197	0.0411	
10	0.1135	0.1487	0.0923	0.0807	0.1811	0.0978	0.0677	0.0617	0.0532	0.0392	0.0513	
11	0.1318	0.1049	0.1302	0.0701	0.2243	0.0804	0.1873	0.0755	0.0569	0.0763	0.0695	
12	0.3065	0.0918	0.0611	0.0893	0.2979	0.0856	0.1968	0.1169	0.0802	0.0641	0.0871	
13	0.2381	0.4317	0.0741	0.0585	0.2423	0.089	0.1527	0.0739	0.0587	0.1409	0.0911	
14	0.1314	0.3241	0.4763	0.0686	0.1161	0.1372	0.1906	0.1234	0.142	0.1686	0.1447	
15	0.2121	0.4993	0.0893	0.0617	0.1077	0.0666	0.2529	0.0968	0.0413	0.0507	0.0629	
16	0.2982	0.26	0.6254	0.4931	0.6287	0.0763	0.5536	0.1685	0.1189	0.144	0.1438	
17	0.2273	0.3857	0.5064	0.5675	1.012	0.9522	0.063	0.101	0.0712	0.1142	0.0955	
18	0.2209	0.1434	0.2735	0.2239	0.4868	0.2643	1.2156	0.064	0.1676	0.1345	0.122	
+gp	0.2209	0.1434	0.2735	0.2239	0.4868	0.2643	1.2156	0.064	0.1676	0.1345		
0 FBAR 6-16	0.1744	0.2043	0.1599	0.1163	0.1948	0.0948	0.1662	0.0814	0.0594	0.0751		

(Table 9) Relative F at age		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
YEAR													
AGE													
4		0.0266	0.6093	0.1513	0.0199	2.6972	1.0578	0.1639	0.2688	0.3463	0.0979	0.0726	0.023
5		0.0484	0.1256	0.3849	0.5521	1.2213	0.8348	0.2707	0.3537	0.1033	0.0571	0.0285	0.0376
6		0.2612	0.208	0.5196	0.7013	0.4138	0.5252	0.8268	0.1566	0.2681	0.1492	0.0114	0.0813
7		0.6567	0.8967	1.2337	1.4954	0.4637	0.6878	0.6198	0.4809	0.1143	0.2491	0.071	0.1674
8		0.9291	1.5675	1.7749	1.7891	0.7737	0.7517	0.7745	1.1135	0.4426	0.1929	0.1689	0.6699
9		0.86	1.5029	1.6537	1.3134	0.3907	1.157	0.4752	1.2046	1.3882	1.4208	0.1206	0.6095
10		0.7482	1.223	1.0256	0.9249	0.8146	1.2458	0.8609	0.6078	1.7502	0.7256	1.0318	0.5497
11		0.9358	0.9214	1.0414	0.7185	1.1649	1.5308	1.2194	1.2304	0.6779	0.9254	0.6735	1.3935
12		0.8444	0.7118	0.8135	0.7695	1.2126	1.4439	1.0374	1.6859	2.0724	2.4161	1.1417	0.9928
13		1.1495	0.8248	0.8732	0.7426	1.4771	0.9694	1.0523	0.995	1.6797	1.1137	1.6249	0.4852
14		1.1266	1.1309	0.8398	0.7557	1.5303	0.9195	0.7249	1.3348	1.8384	2	0.782	3.8873
15		1.7412	0.9371	0.4897	0.9279	1.5579	1.1208	1.9112	0.4757	0.549	0.4089	3.0389	0.8979
16		1.7472	1.076	0.735	0.8617	1.2008	0.6482	1.4975	1.7146	0.2193	1.3982	2.3354	1.2655
17		1.3308	1.5666	1.3031	0.501	1.3868	0.4976	0.7421	0.7682	1.9527	1.034	2.7156	0.7709
18		1.7972	1.4229	2.0212	0.9003	2.4898	1.0713	0.9633	0.4388	0.29	0.5839	1.3809	1.2466
+gp		1.7972	1.4229	2.0212	0.9003	2.4898	1.0713	0.9633	0.4388	0.29	0.5839	1.3809	1.2466
0 REFMEAN		0.3242	0.4904	0.3713	0.5747	0.6682	0.4688	0.7138	0.5459	0.1503	0.0883	0.1333	0.2475

Table 9 Relative F at age		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	MEAN **-*
YEAR												
AGE												
4		0.1919	0.1478	0.1334	0.0689	0.0173	0.0696	0.0122	0.0185	0.0549	0.4857	0.1863
5		0.1388	0.0784	0.2942	0.5055	0.014	0.3695	0.0229	0.0608	0.0721	0.7722	0.3017
6		0.1785	0.1917	0.0903	0.6295	0.0575	1.0489	0.0546	0.2365	0.2462	0.7293	0.404
7		0.5584	0.2518	0.23	0.8058	0.1482	1.1315	0.4231	0.4538	0.3032	0.7032	0.4867
8		0.9825	0.596	0.3704	0.9612	0.4715	0.9753	0.2994	0.7045	0.5322	0.2066	0.4811
9		1.0697	0.853	0.6222	0.6746	1.0901	1.1711	0.5843	0.8016	0.6446	0.2624	0.5695
10		0.6509	0.7281	0.5776	0.6939	0.9297	1.0309	0.4073	0.7575	0.8954	0.5211	0.7247
11		0.7561	0.5136	0.8143	0.6031	1.1519	0.8475	1.1274	0.9273	0.9567	1.0153	0.9664
12		1.7579	0.4495	0.3819	0.7682	1.5299	0.9024	1.1846	1.4364	1.3489	0.8529	1.2127
13		1.3656	2.1133	0.4634	0.5031	1.2442	0.9389	0.9189	0.9074	0.9875	1.8747	1.2565
14		0.7537	1.5864	2.9796	0.5897	0.596	1.447	1.1469	1.5161	2.39	2.2439	2.05
15		1.2164	2.4438	0.5583	0.5309	0.5528	0.7022	1.5218	1.1886	0.6947	0.6747	0.8527
16		1.7104	1.2728	3.9119	4.2401	3.2282	0.8044	3.3318	2.0703	2.0007	1.9159	1.9956
17		1.3033	1.8879	3.1675	4.8802	5.1962	10.0396	0.379	1.2406	1.1984	1.5193	1.3194
18		1.2668	0.7018	1.7106	1.9255	2.4996	2.7863	7.3159	0.7865	2.8197	1.7902	1.7988
+gp		1.2668	0.7018	1.7106	1.9255	2.4996	2.7863	7.3159	0.7865	2.8197	1.7902	
0 REFMEAN		0.1744	0.2043	0.1599	0.1163	0.1948	0.0948	0.1662	0.0814	0.0594	0.0751	

Table 10 Stock number at age (start of year)		Numbers*10**3											
YEAR		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE													
4		54397	42254	23659	21939	139451	144671	26377	12571	14345	13305	16484	16469
5		71308	48798	28357	20238	19626	20810	79724	21232	9822	12322	11935	14772
6		102148	63517	41516	22242	13334	7852	12732	59463	15839	8750	11093	10758
7		125975	84922	51898	30974	13450	9150	5554	6384	49395	13766	7814	10022
8		97234	92129	49501	29703	11867	8927	5997	3229	4443	43934	12185	7004
9		62687	65100	38648	23174	9613	6403	5679	3122	1591	3762	39081	10780
10		47423	42921	28189	18925	9857	6700	3368	3660	1464	1168	3002	34798
11		35323	33668	21320	17429	10064	5175	3380	1648	2377	1018	992	2367
12		27277	23598	19389	13105	10436	4181	2285	1281	762	1942	849	820
13		21512	18771	15061	12970	7620	4200	1923	986	462	505	1420	660
14		20215	13410	11335	9854	7659	2570	2412	821	518	325	414	1034
15		12672	12695	6968	7509	5776	2493	1511	1301	358	356	246	338
16		7208	6520	7255	5257	3986	1845	1334	349	908	299	310	149
17		6366	3702	3481	4997	2899	1617	1232	414	124	795	239	206
18		4688	3742	1554	1942	3390	1038	1159	656	247	84	657	150
+gp		11849	9489	6539	4481	1937	1460	2604	1423	1872	1087	917	2203
0 TOTAL		708281	565237	354670	244741	270966	229094	157271	118542	104526	103415	107637	112529

(Table 10) Stock number at age (start of year)		Numbers*10**3												
YEAR		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	GMST 89-*	AMST 89-*
AGE														
4		26450	50718	85323	133488	190875	377254	267386	199635	162794	86298	0	52392	92852
5		14817	23145	44526	75575	119821	172130	251218	178872	133618	108769	55776	37577	61952
6		13242	13086	20610	38438	64479	108123	111409	167756	119310	89184	68801	28667	45319
7		9540	11615	11386	18381	32325	57693	65614	74005	110306	78814	56595	22192	34493
8		8700	7831	9983	9931	15144	28416	46891	55340	64534	72620	50113	16848	27420
9		5369	6633	6274	8513	8035	12501	23441	40370	47283	41912	47930	11561	19039
10		8388	4031	5042	5139	7122	5880	10122	19248	34220	30503	27546	7992	13322
11		27481	6775	3144	4160	4290	5377	4825	8560	16374	21750	19662	5773	9969
12		1517	21794	5520	2497	3509	3102	4489	3620	7182	10369	13509	4092	7599
13		580	1010	17990	4699	2066	2357	2576	3336	2914	4443	6520	2930	6035
14		529	414	594	15116	4010	1467	1951	2001	2804	1842	2587	2134	4832
15		358	420	271	334	12771	3231	1158	1459	1600	1631	1043	1475	3611
16		245	262	231	224	284	10376	2735	813	1198	1029	1039	1026	2529
17		98	164	183	112	124	137	8699	1423	622	713	598	670	1851
18		154	71	101	100	57	41	48	7391	1164	388	427	418	1363
+gp		323	424	1166	1788	228	506	438	7909	6741	5230	3292		
0 TOTAL		117791	148395	212341	318493	465141	788590	802999	771737	712664	555496	355437		

(Table 11) Spawning stock number at age (spawning time)				Numbers*10** <sup>-3</sup>									
YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
AGE													
4	324	82	23	0	0	0	0	12	0	0	0	0	
5	1130	915	640	78	201	240	234	21	68	24	47	44	
6	3623	2750	1947	983	323	351	554	2519	94	303	198	320	
7	8355	6995	4765	2955	976	778	452	633	6264	382	403	664	
8	10170	11259	6801	5102	1853	1352	842	467	890	20021	507	830	
9	9731	10228	6826	5584	2391	1289	1102	626	416	1821	7783	1046	
10	10059	7873	5778	6208	3061	1649	970	986	500	526	728	7786	
11	11013	8762	6008	7043	3471	1454	992	484	977	474	294	912	
12	10536	8196	7491	6136	3988	1218	684	366	338	903	270	362	
13	9239	8023	7250	6678	3409	1487	575	300	236	240	462	257	
14	9134	6057	5758	5514	3788	1027	978	279	267	153	157	353	
15	6140	6227	3911	4468	3037	1008	550	468	196	168	78	135	
16	3595	3212	4091	3489	2529	1958	635	153	537	154	118	56	
17	3624	2017	1990	3270	1736	1077	736	195	77	427	104	103	
18	2623	1973	856	1262	2323	689	714	371	158	45	204	67	
+gp	8504	7095	4319	3293	1337	917	1679	1082	1295	690	596	1362	
(Table 11) Spawning stock number at age (spawning time)				Numbers*10** <sup>-3</sup>									
YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010			
AGE													
4	0	0	84	265	0	1461	777	773	473	1167			
5	73	252	352	895	357	1496	1946	1212	1035	1153			
6	301	401	694	2995	1662	3013	3342	2109	4155	4816			
7	610	838	721	6407	2815	5504	6084	7686	14295	5777			
8	1200	1054	1153	6815	2595	6576	9823	12132	20137	10396			
9	1349	1395	1099	7260	1991	4277	8514	19003	22279	11267			
10	1443	1399	1852	3921	2284	2350	4514	14953	20329	13429			
11	12355	1660	1154	2462	1944	2915	2410	7309	10688	13713			
12	514	8413	2093	1272	1958	1800	2065	3280	4886	4966			
13	347	344	9421	3048	1335	1286	1426	3090	1992	3506			
14	214	150	285	8888	1687	1031	1146	1836	1979	1243			
15	190	144	125	223	9847	1922	816	1295	860	1051			
16	162	93	75	254	186	5259	1254	606	504	774			
17	69	57	75	48	75	72	5281	1198	243	639			
18	97	26	41	129	41	23	41	4785	814	332			
+gp	195	312	493	1866	147	280	343	6846	2924	3854			

(Table 12) Stock biomass at age (start of year)		Tonnes										
YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE												
4	5440	4099	2579	2106	9204	13020	2691	993	1291	1184	1434	1597
5	11695	8344	3828	3461	3062	2705	9009	2930	1247	1700	1444	1950
6	20940	13466	8884	4626	2827	1775	2763	8384	3009	1584	1952	1872
7	31242	22165	14324	9045	3860	2525	1600	1724	8595	3152	1742	2345
8	27614	27547	16682	10515	4332	3107	2141	1059	1577	9753	3168	1996
9	19872	21548	14879	9177	3797	2529	2300	1199	646	1396	9614	3546
10	16551	15495	13108	8554	4278	3109	1536	1621	682	493	970	10335
11	15224	14915	10980	9150	5163	2551	1738	791	1200	499	469	990
12	13938	12366	11032	7483	5782	2216	1248	683	437	1068	479	433
13	12112	10925	9278	8236	4755	2306	1215	572	281	315	728	441
14	11846	8073	7356	6701	5262	1729	1693	492	322	223	229	583
15	7996	8277	4878	5286	4124	1643	1097	844	244	254	133	168
16	4635	4356	5651	4242	3472	1327	1083	244	677	242	171	100
17	4495	2706	2659	3843	2473	1319	1013	313	98	661	153	148
18	3296	2721	1234	1707	2939	885	1007	521	187	61	404	108
+gp	10427	8730	5833	4181	2133	1332	2778	1360	1747	1199	703	1652
0 TOTALBIO	217321	185729	133186	98313	67461	44078	34910	23732	22241	23784	23794	28264

(Table 12) Stock biomass at age (start of year)		Tonnes									
YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
AGE											
4	2248	5122	6485	12548	17561	33198	29145	20163	19047	10183	
5	2074	3055	4853	9069	14259	19623	30146	23253	17771	16424	
6	2370	2408	3318	6265	10703	16975	15263	28183	21118	16231	
7	2271	2637	2471	4062	6918	12404	13451	16133	20958	17260	
8	2584	2208	2635	2761	4134	7530	11723	15218	14649	19099	
9	1761	2142	2014	2920	2724	4213	7360	13120	12294	12154	
10	3221	1572	1790	1943	2699	2358	4018	7102	10916	9914	
11	9344	2764	1298	1847	1969	2317	2205	3552	6484	7917	
12	783	8674	2550	1244	1688	1331	2335	1586	2341	4013	
13	347	567	6315	2598	955	1160	1396	1475	1582	2031	
14	351	246	331	6439	2370	782	1052	984	1223	831	
15	239	264	158	212	6411	1900	605	827	762	1014	
16	151	188	147	154	202	4379	1091	492	600	542	
17	76	106	93	61	90	75	4254	841	420	337	
18	131	63	70	75	52	34	35	3311	951	201	
+gp	326	404	879	1350	198	391	242	6082	3586	2704	
0 TOTALBIO	28276	32422	35408	53547	72931	108670	124322	142324	134703	120856	

(Table 13) Spawning stock biomass at age (spawning time)		Tonnes										
YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE												
4	32	8	3	0	0	0	0	1	0	0	0	0
5	185	157	86	13	31	31	26	3	9	3	6	6
6	743	583	417	204	69	79	120	355	18	55	35	56
7	2072	1826	1315	863	280	215	130	171	1090	87	90	155
8	2888	3366	2292	1806	676	470	301	153	316	4445	132	236
9	3085	3386	2628	2211	944	509	446	240	169	676	1915	344
10	3510	2842	2687	2806	1329	765	442	437	233	222	235	2312
11	4747	3882	3094	3697	1781	717	510	232	494	232	139	381
12	5384	4295	4263	3504	2209	646	373	195	194	497	152	191
13	5201	4669	4466	4240	2127	816	363	174	144	150	237	171
14	5353	3647	3737	3750	2602	691	687	167	166	105	87	199
15	3874	4060	2738	3146	2168	664	399	304	134	120	42	67
16	2311	2146	3187	2815	2203	1408	516	107	401	125	65	38
17	2559	1474	1520	2514	1481	879	605	147	61	356	67	74
18	1844	1434	680	1109	2014	587	620	294	120	33	126	48
+gp	7484	6528	3853	3072	1472	836	1792	1034	1209	761	457	1022
0 TOTSPBIO	51273	44301	36964	35752	21387	9314	7331	4014	4755	7867	3784	5301
(Table 13) Spawning stock biomass at age (spawning time)		Tonnes										
YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010		
AGE												
4	0	0	6	25	0	129	85	78	55	138		
5	10	33	38	107	42	171	234	158	138	174		
6	54	74	112	488	276	473	458	354	735	876		
7	145	190	156	1416	602	1183	1247	1676	2716	1265		
8	357	297	304	1895	708	1743	2456	3336	4571	2734		
9	442	451	353	2490	675	1441	2673	6176	5793	3267		
10	554	546	657	1482	866	942	1792	5518	6485	4365		
11	4201	677	477	1093	892	1256	1101	3033	4232	4992		
12	265	3349	967	633	942	772	1074	1437	1593	1922		
13	207	193	3307	1686	617	633	773	1366	1081	1602		
14	142	90	159	3786	997	549	617	903	863	560		
15	127	91	73	142	4943	1130	427	735	410	654		
16	100	67	48	174	132	2219	500	367	252	408		
17	53	37	38	26	54	39	2582	708	164	302		
18	83	23	28	98	37	20	30	2144	665	172		
+gp	197	297	372	1409	128	217	190	5264	1556	1992		
0 TOTSPBIO	6937	6412	7096	16949	11912	12918	16239	33252	31309	25423		

(Table 16) Summary (without SOP correction)							
Terminal Fs derived using XSA (Without F shrinkage)							
	RECRUIT	TOTALBIO	ABUNDANCE	TOTSPBIC	LANDINGS	YIELD/SSE	FBAR 6-
	Age 4						
1989	54397	217321	708281	51273	58086	1.1329	0.3242
1990	42254	185729	565237	44301	80223	1.8108	0.4904
1991	23659	133186	354670	36964	48500	1.3121	0.3713
1992	21939	98313	244741	35752	43300	1.2111	0.5747
1993	139451	67461	270966	21387	43100	2.0153	0.6682
1994	144671	44078	229094	9314	17664	1.8965	0.4688
1995	26377	34910	157271	7331	13879	1.8932	0.7138
1996	12571	23732	118542	4014	6101	1.5197	0.5459
1997	14345	22241	104526	4755	1408	0.2961	0.1503
1998	13305	23784	103415	7867	1011	0.1285	0.0883
1999	16484	23794	107637	3784	1095	0.2894	0.1333
2000	16469	28264	112529	5301	3665	0.6914	0.2475
2001	26450	28276	117791	6937	3327	0.4796	0.1744
2002	50718	32422	148395	6412	2964	0.4622	0.2043
2003	85323	35408	212341	7096	2273	0.3203	0.1599
2004	133488	53547	318493	16949	3260	0.1923	0.1163
2005	190875	72931	465141	11912	4039	0.3391	0.1948
2006	377254	108670	788590	12918	5936	0.4595	0.0948
2007	267386	124322	802999	16239	5131	0.316	0.1662
2008	199635	142324	771737	33252	4274	0.1285	0.0814
2009	162794	134703	712664	31309	3639	0.1162	0.0594
2010	86298	120856	555496	25423	4894	0.1925	0.0751
Arith.							
Mean	95734	79831	362298	18204	16262	0.782	0.2774
0 Units	(Thousands)	(Tonnes)	(Thousands)	(Tonnes)	(Tonnes)		

Table 11A

5	Nparams
5	Geometric mean model
52.392	1989-2008 age 4 XSA geomean in millions
0.00000E+000	
0.00000E+000	
0	
0.00000E+000	
20	Ndata
0.038	log residuals
-0.215	
-0.795	
-0.870	
0.979	
1.016	
-0.686	
-1.427	
-1.295	
-1.371	
-1.156	
-1.157	
-0.684	
-0.032	
0.488	
0.935	
1.293	
1.974	
1.630	
1.338	
0	No extra data



**Table 11b: An explanation of the red.sen file input data with an exploitation pattern corresponding to Fstatusquo***N4=1989-2008 age 4 XSA geometric mean*

Name	Value	C.V.	Name	Value	C.V.	Name	Value	C.V.	Name	Value	C.V.
Population at age in 2011			Exploitation pattern (H - Human consumption)			Exploitation pattern (D - Discards)			Exploitation pattern (I - Industrials)		
N4	52392	0.79	sH4	0.01377	0.01971	sD4	0.00	0.00	sl4	0.00	0.00
N5	55776	0.35	sH5	0.0224	0.03083	sD5	0.00	0.00	sl5	0.00	0.00
N6	68801	0.33	sH6	0.02957	0.02198	sD6	0.00	0.00	sl6	0.00	0.00
N7	56595	0.24	sH7	0.0359	0.01742	sD7	0.00	0.00	sl7	0.00	0.00
N8	50113	0.35	sH8	0.0348	0.02108	sD8	0.00	0.00	sl8	0.00	0.00
N9	47930	0.27	sH9	0.0411	0.02293	sD9	0.00	0.00	sl9	0.00	0.00
N10	27546	0.26	sH10	0.05137	0.01136	sD10	0.00	0.00	sl10	0.00	0.00
N11	19662	0.24	sH11	0.06957	0.01098	sD11	0.00	0.00	sl11	0.00	0.00
N12	13509	0.19	sH12	0.08707	0.02706	sD12	0.00	0.00	sl12	0.00	0.00
N13	6520	0.20	sH13	0.09117	0.04374	sD13	0.00	0.00	sl13	0.00	0.00
N14	2587	0.17	sH14	0.14467	0.02272	sD14	0.00	0.00	sl14	0.00	0.00
N15	1043	0.19	sH15	0.06293	0.0297	sD15	0.00	0.00	sl15	0.00	0.00
N16	1039	0.16	sH16	0.1438	0.0248	sD16	0.00	0.00	sl16	0.00	0.00
N17	598	0.18	sH17	0.09547	0.02203	sD17	0.00	0.00	sl17	0.00	0.00
N18	427	0.18	sH18	0.12203	0.05291	sD18	0.00	0.00	sl18	0.00	0.00
N19	3292	0.18	sH19	0.12203	0.05291	sD19	0.00	0.00	sl19	0.00	0.00
Stock weight at age			Catch weight at age (H - Human consumption)			Catch weight at age (D - Discards)			Catch weight at age (I - Industrials)		
WS4	0.112	0.010	WH4	0.130	0.022	WD4	0.00	0.00	WI4	0.00	0.00
WS5	0.138	0.011	WH5	0.143	0.010	WD5	0.00	0.00	WI5	0.00	0.00
WS6	0.176	0.007	WH6	0.188	0.021	WD6	0.00	0.00	WI6	0.00	0.00
WS7	0.209	0.016	WH7	0.224	0.007	WD7	0.00	0.00	WI7	0.00	0.00
WS8	0.255	0.025	WH8	0.268	0.008	WD8	0.00	0.00	WI8	0.00	0.00
WS9	0.292	0.032	WH9	0.308	0.019	WD9	0.00	0.00	WI9	0.00	0.00
WS10	0.338	0.028	WH10	0.341	0.022	WD10	0.00	0.00	WI10	0.00	0.00
WS11	0.392	0.026	WH11	0.401	0.045	WD11	0.00	0.00	WI11	0.00	0.00
WS12	0.384	0.056	WH12	0.398	0.038	WD12	0.00	0.00	WI12	0.00	0.00
WS13	0.481	0.054	WH13	0.477	0.070	WD13	0.00	0.00	WI13	0.00	0.00
WS14	0.460	0.029	WH14	0.488	0.013	WD14	0.00	0.00	WI14	0.00	0.00
WS15	0.555	0.074	WH15	0.525	0.010	WD15	0.00	0.00	WI15	0.00	0.00
WS16	0.545	0.054	WH16	0.540	0.035	WD16	0.00	0.00	WI16	0.00	0.00
WS17	0.580	0.102	WH17	0.589	0.108	WD17	0.00	0.00	WI17	0.00	0.00
WS18	0.594	0.196	WH18	0.537	0.085	WD18	0.00	0.00	WI18	0.00	0.00
WS19	0.606	0.141	WH19	0.647	0.121	WD19	0.00	0.00	WI19	0.00	0.00
Natural mortality at age			Maturity								
M4	0.4	0.00	MT4	0.008	0.006						
M5	0.4	0.00	MT5	0.012	0.005						
M6	0.4	0.00	MT6	0.045	0.011						
M7	0.4	0.00	MT7	0.113	0.041						
M8	0.4	0.00	MT8	0.227	0.103						
M9	0.4	0.00	MT9	0.361	0.110						
M10	0.4	0.00	MT10	0.503	0.080						
M11	0.4	0.00	MT11	0.646	0.023						
M12	0.4	0.00	MT12	0.564	0.110						
M13	0.4	0.00	MT13	0.756	0.058						
M14	0.4	0.00	MT14	0.717	0.021						
M15	0.4	0.00	MT15	0.696	0.159						
M16	0.4	0.00	MT16	0.756	0.220						
M17	0.4	0.00	MT17	0.761	0.266						
M18	0.4	0.00	MT18	0.794	0.088						
M19	0.4	0.00	MT19	0.765	0.181						
Natural mortality multiplier in year			Effort multiplier in year (H - Human consumption)								
K2010	1	0.0	HF2010	1.0	0.0						
K2011	1	0.0	HF2011	1.0	0.0						
K2012	1	0.0	HF2012	1.0	0.0						

Table 12a: Short and medium term SSB projections under a range of Fstatus quo multipliers.

	Relative Fbar					Fsattus quo						
	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	
<b>2013</b>												
5 <sup>th</sup> %ile	21891	21628	21370	21112	20850	<b>20591</b>	20337	20086	19839	19604	19375	
10 <sup>th</sup> %ile	22582	22313	22042	21775	21516	21267	21016	20769	20529	20294	20059	
25 <sup>th</sup> %ile	23370	23098	22830	22564	22302	22039	21776	21517	21269	21027	20788	
50 <sup>th</sup> %ile	25281	24978	24682	24394	24114	<b>23844</b>	23575	23304	23039	22774	22516	
95 <sup>th</sup> %ile	29797	29467	29142	28821	28505	28192	27883	27558	27235	26937	26642	
	Fbar					Fsattus quo						
<b>2020</b>	0.036	0.043	0.050	0.058	0.065	0.072	0.079	0.086	0.094	0.101	0.108	
5 <sup>th</sup> %ile	6728	6408	6121	5849	5597	5354	5111	4900	4694	4499	4318	
10 <sup>th</sup> %ile	7418	7067	6750	6450	6196	5951	5703	5473	5265	5061	4873	
25 <sup>th</sup> %ile	8357	8007	7679	7369	7079	6799	6530	6283	6036	5815	5628	
50 <sup>th</sup> %ile	10723	10332	9953	9613	9285	<b>8969</b>	8680	8405	8134	7894	7663	
95 <sup>th</sup> %ile	15737	15242	14774	14330	13930	13565	13220	12900	12595	12272	11955	
Final assessment data year			<b>2010</b>									
First year for populations in Sen			2011									
First SSB profile 3 years ahead			2013									
Last SSB profile 10 years ahead			2020									
					SSB 2013							
					SSB 2020							

Tab. 12b: SSB and yield 5th, 25th, 50th and 95% %ile probability profiles under 0.5Fstatus quo

	5th %ile	10th %ile	25th %ile	50th %ile	95th %ile
Year	SSB				
2011	25542	26232	27161	29338	33993
2012	23491	24168	24980	<b>26993</b>	31627
2013	20591	21267	22039	<b>23844</b>	28192
2014	17315	17907	18540	20036	23792
2015	14421	14939	15623	16915	20294
2016	11475	12080	12726	14142	17808
2017	9137	9733	10312	11853	15959
2018	7337	7952	8709	10458	15097
2019	6085	6678	7579	9539	14273
2020	5354	5951	6799	8969	13565
Year	Yield				
2011	3382	3455	3578	3822	4417
2012	2955	3040	3161	<b>3392</b>	4007
2013	2549	2626	2745	<b>3012</b>	3635
2014	2139	2234	2355	2665	3359
2015	1809	1915	2034	2332	3052
2016	1536	1631	1770	2061	2825
2017	1267	1364	1504	1836	2594
2018	1114	1224	1348	1677	2448
2019	981	1088	1230	1560	2360
2020	917	999	1145	1477	2350

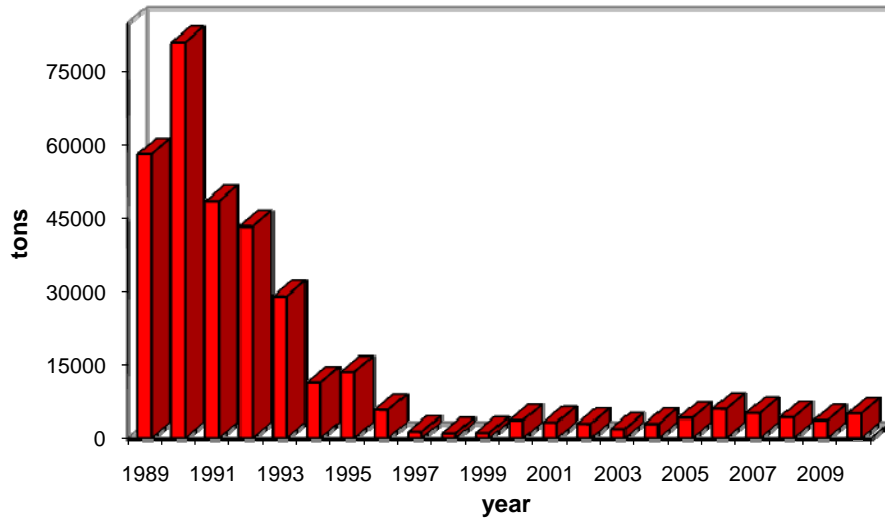


Fig. 1a: STACFIS estimates of beaked redfish commercial catch.

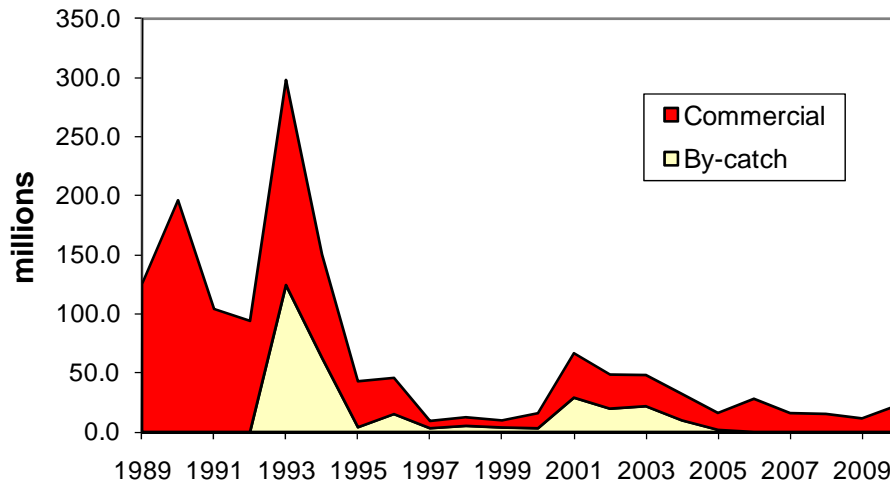
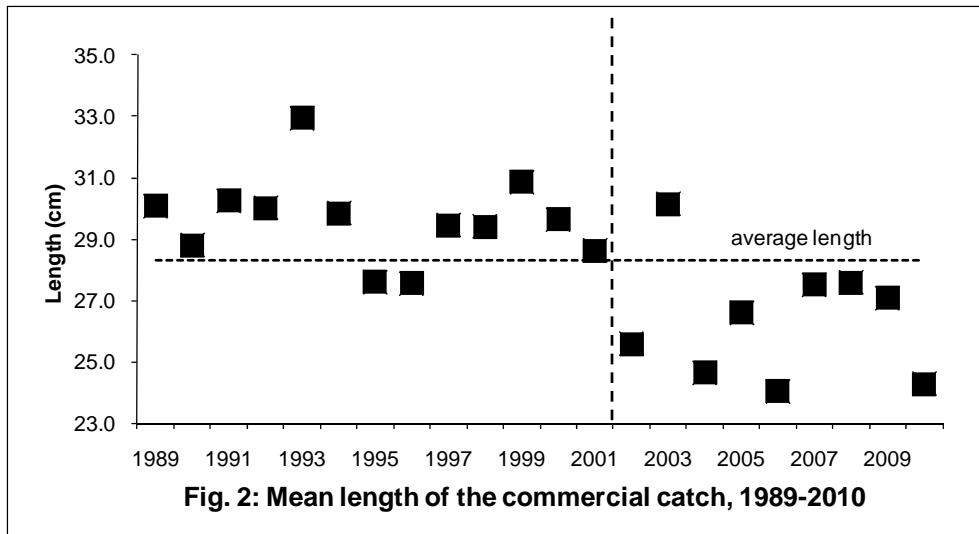
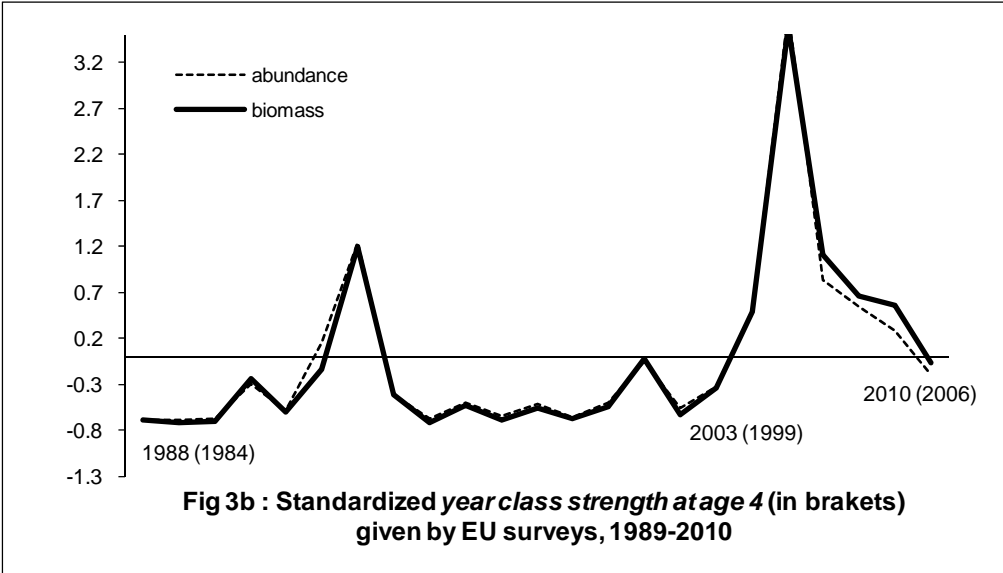
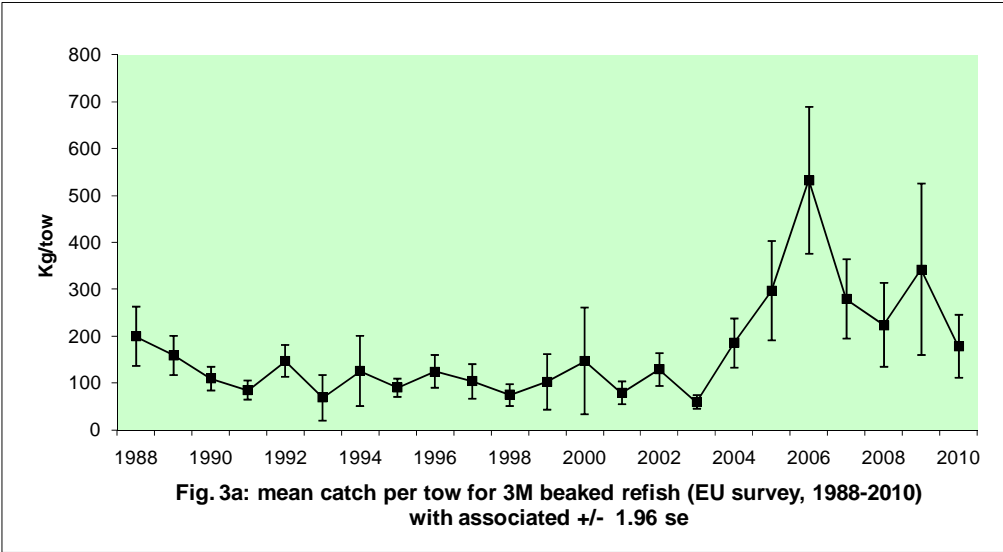
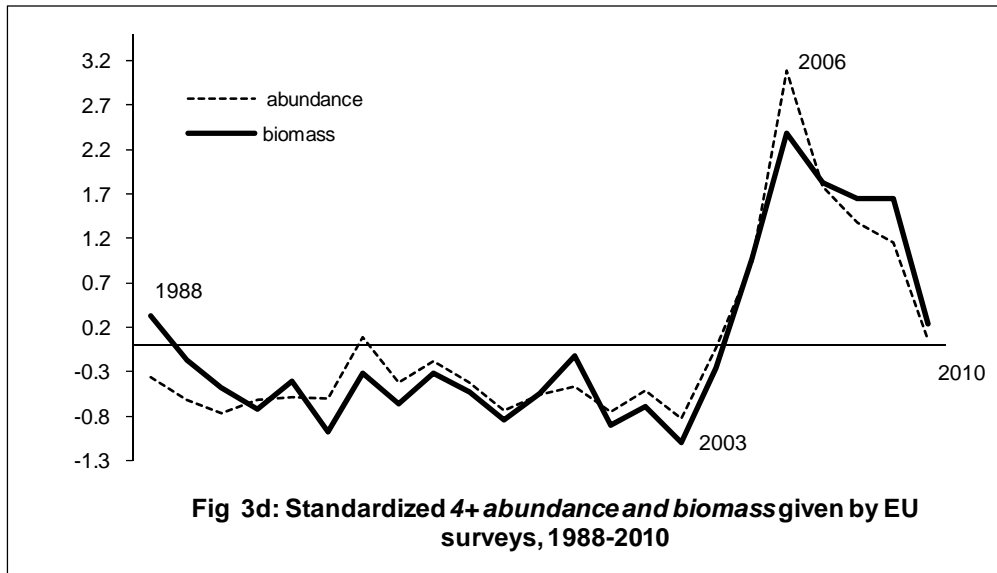
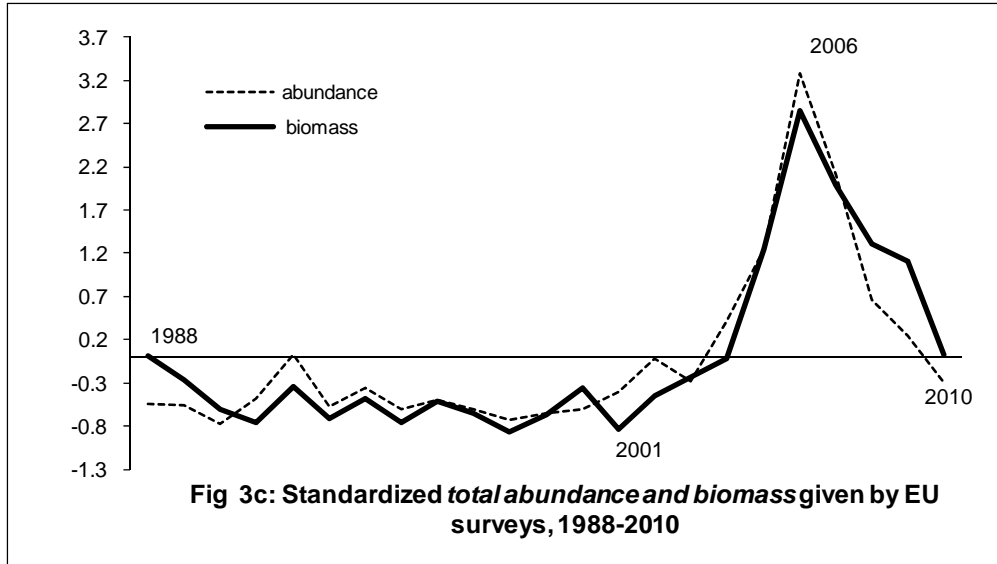
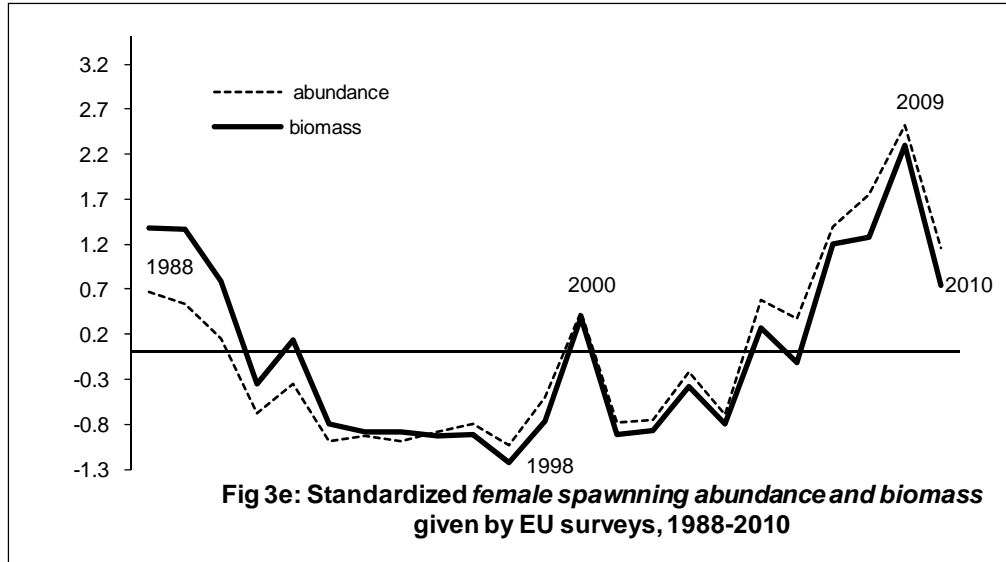


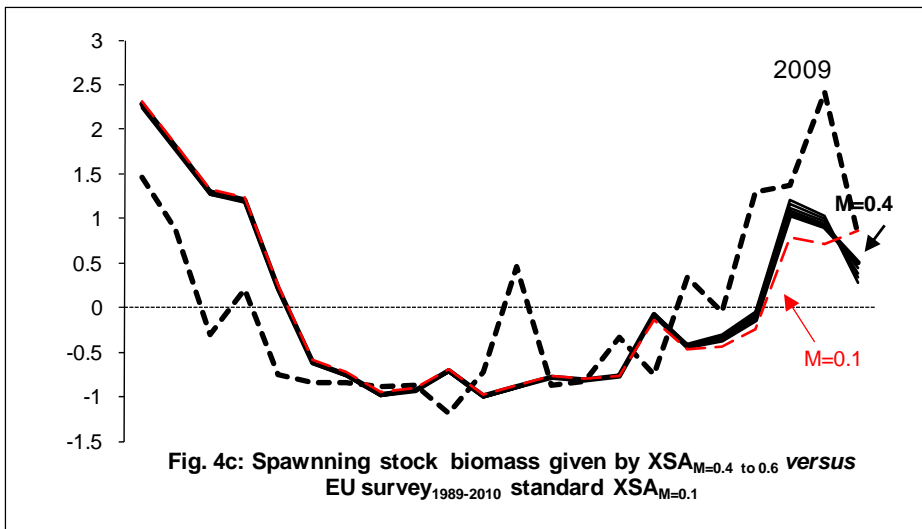
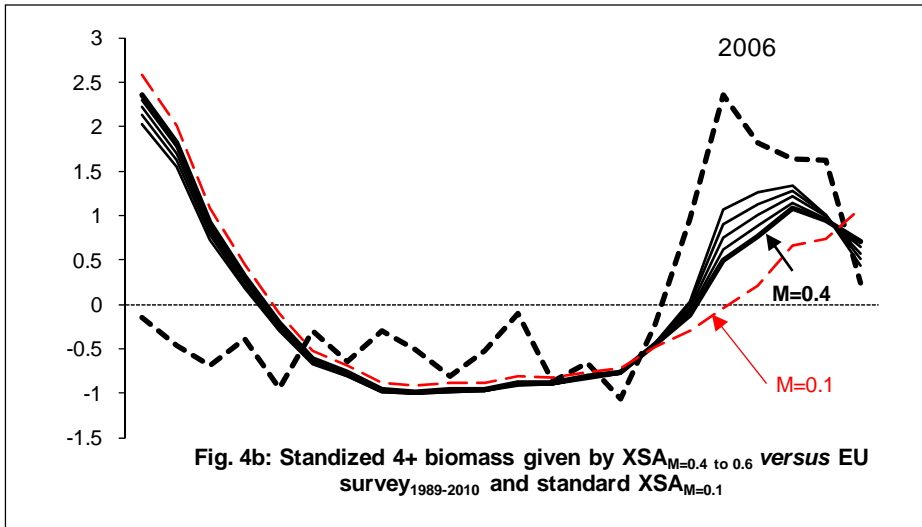
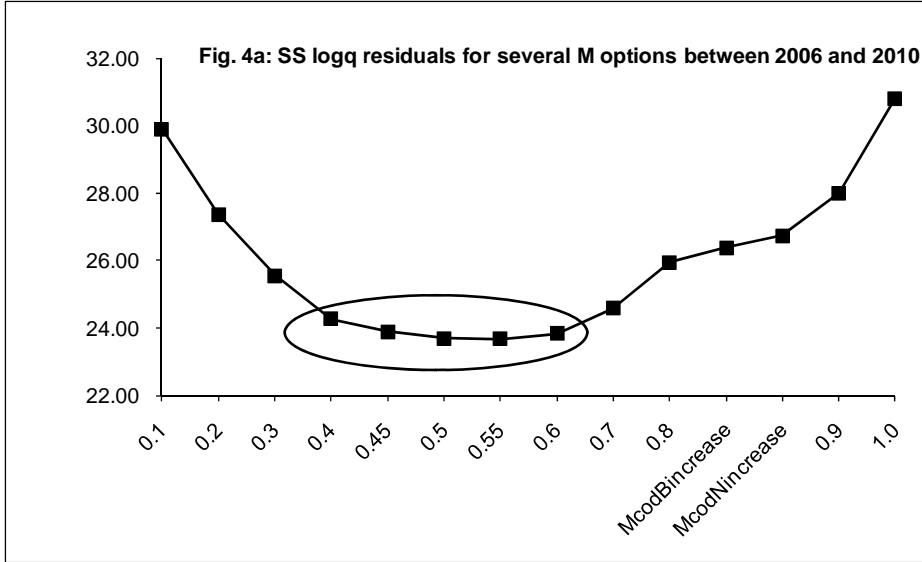
Fig. 1b: Beaked redfish commercial catch and by-catch in numbers



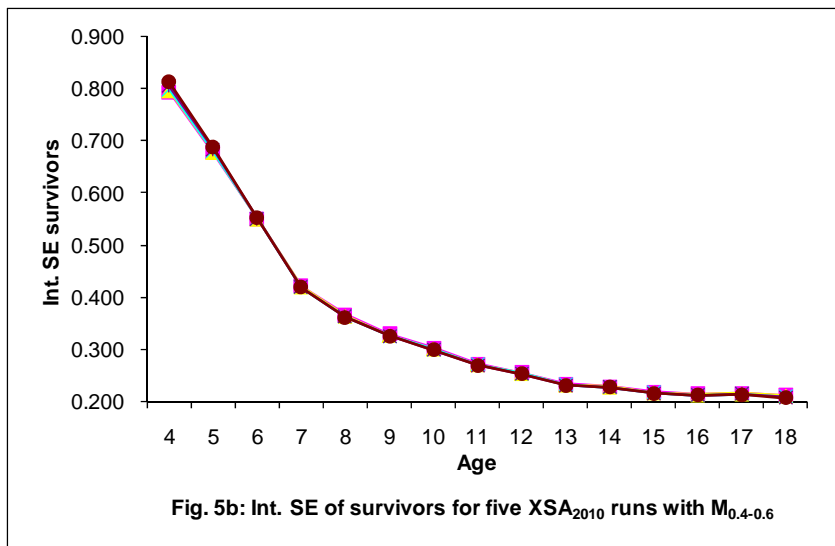
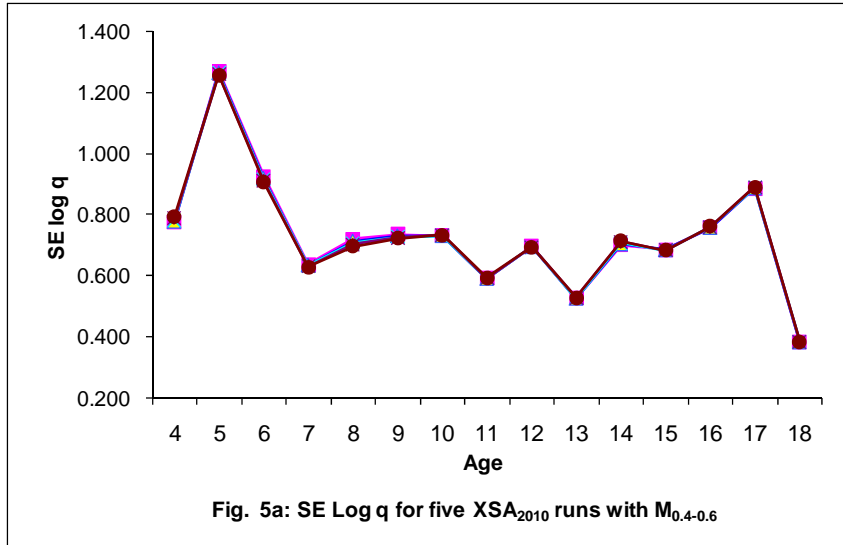


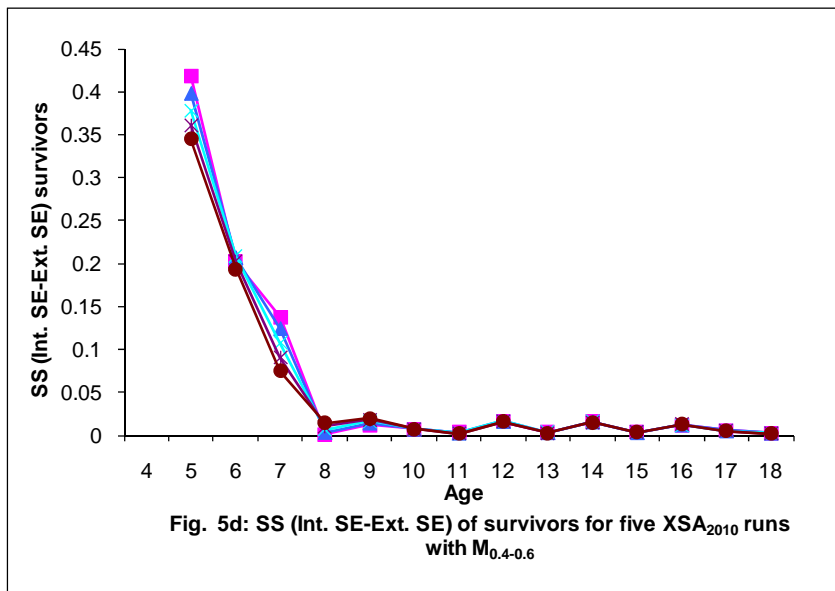
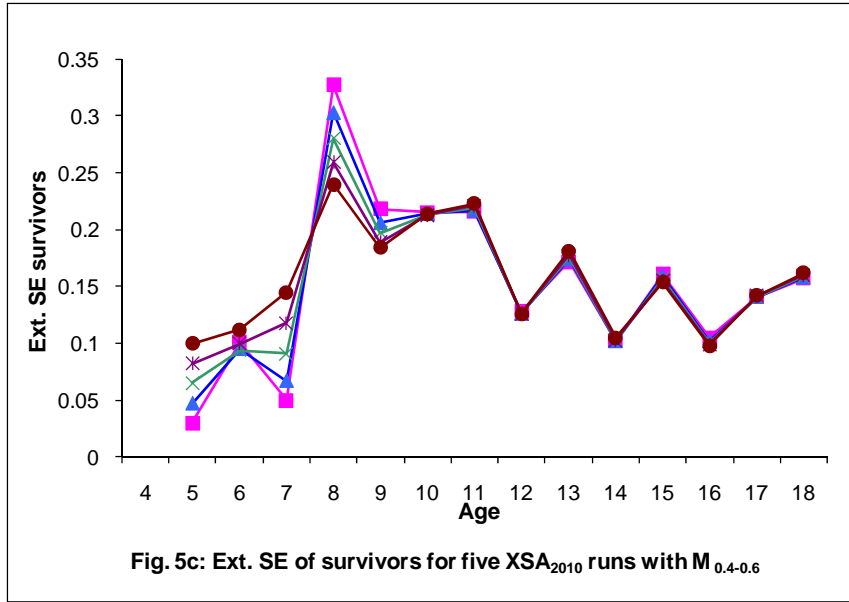












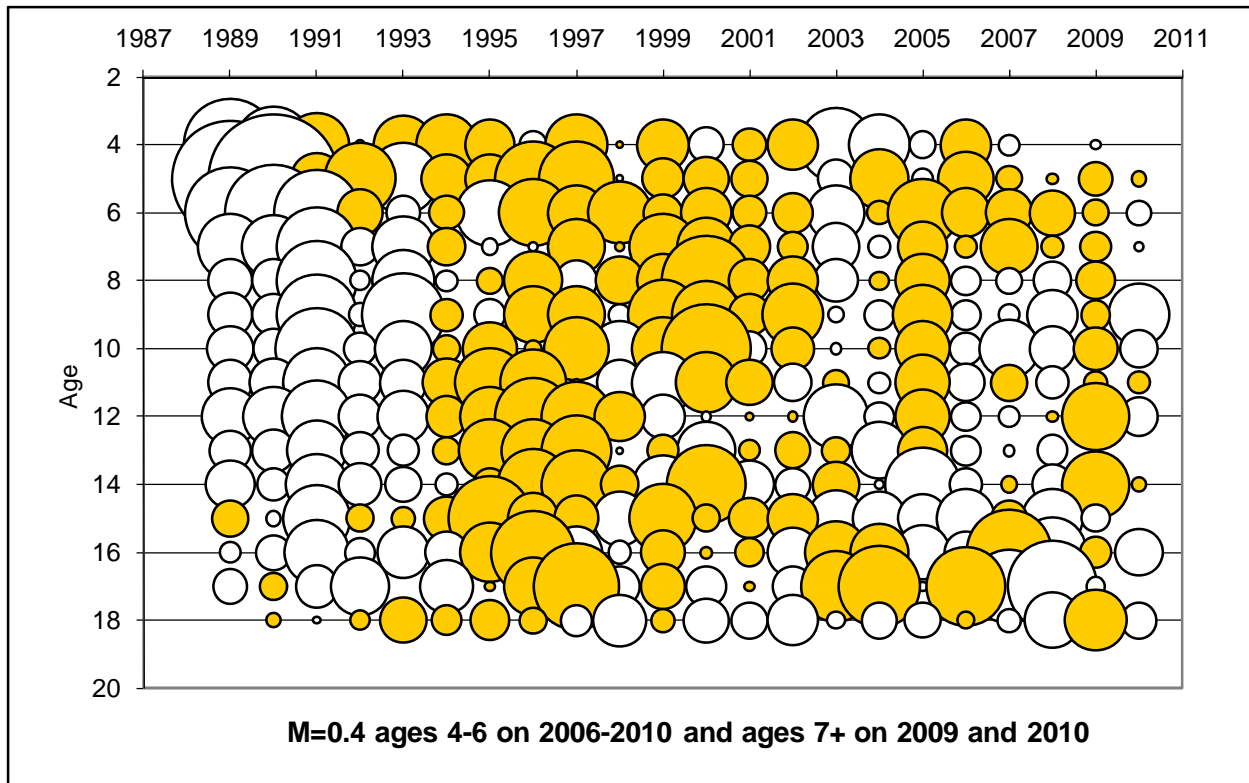
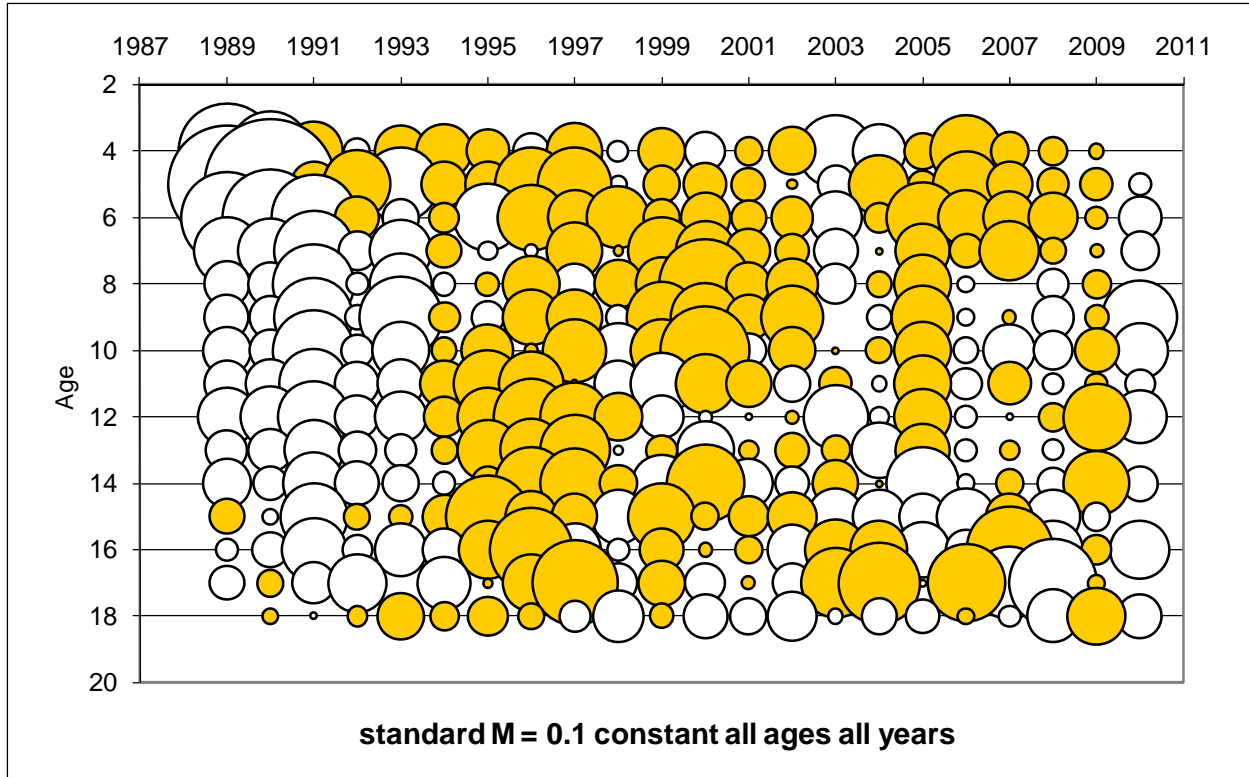


Fig. 6: Residual log q patterns of the XSA2010 for the standard M input ( $M=0.1$  all ages all years) and several M options between 0.4 and 0.6 on 2006-2010 (ages 4-6) and 2009-2010 (ages 7+)

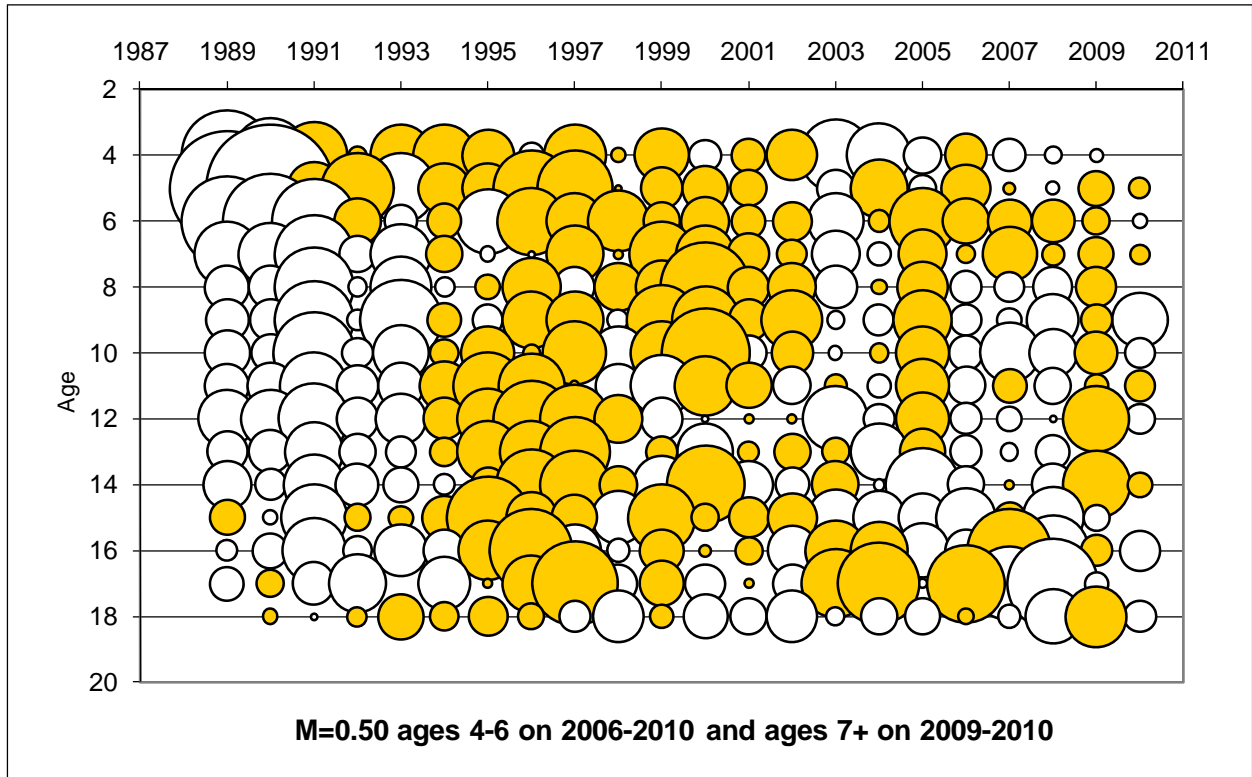
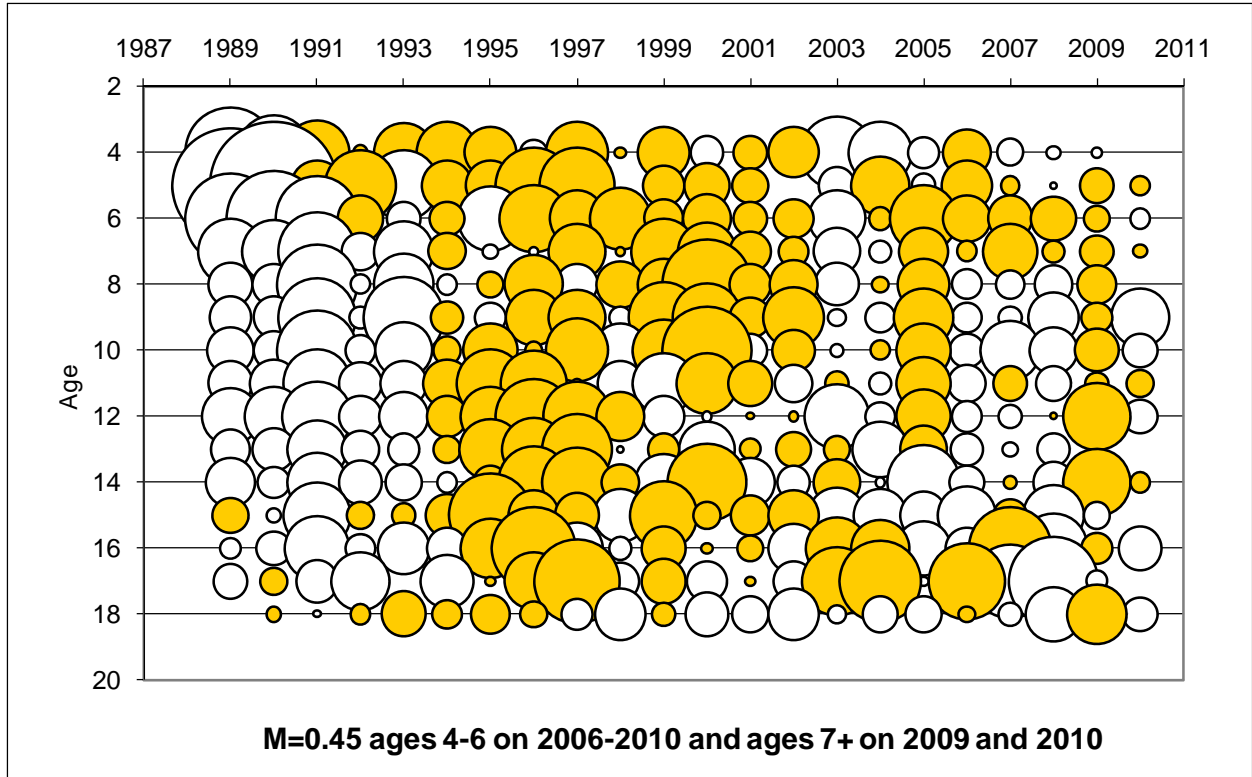


Fig. 6 (cont): Residual log q patterns of the XSA2010 for the standard M input ( $M=0.1$  all ages all years) and several M options between 0.4 and 0.6 on 2006-2010 (ages 4-6) and 2009-2010 (ages 7+)

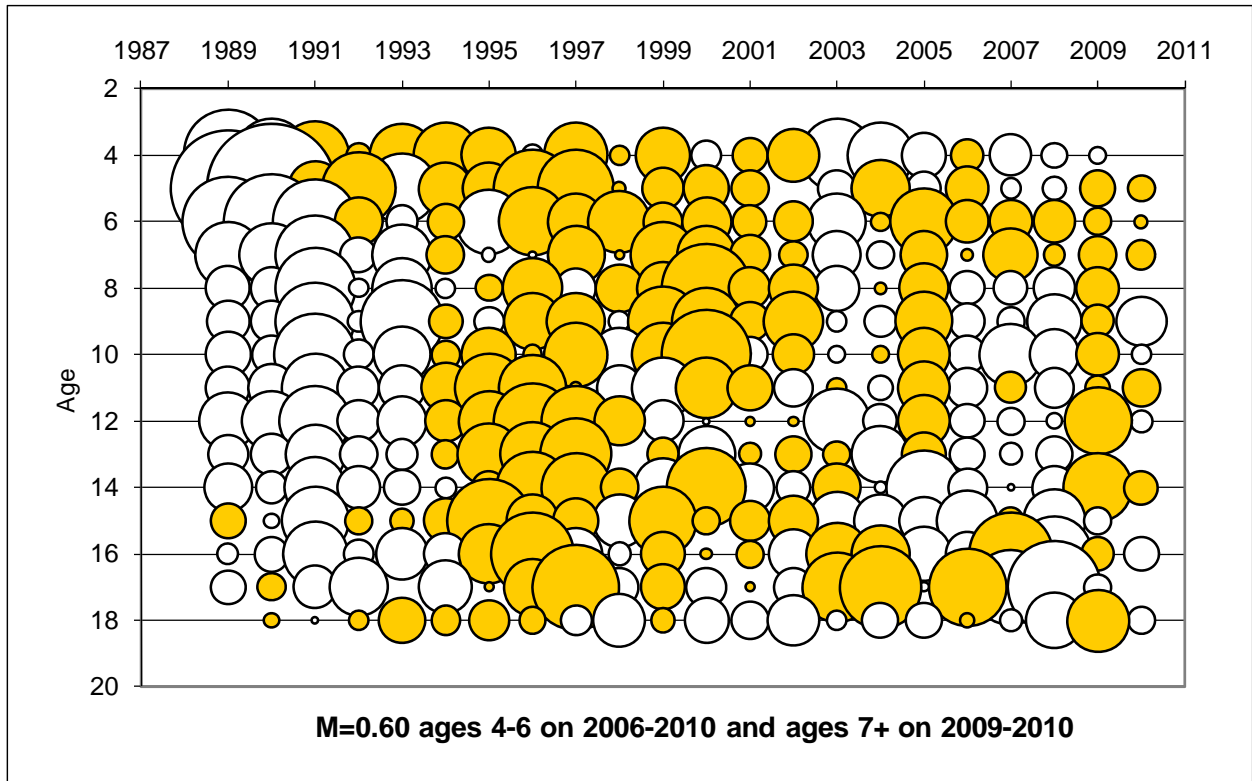
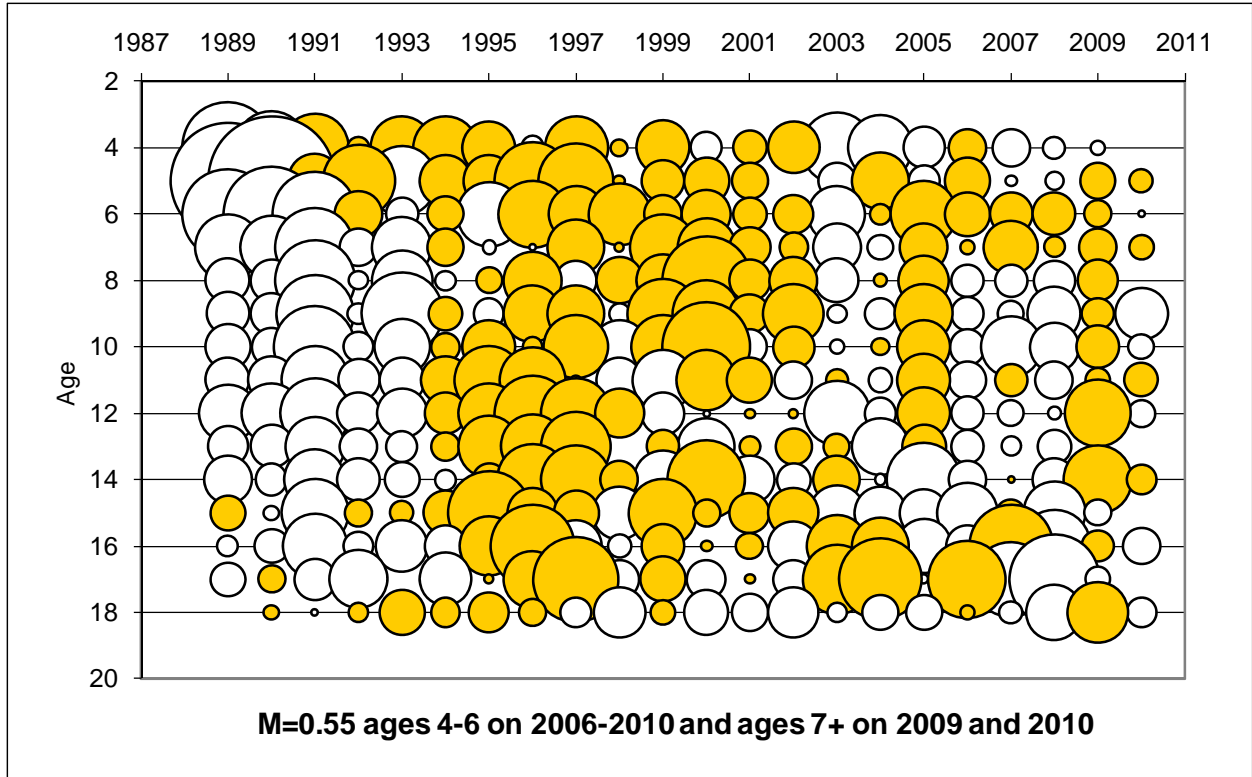


Fig. 6 (cont): Residual log q patterns of the XSA2010 for the standard M input ( $M=0.1$  all ages all years) and several M options between 0.4 and 0.6 on 2006-2010 (ages 4-6) and 2009-2010 (ages 7+)

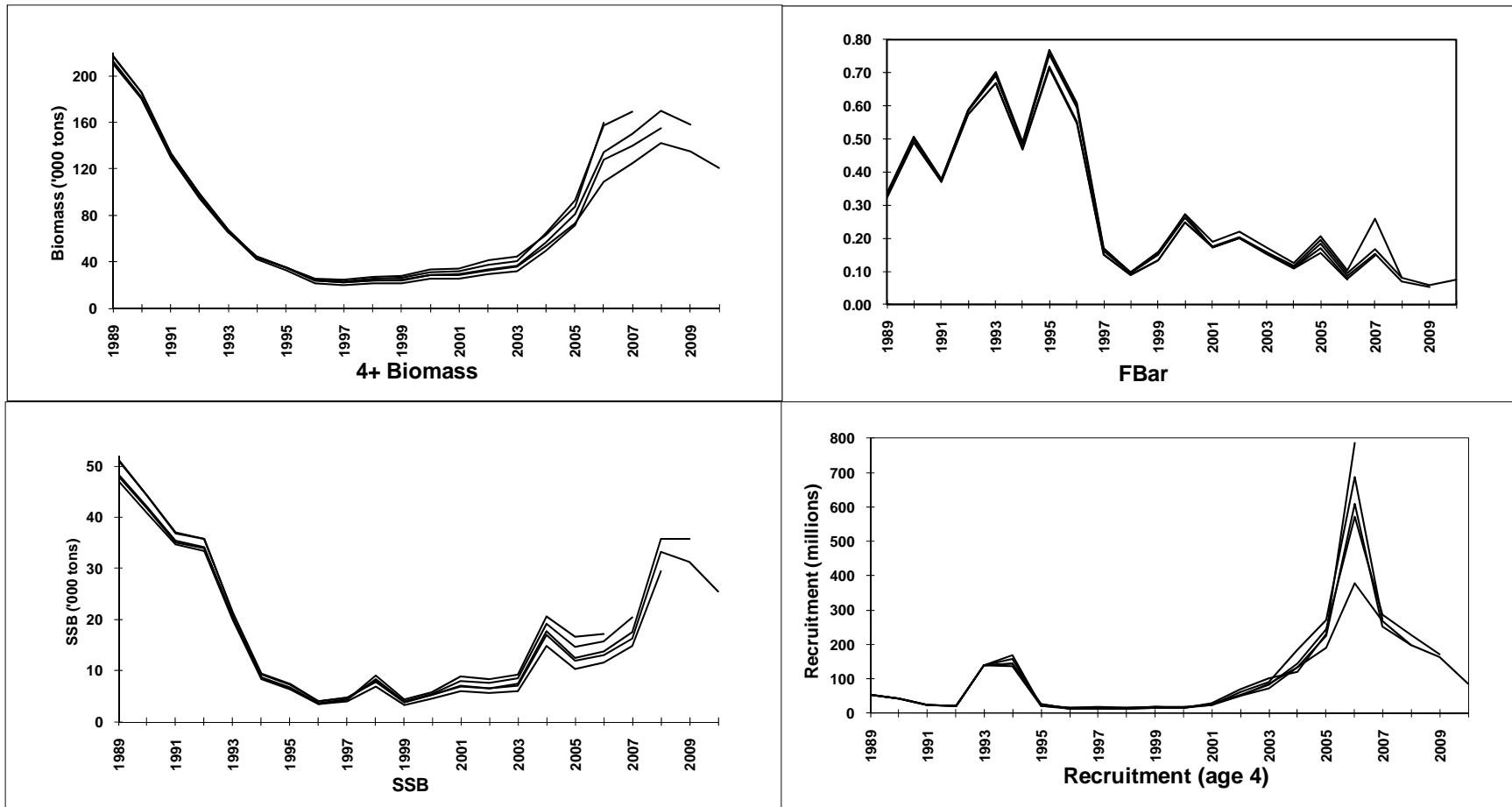


Fig. 7: XSA retrospective analysis, 2010-2006

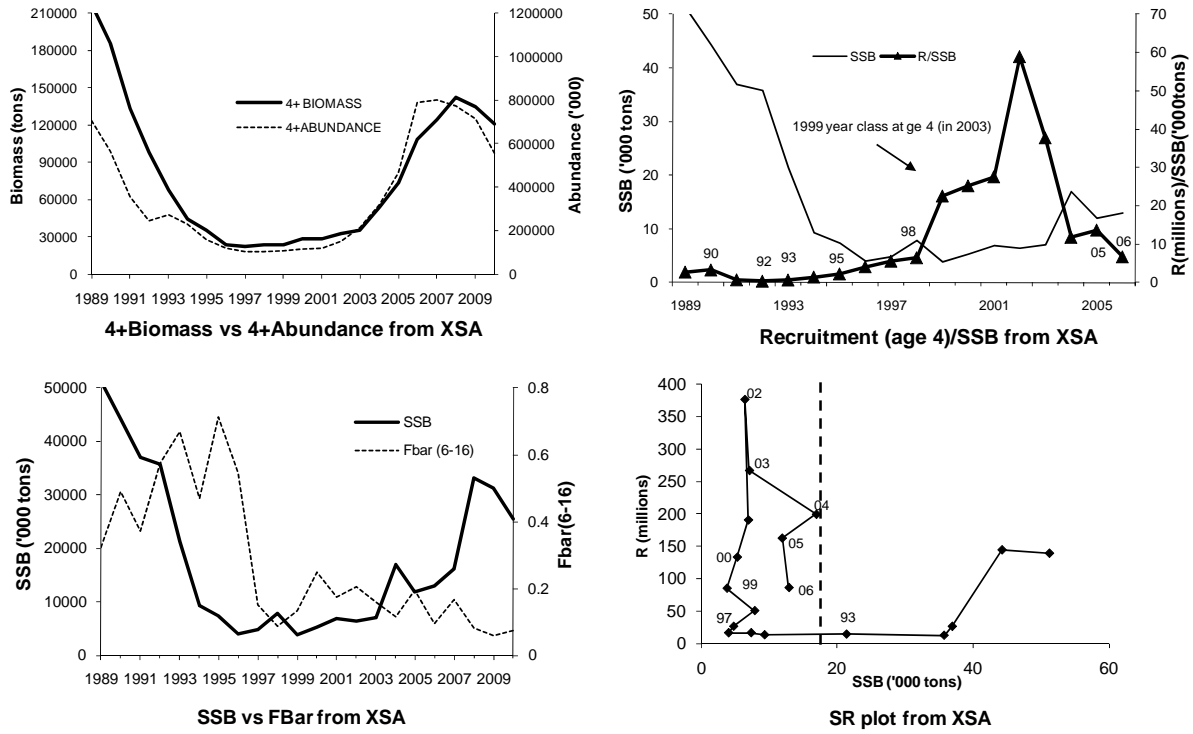


Fig. 8a: XSA results for 2011 assessment.

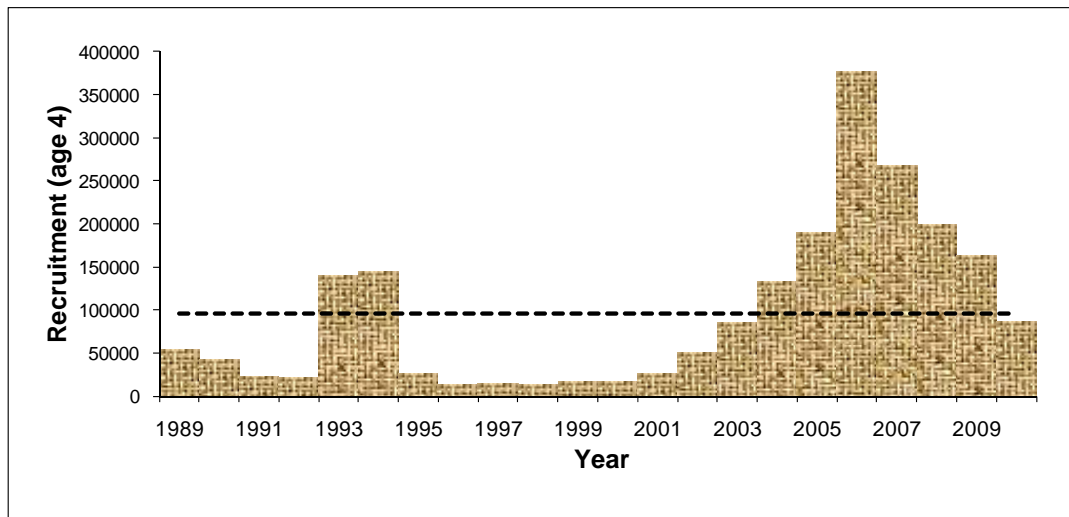


Fig. 8b: Year Class strength at recruitment from 2011 XSA.

