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An assessment of beaked redfish (*S. mentella and S. fasciatus*) in NAFO Division 3M, from a biological based approach to recent levels of natural mortality (2011-2016)

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, and the Flemish Cap cod fishery reopened in 2010. These new realities implied a revision of catch estimates, in order to split recent redfish commercial catch and by-catch from the major fleets on Div. 3M into golden (*S. marinus*) and beaked (*S. mentella* and *S. fasciatus*) redfish catches.

The Extended Survivor Analysis assessment used as tuning file the 1989-2016 EU survey abundance at age matrix included in a revised input framework. Continuing pressure over Flemish Cap redfish stocks by cod predation, at levels higher, or much higher, than the levels prior to 2006 lead to higher natural mortalities since then. In order to include an independent approach to natural mortality in the sensitivity *M* framework, for the more recent years (2011-2016) natural mortality has been estimated from a number of different biological models, some size/age-independent and others size/age-dependent. These different estimates were arranged in two sets and tuned to survey at age data. A natural mortality of 0.1 on 2015-2016 and the natural mortalities adjusted on previous assessments were found to be the most suitable option to *M* input. A 2017-2013 retrospective XSA was performed, confirming the consistency of the present with preceding results as regards stock biomass, female spawning biomass and fishing mortality.

Above average year classes and high survival rates allowed a rapid growth of biomass and abundance 2003 onwards, pulling the stock to a 2008-2010 high. Since 2009 abundance went down for causes other than fishing, being still above the 1990's low in 2016. By the turn of the decade stock biomass and female spawning biomass (SSB) shown marginal declines as well, but reversed on 2011-2012. Individual growth of survivors and low fishing mortalities sustained stock biomass and SSB at high levels till 2015-2016. Recruitment at age 4 increased from 2002 till 2006 and was maintained at a maximum level till 2009. Recruitment declined since then and is kept on 2015-2016 at the low of the weak year classes from the 1990's, while SSB is still well above the size that originated the high 2002-2006 recruitments.

Despite the significant decline so far natural mortality has not flattened yet. If natural mortality and fishing mortality stay at their most recent levels, the actual high of female spawning biomass can hold on 2018-2019. But on the long term it will be natural mortality, namely over pre recruited ages, to determine the future of beaked redfish as a fishery resource.

On 2015 STACFIS remind that projections are based in the assumption that natural mortality stay at its most recent level on the present year and at least on the two next coming years. And that, taking into account the uncertainty

on the present and future level of natural mortality, its impact on female spawning stock biomass at the end of any projection is unknown. On 2017 these constraints are still in place, and therefore short and medium term projections are not presented.

Introduction

There are three stocks of redfish on the Flemish Cap Bank (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*. Beaked redfish represents the majority of redfish biomass (average of 77%, according to the EU Flemish Cap survey series, 1988-2016) and the majority of the redfish commercial catch on the bank.

Flemish Cap beaked redfish are long living species with slow growth, slow maturation and a long recruitment processes 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 are exploited primarily by bottom trawl, but also by pelagic trawl. Due to the similarity of their external morphology their commercial catches 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 as by-catch of the Greenland halibut fishery (Table 1a and 1b, Fig. 1a). This drop of the 3M redfish catches was related with the simultaneous decline of stock biomass and fishing effort deployed in this fishery on the first half o the 1990's. Catch increased again on the 2000's, but at a much smaller scale than in the past and with a small proportion coming from directed redfish fisheries. EU-Portugal, EU-Spain, the Russian Federation and EU-Estonia states are responsible for the bulk of the redfish landings on 2015-2016 (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 Acadian redfish (Casas *et al.*, 2007). Cod stock and cod by-catch also went up, and the Flemish Cap cod fishery reopened in 2010. Redfish catch (including by-catch from cod fisheries) respond positively to those events and went up to 11,000 tons in 2011. On recent years (2012-2016) 3M redfish catch has been within 6,200 and 7,800 tons, a blend of by-catch from cod fishery (depths above 300m, a mixture of golden and beaked redfish), catch from bottom trawl directed fishery (depths between 300-700m, primarily beaked redfish), and by-catch again from Greenland halibut fishery (bellow 700m, 100% deep sea redfish). The 1989-2014 redfish nominal catch is presented on Table 1a.

The no neglect proportion of golden redfish forced the development of a method to split into golden and beaked redfish the annual redfish catches of Portugal, Russia and Spain, from 2005 onwards. Beaked redfish catches from fleets other than these ones were estimated with the average beaked redfish proportion found each year on the redfish catches of Portugal and Spain. This method is fully described on previous assessments (Ávila de Melo *et al.* 2011 and 2013). At the same time the available redfish length sampling from the main fleets has been separated as well on these two categories.

STACFIS catch estimates were available till 2010. Over 2006-2010 an average annual bias of 15% plus was recorded between SACFIS catch estimate and STATLANT nominal catch. In order to mitigate the lack of independent catch data a 15% surplus has been added to the STATLANT catch of each fleet between 2011and 2014. For 2015 and 2016 the annual catch was given by the Daily Catch Reports (DCR's) by country provided by the NAFO Secretariat (Blasdale, T. pers. comm., March 2017). The STACFIS catch estimates (1989-2010), the inflated STALANT catch (2011-2014) and the catch from the DCR's (2015-2016) are the sources of information for the 3M redfish landings and are assembled on Table 1b.

The beaked redfish catch estimates used in the assessment are on Table 1c and Fig. 1a. Finally on Table 1d are tabulated the golden and beaked redfish proportions by depth found in the 2005-2016 EU surveys (Gonzalez, *pers. comm.,*2009-2016; Casas, *pers. comm.*, 2014) 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 between 2001 and 2003 increased again, reaching 1006 tons in 2003. That event does not reflect any expansion of the 3M shrimp fishery and was justified by the income of above average beaked redfish year classes. From Canadian observer data (Kulka and Firth, *pers. comm.*, 1999-2005) the redfish by-catch on the 3M shrimp fishery declined to 471 tons in 2004 and to 80 ton in 2005 (Table 1e) due to the fall of the Flemish Cap shrimp fishery (Skúladóttir and Pétursson, 2006).

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). From 2006 onwards the beaked redfish catch corresponds to the commercial catch only.

Length composition of the commercial catch and by-catch

The 1998-2010 and 2012-2016 3M beaked redfish commercial length weight relationships from the Portuguese commercial catch (Table 2a) (Alpoim and Vargas, 2004; Vargas *et al*, 2005 and 2007-2011 and 2013-2017) were used to compute the mean weights of all commercial catches and correspondent catch numbers at length. Due to the small individual length/weight sample available for 2011 the previous 2010 length weight relationship was applied to the 2011 catch. The 1993-2004 beaked redfish length weight relationships from the EU surveys (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 for that interval.

Length samplings from the Portuguese and Spanish bottom trawl and from the Russian pelagic and bottom trawl are the major inputs 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. Until 2009 the pelagic catch is near 100% of the Russian catch but for 1996, 1998-1999 and 2003-2004. However on recent years this pattern is reversed: no pelagic redfish catch recorded on 2010 and 2012-2016. In 2011 less than half of the Russian redfish catch came from pelagic trawl.

Until 2014 the Portuguese beaked redfish length sampling was applied to the beaked redfish catch of other bottom trawl fleets with the exception of the Russian, Spanish and Japanese fleets for the years where respective length sampling data are available (Table 3a). However, on 2015 and 2016, most of the Portuguese sampling effort was made on beaked redfish catch from shallower depths than the ones traditionally associated with the redfish fishery, while Spanish sampling came from 300-700m bottoms where most of the beaked redfish catch is expected to occur. So Spanish sampling substitute the Portuguese sampling as regards the length distributions of other countries beaked redfish estimated catches on the last couple of years. For details regarding how the length distributions of the Portuguese catches on 1993-1994 and of the Russian catches on 1992-1994 were derived see Ávila de Melo et al., 2009.

Length structure of the commercial catch show relative stability between 1989 and 2001, with annual mean lengths falling within 27-33cm (Table 3b, Fig. 2). Small sizes increase their presence in the commercial catch afterwards, being responsible of annual mean lengths bellow 28cm since then and a general shift of length distributions towards smaller sizes. On the first years of this second interval the presence of small redfish in the commercial catch was the outcome of several recruitment processes from a sequence of abundant year classes. However the maintenance of mean lengths just bellows average since 2007 should reflect a declining exploitable stock, as suggested by the 2007-2016 EU survey results (Fig. 6a).

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 1989-2014 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 2009-2016 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. 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 and the decline of the redfish fishery lead to even younger modal age groups between 1996 and 2004 (despite the implementation of sorting grade escape devices). The 1999-2002 and 2005 cohorts dominated the overall catch through most years of the 2001-2012 interval, some of them on several years, first still in the shrimp by-catch and later on in the commercial fishery (Table 3d). The 2009-2011 year classes at ages 5-6 are the most abundant between 2014 and 2016.

The length weight relationships from the Portuguese commercial catch (Table 2a) were used to calculate mean weights at age in the redfish 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 (1988-2014). 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 in 1996.

For reasons explained 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 in 2003. Swept area is divided according to the Flemish Cap bank stratification proposed by Doubleday (1981) and revised 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. More details regarding the EU survey series can be found in the 2005 assessment (Ávila de Melo *et al*, 2005). The conversion from former *RV Cornide de Saavedra* (CS) to the actual *RV Vizconde de Eza* (VE) units has also been reported that year (González-Troncoso and Casas, 2005).

Length weight relationships

Annual length weight relationships for *S. mentella* and *S. fasciatus* (1992-2016) and for the two species combined (1988-2016) were available from survey data (Troncoso and Casas *pers. comm.*, 2005-2016) (Table 2b). *S. mentella* and *S. fasciatus* length weight relationships were used to get 1992-2016 *SOP* survey biomass for each redfish species. The *Sebastes sp*. length weight relationships were used to get the 1988-1991 *SOP* survey biomasses for beaked redfish.

Survey abundance at length

Each of the redfish categories included in the beaked redfish assemblage (beaked redfish including juveniles, 1988-1989; beaked redfish, 1990-1991; *S. mentella* since 1992; *S. fasciatus* since 1992; juveniles since 1990) had their own survey abundance at length original series up to 2002 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 former series were then linked to the 2003-2016 *RV Vizconde de Eza* length distributions (Troncoso *pers. comm.*, 2005-2016; Casas *pers. comm.*, 2014). 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 one single survey abundance at length matrix for beaked redfish (Table 5a).

Maturity at length

Gonads of the Flemish Cap beaked redfish species were collected since 1994 though not every year. Maturity ogives at length used on previous assessments were from 1994 (*S. fasciatus* and *S. mentella,* Saborido Rey 1994) and 1999 (*S. mentella*, Saborido Rey *pers. comm.*, 1999). New maturity ogives at length were estimated based on microscopic inspection of 5,661 histological sections of gonads collected throughout 12 years between 1994 and 2016 (Saborido Rey *pers. comm.* 2017), 2,445 ovaries for *S. mentella* and 3,216 for *S. fasciatus*. Maturity data were combined for both species within each year and fitted to a logistic function (Saborido Rey and Junquera 1998). For the years in between where data was missing curve parameters were estimated as the weighted average of the adjacent years where maturity ogives were available. The maturity staging criteria was evaluated and agreed in 2016 following a short workshop to deal with observed discrepancies in staging from former analysis (Saborido Rey *pers. comm.* 2017). The new maturity at length results were used in the present assessment (Tables 4a and 4b and Fig.'s 4a and 4b).

Age composition of the survey stock and mature female component

The survey abundance at age for the 3M beaked redfish stock (1989-2016, Table 5b) was obtained using the *S.mentella* age length keys from the 1990-2007 and 2009-2016 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). Due to the scarcity of redfish larger than 40cm either in the survey and commercial catch, a plus group is set at age 19.

As mentioned above, this assessment adopts the new *S. mentella* and *S. fasciatus* maturity ogives at length to get the survey female mature abundance at length of *S. mentella* and *S. fasciatus* each year. For each year these two vectors are summed and converted into the survey beaked redfish mature females at age vector and the correspondent mature female proportion at age vector. Survey female spawning stock abundance and mature female proportion at age (annual and average for the assessment interval) are presented Tables 5c to 5e.

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 spawning female stock (Tables 6a and 6b).

Survey biomass and abundance, 1988-2016

The 1989-2016 survey mean catch per tow for beaked redfish is presented on Table 7a and Fig. 5. 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, exploitable and spawning female stock can be found on Table 7b. Trends of the respective standardized series are on Fig.'s 6a to 6d.

The survey stock abundance and biomass declined on the first years of the survey and were kept at low levels below average till 2003. A sequence of above average year classes (2001-2005), including the strongest of the survey series (2002), coupled with high survival rates, lead the stock and its exploitable part to a maximum in 2006. Year class strength declined afterwards, and the lasts cohorts entering the exploitable stock are among the lowest at age 4 (2010, 2011 and 2012). Total and exploitable stock declined till 2010, showing some recovery between 2010 and 2012, namely the 4 plus component. However the indices declined again afterwards, remaining within the same magnitude in 2015-2016, with a slight increase last year. Stock decline seems to be halted and both biomass and abundance are kept near their average level. But so far there are no signals that recovery has begun. After being at chronically low levels through the 1990's early 2000's spawning female survey indices showed a sharp increase between 2003 and 2009, in part due to high survival rates of the existing cohorts in part due to a decline on maturity at length overlapping most of these years (Fig. 4b and Fig. 6d). Female spawning stock is kept well above average till 2016, regardless wide fluctuations observed since 2009 that are difficult to explain even taking into account a new shift in maturity at length in recent years (2013-2016).

Survey results show the income of abundant year classes on a row (2001-2005) triggering a rapid and sharp increase of stock size on the mid 2000's. Both stock and recruitment fell next as fast as they went up. The stock decline has been interrupted by 2011-2012 but only now, 2015-2016, survey indices suggest the decline may have stopped. The majority of survey indices went down while female spawning stock remained at relatively high levels, suggesting that the high mortality from sources other than fishing has more impact on the very young ages of the incoming cohorts than afterwards through the exploited ages of the beaked redfish life history.

Natural mortality

Since 2004 a rapid increase was observed on survey biomass of golden (*Sebastes marinus*) and Acadian (*Sebastes fasciatus*) redfish. Due to their shallower depth distributions these two redfish species overlap with cod to an extent greater than deep sea redfish (*Sebastes mentella*). On the mid 2000's the Flemish Cap cod stock start recovering, not only in terms of abundance but also in terms of individual growth, leading to a continuous and steep increase of cod biomass between 2006 and 2013 (Gonzalez-Troncoso, 2015). There is a strong possibility that important increases on redfish consumption by cod are associated to this recovery (Pérez-Rodríguez and Saborido-Rey, 2012), leading to anomalous high levels (M> 0.1) of beaked redfish natural mortality, from 2006 onwards.

Attempts to track these changes on natural mortality have been made on previous assessments since 2011 (Ávila de Melo *et al.*, 2011, 2013 and 2015). It is a fact that, since 2006, with recruitments age 4 falling abruptly to the historical low of the most recent 2011 and 2012 year classes, stock dynamics has becoming more and more a mirror of changes in total mortality. And, for a stock with chronically low exploitation levels since 1997, more and more a mirror of changes in natural mortality (M). Finally, within natural mortality, predation by cod should be the main cause of M's higher than 0.1, estimated for Flemish Cap beaked redfish over the last decade.

A sensitivity analysis for a range of M candidates between 0.1 - 0.4 has been carried out prior to each 3M beaked redfish assessment since 2011(Ávila de Melo *et al.* 2015). Having 2006 as the starting year for this sensitivity analysis, time windows of variable width were considered where the best M option should minimize the $SS\log q_{age}$ residuals and maximize correlation between exploitable survey abundance and

XSA abundance. In fact, so far the approach to the actual magnitudes of *M* has been strictly dependent of beaked redfish survey indices, which in turn should capture the dynamics of the ensemble of the two redfish populations at times of very low recruitment, low exploitation and high predation.

By the last 3M beaked redfish assessment STACFIS **recommends** that, *in order to quantify the most likely redfish depletion by cod on Flemish Cap, and be able to have an assessment independent approach to the magnitude of such impact by species and to the size structure of the redfish most affected by cod predation, the existing feeding data from the past EU surveys be analyzed on a refined scale*. STACFIS also **recommended** that *work continue to investigate recent changes in natural mortality*.

However the quantitative analysis of feeding data from the Flemish Cap EU survey is difficult to carry out as consumption of redfish by cod is concerned, either for each of the three species, taking into account that their similarity turns almost impossible to identify stomach contents but for otoliths, or even for redfish as a whole, taking into account that an important but unquantifiable portion of redfish skulls found on cod stomachs came from the processing of commercial catches and not predation, as a consequence of the overlapping of the survey season with the main season for redfish directed fishery on Div.3M.

Despite these constraints, and in order to include an independent approach to natural mortality in the sensitivity *M* framework, the actual beaked redfish natural mortality has been estimated by a number of different published models derived from cross-species comparative analyses, namely Hewitt and Hoenig (2005), Hoenig (1983), Jensen (1996) and Pauly (1980) as size/age-independent methods, and Charnov *et al.* (2013), Gislason *et al.* (2010) and Chen and Watanabe (1989) as size/age-dependent methods. For the later group of methods we do not consider the existence of senescence in redfish, i.e. we have only used the function that describes mortality curve consisting on decreasing mortality with increasing size. For the two size/age-dependent methods, we estimated an average *M* from ages 4 to 15 (for ages older than 15 survey sampling is scarce leading to highly variable results regarding mean length at age). Length at age keys were combined for both beaked species and assembled for two periods (2011-2016 and 2015-2016). Age length data from those keys was finally fitted to von Bertalanfy growth models each for one of the two periods considered. Input parameters, growth curves and *M* results are shown in Table 8a (2011-2016) and 8b (2015-2016) and Fig. 7a and 7b (von Bertalanfy curves) and Fig. 8a and 8b (size/age dependent *M*)

The 2017 XSA Assessment

Wide inter-annual variability can be observed on bottom trawl survey indices for each of the three redfish species existing on the Flemish Cap bank, caused by the scattered occurrence of large schools and changes in redfish availability as regards the vertical opening of the bottom net. When abundance at length survey indices for the two beaked redfish species are lumped together and then turn into survey abundance at age those fluctuations originate annual patterns in the catchabilities that relate survey indices at age with stock size at age, and may print year effect patterns on diagnostic results such as log catchability residuals. Nevertheless, the long EU survey series seems to reflect well the overall dynamic of the beaked redfish stock and has been considered a valid tool to calibrate an XSA based assessment (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 9. Natural mortality over 2006-2014 remained unchanged on the first run of sensitivity analysis, and kept at 0.14 on 2015 and 2016 (Ávila de Melo et al., 2015).

A female maturity ogive at age matrix was build using three year moving averages of annual mature female proportions at age. February, the spawning peak of 3M *Sebastes mentella*, (Saborido-Rey, 1994), was the month used to estimate the proportion of F and M before spawning. The assessment starts at age 4 (the first 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 1989-2016 EU survey abundance at age matrix, with the 1989-2002 indices converted into the new *RV Vizconde de Eza* units (Casas *et al.*, 2017).

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 eight 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 (fishing mortalities at age are usually not stable on last ages of each cohort or last years of the assessment interval).
- Fishing mortality at oldest true age of each cohort were not shrunk either.
- Survivors at younger ages were not shrunk to mean of abundance on those ages on previous years.

A run with catchability independent of year-class strength on all ages till the age 16 showed no significant *t* values for the slopes of *log* survey index/*log* abundance linear regressions at recruiting ages 4 and 5 (*Student's t* test with 26 degrees of freedom = No. points – 2, significance level of 0.05). This lack of a trend on the regression slopes for the youngest ages led us to accept catchability independent with respect to year class strength on all ages.

Since last assessment age 16 is the first age at which catchability is considered to be independent of age. Retrieving the independent catchability range to the next younger age was shown to speed the way to convergence despite triggering slight increases on catchabilities at age that would reflect on minimal increases in fishing mortality and minimal declines in abundance and biomass (Ávila de Melo et al., 2015). In order to avoid overweight of each cohort's terminal population estimate by their preceding older ages, the minimum allowable standard error of the *log* catchability on the last true ages of each cohort was set at 0.5.

In summary, apart the use of the new maturity at length ogives to get female maturity at age and spawning stock biomass each year, the 2017 XSA framework remained unchanged from previous assessments (Ávila de Melo *et al*., 2013 and 2015): no recruiting ages with catchability dependent of year-class strength, constant catchability at the last couple of true ages, and a minimum 0.5 standard error for survivor estimates from the oldest ages of each cohort.

Sensitivity analysis around possible levels of natural mortality on recent years

Before 2006 M remained at 0.1.The rational to select the best options for natural mortality between 2006 and 2014 are thoroughly explained in the sensitivity analysis sections of last assessments (Ávila de Melo *et al*., 2011, 2013 and 2015). Based on survey data Flemish Cap cod biomass has grown since 2006 reaching an historical high on 2014, while combined *S. mentella* and *S. fasciatus* declined as a single (beaked redfish) stock (Casas, 2017). At the same time beaked redfish catch remained at low levels, even droping by half between 2011 and 2014 (Table 1c). Under such scenario one should expect that, between 2006 and 2014,

- M may varied but should have stayed above 0.1,
- F should be below M ,
- And therefore the closer is the relation between abundance at age by the survey and abundance at age by the model, the closer is M in the model to the real magnitude of natural mortality (since within this time window the major part of total mortality that has driven

abundance is from causes other than fishing).

A natural mortality of 0.4 was tuned to ages 4-6 between 2006 and 2010, and extended to all ages in 2009-2010. Since then natural mortality was assumed to be again an age independent parameter and on 2011-2012 declined to 0.125, a level much closer to what is considered the magnitude of natural mortality on redfish stocks (0.1). However, on 2013-2014 the best fit to survey data implied again a marginal increase of M to 0.14.

Cod survey biomass has substantially declined on 2015 and 2016 and so the predation pressure over the beaked redfish unit may have slowdown on the last couple of years. If so the above rational may not be enough to justify by itself the search for an optimal M . An independent evaluation of natural mortality has been therefore introduced, using several biological (growth/longevity/maturity/environment) based models to estimate several "XSA free" M candidates (for details see section on natural mortality above), constant over age and time on two alternate time periods: (1) 2015-2016, keeping the whole range of previously adopted M 's back in time or (2) 2011-2016, assuming that after2010 M fell from the high former level to a low level more or less constant since then. These two sets of natural mortality candidates were then in contest for a better XSA fit to the 2011-2016 survey data, and the correspondent runs were labeled according their M input, as tabulated bellow:

XSA2017$_{\text{sensitivity analysis}}$ M options for	Hoenig	Hewitt & Hoenig	2013-2014 status quo	Pauly	Chen & Watanabe[1]	Jensen	Gislason[1]
2015-2016	0.1	0.11	0.14	0.16	0.17	0.19	0.2
2011-2016	0.1	0.11	0.14	0.16	0.17	0.22	0.2

[1] average M age 4-15

All XSA 2017 runs	M = 0.40 on ages 4 - 6 on 2006 - 2008, and on all ages groups on 2009 - 2010;
M2015-2016 XSA 2017 runs	M = 0.125 on all age groups on 2011-2012.(XSA2013 & 2015 assessment framework)
	M = 0.14 on all age groups on 2013-2014.(XSA2015 assessment framework)
M2011-2016 XSA 2017 runs	M is kept constant on all age groups on 2011-2016

The goodness of fit of the model runs to survey data is measured by the following diagnostics

1. Lower $SS \log q_{age}$ residuals on 2015-2016 (for which a "best" M option is needed in either time scenario);
2. Lower $SS \log q_{age}$ residuals back to 2011 (M decline from the anomalous high 2006-2010 level);
3. Higher correlation between exploitable (4+) survey abundance and XSA abundance over recent years (2011-2016).

In the event of a tie between M candidates each of the three criteria has an importance according to the order of their presentation above.

Diagnostics results for the two sets of runs are shown below on Table 10a (2015-2016) and Table 10b (2011-2016) under a traffic light format, and on Fig's 9a, 9b and 9c.

Tab 10a: Key diagnostics of seven sensitive XSA_{2017} runs ($M_{status\ quo}$ and a set of 2015-2016 "biological" M candidates)

	Hoenig	Hewitt & Hoenig	status quo	Pauly	Chen &Watanabe[1]	Jensen	Gislason[1]
$M_{2015\text{-}2016}$	**0.1**	**0.11**	**0.14**	**0.16**	**0.17**	**0.19**	**0.2**
SS log q residuals$_{2015\text{-}2016}$	6.68	6.70	6.82	6.92	6.96	7.10	7.15
SS log q residuals$_{2011\text{-}2016}$	23.08	23.14	23.38	23.55	23.66	23.83	23.93
XSA *versus* SURVEY $r^2_{2011\text{-}2016}$	0.897	0.894	0.887	0.883	0.880	0.875	0.872

Tab 10b: Key diagnostics of seven sensitive XSA_{2017} runs ($M_{status\ quo}$ and a set of 2011-2016 "biological" M candidates)

	Hoenig	Hewitt & Hoenig	status quo	Pauly	Chen &Watanabe[1]	Gislason[1]	Jensen
$M_{2011\text{-}2016}$	**0.1**	**0.11**	**0.14**	**0.16**	**0.17**	**0.2**	**0.22**
SS log q residuals$_{2015\text{-}2016}$	6.76	6.74	6.80	6.96	7.05	7.50	7.95
SS log q residuals$_{2011\text{-}2016}$	23.02	23.08	23.49	23.85	24.16	25.13	26.01
XSA *versus* SURVEY $r^2_{2011\text{-}2016}$	0.886	0.887	0.887	0.886	0.886	0.883	0.881

A minimum $SS\ \log q_{age}$ residuals plateau is clearly found for M 0.1 and 0.11 regardless the time interval considered (Fig's 9a and 9b). These low "back to normal" values for natural mortality also give higher correlations between XSA and survey results for the two last years. But correlation decrease to a lower level if the analysis is extended till 2011, showing little response if a constant M is considered between 2011 and 2016 (Fig. 9c).

M 0.1 is the best 2015-2016 option if the previous 2011-2014 levels of natural mortality are kept and M 0.11 is the best 2011-2016 average level of natural mortality. The diagnostics were compared afterwards just for the two best options, complemented with the comparison of the respective (average) internal and external survivals at age standard errors (measuring the variability around survivors at age, in other words, the consistency of the stock at age available for projections).

Diagnostics results for the two selected runs are shown below on Table 10c

Tab 10c: Key and complementary diagnostics for the best rur of each set (best $M_{2015\text{-}2016}$ run versus best $M_{2011\text{-}2016}$ run)

	$M_{2015\text{-}2016}$ **0.1**$_{\text{Hoenig}}$	$M_{2011\text{-}2016}$ **0.11**$_{\text{Hewitt \& Hoenig}}$
SS log q residuals$_{2015\text{-}2016}$	6.68	6.74
SS log q residuals$_{2011\text{-}2016}$	23.079	23.076
XSA$_{versus}$ SURVEY $r^2_{2011\text{-}2016}$	0.897	0.887
Survivors Aver Int s.e	0.3260	0.3363
Survivors Aver Ext s.e	0.1765	0.1829

From the above traffic light frame, the left option diagnostics from the M 0.1 2015-2016 run, keeping the 2011-2012 and 2013-2014 M's stick to the previous adopted assessments (Ávila de Melo *et al.*, 2013 and 2015), has a clear better outlook than the right option diagnostics from the M 0.11 2011-2016 average level run.

Therefore **the 2017 XSA assessment has run with a natural mortality of 0.1 on 2015-2016, and keeping the previous natural mortality levels from the past 3M beaked redfish analytical assessments.**

Diagnostics

The 2017 diagnostics (Table 11) kept the main features from past assessments: high residuals associated with mean *log* catchabilities most obvious at younger ages on older years, high survivors *s.e.*'s, together with a familiar patchwork of $\log q_{age}$ residuals (Fig. 10). Positive *log q* residuals dominate during the intermediate years of 1994-2000, after the 1989-1993 years with a clear negative pattern. Between 1989 and 1991, large to very large residuals were maintained from one age to the next within some of the major cohorts (1982-1985), suggesting that these year classes may be overestimated by the model. From 2002 onwards residuals start getting smaller and scattered, while the marked alternate negative/positive pattern of the two previous intervals fades away.

Retrospective Analysis

A retrospective $XSA_{2016\text{-}2012\ (last\ year)}$ was carried out for checking patterns and magnitude of bias on the main results of recent assessments back in time (Table 12ab, Fig. 11). It covers a period of unrest on the dynamics of the stock, driven by an important increase of natural mortality and subsequent decline and the continuous fall of recruitment at age 4. Reverse retrospective patterns of small magnitude (<10% most years between the two last 2015 and 2017 assessments) are observed on exploitable, female spawning biomass and recruitment (under estimate) and average fishing mortality (over estimate) (Tables 12a and 12b, Fig. 11). Exception to these consistent retrospective results is the high positive biases associated with the magnitude of the 2009-2011 year classes at age 4, as estimated in 2017 back to 2014. The very small size of these cohorts makes them difficult to quantify on their first age within the assessment, contributing to their high relative retrospective bias.

Retrospective Analysis is a useful check to consistency of stock assessment over time. From the possible causes of retrospective patterns – patterns of catch misreporting, patterns on catchability at age or misspecification of natural mortality (Sinclair *et al*., 1990) – the last two causes seem most likely impact this redfish assessment. However, the adjustment of the recent 2011-2016 M's by a sensitivity analysis where the search for adequate 3M beaked redfish natural mortality came from combined biology fit and survey fit seems to have smoothed the retrospective patterns on the 2017 XSA.

2017 XSA Results

Very high fishing mortalities until 1996 forced a rapid decline of abundance, biomass and female spawning biomass (Table 13, Fig. 12a: *4+ Biomass vs 4+ Abundance and Fem Spawning Biomass vs FBar*). With low fishing mortalities since then the stock decline was halted. But the weak 1991-1999 year classes kept the stock size depressed till 2002-2003, basically sustained by the survival and growth of the existing cohorts. Above average year classes coupled with low fishing mortalities allowed a rapid growth of biomass and abundance since 2003, pulling the stock to a 2008-2010 high. From 2009 onwards abundance went down for causes other than fishing, being still on 2016 at a level above the 1995-2001 low. Biomass shown limited decline between 2009 and 2011 but the trend was reversed by 2011-2012. Due to individual growth and low fishing mortalities of surviving cohorts stock size in weight has recovered and was sustained on 2015-2016 at a high level. Same caveats', plus a thorough revision of maturity at length over time, are valid to explain female spawning biomass overall growth since 2003 and its maintenance at maximum level even on most recent years.

Recruitment at age 4 increased from 2002 till 2006 and was kept at maximum levels till 2009, with 2005 year class as the most abundant recruitment of the assessment interval (Table 13, Fig. 12b). Recruitment to exploitable stock declined continuously since then and was on 2015-2016 at the lowest level of the series.

The reproductive potential of the stock increased steadily from the late 1990's to 2002, was kept at a maximum level until 2005, but has felled abruptly and continuously since then (Fig. 12a, *R/SSB plot*). The stock returned to the low productivity regime of most of the 1990's. Meanwhile SSB rose to a maximum level well above the average size that originated the high 2002-2006 recruitments (Fig. 12a, *SR plot*). The persistence of this apparent very low reproductive potential at a time where 3M cod is still a recovered stock with a high SSB (Gonzalez, 2017) reflects that pre-recruited beaked redfish year classes continue to be prematurely depressed regardless their strength, most likely exposed to high mortalities by cod predation.

Final quality considerations on the 2017 assessment

An "erratic" pelagic-demersal distribution associated with schooling will always doom redfish analytical assessments tuned by bottom surveys to year effects reflected on poor diagnostics. Nevertheless, when a stock unit shows a clear dynamics and an apparently stable bottom-water column distribution, as it seems to be the case for 3M beaked redfish over the 2000's, survey results allow consistent assessment results over time. Despite the abrupt increase on natural mortality and its further step wards decline to the actual level, usually associated with redfish species, the sound retrospective analysis suggests that after all the 2017 ends with consistent survivor's results. However natural mortality has been changing over the past 11 years and the actual landing on its expected level still need to be confirmed on coming years.

On 2015 STACFIS remind that projections are based in the assumption that natural mortality stay at its most recent level on the present year and at least on the two next coming years. And that, taking into account the uncertainty on the present and future level of natural mortality, its impact on female spawning stock biomass at the end of any projection is unknown. So, regardless the fishing mortality options considered, projections could not be accepted as the basis to recommend an allowable catch for this stock. Even on the short term.

So far the level of natural mortality has not flattened yet. In other words, on 2017 the above constraints are still in place, and therefore short and medium term projections are not presented.

Yield per recruit analysis (ypr)

In order to get proxy's of $F_{0.1}$ and $F_{\max}$ in line with the most recent natural mortality estimate a new yield per recruit analysis (*ypr*) with M = 0.10 was performed, with all other inputs averaged from the interval where beaked redfish natural mortality took off (2006-2016). Partial recruitment (PR) was assumed flat top at the last three (true) ages considered on the XSA, and a relative F @age 4-18 vector was given each year by the ratio of the F 's @age to $F_{bar16-18}$. The average relative F @age vector was the adopted PR of this *ypr* analysis. In order to reduce the weight of the plus group on the final results, ages were virtually extended to age 29 with a plus group set at age 30. Mean weights and female maturity were kept constant and were the ones of the XSA 19 plus group. Input vectors are presented on Table 14.

As expected decreasing natural mortality led to deflated yield per recruit results, with $F_{0.1}$ = 0.086 and $F_{\max}$ = 0.163 ($F_{bar16-18}$). Taking into account the high variability on natural mortality and partial recruitment over the period considered deriving the inputs of this analysis, the results regarding $F_{0.1}$ and $F_{\max}$ are at the moment candidates to 3M beaked redfish fishing mortality reference points that still need to be confirmed in near future. Last yield per recruit analysis performed with the natural mortality at 0.1, the M level commonly accepted for slow growth/long living fish stocks such as redfish stocks, lead to a $F_{0.1}$ at 0.1 (Ávila de Melo et al., 2002).

Conclusions

The stock started to decline in the late 2000's, despite recovery observed since 2003 on biomass and namely on female spawning biomass. The recent high levels of biomass are supported by low fishing mortalities and individual growth of survivors. Abundance decline since 2009 is more pronounced on the size of year classes entering the exploitable stock but is also continuous on the overall 4 plus abundance. Natural mortality declined substantially on 2011-2012 and stayed in the vicinity of its usual level value, though with a marginal increase on 2013-2014. On most recent years, 2015-2016, natural mortality landed at 0.1, its 1980's-1990's assumed magnitude. at 0.1. Taking into account the extension to the present of the actual low recruitment/high SSB relationship, cod pressure on redfish pre recruited ages is likely to be still at a high level.

If natural mortality and fishing mortality stay at their most recent levels, the actual high of female spawning biomass can hold on 2018-2019. But on the long term it will be natural mortality, namely over pre recruited ages, to determine the future of beaked redfish as a fishery resource.

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Table 1a: 3M Redfish nominal catches (ton) by country, 1989-2016.

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015[1]	2016[1]
CAN			2		10							5											2					
CUB	1765	4195	1772	2303	945						2												875	600				
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								128
SUN/RUS	13937	34581	24661	2937	2035	2980	3560	52		7	108	1864	1281	1155	115	6	1023	849	780	1212	1184	927	1571	0	1808	1342	1332	790
UKR															5	3		1										
E-LVA				7441	5099	94	304					13	11			2	48	250			58		71					
E-LTU					2128									10	1		522	397	542			348	478			0.122		
E-EST						47	863	13				631	158	5	23	60	1093	1249	728	950	1643	1161	820		1036	601	498	504
E-SP	213	2007	6324	3647	100	610	165	113	129	262	268	348	272	220	633	266	542	596	533	1225	745	892	339	512	416	1031	1318	1408
E PRT	13012	11665	3787	3198	4781	5630	1284	281	83	259	97	925	1590	1513	1113	2574	2696	2594	2357	3707	5027	4703	5024	4236	3493	3462	3720	3685
EU																								0		7		
FR-STP										2							10			8			68	69				
UK																						1	2		8			10
KOR-S	17885	8332	2936	8350	2962																							
FAROE IS.				16			15	1						6		6				215	1	122	420	0	10	5	75.3	70
NORWAY						8																		0				
Total	47697	66887	40914	29317	19027	9883	6748	1140	423.8	970.7	795	3828	3392	2976	1988	3126	6417	6319	5553	7920	8658	8154	9670	5417	6771	6449	6944	6595

[1] From NAFO Daily Catch Reports

Table 1b: Redfish commercial catches on Div. 3M from various sources (STACFIS, 1989-2010; based on STATLANT plus 15%, 2011-2014; based on Daily Catch Records, 2015-2016).

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	58100	81000	48500	43300	29000	11300	13500	5789	1300	971	1068	3658	3224	2934	1881	2923	6550	7156	6662	8465	11317	8496	11121	6150	7778	7416	6944	6595

Table 1c: Beaked redfish on Div. 3M commercial catch estimates from various sources (STACFIS, 1989-2010; based on STALANT, 2011-2014; based on Daily Catch Records, 2015-2016).

From 2005 onwards also using information on distribution by depth of the EU survey redfish catch by species (D. Gonzalez pers. comm.) and of the commercial redfish catch of Portugal, Russia (M. Pochtar and K. Fromin *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	2011	2012	2013	2014	2015	2016
Total	58100	81000	48500	43300	29000	11300	13500	5789	1300	971	1068	3658	3224	2934	1881	2923	4148	5997	5149	4277	3656	5410	8994	6281	5168	4565	5243	6232

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 and Mikel Casas pers. comm.).

<200m	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	**200-300m**	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
golden	36.1	51.1	97.9	100.0	100.0	100.0	90.0	96.5	99.0	98.9	98.0	99.2	golden	54.5	50.7	32.4	68.3	84.9	68.3	52.9	63.5	65.4	91.8	94.5	80.8
beaked	63.9	48.9	2.1	0.0	0.0	0.0	10.0	3.5	1.0	1.1	2.0	0.8	beaked	45.5	49.3	67.6	31.7	15.1	31.7	47.1	36.5	34.6	8.2	5.5	19.2

300-400m	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	**400-700m**	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
golden	18.8	5.9	12.0	28.5	22.0	28.5	3.7	5.5	10.0	34.1	25.9	10.2	golden	2.1	5.0	1.3	8.8	0.9	8.8	0.6	0.0	1.3	0.3	0.4	0.2
beaked	81.2	94.1	88.0	71.5	78.0	71.5	96.3	94.5	90.0	65.9	74.1	89.8	beaked	97.9	95.0	98.7	91.2	99.1	91.2	99.4	100.0	98.7	99.7	99.6	99.8

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) [2]	11970	5903	374	550	157	191	96	106	738	767	1006	471	80

Table 1f: 3M Redfish catch in numbers(millions), 1989-2014.

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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	24.4	28.8	17.1	20.0	16.6	20.5	24.6
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	24.4	28.8	17.1	20.0	16.6	20.5	24.6

Table 2a: Length weight relationships for 3M beaked redfish from commercial catch (Alpoim,2004; Vargas, 2005, 2007-2011 and 2013-2016)

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
2011		
2012	0.0323	2.7743
2013	0.0114	3.0575
2014	0.0106	3.0799
2015	0.0127	3.0175
2016	0.0285	2.7710

Table 2b: Length weight relationships for 3M beaked redfish from EU survey (Troncoso and Casas, pers. comm. 2005-2016)

	S. mentella		*S. fasciatus*		*Sebastes sp.*	
Year	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
2011	0.015	2.973	0.023	2.875	0.021	2.893
2012	0.016	2.960	0.024	2.861	0.021	2.886
2013	0.021	2.874	0.032	2.779	0.0294	2.787
2014	0.016	2.968	0.024	2.873	0.0236	2.866
2015	0.017	2.952	0.0237	2.881	0.023	2.875
2016	0.022	2.875	0.0291	2.819	0.0257	2.844

Table 3a: Availability of length data for commercial catches and by-catch of 3M beaked redfish, 1989-2016

	Portugal	Spain	Japan	Russia	Canada (b
1989	●			●	
1990	●			●	
1991	●			●	
1992	●			///	
1993	///			///	●
1994	///			///	●
1995	●			●	●
1996	●		●	###	●
1997	●				●
1998	●	●	●	●	●
1999	●			●	●
2000	●			●	●
2001	●	●		●	●
2002	●			●	●
2003	●	●	●	●	●
2004	●	●		###	●
2005		●		●	
2006	●	●		●	
2007	●	●		●	
2008	●			●	
2009	●				
2010	●			●	
2011	●	●			
2012	●	●			
2013	●	●			
2014	●	●		●	
2015	●	●		●	
2016	●	●		●	

● 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, 1989-2016.

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
6																												
7																												
8																												2
9																												2
10	3													10			3	16	12					7				20
11				1	3									48		1	18	40	41			3	1	9	1	1	6	57
12	3			1	7							5		220		3	108	86	133		1	9	3	23	4	1	10	71
13	11				5							11		723		5	381	70	172		5	28	27	36	7	6	48	140
14	25	4			40	4						1		590		12	509	91	88		5	99	87	69	5	5	119	143
15	8	73		1	120	15				2		6	4	175		43	474	112	23	6	37	248	209	95	35	26	160	160
16	30	190		4	167	66		20				1	4	70		203	516	313	18	14	68	341	309	122	68	62	164	223
17	59	724		3	55	244		20	1	2		6	20	53	6	352	423	436	31	12	102	481	352	162	135	108	287	303
18	30	2489	156	6	39	607	118	20		1		17	57	84	6	464	285	635	138	47	121	669	586	222	210	180	370	365
19	11	5774	647	97	54	922	265	66	6	8	1	27	41	144		666	183	1296	433	166	147	912	806	388	392	313	647	537
20	111	6179	1331	418	71	491	1142	360	8	13	1	50	43	187		**1165**	157	2168	371	381	226	1559	1452	709	368	320	1113	1202
21	383	2904	1234	1987	125	427	2874	964	14	28	1	48	63	173	2	**1513**	132	**3104**	658	622	308	**2254**	**2130**	**1038**	1004	770	1780	1710
22	1149	1205	1179	3834	337	408	5895	**2215**	41	52	2	103	117	166	4	**1512**	159	**3939**	490	1032	535	**3696**	**3198**	**1637**	1622	**1182**	2726	2717
23	3766	1927	945	3016	668	457	5715	**1641**	104	94	1	112	197	175	30	**961**	216	**3658**	720	794	869	**3261**	**2778**	**1496**	1785	**1135**	2607	2466
24	8408	5526	1697	1690	1116	701	1691	**1324**	**263**	116	9	206	277	284	89	845	287	**3179**	760	1198	981	1671	1543	755	**1984**	**839**	1485	1414
25	**14733**	**11932**	3737	2468	1159	870	1157	785	**325**	**222**	118	317	451	414	262	720	555	2261	947	787	**1257**	1151	990	533	**2400**	**978**	999	1251
26	**14793**	**19979**	6292	7519	1577	1020	793	513	**310**	**223**	112	717	891	511	363	571	724	1427	**1471**	**1760**	**1266**	848	821	500	**2634**	**1339**	842	1833
27	**11148**	**25688**	**10368**	**11599**	1701	986	953	740	198	**207**	220	**1322**	**1241**	672	**516**	596	**927**	1181	**1876**	**2050**	**1145**	775	774	389	**2376**	**1261**	758	1497
28	7059	**26047**	**12852**	**11899**	2456	1688	1185	758	169	173	**303**	**1654**	**1450**	**854**	**535**	553	**1057**	1058	**1405**	**2306**	**1086**	886	963	538	1518	**1115**	885	1650
29	5773	**20113**	**15100**	8677	2448	**2039**	**1476**	855	210	168	**301**	**1467**	**1193**	**841**	**588**	426	**1111**	779	**1348**	1244	877	870	1115	598	1056	747	821	1617
30	7424	**15200**	**13056**	7505	3277	**1987**	**1506**	899	248	162	191	**1036**	996	**814**	475	384	779	619	**1350**	692	590	838	**1802**	1008	680	665	1067	1575
31	6972	**10134**	7456	5452	**3846**	**2327**	**1257**	954	223	172	204	677	537	625	390	269	770	444	998	437	596	627	**1886**	**1181**	512	544	1004	1247
32	7393	8308	7054	4705	**3974**	**2611**	**1304**	891	248	157	242	451	339	463	359	304	525	353	850	272	434	500	**2230**	**1463**	345	431	700	888
33	7030	6551	3519	4150	**4831**	1963	1219	689	268	112	169	321	210	366	331	319	543	262	639	311	300	398	**1969**	**1327**	251	424	536	568
34	6927	6397	3891	4309	**4283**	1347	1008	672	107	74	75	300	146	221	258	204	527	193	463	208	216	234	1018	677	190	425	485	343
35	6520	5486	3101	4286	**3737**	1154	1035	281	76	54	136	187	77	111	200	111	536	169	312	59	156	181	587	404	149	370	271	209
36	4920	4398	2620	3104	3474	776	1041	198	43	47	72	151	38	70	94	76	412	124	162	230	88	101	372	282	85	292	207	163
37	4080	3047	2394	2336	2914	404	915	220	24	46	65	150	31	26	47	53	105	47	33	105	64	57	265	176	64	222	88	98
38	2441	2206	1672	1582	1753	366	749	103	27	33	7	113	37	18	16	50	25	36	28	158	44	34	222	187	52	173	82	33
39	1566	1557	1748	1343	2453	328	488	125	11	29	30	56	17	14	8	31	25	15	34	59	14	2	137	87	29	136	79	18
40	946	769	1024	917	1151	191	469	45	3	16	2	34	10	7	2	33	7	14	5	137	5	4	108	97	3	77	43	14
41	504	581	640	522	517	105	346	38	12	11	4	26	5	1		41	34	17	16	65	4		50	80	6	74	26	14
42	341	345	201	214	476	37	164	46	5	8		19	6	2		14		11	6	61	2		**19**	25	6	31	57	8
43	289	264	283	237	118	10	69	18	1	3	1	25	3	5	2	18		11	3	52	1		**9**	19		18	15	7
44	135	130	19	172	170	9	50	3	6	2		14	2			12		4	8	26	2		20	21		13	12	6
45	143	73	14	39	26	9	34	2	1		2	3	1		1	6		3	3	5	2			0.3		1	5	3
46	75	32	8	9	17		7	4	1	1		10	1			5		4	5	20			2			0.4	22	6
47	46	16			17		19	1	1			6						1		7	1					0.1	2	0.2
48	28	12	8	17			4						1			1		1		10						0.2	0.4	
49	4	12																1	3							0.1		8.5
50	11	4						27											8					13		0.1		
51	4	12																						0.4		0.0		4.2
52	4																									0.1		
53	7	16																1	2							0.1		
54		8																										
55		4																										0.9
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	312	361	258	319	255	253
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	26.9	27.7	26.0	27.5	25.7	25.8

Table 3c: Length composition (absolute frequencies in'000s) of the 3M redfish total annual catch, 1989-2016 (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	2011	2012	2013	2014	2015	2016
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												2
9							5	211	71	40	812	55	4218	538	1432	355												2
10	3						3	416	258	45	845	193	6537	888	1454	593	3	16	12					7				20
11				1	3		15	1056	569	391	390	593	6275	1655	913	1055	18	40	41			3	1	9	1	1	6	57
12	3			1	9	19	36	841	512	1830	313	1011	4996	3205	1368	1498	108	86	133		1	9	3	23	4	1	10	71
13	11			0	29	338	34	459	164	1721	286	761	2126	5809	2741	1229	381	70	172		5	28	27	36	7	6	48	140
14	25	4		0	257	979	64	488	120	340	97	182	746	4660	2546	1093	509	91	88		5	99	87	69	5	5	119	143
15	8	73		1	1998	2232	247	731	119	63	90	90	531	1946	1886	1022	474	112	23	6	37	248	209	95	35	26	160	160
16	30	190		4	7682	7312	430	1713	647	116	86	50	522	865	1994	999	516	313	18	14	68	341	309	122	68	62	164	223
17	59	724		3	29380	17576	758	1182	184	85	62	22	453	430	2513	987	423	436	31	12	102	481	352	162	135	108	287	303
18	30	2489	156	6	47422	21654	1105	758	61	32	41	27	339	339	1751	815	285	635	138	47	121	669	586	222	210	180	370	365
19	11	5774	647	97	30110	11939	1086	444	68	34	39	35	146	297	657	927	183	1296	433	166	147	912	806	388	392	313	647	537
20	111	6179	1331	418	6815	2807	1569	428	85	19	14	60	89	265	224	1398	157	2168	371	381	226	1559	1452	709	368	320	1113	1202
21	383	2904	1234	1987	1117	745	3001	1058	75	39	7	52	91	209	183	1690	132	3104	658	622	308	2254	2130	1038	1004	770	1780	1710
22	1149	1205	1179	3834	697	521	5922	2220	82	65	9	105	142	186	93	1588	159	3939	490	1032	535	3696	3198	1637	1622	1182	2726	2717
23	3766	1927	945	3016	669	457	5722	1641	126	102	6	114	210	187	80	988	216	3658	720	794	869	3261	2778	1496	1785	1135	2607	2466
24	8408	5526	1697	1690	1116	701	1694	1324	273	135	11	208	288	290	108	857	287	3179	760	1198	981	1671	1543	755	1984	839	1485	1414
25	14733	11932	3737	2468	1159	870	1162	785	328	237	122	317	455	417	272	727	555	2261	947	787	1257	1151	990	533	2400	978	999	1251
26	14793	19979	6292	7519	1577	1020	798	513	311	243	112	719	893	513	364	574	724	1427	1471	1760	1266	848	821	500	2634	1339	842	1833
27	11148	25688	10368	11599	1701	986	957	740	198	217	223	1322	1242	672	517	597	927	1181	1876	2050	1145	775	774	389	2376	1261	758	1497
28	7059	26047	12852	11899	2456	1688	1192	758	169	174	303	1654	1451	855	536	553	1057	1058	1405	2306	1086	886	963	538	1518	1115	885	1650
29	5773	20113	15100	8677	2448	2039	1483	855	210	169	301	1467	1194	841	589	426	1111	779	1348	1244	877	870	1115	598	1056	747	821	1617
30	7424	15200	13056	7505	3277	1987	1509	899	248	162	191	1036	996	815	475	384	779	619	1350	692	590	838	1802	1008	680	665	1067	1575
31	6972	10134	7456	5452	3846	2327	1258	954	223	172	204	677	537	626	390	270	770	444	998	437	596	627	1886	1181	512	544	1004	1247
32	7393	8308	7054	4705	3974	2611	1304	891	248	158	242	451	339	464	359	304	525	353	850	272	434	500	2230	1463	345	431	700	888
33	7030	6551	3519	4150	4831	1963	1219	689	268	112	169	321	210	366	331	319	543	262	639	311	300	398	1969	1327	251	424	536	568
34	6927	6397	3891	4309	4283	1347	1008	672	107	75	75	300	146	221	258	204	527	193	463	208	216	234	1018	677	190	425	485	343
35	6520	5486	3101	4286	3737	1154	1035	281	76	54	136	187	77	111	200	111	536	169	312	59	156	181	587	404	149	370	271	209
36	4920	4398	2620	3104	3474	776	1041	198	43	47	72	151	38	70	94	76	412	124	162	230	88	101	372	282	85	292	207	163
37	4080	3047	2394	2336	2914	404	915	220	24	46	65	150	31	26	47	53	105	47	33	105	64	57	265	176	64	222	88	98
38	2441	2206	1672	1582	1753	366	749	103	27	33	7	113	37	18	16	50	25	36	28	158	44	34	222	187	52	173	82	33
39	1566	1557	1748	1343	2453	328	488	125	11	29	30	56	17	14	8	31	25	15	34	59	14	2	137	87	29	136	79	18
40	946	769	1024	917	1151	191	469	45	3	16	2	34	10	7	2	33	7	14	5	137	5	4	108	97	3	77	43	14
41	504	581	640	522	517	105	346	38	12	11	4	26	5	1		41	34	17	16	65	4		50	80	6	74	26	14
42	341	345	201	214	476	37	164	46	5	8		19	6	2		14		11	6	61	2		19	25	6	31	57	8
43	289	264	283	237	118	10	69	18	1	3	1	25	3	5	2	18		11	3	52	1		9	19		18	15	7
44	135	130	19	172	170	9	50	3	6	2		14	2			12		4	8	26	2		20	21		13	12	6
45	143	73	14	39	26	9	34	2	1		2	3	1		1	6		3	3	5	2			0.3		1	5	3
46	75	32	8	9	17		7	4	1	1		10	1			5		4	5	20			2			0.4	22	6
47	46	16			17		19	1	1			6						1		7	1					0.1	2	0.2
48	28	12	8	17			4						1			1		1		10						0.2	0.4	
49	4	12																1	3							0.1		8
50	11	4						27											8					13		0.1		
51	4	12																						0.369				4
52	4	0																								0.1		
53	7	16																1	2							0.1		
54		8																										
55		4																										1
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	28842	16379	19978	14284	20529	24591
weight (ton)	58100	81000	48500	43300	40970	17203	13874	6339	1457	1162	1164	3764	3962	3701	2887	3612	4148	5997	5149	4277	3656	5056	8994	5910	5163	4553	5243	6232

Table 3d: Catch in numbers at age (' 000) of 3M redfish, 1989-2016, 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	2002
2009	0	66	163	434	468	1419	1613	1645	1455	1452	741	453	136	304	53	110	35	147	862	11556	2001
2010	0	1118	1097	2735	5422	4200	3570	981	715	1017	1383	557	506	247	70	120	66	42	579	24426	2005
2011	84	435	801	3354	3677	4247	2133	1028	873	1848	1831	2655	684	682	1122	1108	401	372	1511	28849	2005
2012	75	253	245	1093	1812	1877	1483	879	373	257	624	1192	2036	1029	775	469	140	43	2430	17085	1999
2013	11	90	297	694	1719	3672	5599	3229	1522	948	425	398	204	257	243	75	180	74	343	19978	2006
2014	61	317	590	1401	3672	2118	2057	1473	1102	532	429	383	153	386	512	275	198	44	854	16558	2009
2015	15	342	751	1260	3928	5100	2040	1910	1849	1013	1275	519	465	195	530	94	72	60	336	21754	2009
2016	151	522	684	1086	3928	3923	3439	1623	1910	2029	1608	1751	456	612	208	155	211	126	169	24591	2010/2011

Table 3e: Weights at age in the catch and by-catch (Kg) of 3M redfish, 1989-2016.

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			0.000	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			0.000	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	0.015	0.034	0.057	0.085	0.144	0.190	0.260	0.307	0.371	0.354	0.456	0.532	0.661	0.567	0.506	0.664	0.718	0.754	0.803
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	0.220	0.276	0.310	0.357	0.392	0.442	0.493	0.501	0.530	0.575	0.497	0.529	0.589
2011	0.041	0.057	0.080	0.133	0.152	0.183	0.208	0.299	0.327	0.433	0.430	0.481	0.385	0.455	0.468	0.551	0.597	0.483	0.722
2012	0.040	0.068	0.095	0.138	0.170	0.203	0.247	0.290	0.336	0.395	0.407	0.509	0.508	0.502	0.576	0.634	0.625	0.463	0.734
2013	0.029	0.060	0.082	0.103	0.149	0.179	0.237	0.276	0.331	0.363	0.395	0.420	0.512	0.489	0.493	0.477	0.588	0.575	0.613
2014	0.031	0.050	0.080	0.110	0.140	0.179	0.245	0.286	0.339	0.421	0.422	0.474	0.486	0.532	0.586	0.523	0.699	0.552	0.805
2015	0.024	0.046	0.077	0.104	0.143	0.173	0.239	0.272	0.325	0.380	0.382	0.421	0.401	0.490	0.445	0.562	0.518	0.494	0.760
2016	0.027	0.051	0.082	0.114	0.149	0.170	0.223	0.268	0.309	0.352	0.371	0.393	0.430	0.424	0.493	0.567	0.565	0.610	0.806

Table 4a: 3M beaked redfish new maturity ogives at length (*S. mentella*, *S.fasciatus* and *Sebastes spp.*), 1994-2016

Year	1994	1996	1999	2000	2004	2007	2011	2012	2013	2014	2015	2016
a	-17.17	-15.16	-8.83	-6.64	-7.68	-8.41	-25.76	-36.36	-31.5	-33.94	-29.79	-15.03
b	0.61	0.54	0.31	0.23	0.27	0.33	1	1.44	1.25	1.33	1.13	0.53
n	402	93	340	94	379	411	476	603	467	412	432	509
L50	27.94	27.97	28.31	28.98	28.09	25.72	25.86	25.3	25.17	25.5	26.29	28.42

Table 4b: 3M beaked redfish mean length at maturity (*S. mentella*, *S.fasciatus* and *Sebastes spp.*), 1994-2016

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
S. mentella	30.14	30.03	29.90	29.74	29.56	29.32	29.11	29.00	28.88	28.61	27.74	27.28	26.80
S. fasciatus	26.53	26.66	26.80	26.91	27.06	27.34	28.75	28.57	28.51	28.46	28.38	27.26	26.39
Sebastes spp.	**27.94**	**27.95**	**27.97**	**28.05**	**28.15**	**28.31**	**28.98**	**28.81**	**28.71**	**28.53**	**28.09**	**27.27**	**26.55**

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
S. mentella	25.79	25.88	25.91	25.92	25.93	25.93	26.02	26.12	26.23	28.59
S. fasciatus	25.69	25.68	25.67	25.66	25.65	24.15	23.10	24.44	26.43	28.14
Sebastes spp.	**25.72**	**25.79**	**25.83**	**25.85**	**25.86**	**25.30**	**25.17**	**25.50**	**26.29**	**28.42**

Table 5a: 3M beaked redfish abundance at length ('000s) from EU bottom trawl survey series (1988-2002 by RV Cornide Saavedra (CS), 2003-2016 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
4															
5											2868				
6		73	239	1042				144			956			455	1091
7	1203	160	1952	39644	4931	1102		31	2453		695	291		1240	9720
8	8538	1890	15439	194701	117561	3160		594	12310	1359	3390	2417	1883	18643	14581
9	8327	2007	11861	90135	75875	1764		1816	6548	2887	6048	12420	6848	152327	44733
10	7082	2894	846	9088	57005	7812	274	1889	867	1615	1573	8840	5242	246451	53017
11	20338	8434	412	17232	332037	36153	1573	3397	1762	4312	2626	3052	4412	29300	52317
12	39345	20228	390	18876	381332	46734	2665	9269	5827	12810	13751	2976	15579	9424	115720
13	27472	21581	1062	5790	90012	29392	5209	4666	5993	14318	22307	4851	30605	16454	247642
14	4000	46259	1865	1174	16174	79964	25338	4768	8609	7064	11124	4639	18860	19286	292527
15	802	87282	2527	1706	27540	165019	58046	9835	16820	13161	14504	19442	6447	31061	99677
16	1034	71271	6765	8180	41045	138724	130198	24357	14379	23773	29969	39114	4277	71951	73453
17	1499	22119	15552	25997	9939	29763	219435	64809	23877	29710	20988	26097	8270	56570	59348
18	1140	3665	17573	47123	7593	9245	230202	110934	54208	30013	13414	32861	19781	22594	72239
19	4032	2167	10349	74331	14615	4970	121884	144384	108902	36047	14029	29489	27898	12501	74283
20	7430	3097	2514	83897	24467	3328	33879	100682	153048	68928	13962	20335	29190	18149	55461
21	16559	4479	1078	40486	46504	3306	16450	38742	135158	101923	18530	14731	24042	24890	28013
22	33994	9816	3011	10581	70167	5125	8472	9863	83283	98256	33310	17528	21181	25754	23745
23	68369	18570	10028	3744	51568	7222	7632	3978	37902	62655	56319	29378	18209	17298	19916
24	102943	33229	13236	3855	23847	8078	9824	3261	17322	24171	57007	61585	29389	15498	21186
25	108959	50665	28825	7720	10049	5812	11309	3704	7875	9733	33609	75417	54137	14734	16263
26	79514	60423	42888	9638	12417	5431	9941	4600	4102	5921	14895	57490	76085	18293	14695
27	33899	49923	41939	9642	16819	4256	6971	4265	5830	4280	5807	20106	78418	17465	13793
28	13963	31600	28902	8402	18154	4326	8135	4642	4150	3998	2710	6614	54137	13151	12150
29	6818	17451	16287	5836	12743	3066	6925	4694	4325	2790	1258	2472	21494	7232	9235
30	9150	10747	9819	4833	11009	2882	4765	4493	2995	3195	828	804	4582	5003	5643
31	7567	8245	7209	3513	7557	2362	3995	3479	2489	1977	959	701	1715	1439	2210
32	8886	9234	6686	3034	4866	1882	3611	2792	2280	1514	762	652	890	782	818
33	8570	6908	5710	3287	4450	2012	2463	2304	2050	1291	619	470	1120	337	572
34	7451	6529	6333	3279	4276	1660	1613	1897	1410	981	517	401	578	405	286
35	5646	6544	4312	2567	3486	1536	1468	1591	948	590	293	347	382	199	122
36	4929	5410	3975	2295	2635	1518	1039	1441	757	544	310	221	388	161	113
37	3631	3912	3065	1811	2014	1425	590	1205	568	305	194	134	357	67	68
38	3166	2501	2223	1488	1620	904	549	717	402	212	142	81	67	80	54
39	3092	4145	2425	1739	2156	1392	520	932	471	212	168	78	131	67	27
40	2090	2908	1634	1079	1410	831	379	493	266	143	65	39	87	27	14
41	1499	1192	842	471	586	378	225	433	243	124	77	26	44	54	14
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		65	13	29	40	14
44	84	87	51	53	165	168	28	36	23	25	26		15		
45	84	87	67	53	45	26	28	36	23		13	26			
46		58	17	53	30	26		36			13				
47			34	11		26		12							
48						39			12						
total	664025	638823	330614	748931	1509292	623284	935746	581692	730719	570876	400725	496163	566768	869393	1434771

Length (cm)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
4								60				6		
5	63							8						
6	2905					136	54	23		79	148		8	6
7	11241	286	499	304	1547	573	477	369	93	176	299	29	104	73
8	19009	12530	5985	94129	26849	5315	2640	2873	22	679	618	1107	1257	275
9	10989	69454	8679	410980	214426	4271	5731	8073	746	1411	1186	6523	3578	464
10	5810	181225	11172	569937	471628	5446	3386	11485	4620	423	1299	1922	1354	751
11	13578	178289	47283	83653	269398	21536	5348	23157	4759	776	1442	983	885	1227
12	38207	306313	109207	93826	255837	62810	7229	29988	6950	4118	1788	1438	4655	3534
13	31594	217455	305354	168066	460809	135178	7342	25966	15311	9633	3131	2223	8877	9595
14	34465	109487	563721	368890	359968	146220	14300	20163	30837	14883	3505	3070	10715	7083
15	61037	59669	496389	570816	235990	109149	37040	25053	48357	25999	6484	1617	4525	3772
16	96960	93021	321931	705419	132602	150419	74563	26704	50389	45269	17687	1417	4320	9607
17	87339	130177	216267	1022160	204730	200256	106859	34783	34593	52347	31911	2773	4467	16026
18	40866	155247	199060	785217	363584	236520	147862	62837	35136	53475	38805	4709	4324	12224
19	28312	179357	182684	502051	489233	195040	182429	88896	54993	45700	37724	10856	5135	8913
20	22778	156658	169721	357550	396759	241170	274446	108084	108351	56535	39184	16088	8006	5861
21	18751	86575	163284	189221	256720	256356	244424	138236	158583	85639	40895	15534	12036	7385
22	12635	48011	179265	120687	144663	241869	209744	150168	160054	170639	53157	20601	19944	9485
23	8313	29273	132897	99934	101176	141913	137275	112686	134422	229288	86481	29962	22363	11989
24	7521	18368	81899	76563	71205	106627	138138	74872	101986	207034	113144	47408	25442	17167
25	7312	11706	41610	57756	42237	61464	93215	61323	58822	138854	120194	71544	34361	26812
26	7561	11260	32227	25060	38613	45511	49136	37645	31084	89036	103975	87171	47505	36954
27	7875	8280	18476	13669	25283	31512	37652	24648	20314	44921	66107	77264	57230	56320
28	6742	7280	12570	8322	13766	20128	19937	16266	12887	24186	39337	55550	56570	63205
29	4988	5204	8890	5071	8331	10536	19353	10922	6369	14517	22292	29457	38241	52836
30	3945	3753	7874	5648	9541	3737	6364	6414	3902	10679	13479	15175	27938	39903
31	2264	2651	3273	2393	3284	5765	4025	2468	2551	6786	6348	9152	13637	21091
32	1556	1835	2954	1722	2100	1171	2631	1586	1917	4326	5045	5462	7251	14203
33	756	1132	1085	1340	3374	1034	2360	1450	1031	4062	2836	3982	3708	6908
34	639	762	736	479	909	371	175	572	383	2266	2037	2924	2433	2999
35	171	323	310	383	238	312	1587	151	21	721	581	1394	3185	1910
36	207	166	174	192	71	29	563	60	21	693	536	1951	1877	1036
37	135	108	29		20	29	249	50	21	322	607	272	800	662
38	117	98	29	96	10	39	46	30	11		105	415	1245	65
39	117		19			29	46	101		171	219	88	263	64
40	45			95	10	20	1657						283	
41	9	10				10	37		10		10		10	
42	9					10		10				125		
43														
44	9													
45														
46		10												
47														
48														
total	596833	2085973	3325555	6341632	4604910	2442512	1838324	1108180	1089546	1345643	862595	530193	438533	450404

Table 5b: 3M beaked redfish abundance at age ('000s) from EU bottom trawl survey series, 1989-2016.

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	664025	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	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	481	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	50017	119643	202461	63004	84160	24769	14624	10827	6967	3974	2233	1323	11068	465	53	248	274	52	669	596833	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	22890	174292	86905	187410	250116	157413	138615	34940	18552	15351	12900	4018	1728	910	286	310	209	145	1189	1108180	2005
2011	49172	91360	75528	218920	223439	244352	115969	25006	13555	13365	6080	4043	4378	852	2009	790	101	319	310	1089546	2005
2012	19153	81326	79996	131612	202027	313659	292199	139414	29159	6307	13926	9276	10094	6559	2852	1808	265	271	5742	1345643	2005
2013	9912	22790	54171	80792	80595	166954	248641	109374	38934	20075	7757	6820	2721	3361	3395	893	1498	739	3172	862595	2006
2014	14231	5572	8012	18283	44969	67747	151366	101293	59229	16226	14018	9358	2155	4406	5510	3283	1107	382	3047	530193	2007
2015	11841	24444	11450	10420	28486	56936	71896	67015	53847	26296	29895	11870	10423	3259	11819	1959	1721	1035	3922	438533	2008
2016	6330	23840	29284	14054	18621	21224	60564	44506	65870	59059	41005	38476	9047	11583	2508	1285	1611	887	648	450404	2009

Table 5c: 3M beaked redfish mature female abundance at age ('000s) from EU survey series, 1988-2016.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+	Total
1988	0	10	19	166	457	3852	11667	11447	6085	3947	3723	2798	3047	2824	2606	1536	1405	1278	6465	63303
1989	0	8	140	91	157	1545	7734	11709	7329	4218	3366	2593	2910	2829	2722	1561	1440	1231	7823	59258
1990	1	0	60	76	59	840	5392	9830	6743	3922	2988	2245	2655	2529	2300	1346	1110	1020	4432	47488
1991	8	5	4	536	895	834	2102	2501	2086	1445	1634	1659	1620	1449	597	1054	768	445	2433	22059
1992	3	71	34	104	1691	1817	2280	4334	4320	3147	2222	1829	1981	1668	1644	1413	818	811	1614	31692
1993	0	10	17	128	136	995	925	1009	463	779	778	761	707	834	676	942	598	983	1068	11780
1994	0	4	70	966	425	1006	1912	1682	1508	1510	1247	900	674	478	515	344	302	405	665	14540
1995	0	3	103	524	1952	393	968	1390	1023	1110	1261	714	520	518	563	495	295	423	1341	13490
1996	1	6	40	59	2722	6023	1573	1802	1544	978	842	875	509	580	483	388	287	280	788	19732
1997	0	2	10	110	475	2724	6144	2287	1841	1263	705	605	333	403	113	157	201	67	428	17857
1998	0	4	31	50	213	933	1560	5282	785	120	119	647	86	96	26	61	155	9	231	10373
1999	0	12	152	447	514	1184	3118	4740	15008	1341	102	153	340	41	101	99	103	199	307	27796
2000	0	35	53	200	752	1135	3056	10012	9198	29716	1352	162	97	638	83	55	60	34	615	57164
2001	2258	483	2151	2262	2328	2212	2355	2618	1830	1744	6453	318	107	65	71	56	20	24	175	22639
2002	562	5162	6753	8933	2851	2594	2143	2393	2875	1761	1101	5183	303	81	111	28	26	9	62	30454
2003	0	124	556	254	747	716	1012	1258	1342	1114	913	647	3199	281	36	173	156	39	502	12389
2004	986	5791	5404	4531	19242	6961	3628	2527	1684	1267	975	698	755	3321	56	160	157	31	331	46324
2005	70	11628	9758	13128	12576	24678	13518	10161	5776	3593	2438	2076	818	457	1686	33	26	12	9	90985
2006	2578	10966	23110	44701	34122	28193	16832	8369	4095	1536	1187	698	533	384	424	1866	128	23	186	143277
2007	1564	4593	9967	20852	31767	23137	47394	18443	12148	2803	3137	2111	1127	1035	500	4838	1233	9	341	170875
2008	6	1306	2982	8767	17032	56713	40101	24867	13195	5696	2690	1556	936	564	140	67	52	1583	49	174010
2009	2	116	371	5845	9428	32350	34169	28608	18502	17365	6198	5430	817	2585	312	573	277	1195	6472	170128
2010	6	426	488	2332	9640	15937	31251	13455	8568	8272	7795	2554	1266	659	247	257	151	124	894	103402
2011	54	287	499	4006	5751	16811	14267	10351	6295	6217	3592	2756	2307	651	1416	505	97	298	288	75608
2012	25	393	657	2407	6189	16783	31076	24801	9625	3264	6769	5191	5948	3740	1825	1223	233	160	3811	123044
2013	8	107	584	1620	2925	8395	29800	25487	18228	11235	5074	5105	2236	2717	2665	731	1241	663	2731	120853
2014	0	0	8	98	855	4540	38003	45406	35312	12416	9594	6854	1563	3127	4300	2594	797	247	2693	168401
2015	0	4	14	39	489	1973	6635	10373	15490	11550	13469	5875	4909	1968	5455	1021	861	669	2039	82816
2016	3	32	104	144	464	865	3626	5903	15465	22357	21056	22619	5851	7857	2206	1218	1519	853	625	112627

Table5d: 3M beaked reddish proportion of mature females at age, from the EU survey series, 1988-2016.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1988	0.000	0.000	0.002	0.008	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	0.000	0.000	0.001	0.005	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	0.000	0.000	0.002	0.003	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	0.000	0.001	0.003	0.007	0.047	0.103	0.188	0.258	0.345	0.421	0.489	0.537	0.585	0.627	0.696	0.674	0.682	0.771
1992	0.000	0.000	0.001	0.002	0.012	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	0.000	0.000	0.000	0.013	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	0.001	0.001	0.005	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	0.000	0.000	0.002	0.005	0.006	0.047	0.108	0.159	0.217	0.280	0.310	0.307	0.317	0.360	0.367	0.474	0.487	0.577	0.779
1996	0.000	0.000	0.001	0.002	0.014	0.015	0.134	0.208	0.271	0.352	0.414	0.449	0.514	0.519	0.545	0.588	0.634	0.642	0.696
1997	0.000	0.000	0.000	0.001	0.005	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	0.000	0.000	0.001	0.007	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	0.001	0.003	0.006	0.011	0.031	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	0.001	0.002	0.006	0.012	0.025	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	0.005	0.009	0.018	0.026	0.045	0.052	0.080	0.129	0.204	0.341	0.240	0.373	0.351	0.372	0.357	0.357	0.361	0.369	0.749
2002	0.005	0.011	0.017	0.038	0.046	0.056	0.071	0.108	0.162	0.359	0.363	0.371	0.522	0.494	0.460	0.341	0.427	0.417	0.435
2003	0.000	0.001	0.003	0.004	0.009	0.029	0.069	0.116	0.193	0.280	0.409	0.489	0.289	0.603	0.685	0.697	0.569	0.759	0.751
2004	0.004	0.008	0.018	0.031	0.045	0.067	0.105	0.147	0.202	0.272	0.412	0.537	0.639	0.379	0.779	0.689	0.628	0.758	0.673
2005	0.003	0.009	0.015	0.031	0.043	0.053	0.109	0.215	0.282	0.331	0.494	0.539	0.492	0.697	0.553	0.514	0.568	0.592	0.571
2006	0.002	0.009	0.019	0.029	0.045	0.075	0.126	0.219	0.341	0.414	0.479	0.439	0.543	0.586	0.716	0.448	0.601	0.959	0.863
2007	0.002	0.005	0.011	0.039	0.049	0.060	0.167	0.277	0.485	0.738	0.818	0.888	0.909	0.902	0.868	0.720	0.814	0.656	0.848
2008	0.000	0.003	0.010	0.020	0.041	0.101	0.225	0.377	0.486	0.586	0.644	0.672	0.673	0.706	0.542	0.429	0.395	0.695	0.445
2009	0.000	0.001	0.002	0.017	0.024	0.111	0.137	0.224	0.312	0.467	0.626	0.504	0.804	0.678	0.650	0.761	0.924	0.884	0.749
2010	0.000	0.002	0.006	0.012	0.039	0.101	0.225	0.385	0.462	0.539	0.604	0.636	0.733	0.724	0.863	0.830	0.722	0.855	0.752
2011	0.001	0.003	0.007	0.018	0.026	0.069	0.123	0.414	0.464	0.465	0.591	0.682	0.527	0.765	0.705	0.639	0.966	0.932	0.928
2012	0.001	0.005	0.008	0.018	0.031	0.054	0.106	0.178	0.330	0.518	0.486	0.560	0.589	0.570	0.640	0.676	0.879	0.590	0.664
2013	0.001	0.005	0.011	0.020	0.036	0.050	0.120	0.233	0.468	0.560	0.654	0.749	0.821	0.808	0.785	0.818	0.829	0.898	0.861
2014	0.000	0.000	0.001	0.005	0.019	0.067	0.251	0.448	0.596	0.765	0.684	0.732	0.726	0.710	0.781	0.790	0.720	0.647	0.884
2015	0.000	0.000	0.001	0.004	0.017	0.035	0.092	0.155	0.288	0.439	0.451	0.495	0.471	0.604	0.462	0.521	0.501	0.646	0.520
2016	0.000	0.001	0.004	0.010	0.025	0.041	0.060	0.133	0.235	0.379	0.513	0.588	0.647	0.678	0.879	0.948	0.943	0.962	0.965

Table 5e: maturity ogive at age for 3M beaked reddish as the average proportion of mature females at age, from the EU survey series, 1989-2016.

Fem proportion	0.001	0.003	0.006	0.013	0.024	0.052	0.109	0.208	0.298	0.387	0.457	0.497	0.538	0.563	0.590	0.619	0.643	0.671	0.718
cv 1989-2016	0.002	0.003	0.006	0.012	0.015	0.024	0.053	0.110	0.128	0.152	0.144	0.149	0.163	0.149	0.163	0.182	0.164	0.170	0.131

Table 6a: Weights at age of the 3M beaked redfish stock (Kg) from EU surveys, 1989-2016.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
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	0.009	0.035	0.061	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	0.015	0.048	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
2011	0.037	0.059	0.081	0.138	0.156	0.189	0.215	0.293	0.310	0.314	0.363	0.412	0.337	0.447	0.412	0.437	0.582	0.488	0.575
2012	0.034	0.062	0.084	0.120	0.159	0.194	0.225	0.252	0.296	0.350	0.349	0.405	0.447	0.423	0.475	0.485	0.593	0.441	0.485
2013	0.029	0.071	0.092	0.114	0.163	0.200	0.247	0.284	0.335	0.363	0.386	0.419	0.476	0.469	0.460	0.479	0.528	0.558	0.548
2014	0.022	0.057	0.096	0.128	0.164	0.219	0.273	0.310	0.345	0.413	0.389	0.421	0.492	0.522	0.527	0.504	0.589	0.577	0.604
2015	0.023	0.050	0.087	0.121	0.168	0.211	0.281	0.311	0.358	0.407	0.412	0.447	0.429	0.533	0.454	0.536	0.537	0.544	0.710
2016	0.028	0.053	0.090	0.115	0.162	0.205	0.264	0.316	0.350	0.385	0.412	0.434	0.457	0.464	0.552	0.651	0.645	0.705	0.725

Table 6b: Weights at age of the 3M mature female beaked redfish stock (Kg) from EU surveys, 1989-2016.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989	0.013	0.035	0.069	0.131	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	0.012	0.032	0.095	0.113	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	0.926
1991	0.013	0.032	0.070	0.120	0.146	0.249	0.304	0.354	0.406	0.473	0.528	0.585	0.629	0.661	0.713	0.791	0.778	0.809	0.907
1992	0.014	0.034	0.074	0.123	0.182	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	0.011	0.043	0.057	0.075	0.177	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	0.000	0.051	0.090	0.101	0.149	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	0.012	0.029	0.084	0.117	0.124	0.226	0.296	0.365	0.412	0.459	0.516	0.546	0.638	0.723	0.740	0.837	0.854	0.889	1.079
1996	0.012	0.038	0.067	0.080	0.162	0.163	0.280	0.337	0.389	0.449	0.483	0.536	0.583	0.606	0.658	0.703	0.758	0.800	0.960
1997	0.000	0.033	0.071	0.105	0.145	0.225	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	0.036	0.068	0.097	0.146	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	0.037	0.067	0.093	0.127	0.190	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	0.038	0.073	0.103	0.141	0.187	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	0.015	0.029	0.063	0.090	0.142	0.185	0.242	0.307	0.344	0.390	0.374	0.514	0.603	0.665	0.667	0.623	0.776	0.853	1.035
2002	0.014	0.036	0.054	0.106	0.134	0.190	0.233	0.301	0.342	0.400	0.455	0.409	0.557	0.587	0.616	0.715	0.644	0.888	0.968
2003	0.000	0.041	0.065	0.082	0.123	0.184	0.234	0.274	0.334	0.378	0.432	0.476	0.398	0.560	0.584	0.651	0.524	0.694	0.778
2004	0.015	0.033	0.071	0.100	0.124	0.172	0.229	0.284	0.353	0.402	0.472	0.523	0.569	0.466	0.635	0.676	0.553	0.756	0.719
2005	0.013	0.043	0.064	0.100	0.121	0.175	0.237	0.282	0.344	0.386	0.476	0.496	0.488	0.586	0.520	0.705	0.719	0.900	0.861
2006	0.014	0.048	0.075	0.093	0.122	0.172	0.229	0.282	0.352	0.408	0.451	0.442	0.513	0.542	0.596	0.445	0.546	0.839	0.805
2007	0.016	0.032	0.062	0.113	0.130	0.147	0.240	0.276	0.356	0.400	0.462	0.522	0.544	0.539	0.525	0.409	0.492	0.730	0.556
2008	0.015	0.048	0.080	0.109	0.146	0.188	0.234	0.285	0.331	0.376	0.425	0.443	0.439	0.476	0.540	0.565	0.540	0.443	0.625
2009	0.017	0.064	0.090	0.186	0.150	0.210	0.222	0.251	0.304	0.328	0.402	0.334	0.553	0.449	0.496	0.506	0.676	0.855	0.569
2010	0.016	0.061	0.100	0.134	0.161	0.200	0.235	0.269	0.294	0.330	0.368	0.397	0.462	0.457	0.639	0.523	0.479	0.518	0.520
2011	0.044	0.063	0.084	0.165	0.168	0.212	0.235	0.298	0.317	0.331	0.378	0.427	0.345	0.451	0.420	0.435	0.582	0.488	0.575
2012	0.042	0.065	0.086	0.125	0.164	0.204	0.246	0.273	0.306	0.351	0.354	0.414	0.455	0.434	0.494	0.515	0.594	0.441	0.509
2013	0.035	0.074	0.100	0.120	0.167	0.209	0.267	0.301	0.351	0.378	0.392	0.424	0.484	0.474	0.473	0.481	0.539	0.559	0.557
2014	0.038	0.063	0.104	0.133	0.172	0.237	0.281	0.315	0.342	0.392	0.376	0.404	0.463	0.497	0.499	0.477	0.565	0.547	0.586
2015	0.030	0.057	0.098	0.127	0.176	0.220	0.291	0.328	0.371	0.428	0.428	0.465	0.450	0.526	0.478	0.527	0.520	0.543	0.696
2016	0.031	0.057	0.095	0.122	0.173	0.214	0.269	0.338	0.375	0.421	0.433	0.456	0.476	0.480	0.555	0.652	0.645	0.706	0.725

Table 7a: 3M beaked redfish survey mean catch per tow from EU bottom trawl survey series (1988-2002 by RV Cornide Saavedra (CS), 2003-2016 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
mean weight per tow (Kg/tow)	199	159	109	85	147	68	125	90	125	104	74	103	146
SE	32	21	13	10	17	24	38	10	17	18	12	30	57
CV	16%	13%	12%	12%	12%	36%	30%	11%	14%	18%	16%	29%	39%

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
mean weight per tow (Kg/tow)	78	129	57	185	297	532	279	224	342	178	132	183	233	178	158	169
SE	12	17	7	26	53	79	43	45	92	34	16	23	26	26	19	23
CV	16%	13%	13%	14%	18%	15%	15%	20%	27%	19%	12%	12%	11%	15%	12%	14%

Table 7b: 3M beaked redfish abundance, stock and female spwanning biomass ('000 tons) from EU bottom trawl survey series (1988-2002 by RV Cornide Saavedra (CS), 2003-2016 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
abundance (millions)	664	639	331	749	1509	623	936	582	731	571	401	496	567	869
4+abundance (millions)	541	362	265	367	385	376	840	497	657	502	284	410	471	273
biomass ('000 ton)	160	128	89	72	119	78	105	73	100	84	60	82	118	64
4+ biomass ('000 ton)	155	113	86	67	92	45	100	71	101	82	56	81	116	51
female spawning biomass ('000 ton)	28	28	23	12	16	7	7	7	7	6	3	8	19	7
SSB proportion	18%	22%	25%	16%	14%	9%	6%	9%	7%	8%	5%	9%	16%	10%

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
abundance (millions)	1435	597	2086	3326	6342	4605	2443	1838	1108	1090	1346	863	530	439	450
4+abundance (millions)	437	227	759	1402	2854	1971	1708	1553	824	873	1165	776	502	391	391
biomass ('000 ton)	107	50	157	302	485	386	308	286	164	168	251	188	143	127	136
4+ biomass ('000 ton)	69	34	106	209	329	282	267	266	147	159	242	182	144	124	132
female spawning biomass ('000 ton)	8	4	10	20	24	39	40	47	27	20	36	39	57	34	48
SSB proportion	7%	9%	6%	7%	5%	10%	13%	16%	16%	12%	14%	21%	40%	26%	36%

Table 8a: 3M beaked redfish growth/maturity based methods to estimate natural mortality I

M2011-2016				
Inputs				
Von Bertalanfy age-length growth		fasciatus	mentella	Combined
growth parameters	L∞	38.2895	37.6671	37.9043
	K	0.1127	0.1250	0.1196
	t0	-2.1354	-1.8502	-1.9525
	maximum age			40
other parameters	temp (ºC)			3.5
	Age at maturity			7.6
	n			5624

Results

M Size-independent	
Method	
Hewitt and Hoenig (2005)	0.11
Hoenig (1983)	0.10
Pauly (1980)	0.16
Jensen (1996)	0.22

Table 8b: 3M beaked redfish growth/maturity based methods to estimate natural mortality II

2015-2016				
Inputs				
growth parameters	L∞	fasciatus	mentella	Combined
	Linf	39.6433	38.1161	38.7981
	K	0.1121	0.1268	0.1197
	t0	-1.8767	-1.5716	-1.7175
	maximum age			40
other parameters	temp (ºC)			3.5
	Age at maturity			8.5
	n			1757

Results

Size-independent	
Method	M
Hewitt and Hoenig (2005)	0.11
Hoenig (1983)	0.10
Pauly (1980a) length	0.16
Jensen (1996)	0.19

Table 9: Redfish NAFO Division 3M input files for 2017 2017 XSA Assessment

REDFISH NAFO DIVISION 3M INDEX OF INPUT XSA FILES 2017

	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	2016
4	19
5	
58086	
80223	
48500	
43300	
43100	
17664	
13879	
6101	
1408	
1011	
1095	
3841	
3327	
2964	
2273	
3260	
4039	
5936	
5131	
4274	
3639	
5235	
8904	
6736	
5133	
4507	
5169	
6147	

REDFISH NAFO 3M CATCH NUMBERS thousands

1	2														
1989	2016														
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
2735	5422	4200	3570	981	715	1017	1383	557	506	247	70	120	66	42	579
3354	3677	4247	2133	1028	873	1848	1831	2655	684	682	1122	1108	401	372	1511
1093	1812	1877	1483	879	373	257	624	1192	2036	1029	775	469	140	43	2430
694	1719	3672	5599	3229	1522	948	425	398	204	257	243	75	180	74	343
1401	3672	2118	2057	1473	1102	532	429	383	153	386	512	275	198	44	854
1260	3928	5040	1624	1223	1018	1032	1217	667	479	343	661	152	126	101	548
1086	3928	3923	3439	1623	1910	2029	1608	1751	456	612	208	155	211	126	169

REDFISH NAFO 3M CATCH WEIGHT AT AGE kg

1	3														
1989	2016														
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
0.085	0.144	0.190	0.260	0.307	0.371	0.354	0.456	0.532	0.661	0.567	0.506	0.664	0.718	0.754	0.803
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	0.220	0.276	0.310	0.357	0.392	0.442	0.493	0.501	0.530	0.575	0.497	0.529	0.589
0.133	0.152	0.183	0.208	0.299	0.327	0.433	0.430	0.481	0.385	0.455	0.468	0.551	0.597	0.483	0.722
0.138	0.170	0.203	0.247	0.290	0.336	0.395	0.407	0.509	0.508	0.502	0.576	0.634	0.625	0.463	0.734
0.103	0.149	0.179	0.237	0.276	0.331	0.363	0.395	0.420	0.512	0.489	0.493	0.477	0.588	0.575	0.613
0.110	0.140	0.179	0.245	0.286	0.339	0.421	0.422	0.474	0.486	0.532	0.586	0.523	0.699	0.552	0.805
0.104	0.143	0.173	0.234	0.263	0.336	0.409	0.417	0.452	0.430	0.503	0.495	0.566	0.533	0.509	0.768
0.114	0.149	0.170	0.223	0.268	0.309	0.352	0.371	0.393	0.430	0.424	0.493	0.567	0.565	0.610	0.806

REDFISH NAFO 3M STOCK WEIGHT AT AGE kg

1	4														
1989	2016														
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
0.138	0.156	0.189	0.215	0.293	0.310	0.314	0.363	0.412	0.337	0.447	0.412	0.437	0.582	0.488	0.575
0.120	0.159	0.194	0.225	0.252	0.296	0.350	0.349	0.405	0.447	0.423	0.475	0.485	0.593	0.441	0.485
0.114	0.163	0.200	0.247	0.284	0.335	0.363	0.386	0.419	0.476	0.469	0.460	0.479	0.528	0.558	0.548
0.128	0.164	0.219	0.273	0.310	0.345	0.413	0.389	0.421	0.492	0.522	0.527	0.504	0.589	0.577	0.604
0.121	0.168	0.211	0.281	0.311	0.358	0.407	0.412	0.447	0.429	0.533	0.454	0.536	0.537	0.544	0.710
0.115	0.162	0.205	0.264	0.316	0.350	0.385	0.412	0.434	0.457	0.464	0.552	0.651	0.645	0.705	0.725

REDFISH NAFO 3M NATURAL MORTALITY (from 2015 assessment)

1	5														
1989	2016														
4	19														
1															
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14

REDFISH NAFO 3M PROPORTION MATURE FEMALES

1	6														
1989	2016														
4	19														
1															
0.005	0.019	0.043	0.083	0.128	0.172	0.208	0.295	0.386	0.463	0.490	0.533	0.542	0.592	0.581	0.754
0.005	0.019	0.043	0.083	0.128	0.172	0.208	0.295	0.386	0.463	0.490	0.533	0.542	0.592	0.581	0.754
0.004	0.016	0.046	0.095	0.155	0.204	0.251	0.329	0.416	0.493	0.529	0.571	0.598	0.619	0.611	0.759
0.003	0.014	0.040	0.091	0.166	0.234	0.295	0.361	0.433	0.508	0.550	0.592	0.653	0.641	0.687	0.758
0.002	0.011	0.039	0.089	0.170	0.242	0.311	0.363	0.403	0.465	0.514	0.543	0.824	0.669	0.722	0.742
0.001	0.010	0.039	0.083	0.156	0.223	0.297	0.329	0.347	0.393	0.461	0.470	0.767	0.654	0.714	0.714
0.002	0.008	0.046	0.094	0.154	0.210	0.282	0.309	0.313	0.336	0.401	0.400	0.698	0.600	0.643	0.708
0.003	0.009	0.036	0.109	0.172	0.230	0.312	0.347	0.359	0.384	0.435	0.440	0.528	0.583	0.625	0.721
0.003	0.008	0.032	0.090	0.276	0.327	0.363	0.398	0.411	0.438	0.454	0.463	0.529	0.556	0.588	0.706
0.002	0.009	0.023	0.071	0.237	0.322	0.352	0.395	0.417	0.443	0.462	0.452	0.502	0.544	0.502	0.668
0.003	0.008	0.028	0.049	0.208	0.264	0.311	0.390	0.419	0.404	0.413	0.407	0.436	0.502	0.440	0.649
0.004	0.010	0.024	0.061	0.101	0.186	0.217	0.386	0.376	0.448	0.390	0.429	0.488	0.560	0.474	0.641
0.013	0.023	0.036	0.071	0.130	0.187	0.248	0.366	0.392	0.454	0.385	0.438	0.477	0.530	0.491	0.669
0.023	0.034	0.044	0.072	0.126	0.208	0.292	0.354	0.365	0.496	0.426	0.454	0.460	0.503	0.478	0.601
0.023	0.033	0.046	0.073	0.118	0.186	0.327	0.337	0.411	0.387	0.490	0.501	0.465	0.453	0.515	0.645
0.024	0.033	0.051	0.082	0.124	0.186	0.304	0.395	0.466	0.483	0.492	0.641	0.576	0.542	0.645	0.620
0.022	0.032	0.049	0.095	0.160	0.226	0.294	0.438	0.522	0.473	0.560	0.672	0.633	0.589	0.703	0.665
0.030	0.044	0.065	0.114	0.194	0.275	0.339	0.462	0.505	0.558	0.554	0.683	0.550	0.599	0.770	0.702
0.033	0.046	0.063	0.134	0.237	0.369	0.494	0.597	0.622	0.648	0.728	0.712	0.560	0.661	0.736	0.761
0.029	0.045	0.079	0.173	0.291	0.437	0.579	0.647	0.666	0.708	0.731	0.709	0.532	0.603	0.770	0.719
0.025	0.038	0.091	0.176	0.293	0.428	0.597	0.696	0.688	0.795	0.762	0.687	0.637	0.711	0.745	0.680
0.016	0.034	0.105	0.196	0.329	0.420	0.530	0.625	0.604	0.736	0.702	0.685	0.673	0.680	0.811	0.648
0.016	0.029	0.094	0.162	0.341	0.413	0.490	0.607	0.607	0.688	0.722	0.739	0.743	0.870	0.890	0.810
0.016	0.032	0.075	0.152	0.326	0.419	0.507	0.560	0.626	0.616	0.686	0.736	0.715	0.855	0.792	0.781
0.019	0.031	0.058	0.116	0.275	0.421	0.514	0.577	0.663	0.646	0.714	0.710	0.711	0.891	0.807	0.818
0.015	0.029	0.057	0.159	0.286	0.465	0.614	0.608	0.680	0.712	0.696	0.735	0.762	0.809	0.711	0.803
0.010	0.024	0.051	0.154	0.279	0.451	0.588	0.596	0.659	0.673	0.707	0.676	0.710	0.683	0.730	0.755
0.006	0.020	0.047	0.134	0.245	0.373	0.528	0.549	0.605	0.614	0.664	0.707	0.753	0.721	0.752	0.790
0.007	0.021	0.038	0.076	0.144	0.261	0.409	0.482	0.541	0.559	0.641	0.670	0.734	0.722	0.804	0.743

REDFISH NAFO 3M PROPORTION OF F BEFORE SPAWNING

1	7
1989	2016
4	19
3	
0.08	

REDFISH NAFO 3M PROPORTION OF M BEFORE SPAWNING

1	8
1989	2016
4	19
3	
0.08	

REDFISH NAFO 3M F ON OLDEST AGE GROUP BY YEAR

1	9
1989	2016
4	19
5	
0.5592	
0.6661	
0.7199	
0.4988	
1.6034	
0.4662	
0.6499	
0.2268	
0.0416	
0.0495	
0.1787	
0.2989	
0.197	
0.1416	
0.2445	
0.2129	
0.4406	
0.2387	
1.1436	
0.0526	
0.1359	
0.127	
0.9179	
0.1166	
0.1329	
0.0906	
0.1134	
0.1134	

REDFISH NAFO 3M F AT AGE IN LAST YEAR

1	10														
1989	2016														
4	19														
2															
0.0382	0.0497	0.0435	0.0432	0.0303	0.0241	0.0222	0.0263	0.0482	0.0673	0.0719	0.1577	0.1642	0.2014	0.1134	0.1134

REDFISH NAFO 3M SURVEY TUNNING DATA

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EU BOTTOM TRAWL SURVEY

1989	2016																
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	63004	84160	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	187410	250116	157413	138615	34940	18552	15351	12900	4018	1728	910	286	310	209	145	1189
10555	218920	223439	244352	115969	25006	13555	13365	6080	4043	4378	852	2009	790	101	319	310
10555	131612	202027	313659	292199	139414	29159	6307	13926	9276	10094	6559	2852	1808	265	271	5742
10555	80792	80595	166954	248641	109374	38934	20075	7757	6820	2721	3361	3395	893	1498	739	3172
10555	18283	44969	67747	151366	101293	59229	16226	14018	9358	2155	4406	5510	3283	1107	382	3047
10555	10420	28486	56936	71896	67015	53847	26296	29895	11870	10423	3259	11819	1959	1721	1035	3922
10555	14054	18621	21224	60564	44506	65870	59059	41005	38476	9047	11583	2508	1285	1611	887	648

Table 10a: Key diagnostics of seven sensitive XSA2017 runs (Mstatus quo and a set of 2015-2016 "biological" M candidates)

	Hoenig	Hewitt & Hoenig	status quo	Pauly	Chen &Watanabe[1]	Jensen	Gislason[1]
$M_{2015\text{-}2016}$	**0.1**	**0.11**	**0.14**	**0.16**	**0.17**	**0.19**	**0.2**
SS log q residuals$_{2015\text{-}2016}$	6.68	6.70	6.82	6.92	6.96	7.10	7.15
SS log q residuals$_{2011\text{-}2016}$	23.08	23.14	23.38	23.55	23.66	23.83	23.93
XSA *versus* SURVEY $r^2_{2011\text{-}2016}$	0.897	0.894	0.887	0.883	0.880	0.875	0.872

Table 10b: Key diagnostics of seven sensitive XSA2017 runs (Mstatus quo and a set of 2011-2016 "biological" M candidates)

	Hoenig	Hewitt & Hoenig	status quo	Pauly	Chen &Watanabe[1]	Gislason[1]	Jensen
$M_{2011\text{-}2016}$	**0.1**	**0.11**	**0.14**	**0.16**	**0.17**	**0.2**	**0.22**
SS log q residuals$_{2015\text{-}2016}$	6.76	6.74	6.80	6.96	7.05	7.50	7.95
SS log q residuals$_{2011\text{-}2016}$	23.02	23.08	23.49	23.85	24.16	25.13	26.01
XSA *versus* SURVEY $r^2_{2011\text{-}2016}$	0.886	0.887	0.887	0.886	0.886	0.883	0.881

Tab 10c: Key and complementary diagnostics for the best runs of each set (best M2015-2016 run versus best M2011-2016 run)

	$M_{2015\text{-}2016}$	$M_{2011\text{-}2016}$
	0.1$_{\text{Hoenig}}$	**0.11**$_{\text{Hewitt \& Hoenig}}$
SS log q residuals$_{2015\text{-}2016}$	6.68	6.74
SS log q residuals$_{2011\text{-}2016}$	23.079	23.076
XSA$_{versus}$ SURVEY $r^2_{2011\text{-}2016}$	0.897	0.887
Survivors Aver Int s.e	0.3260	0.3363
Survivors Aver Ext s.e	0.1765	0.1829

Table 11: 2017 Extended Survivor Analysis summary of diagnostics (Lowestoft VPA Version 3.1).

single EU survey, 1989-2014
M=0.1 all ages 1989-2005
M=0.4 ages 4-6 2006-2010 and ages 7+ 2009-2010
M=0.125 all ages 2011-2012
M=0.14 all ages 2013-2014
M=0.10 all ages 20115-2016

REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2017
CPUE data from file red3mtun.txt

Catch data for 28 years. 1989 to 2016. Ages 4 to 19.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU BOTTOM TRAWL SURV	1989	2014	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 >= 16

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 44 iterations

Log catchability residuals.
Fleet : EU BOTTOM TRAWL SURV

Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
4	**-1.83**	**-1.18**	**1.11**	0.18	0.98	0.93	0.69	-0.07	0.89	0.05	0.42	-0.6	0.13	0.61
5	**-3.06**	**-3.79**	0.69	**1.25**	**-1.07**	0.66	0.52	**1.35**	**1.36**	-0.06	0.33	0.18	-0.11	-0.19
6	-1.88	**-2.09**	**-1.61**	0.53	-0.23	0.3	-0.96	0.96	0.69	0.88	0.23	0.48	-0.05	-0.09
7	-0.99	-0.94	**-1.45**	-0.32	-0.85	0.31	-0.05	-0.02	0.61	-0.04	0.96	0.66	0.27	-0.17
8	-0.36	-0.33	**-1.39**	0.01	-0.77	-0.01	0.24	0.87	-0.29	0.48	0.67	**1.91**	0.34	0.51
9	-0.27	-0.25	**-1.28**	0.03	-1.4	0.39	-0.07	0.89	0.9	0.05	**1.17**	**1.15**	0.49	0.83
10	-0.3	-0.17	**-1.35**	-0.03	-0.55	0.37	0.83	0.25	**1.11**	-0.51	**1.1**	**1.86**	-0.17	0.55
11	-0.33	-0.4	-0.94	-0.3	-0.38	0.65	1.2	**1.09**	0.13	-0.37	-0.77	0.96	0.43	-0.29
12	-0.63	-0.69	-1.02	-0.27	-0.46	0.52	0.94	**1.46**	**1.18**	0.68	-0.3	0.11	0.15	-0.02
13	-0.23	-0.28	-0.67	-0.16	-0.07	0.29	1	0.99	**1.26**	0.08	0.36	-0.62	0.23	0.45
14	-0.38	-0.09	-0.71	-0.29	-0.14	0.05	0.36	**1.29**	**1.16**	0.43	-0.69	**1.53**	-0.42	-0.13
15	0.22	-0.11	-1.11	0.11	0.05	0.38	**1.53**	0.48	0.34	-0.84	0.95	0.04	0.25	0.48
16	-0.01	-0.21	-0.86	-0.11	-0.56	-0.35	0.85	**1.62**	-0.6	-0.09	0.39	0.04	0.18	-0.54
17	-0.21	0.24	-0.35	-0.67	-0.2	-0.58	0.06	0.76	**1.64**	-0.3	0.49	-0.42	0.02	-0.38
18	0	0.04	-0.04	0.09	0.46	0.16	0.35	0.15	-0.26	-0.7	0.16	-0.48	-0.41	-0.63

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
4	**-1.18**	-0.62	0.26	**1.18**	0.3	-0.1	-0.31	-0.63	-0.07	0.11	-0.2	-0.63	-0.43	0
5	-0.38	0.78	0.1	**1.03**	0.64	0.35	0.1	-0.32	-0.27	-0.09	-0.31	-0.67	0.09	0.88
6	-0.95	0.01	**1.03**	0.7	0.82	0.94	0.44	-0.37	-0.03	0.25	-0.08	-0.26	-0.14	0.48
7	-1.03	-0.39	0.42	0.03	0.84	0.4	0.65	0.24	-0.29	0.4	0.29	0.09	0.07	0.3
8	-0.72	-0.39	0.43	-0.27	-0.17	-0.11	0.72	-0.56	-0.85	0.37	-0.09	-0.09	-0.24	0.08
9	-0.07	-0.46	0.36	-0.39	-0.13	-0.54	0.48	-0.4	-0.85	-0.17	-0.37	-0.15	-0.21	0.25
10	-0.05	0.12	0.4	-0.76	-0.97	-0.51	0.5	-0.02	0	-1.06	0.03	-0.67	-0.42	0.42
11	0.19	-0.2	0.61	-0.7	-0.36	-0.52	0.02	0.1	-0.41	0.43	-0.5	0.03	0.28	0.35
12	-0.94	-0.14	0.55	-0.3	-0.55	-0.69	0.75	-0.42	-0.65	0.26	-0.1	-0.14	0.03	0.69
13	0.12	-0.68	0.57	-0.37	-0.14	-0.7	-1	-0.39	0.2	0.81	-0.57	-0.88	0.32	0.09
14	0.66	-0.07	-1.21	-0.22	-0.13	-0.49	0.51	-0.78	-0.82	0.75	-0.16	-0.03	-0.44	0.45
15	-0.81	-0.71	-0.8	-0.98	0.08	-1.27	-0.53	**-1.48**	0.73	**0.92**	0.49	0.69	1.31	-0.41
16	0.92	0.84	-0.58	-0.53	1.62	-1.16	-0.08	-0.71	0	0.98	-0.16	0.45	-0.38	-0.97
17	**1.12**	**1.55**	-0.01	**1.48**	-1.39	-1.96	-0.16	-0.89	-1.15	-0.53	1.23	0.29	-0.02	-0.44
18	-0.15	-0.36	-0.4	-0.02	-0.2	-0.84	0.74	-0.4	0.27	0.34	0.78	0.16	0.45	-0.54

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	-8.4124	-8.3197	-8.3488	-8.4417	-8.7741	-9.1541	-9.5634	-9.7632	-9.7752	-9.9852	-9.8687	-10.0245	-9.8091	-9.8091	-9.8091
S.E(Log q)	0.7316	1.1445	0.8396	0.6048	0.642	0.647	0.7133	0.5623	0.6454	0.5947	0.6633	0.7911	0.7291	0.8784	0.4235

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	0.97	0.269	8.49	0.71	28	0.72	-8.41
5	1.25	-0.883	7.73	0.32	28	1.44	-8.32
6	1.08	-0.439	8.17	0.51	28	0.92	-8.35
7	1.08	-0.569	8.29	0.67	28	0.66	-8.44
8	1.32	-2.043	8.34	0.61	28	0.8	-8.77
9	1.3	-2.069	8.95	0.65	28	0.79	-9.15
10	1.21	-1.464	9.58	0.64	28	0.85	-9.56
11	1.12	-1.107	9.83	0.77	28	0.63	-9.76
12	1.35	-2.676	10.11	0.7	28	0.78	-9.78
13	1.25	-2.356	10.38	0.77	28	0.69	-9.99
14	1.2	-1.721	10.22	0.74	28	0.77	-9.87
15	1.02	-0.205	10.08	0.73	28	0.83	-10.02
16	1.2	-1.582	10.31	0.71	28	0.85	-9.81
17	1.55	-3.421	11.49	0.6	28	1.15	-9.84
18	0.92	1.655	9.57	0.94	28	0.38	-9.86
1							

Terminal year survivor and F summaries :

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 2012

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	5289	0.745	0	0	1	1	0.178

Age 5 Catchability constant w.r.t. time and dependent on age
Year class = 2011

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	1708	0.63	0.614	0.97	2	1	1.159

Age 6 Catchability constant w.r.t. time and dependent on age
Year class = 2010

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	3651	0.518	0.357	0.69	3	1	0.704

Age 7 Catchability constant w.r.t. time and dependent on age
Year class = 2009

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	17480	0.394	0.181	0.46	4	1	0.172

Age 8 Catchability constant w.r.t. time and dependent on age
Year class = 2008

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	23420	0.336	0.075	0.22	5	1	0.064

Age 9 Catchability constant w.r.t. time and dependent on age
Year class = 2007

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	42950	0.299	0.079	0.26	6	1	0.041

Age 10 Catchability constant w.r.t. time and dependent on age
Year class = 2006

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	49020	0.277	0.137	0.5	7	1	0.039

Age 11 Catchability constant w.r.t. time and dependent on age
Year class = 2005

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	44769	0.249	0.114	0.46	8	1	0.034

Age 12 Catchability constant w.r.t. time and dependent on age
Year class = 2004

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	30109	0.233	0.151	0.65	9	1	0.054

Age 13 Catchability constant w.r.t. time and dependent on age
Year class = 2003

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	15990	0.218	0.11	0.51	10	1	0.027

Age 14 Catchability constant w.r.t. time and dependent on age
Year class = 2002

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	12682	0.207	0.215	1.04	11	1	0.045

Age 15 Catchability constant w.r.t. time and dependent on age
Year class = 2001

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	7664	0.202	0.162	0.8	12	1	0.025

Age 16 Catchability constant w.r.t. time and dependent on age
Year class = 2000

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	5521	0.198	0.181	0.91	13	1	0.026

Age 17 Catchability constant w.r.t. time and dependent on age
Year class = 1999

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	4020	0.199	0.156	0.78	14	1	0.049

Age 18 Catchability constant w.r.t. time and age (fixed at the value for age) 17
Year class = 1998

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	Survivors	s.e	s.e	Ratio		Weights	F
	2451	0.185	0.116	0.63	15	1	0.048

Table 12a: Main results of retrospective 2017 $XSA_{2016-2012}$

Biomass	2016	2015	2014	2013	2012
1989	220	219	218	218	216
1990	188	187	186	186	185
1991	135	134	134	134	132
1992	100	99	99	99	98
1993	68	68	68	68	67
1994	46	45	45	45	44
1995	37	36	36	36	35
1996	26	25	25	25	24
1997	25	24	24	23	22
1998	27	26	25	25	24
1999	27	27	26	26	25
2000	33	33	32	32	30
2001	34	34	33	33	31
2002	40	40	39	39	36
2003	44	44	43	42	40
2004	62	63	62	60	58
2005	78	80	79	80	78
2006	102	104	101	102	102
2007	114	115	112	112	112
2008	141	140	133	135	136
2009	144	141	137	140	141
2010	140	134	131	134	131
2011	121	115	113	114	112
2012	130	124	121	123	120
2013	133	125	122	124	
2014	144	133	130		
2015	134	124			
2016	125				

7+FemBiom	2016	2015	2014	2013	2012
1989	54	54	53	53	52
1990	51	51	50	50	49
1991	42	42	41	41	41
1992	34	34	33	33	33
1993	20	20	20	20	19
1994	9	9	9	9	9
1995	8	8	8	8	8
1996	5	5	5	5	4
1997	5	4	4	4	4
1998	6	5	5	5	5
1999	5	4	4	4	4
2000	7	7	6	6	6
2001	7	7	7	7	6
2002	8	8	8	8	7
2003	9	9	9	9	8
2004	13	13	12	12	11
2005	16	16	16	16	15
2006	21	21	20	20	19
2007	28	28	27	27	25
2008	40	41	39	39	37
2009	37	37	36	36	35
2010	34	34	33	33	33
2011	29	29	28	29	29
2012	40	39	38	38	38
2013	46	44	43	44	
2014	60	57	55		
2015	59	56			
2016	54				

FBAR	2016	2015	2014	2013	2012
1989	0.319	0.321	0.323	0.323	0.326
1990	0.484	0.486	0.489	0.489	0.493
1991	0.368	0.369	0.370	0.370	0.372
1992	0.568	0.570	0.573	0.573	0.577
1993	0.654	0.659	0.664	0.665	0.673
1994	0.459	0.462	0.466	0.467	0.473
1995	0.690	0.699	0.708	0.711	0.726
1996	0.518	0.528	0.539	0.542	0.561
1997	0.142	0.144	0.147	0.148	0.153
1998	0.084	0.085	0.087	0.088	0.090
1999	0.124	0.127	0.130	0.131	0.137
2000	0.233	0.237	0.242	0.243	0.252
2001	0.160	0.162	0.166	0.166	0.173
2002	0.187	0.190	0.194	0.195	0.201
2003	0.144	0.147	0.150	0.151	0.157
2004	0.098	0.099	0.102	0.102	0.108
2005	0.159	0.161	0.165	0.166	0.175
2006	0.075	0.075	0.077	0.079	0.083
2007	0.126	0.126	0.130	0.132	0.144
2008	0.062	0.062	0.064	0.065	0.069
2009	0.043	0.043	0.044	0.045	0.048
2010	0.058	0.058	0.061	0.061	0.064
2011	0.192	0.192	0.198	0.203	0.278
2012	0.119	0.117	0.125	0.135	0.170
2013	0.039	0.040	0.041	0.042	
2014	0.037	0.036	0.037		
2015	0.051	0.058			
2016	0.112				

REC	2016	2015	2014	2013	2012
1989	54.5	54.5	54.4	54.4	54.4
1990	42.3	42.3	42.3	42.3	42.2
1991	23.7	23.7	23.7	23.7	23.6
1992	22.0	22.0	22.0	22.0	21.9
1993	139.5	139.5	139.5	139.5	139.4
1994	154.6	153.2	151.0	150.5	146.5
1995	27.7	27.7	27.4	27.3	26.6
1996	13.1	13.0	12.8	12.8	12.6
1997	16.4	16.3	16.1	16.0	15.7
1998	15.1	15.0	14.9	14.9	14.6
1999	23.6	23.5	23.3	23.3	19.6
2000	26.9	26.8	26.5	25.7	22.9
2001	34.6	34.4	31.7	30.7	29.8
2002	58.8	63.4	63.4	62.2	59.0
2003	93.6	94.6	98.0	94.1	95.0
2004	121.6	131.2	119.6	118.0	127.3
2005	148.1	153.0	158.3	183.8	191.2
2006	251.2	239.8	221.3	220.6	240.3
2007	212.4	209.9	204.8	199.7	195.0
2008	259.5	233.5	207.6	226.2	236.8
2009	256.1	234.1	242.0	250.1	257.3
2010	188.0	172.9	175.0	178.5	139.1
2011	109.1	101.0	105.2	96.9	93.5
2012	54.5	52.1	47.2	50.7	55.1
2013	45.8	35.6	31.0	34.8	
2014	16.6	11.5	8.6		
2015	8.0	5.2			
2016	7.0				

Table 12b: Relative retrospective bias between the two last 3M beaked redfish assessments.

2017/2015 XSA				
ratios (%)	Biomass	SSB	FBAR	REC
1989	1.0%	2.6%	-1.3%	0.1%
1990	1.0%	2.2%	-1.0%	0.2%
1991	1.1%	2.2%	-0.6%	0.1%
1992	1.2%	2.3%	-0.8%	0.1%
1993	1.1%	2.2%	-1.5%	0.0%
1994	2.0%	3.5%	-1.5%	2.4%
1995	2.7%	4.3%	-2.5%	1.1%
1996	3.6%	5.3%	-3.8%	2.7%
1997	4.5%	7.4%	-3.5%	2.1%
1998	4.5%	7.0%	-3.7%	1.6%
1999	3.6%	4.8%	-5.0%	1.4%
2000	3.8%	5.9%	-3.9%	1.5%
2001	4.0%	4.8%	-3.4%	9.4%
2002	2.6%	5.1%	-3.3%	-7.2%
2003	1.5%	4.9%	-3.7%	-4.5%
2004	1.3%	5.3%	-3.3%	1.7%
2005	-0.6%	3.7%	-3.5%	-6.5%
2006	1.8%	2.7%	-2.8%	13.5%
2007	2.3%	1.6%	-3.6%	3.7%
2008	5.9%	2.1%	-3.9%	25.0%
2009	5.4%	0.3%	-2.3%	5.8%
2010	6.6%	2.8%	-4.3%	7.4%
2011	6.6%	3.5%	-3.1%	3.8%
2012	7.7%	5.9%	-4.8%	15.4%
2013	9.4%	7.3%	-5.1%	47.6%
2014	10.8%	8.7%	-0.5%	94.0%

Table 13: XSA results for 2015 assessment

Run title : REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2015

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	2001	2002
AGE														
4	0.0086	0.2981	0.056	0.0114	1.8014	0.4554	0.111	0.1399	0.0453	0.0076	0.0067	0.0035	0.0254	0.026
5	0.0157	0.0615	0.1425	0.3164	0.8139	0.3909	0.1718	0.1817	0.0147	0.0044	0.0033	0.0065	0.0147	0.0121
6	0.0846	0.1019	0.1925	0.4014	0.2755	0.2451	0.589	0.0748	0.0376	0.0125	0.0013	0.0177	0.0215	0.0235
7	0.2127	0.439	0.4576	0.8563	0.3081	0.3208	0.4396	0.2617	0.0149	0.0205	0.009	0.0358	0.0849	0.035
8	0.3004	0.7678	0.6569	1.026	0.5134	0.3496	0.5485	0.6014	0.0663	0.0148	0.021	0.1565	0.1457	0.1046
9	0.2785	0.7336	0.6126	0.7501	0.2601	0.536	0.3355	0.6481	0.2054	0.125	0.0139	0.1395	0.1741	0.1442
10	0.2419	0.5988	0.3778	0.5293	0.5379	0.5806	0.6017	0.3266	0.2572	0.0629	0.1369	0.1165	0.1039	0.1372
11	0.3012	0.4501	0.3857	0.4081	0.7723	0.7017	0.8597	0.6454	0.0999	0.0796	0.088	0.3429	0.1106	0.0951
12	0.2709	0.3456	0.3003	0.4405	0.7927	0.666	0.7072	0.8929	0.2923	0.2086	0.1477	0.2401	0.3041	0.0756
13	0.367	0.3986	0.3198	0.4233	0.9792	0.4366	0.7268	0.4989	0.2397	0.0911	0.2107	0.116	0.2312	0.4267
14	0.3586	0.5412	0.3054	0.4256	1.0051	0.4245	0.4851	0.6808	0.244	0.1657	0.0958	0.914	0.1264	0.3118
15	0.5452	0.4471	0.1756	0.5166	0.9971	0.5069	1.311	0.2365	0.0748	0.0313	0.3721	0.2012	0.1943	0.4733
16	0.5425	0.4975	0.2624	0.4716	0.7542	0.2806	0.9864	0.8334	0.0296	0.1108	0.2629	0.278	0.2626	0.2329
17	0.3935	0.7071	0.4397	0.2734	0.8396	0.2112	0.4702	0.3584	0.2402	0.0815	0.3158	0.1543	0.1949	0.3237
18	0.5011	0.596	0.6338	0.4439	1.4444	0.416	0.5887	0.2022	0.0359	0.0408	0.1618	0.2562	0.1711	0.1195
+gp	0.5011	0.596	0.6338	0.4439	1.4444	0.416	0.5887	0.2022	0.0359	0.0408	0.1618	0.2562	0.1711	0.1195
0 FBAR 6-16	0.3185	0.4837	0.3679	0.5681	0.6541	0.4589	0.6901	0.5182	0.142	0.0839	0.1236	0.2326	0.1599	0.1873

(Table 8 cont) Fishing mortality (F) at age

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	FBAR **-**
AGE															
4	0.0194	0.0088	0.0043	0.0099	0.0025	0.0012	0.0021	0.0179	0.0333	0.0216	0.0164	0.0947	0.1816	0.1784	0.1516
5	0.0403	0.0534	0.003	0.0454	0.0057	0.0062	0.0033	0.0394	0.0321	0.0209	0.04	0.1059	0.377	1.1592	0.5474
6	0.0109	0.0621	0.0101	0.1098	0.0118	0.0292	0.0185	0.0452	0.0418	0.0191	0.0501	0.0595	0.1898	0.7041	0.3178
7	0.0217	0.0696	0.0243	0.0965	0.0783	0.0486	0.0276	0.0726	0.031	0.017	0.0678	0.0337	0.0545	0.1716	0.0866
8	0.0396	0.064	0.0665	0.0771	0.0444	0.0644	0.042	0.0257	0.0286	0.0148	0.0437	0.0215	0.0232	0.0638	0.0362
9	0.084	0.0513	0.113	0.0782	0.0796	0.0579	0.0433	0.0282	0.0306	0.012	0.0299	0.0177	0.0171	0.0414	0.0254
10	0.0746	0.0672	0.1129	0.0482	0.0464	0.0498	0.0469	0.0472	0.1012	0.0104	0.0357	0.0123	0.019	0.0386	0.0233
11	0.1187	0.0557	0.1818	0.0476	0.0858	0.0505	0.0454	0.0706	0.1201	0.0416	0.02	0.0191	0.0324	0.0336	0.0284
12	0.0549	0.0806	0.2272	0.0672	0.1099	0.0492	0.0523	0.0535	0.2016	0.0989	0.0314	0.0212	0.0344	0.0538	0.0365
13	0.0601	0.0523	0.2148	0.0647	0.1168	0.0388	0.0234	0.0937	0.0918	0.2158	0.0205	0.0142	0.0306	0.0268	0.0239
14	0.4676	0.0548	0.1027	0.1189	0.1329	0.0912	0.0707	0.0664	0.1888	0.179	0.0353	0.0462	0.0369	0.0449	0.0426
15	0.0851	0.0603	0.0845	0.0583	0.2128	0.0645	0.0299	0.0255	0.5199	0.3114	0.0543	0.086	0.0956	0.0255	0.069
16	0.5703	0.4629	0.6077	0.0587	0.4629	0.1368	0.0763	0.108	0.7583	0.3901	0.0412	0.0754	0.0305	0.0264	0.0441
17	0.4322	0.4832	0.8863	0.8838	0.0477	0.0796	0.0565	0.0736	0.6839	0.1773	0.2345	0.1367	0.0413	0.0487	0.0756
18	0.216	0.1798	0.3761	0.2097	0.9883	0.0477	0.1281	0.1098	0.821	0.127	0.1245	0.0772	0.088	0.0477	0.071
+gp	0.216	0.1798	0.3761	0.2097	0.9883	0.0477	0.1281	0.1098	0.821	0.127	0.1245	0.0772	0.088	0.0477	
0 FBAR 6-16	0.1443	0.0982	0.1587	0.075	0.1256	0.0619	0.0433	0.0579	0.1922	0.1191	0.0391	0.037	0.0513	0.1119	

	(Table 9) Relative F at age														
	YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	AGE														
	4	0.027	0.6162	0.1523	0.0201	2.7539	0.9924	0.1609	0.2699	0.3189	0.0907	0.0545	0.015	0.1591	0.1388
	5	0.0493	0.1271	0.3873	0.557	1.2442	0.8517	0.249	0.3505	0.1039	0.0521	0.027	0.0277	0.0919	0.0647
	6	0.2655	0.2107	0.5234	0.7066	0.4211	0.5341	0.8536	0.1444	0.2651	0.1491	0.0106	0.076	0.1343	0.1253
	7	0.6679	0.9074	1.2439	1.5074	0.471	0.699	0.6371	0.5049	0.1052	0.2445	0.0726	0.1539	0.5307	0.1871
	8	0.9431	1.5872	1.7858	1.8061	0.7848	0.7618	0.7949	1.1604	0.4668	0.1762	0.1696	0.6727	0.9112	0.5585
	9	0.8745	1.5165	1.6652	1.3203	0.3976	1.168	0.4861	1.2505	1.4466	1.4899	0.1126	0.6	1.0886	0.7698
	10	0.7595	1.2379	1.0269	0.9318	0.8223	1.2651	0.872	0.6303	1.8114	0.7503	1.1081	0.5009	0.6495	0.7325
	11	0.9457	0.9304	1.0484	0.7183	1.1806	1.5289	1.2458	1.2454	0.704	0.9486	0.7126	1.4745	0.6917	0.5079
	12	0.8505	0.7145	0.8165	0.7755	1.2118	1.4511	1.0248	1.723	2.059	2.487	1.1954	1.0325	1.9012	0.4037
	13	1.1522	0.824	0.8692	0.7452	1.497	0.9513	1.0532	0.9627	1.6881	1.0855	1.7048	0.4989	1.446	2.2787
	14	1.126	1.1188	0.8301	0.7492	1.5365	0.9249	0.703	1.3138	1.7184	1.9752	0.775	3.93	0.7904	1.665
	15	1.7119	0.9242	0.4774	0.9093	1.5244	1.1044	1.8999	0.4565	0.5267	0.3728	3.0113	0.8651	1.2147	2.5277
	16	1.7033	1.0283	0.7133	0.8302	1.153	0.6115	1.4295	1.6081	0.2086	1.3208	2.1274	1.1953	1.6417	1.2439
	17	1.2355	1.4617	1.1952	0.4814	1.2835	0.4601	0.6814	0.6916	1.6921	0.972	2.5555	0.6635	1.2188	1.7284
	18	1.5733	1.2321	1.7228	0.7814	2.2081	0.9064	0.8531	0.3902	0.253	0.4868	1.3093	1.1015	1.0701	0.6383
	+gp	1.5733	1.2321	1.7228	0.7814	2.2081	0.9064	0.8531	0.3902	0.253	0.4868	1.3093	1.1015	1.0701	0.6383
0	REFMEAN	0.3185	0.4837	0.3679	0.5681	0.6541	0.4589	0.6901	0.5182	0.142	0.0839	0.1236	0.2326	0.1599	0.1873

	(Table 9 cont) Relative F at age															
	YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	MEAN **-**
	AGE															
	4	0.1346	0.0895	0.0274	0.1323	0.0203	0.0187	0.0478	0.3098	0.1731	0.1812	0.4189	2.5621	3.5424	1.5949	2.5665
	5	0.279	0.5432	0.0189	0.6058	0.0457	0.1008	0.0761	0.681	0.1672	0.1756	1.0223	2.8646	7.3526	10.363	6.8601
	6	0.0753	0.6321	0.0639	1.4641	0.0943	0.472	0.4271	0.7809	0.2175	0.1601	1.2827	1.61	3.7021	6.2945	3.8688
	7	0.1504	0.7084	0.1531	1.2867	0.6237	0.7847	0.6378	1.2549	0.1613	0.143	1.7349	0.9114	1.0625	1.5336	1.1692
	8	0.2744	0.651	0.4194	1.0275	0.3535	1.0404	0.9711	0.4446	0.1489	0.1244	1.1166	0.5805	0.4533	0.5707	0.5348
	9	0.5823	0.5217	0.7119	1.0422	0.6337	0.9349	0.9995	0.488	0.1594	0.1008	0.766	0.4779	0.3325	0.3704	0.3936
	10	0.5166	0.684	0.7113	0.6431	0.3691	0.8049	1.0822	0.8158	0.5267	0.0876	0.9124	0.3326	0.3706	0.3452	0.3495
	11	0.8223	0.5672	1.1455	0.6346	0.683	0.8164	1.0485	1.22	0.625	0.3493	0.5114	0.5161	0.6325	0.3003	0.483
	12	0.3804	0.8205	1.4316	0.8962	0.8751	0.7944	1.207	0.9242	1.0492	0.8301	0.8039	0.5721	0.67	0.4813	0.5745
	13	0.4163	0.5321	1.3538	0.8618	0.9296	0.6265	0.5412	1.6183	0.4778	1.8119	0.5248	0.3845	0.5969	0.2393	0.4069
	14	3.2403	0.5582	0.6472	1.5845	1.058	1.4737	1.6335	1.1472	0.9826	1.5032	0.9038	1.2485	0.7189	0.4012	0.7895
	15	0.5899	0.6136	0.5328	0.777	1.6945	1.0416	0.6894	0.4406	2.7057	2.6147	1.3893	2.3262	1.8653	0.2279	1.4731
	16	3.9518	4.7112	3.8296	0.7824	3.6856	2.2105	1.7627	1.8655	3.9459	3.275	1.0541	2.0401	0.5953	0.2356	0.957
	17	2.9948	4.9181	5.5853	11.7806	0.3794	1.2854	1.3043	1.2724	3.559	1.4882	5.9994	3.6967	0.8058	0.4355	1.646
	18	1.497	1.8297	2.3698	2.7948	7.868	0.7705	2.9585	1.8976	4.2724	1.0663	3.1842	2.0887	1.7161	0.4268	1.4105
	+gp	1.497	1.8297	2.3698	2.7948	7.868	0.7705	2.9585	1.8976	4.2724	1.0663	3.1842	2.0887	1.7161	0.4268	
0	REFMEAN	0.1443	0.0982	0.1587	0.075	0.1256	0.0619	0.0433	0.0579	0.1922	0.1191	0.0391	0.037	0.0513	0.1119	

(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	2001	2002
AGE														
4	54492	42343	23712	21977	139475	154612	27714	13146	16436	15110	23642	26942	34648	58806
5	71357	48884	28438	20286	19660	20832	88718	22442	10342	14214	13568	21249	24293	30563
6	102281	63561	41594	22315	13377	7883	12751	67602	16933	9221	12805	12236	19103	21661
7	126054	85042	51938	31045	13515	9190	5582	6402	56759	14756	8240	11571	10877	16918
8	97458	92201	49610	29739	11931	8986	6033	3254	4459	50597	13081	7389	10102	9041
9	62740	65303	38712	23273	9645	6461	5732	3154	1614	3776	45111	11590	5718	7901
10	47537	42969	28372	18984	9947	6729	3420	3709	1493	1189	3015	40254	9121	4347
11	35539	33771	21363	17595	10117	5256	3407	1696	2421	1044	1010	2379	32417	7439
12	27525	23794	19482	13144	10586	4229	2358	1305	805	1982	873	837	1528	26261
13	21787	18996	15238	13055	7656	4336	1966	1052	483	544	1456	681	596	1020
14	20522	13658	11538	10014	7736	2602	2535	860	578	344	449	1067	549	428
15	13004	12973	7193	7692	5920	2562	1540	1412	394	410	264	369	387	438
16	7444	6821	7507	5460	4152	1976	1396	376	1009	331	359	165	273	288
17	6857	3915	3753	5225	3083	1767	1351	471	148	886	268	250	113	190
18	5252	4186	1747	2188	3596	1205	1295	764	298	105	739	177	194	84
+gp	13283	10624	7360	5053	2058	1696	2912	1656	2263	1365	1033	2589	407	503
0 TOTAL	713132	569041	357557	247045	272455	240321	168711	129299	116434	115873	125912	139745	150326	185889

(Table 10 cont)	Stock number at age (start of year)		Numbers*10**-3													
YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	GMST 89-**	AMST 89-**
AGE																	
4	93556	121638	148092	251164	212374	259513	256146	187976	109149	54488	45820	16625	7975	6987	0	59778	92677
5	51845	83025	109099	133418	166697	141997	173755	171345	123765	93173	47058	39187	13147	6017	5289	47887	68047
6	27321	45060	71220	98421	85459	111100	94591	116088	110417	105768	80523	39308	30644	8159	1708	38652	54177
7	19145	24454	38317	63793	59111	56610	72329	62245	74378	93453	91576	66579	32198	22933	3651	31388	44995
8	14781	16951	20639	33838	52411	49456	48795	47163	38801	63634	81079	74392	55963	27589	17480	24109	35993
9	7369	12855	14388	17473	28347	45364	41958	31361	30811	33276	55331	67476	63300	49474	23420	16960	26028
10	6190	6130	11050	11628	14621	23687	38739	26934	20437	26370	29016	46684	57633	56308	42950	11950	18560
11	3429	5198	5186	8932	10026	12630	20391	24779	17222	16299	23030	24341	40089	51167	49020	8547	13343
12	6121	2756	4449	3913	7706	8326	10865	13062	15477	13478	13798	19625	20761	35116	44769	5990	9780
13	22032	5242	2300	3207	3310	6247	7172	6912	8300	11165	10775	11624	16704	18151	30109	4109	7198
14	602	18773	4502	1679	2720	2665	5437	4696	4219	6682	7940	9177	9963	14659	15990	2898	5460
15	283	341	16080	3676	1349	2155	2201	3396	2946	3083	4930	6663	7618	8689	12682	1940	3910
16	247	235	291	13370	3138	987	1828	1432	2219	1546	1992	4059	5315	6264	7664	1287	2650
17	207	126	134	143	11408	1787	779	1135	862	917	923	1662	3273	4665	5521	807	1860
18	124	121	70	50	54	9842	1493	493	707	384	678	635	1260	2841	4020	527	1403
+gp	1436	2181	281	621	491	10533	8662	6729	2846	21644	3136	12303	6831	3808	5736		
0 TOTAL	254688	345088	446099	645326	659222	742899	785143	705747	562555	545359	497606	440341	372674	322828	270012		

(Table 11) Spawning stock number at age (spawning time)		Numbers*10**-3												
YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE														
4	270	164	70	44	120	296	82	39	32	45	94	347	789	1339
5	1343	772	390	216	183	160	781	176	92	113	135	485	818	1000
6	4334	2877	1625	836	506	353	434	2133	385	256	305	436	832	987
7	10204	7738	4520	2559	1086	835	583	560	3993	716	498	813	772	1222
8	12081	13333	7751	4620	1772	1335	985	849	1043	10428	1308	941	1248	1050
9	10469	12462	8557	5262	2090	1289	1273	972	507	979	8314	2126	1163	1441
10	9621	10199	8056	5614	2807	1797	1009	1301	511	365	642	9811	2620	1395
11	10153	10632	7418	6133	3104	1523	1095	636	941	402	384	840	11284	2468
12	10314	9552	8170	5073	3420	1245	793	495	325	810	322	319	540	10643
13	9717	8999	7485	5822	2760	1396	707	439	208	216	636	304	288	378
14	9694	6864	6143	4935	3264	1000	1052	367	260	139	172	379	230	203
15	6582	7090	4165	3976	2549	976	605	637	176	165	109	158	172	209
16	3833	3889	4762	4298	2975	1338	676	184	501	142	170	76	122	131
17	3902	2272	2304	3392	1870	1034	752	253	78	438	145	130	55	83
18	2908	2419	1132	1512	2269	743	766	438	148	46	343	84	91	42
+gp	9545	7627	5261	3590	1299	1152	1987	1141	1495	876	648	1683	239	319

(Table 11 cont) Spawning stock number at age (spawning time)		Numbers*10**-3												
YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
AGE														
4	2224	2653	4406	8021	5964	6283	3969	2909	1724	1023	679	163	47	48
5	1692	2624	4761	5922	7262	5223	5720	4797	3911	2855	1345	922	253	114
6	1381	2180	4589	5953	6532	9769	9605	10531	8171	6064	4521	1973	1407	291
7	1555	2292	4325	8415	10081	9846	13700	9709	11165	10718	14321	10112	4262	1705
8	1812	2677	3951	7907	15076	14301	15496	15544	12495	17305	22850	20489	13576	3921
9	1351	2870	3890	6356	12211	19172	17009	12516	12750	13857	25382	30050	23391	12768
10	1856	1778	3683	5676	8367	13973	19811	12734	10176	13408	17567	27118	30142	22776
11	1331	2249	2343	5270	6391	8686	12298	14485	9457	9280	13824	14324	21777	24400
12	2817	1418	2189	2401	5047	5660	6329	7646	9439	8777	9255	12767	12426	18765
13	10506	2450	1252	2051	2303	4911	5103	4572	5025	7018	7574	7727	10150	10044
14	283	10383	2454	1201	1952	2000	3676	3267	2823	4656	5449	6392	6543	9288
15	179	227	10821	2584	933	1461	1457	2426	2059	2114	3568	4424	5302	5763
16	135	143	151	7393	1596	617	1184	1022	1478	1055	1496	2833	3961	4552
17	107	71	74	88	6798	1252	510	951	691	798	725	1110	2333	3328
18	78	83	52	36	38	7246	1161	421	519	304	472	456	934	2258
+gp	868	1418	190	461	324	7078	5380	5233	2061	17351	2465	9129	5316	2796

(Table 12) Stock biomass at age (start of year)	Tonnes													
YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE														
4	5449	4107	2585	2110	9205	13915	2827	1038	1479	1345	2057	2613	2945	5939
5	11702	8359	3839	3469	3067	2708	10025	3097	1313	1962	1642	2805	3401	4034
6	20968	13475	8901	4641	2836	1782	2767	9532	3217	1669	2254	2129	3419	3986
7	31261	22196	14335	9065	3879	2536	1608	1728	9876	3379	1837	2708	2589	3840
8	27678	27568	16719	10528	4355	3127	2154	1067	1583	11233	3401	2106	3000	2550
9	19888	21615	14904	9216	3810	2552	2322	1211	655	1401	11097	3813	1875	2552
10	16591	15512	13193	8581	4317	3122	1560	1643	696	502	974	11955	3503	1695
11	15317	14961	11002	9238	5190	2591	1751	814	1222	512	478	994	11022	3035
12	14065	12468	11086	7505	5865	2241	1287	696	461	1090	492	442	788	10452
13	12266	11055	9387	8290	4777	2380	1243	610	294	339	747	455	356	572
14	12026	8222	7488	6810	5314	1751	1780	516	359	236	248	602	364	255
15	8206	8458	5035	5415	4227	1688	1118	917	269	293	143	183	259	275
16	4787	4557	5848	4406	3617	1421	1134	262	753	268	198	111	168	207
17	4841	2862	2867	4018	2630	1442	1110	356	116	737	172	179	87	122
18	3692	3044	1387	1923	3118	1026	1125	606	226	77	454	127	165	75
+gp	11689	9774	6565	4714	2266	1546	3107	1583	2111	1506	791	1942	411	479
0 TOTALBIO	220427	188234	135140	99929	68473	45831	36917	25677	24631	26547	26985	33165	34353	40070

(Table 12 cont) Stock biomass at age (start of year)	Tonnes													
YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
AGE														
4	7110	11434	13624	22102	23149	26211	29969	22181	15063	6539	5223	2128	965	803
5	5651	9963	12983	15210	20004	18460	23109	25873	19307	14814	7671	6427	2209	975
6	4399	7345	11823	15452	11708	18665	16743	21128	20869	20519	16105	8608	6466	1673
7	4154	5404	8200	13715	12118	12341	13742	13632	15991	21027	22619	18176	9048	6054
8	3902	4712	5635	8967	13103	13600	11076	12404	11369	16036	23026	23062	17405	8718
9	2365	4409	4877	5888	8901	14743	10909	9095	9551	9850	18536	23279	22661	17316
10	2197	2317	4188	4663	5805	8740	12358	8754	6417	9230	10533	19280	23457	21679
11	1416	2308	2380	3850	4582	5242	8075	9019	6252	5688	8890	9469	16517	21081
12	2828	1372	2140	1679	4007	3647	3542	5055	6377	5459	5781	8262	9280	15240
13	7733	2899	1063	1578	1794	2761	3894	3159	2797	4991	5129	5719	7166	8295
14	336	7997	2661	895	1466	1311	2371	2118	1886	2826	3724	4790	5310	6802
15	165	217	8072	2161	705	1222	1048	2112	1214	1464	2268	3511	3459	4796
16	157	161	207	5642	1252	597	916	755	970	750	954	2046	2849	4078
17	105	69	97	79	5579	1056	526	537	502	544	488	979	1757	3009
18	86	92	64	42	39	4409	1220	255	345	169	378	366	686	2003
+gp	1083	1647	244	480	272	8100	4608	3479	1637	10497	1718	7431	4850	2761
0 TOTALBIO	43690	62346	78257	102403	114482	141105	144107	139556	120545	130403	133043	143534	134084	125283

(Table 13) Spawning stock biomass at age (spawning time) Tonnes

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE														
4	27	16	8	4	8	27	8	3	3	4	8	34	67	135
5	220	132	53	37	29	21	88	24	12	16	16	64	115	132
6	888	610	348	174	107	80	94	301	73	46	54	76	149	182
7	2531	2020	1248	747	312	231	168	151	695	164	111	190	184	277
8	3431	3986	2612	1636	647	465	352	279	370	2315	340	268	371	296
9	3319	4125	3294	2084	825	509	516	373	206	363	2045	700	382	466
10	3358	3682	3746	2538	1218	834	460	576	238	154	207	2914	1006	544
11	4376	4710	3820	3220	1592	751	563	305	475	197	182	351	3837	1007
12	5270	5005	4649	2897	1895	660	433	264	186	446	181	169	279	4236
13	5471	5237	4611	3697	1722	766	447	255	127	135	326	203	172	212
14	5680	4132	3987	3356	2243	673	739	220	161	96	95	214	152	121
15	4154	4623	2916	2799	1820	643	439	413	120	118	59	78	115	132
16	2464	2598	3709	3469	2591	962	549	129	374	115	94	51	75	94
17	2755	1661	1760	2609	1595	844	618	191	62	365	93	93	43	54
18	2044	1759	899	1329	1968	633	665	348	112	33	211	61	77	38
+gp	8400	7017	4693	3349	1430	1051	2120	1091	1395	966	497	1263	242	304
0 TOTSPBIO	54389	51312	42352	33943	20001	9149	8260	4923	4609	5532	4520	6728	7264	8228

(Table 13 cont) Spawning stock biomass at age (spawning time) Tonnes

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
AGE														
4	169	249	405	706	650	635	464	343	238	123	77	21	6	6
5	184	315	567	675	871	679	761	724	610	454	219	151	43	19
6	222	355	762	935	895	1641	1700	1917	1544	1176	904	432	297	60
7	337	506	926	1809	2067	2146	2603	2126	2401	2412	3537	2760	1197	450
8	478	744	1079	2095	3769	3933	3518	4088	3661	4361	6489	6352	4222	1239
9	434	985	1319	2142	3834	6231	4422	3630	3953	4102	8503	10367	8374	4469
10	659	672	1396	2276	3322	5156	6320	4139	3195	4693	6377	11200	12268	8769
11	550	998	1075	2271	2921	3604	4870	5273	3433	3239	5336	5572	8972	10053
12	1301	706	1053	1030	2624	2479	2063	2959	3889	3555	3878	5375	5554	8144
13	3688	1355	578	1009	1248	2171	2771	2089	1693	3137	3605	3802	4354	4590
14	158	4423	1450	640	1052	984	1603	1473	1262	1970	2556	3337	3488	4310
15	105	144	5432	1520	488	829	693	1509	848	1004	1641	2331	2407	3181
16	86	98	107	3120	637	373	593	538	646	511	717	1428	2123	2963
17	55	39	54	48	3324	740	345	450	402	473	383	654	1253	2147
18	54	63	47	30	28	3246	948	218	253	134	263	263	508	1592
+gp	655	1071	165	356	179	5443	2862	2705	1185	8415	1351	5514	3774	2027
0 TOTSPBIO	9135	12723	16414	20663	27909	40291	36537	34182	29213	39758	45837	59558	58841	54017

(Table 16) Summary (without SOP correction)							
Terminal Fs derived using XSA (Without F shrinkage)							
	RECRUITS	TOTALBIO	TOTALABUNDANC	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 6-16
	Age 4						
1989	54492	220427	713132	54389	58086	1.068	0.3185
1990	42343	188234	569041	51312	80223	1.5634	0.4837
1991	23712	135140	357557	42352	48500	1.1452	0.3679
1992	21977	99929	247045	33943	43300	1.2757	0.5681
1993	139475	68473	272455	20001	43100	2.1549	0.6541
1994	154612	45831	240321	9149	17664	1.9307	0.4589
1995	27714	36917	168711	8260	13879	1.6803	0.6901
1996	13146	25677	129299	4923	6101	1.2394	0.5182
1997	16436	24631	116434	4609	1408	0.3055	0.142
1998	15110	26547	115873	5532	1011	0.1828	0.0839
1999	23642	26985	125912	4520	1095	0.2422	0.1236
2000	26942	33165	139745	6728	3841	0.5709	0.2326
2001	34648	34353	150326	7264	3327	0.458	0.1599
2002	58806	40070	185889	8228	2964	0.3602	0.1873
2003	93556	43690	254688	9135	2273	0.2488	0.1443
2004	121638	62346	345088	12723	3260	0.2562	0.0982
2005	148092	78257	446099	16414	4039	0.2461	0.1587
2006	251164	102403	645326	20663	5936	0.2873	0.075
2007	212374	114482	659222	27909	5131	0.1838	0.1256
2008	259513	141105	742899	40291	4274	0.1061	0.0619
2009	256146	144107	785143	36537	3639	0.0996	0.0433
2010	187976	139556	705747	34182	5235	0.1532	0.0579
2011	109149	120545	562555	29213	8904	0.3048	0.1922
2012	54488	130403	545359	39758	6736	0.1694	0.1191
2013	45820	133043	497606	45837	5133	0.112	0.0391
2014	16625	143534	440341	59558	4507	0.0757	0.037
2015	7975	134084	372674	58841	5169	0.0878	0.0513
2016	6987	125283	322828	54017	6147	0.1138	0.1119
2017			270012				
Arith.							
Mean	86591	93543		26653	14103	0.5936	0.2251
0 Units							

Table 14: Yield per recruit parameters for 3M beaked redfish short term projections (2016-2018)

Age	mean weights 2006-2016			% mat females	PR	Ref. M
	stock	catch	stock mat f	2006-2016	2006-2016	2015-2016
4	0.022	0.118	0.127	0.018	0.842	0.10
5	0.052	0.146	0.171	0.032	3.416	0.10
6	0.083	0.179	0.215	0.070	2.110	0.10
7	0.115	0.230	0.265	0.148	0.747	0.10
8	0.147	0.276	0.299	0.277	0.401	0.10
9	0.185	0.328	0.337	0.406	0.331	0.10
10	0.232	0.381	0.376	0.534	0.335	0.10
11	0.277	0.413	0.380	0.596	0.385	0.10
12	0.320	0.442	0.419	0.631	0.474	0.10
13	0.367	0.476	0.468	0.677	0.424	0.10
14	0.398	0.497	0.469	0.703	0.606	0.10
15	0.422	0.532	0.492	0.717	0.697	0.10
16	0.465	0.531	0.492	0.689	0.875	0.10
17	0.483	0.595	0.568	0.754	1.047	0.10
18	0.514	0.577	0.516	0.793	1.078	0.10
19	0.504	0.743	0.556	0.771	1.078	0.10
20	0.504	0.743	0.556	0.771	1.078	0.10
21	0.504	0.743	0.556	0.771	1.078	0.10
22	0.504	0.743	0.556	0.771	1.078	0.10
23	0.504	0.743	0.556	0.771	1.078	0.10
24	0.504	0.743	0.556	0.771	1.078	0.10
25	0.504	0.743	0.556	0.771	1.078	0.10
26	0.504	0.743	0.556	0.771	1.078	0.10
27	0.504	0.743	0.556	0.771	1.078	0.10
28	0.504	0.743	0.556	0.771	1.078	0.10
29	0.504	0.743	0.556	0.771	1.078	0.10
30	0.504	0.743	0.556	0.771	1.078	0.10

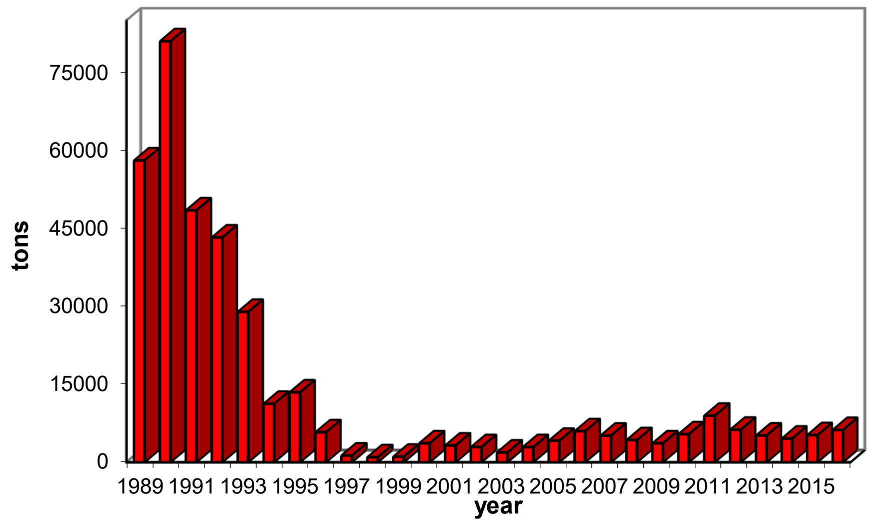


Fig. 1a: Beaked redfish commercial catch.

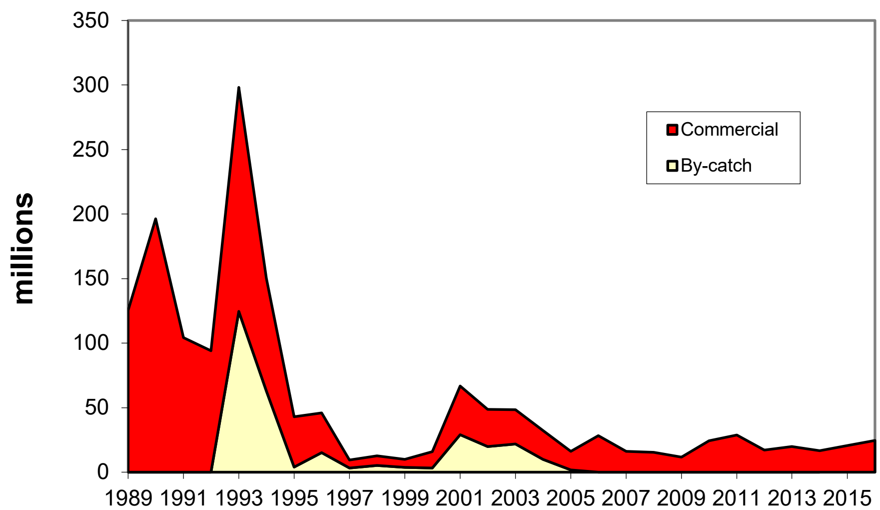


Fig. 1b: Beaked redfish commercial catch and by-catch in numbers

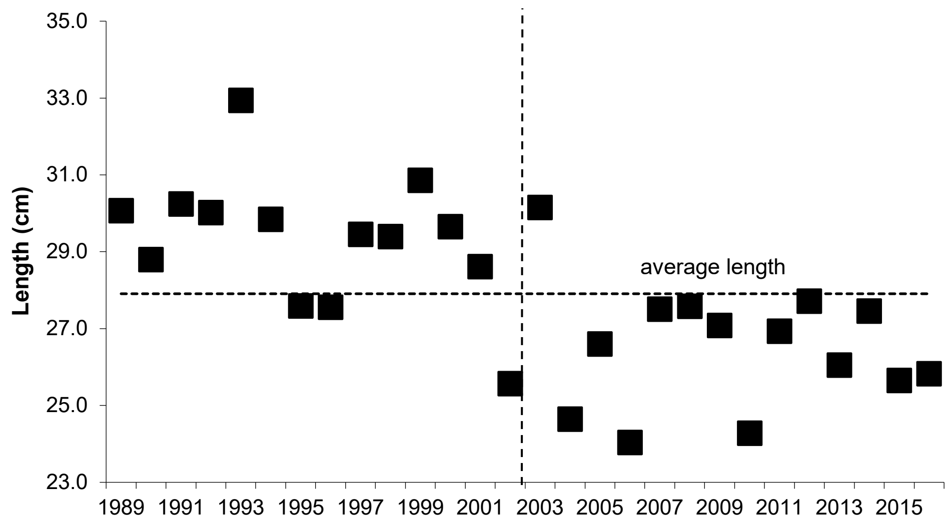


Fig. 2: Mean length of the commercial catch, 1989-2016

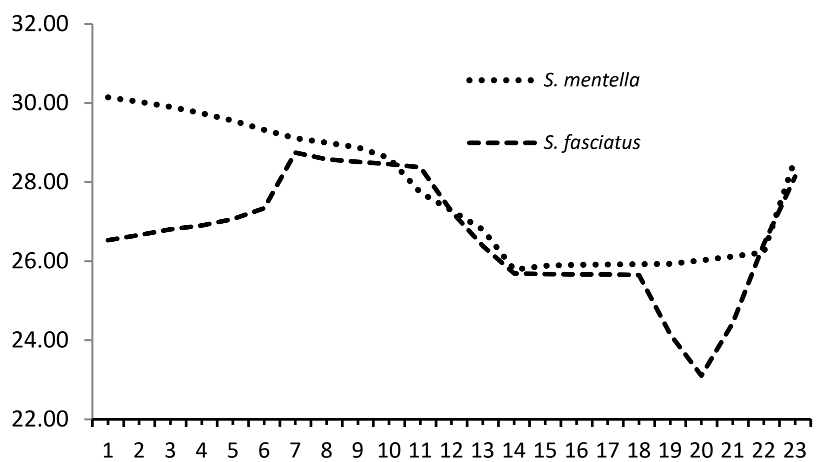


Fig. 4a: 3M *S. mentella* and *S. fasciatus* mean length at maturity 1994-2016

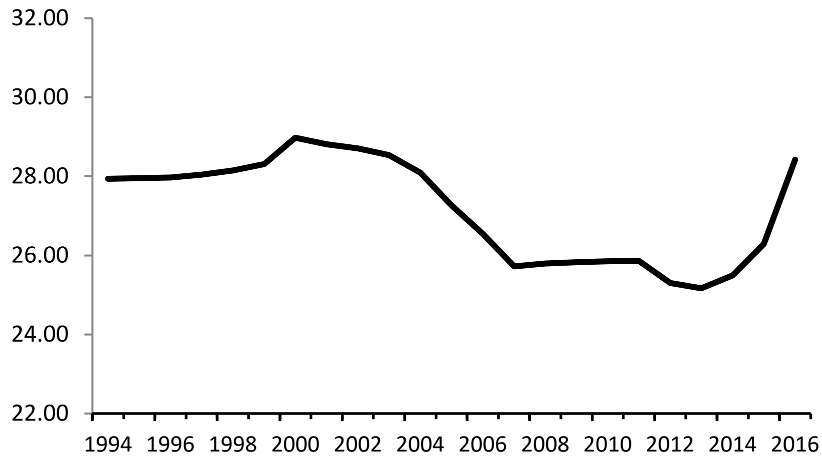


Fig. 4b: 3M beaked redfish mean length at maturity 1994-2016

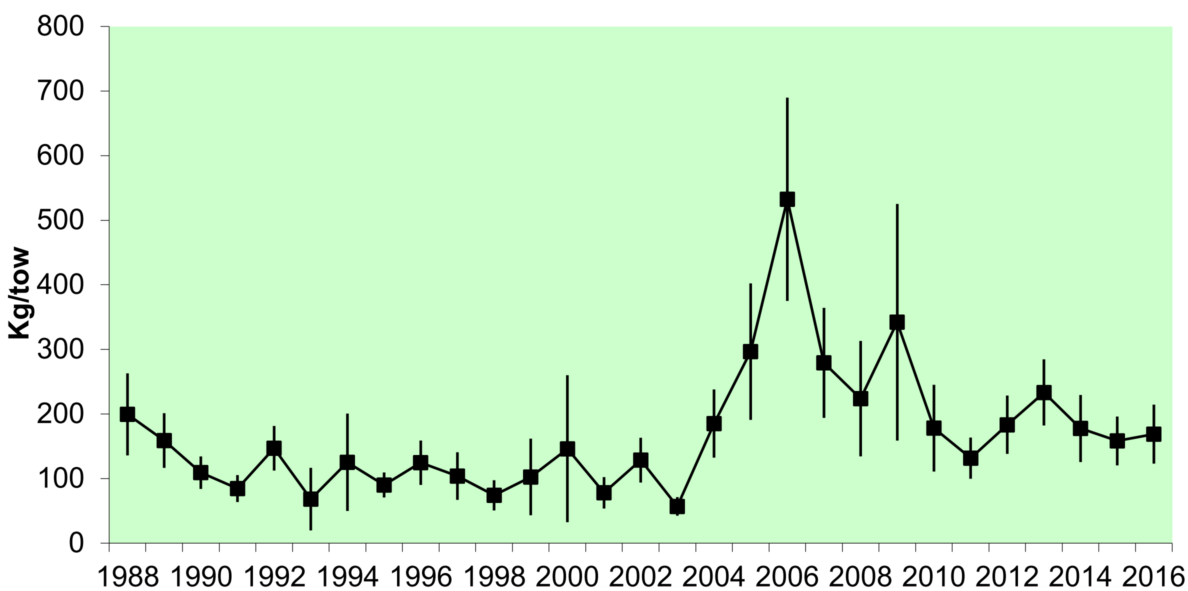


Fig. 5: mean catch per tow for 3M beaked refish (EU survey, 1988-2016) with associated +/- 1.96 se

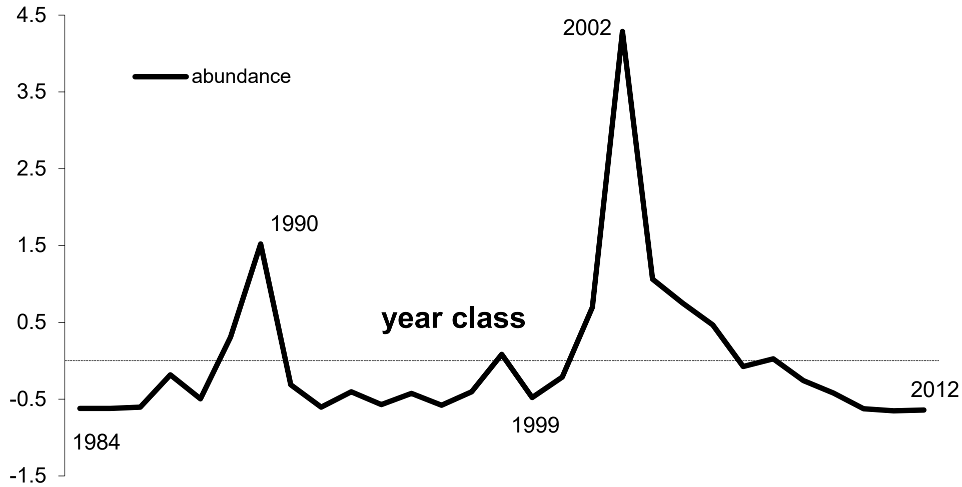


Fig 6a : Standardized *year class strength at age 4* given by EU surveys, 1988-2016

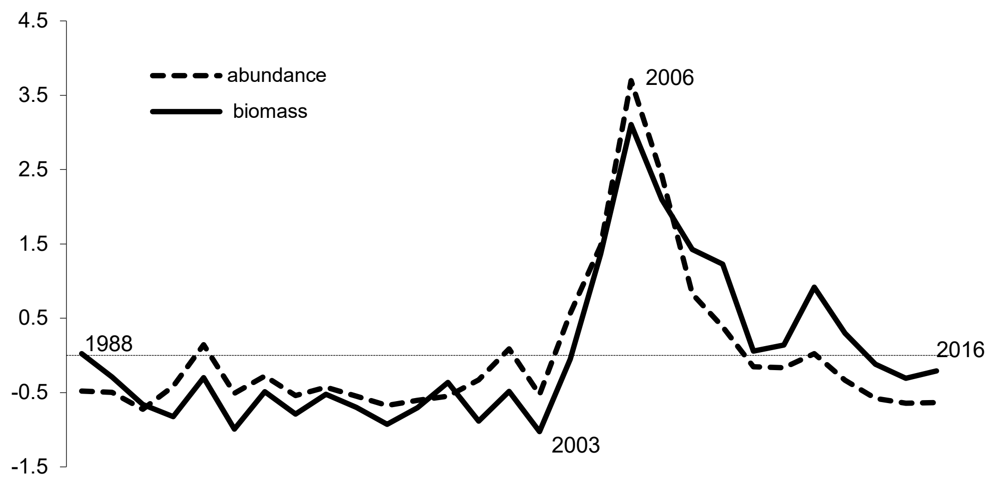


Fig 6b: Standardized *total abundance and biomass* given by EU surveys, 1988-2016

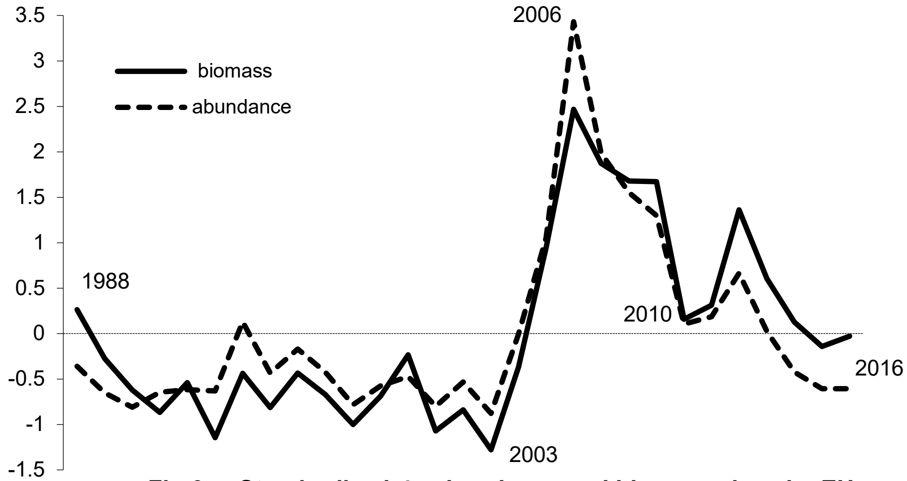


Fig 6c : Standardized *4+ abundance and biomass* given by EU surveys, 1988-2016

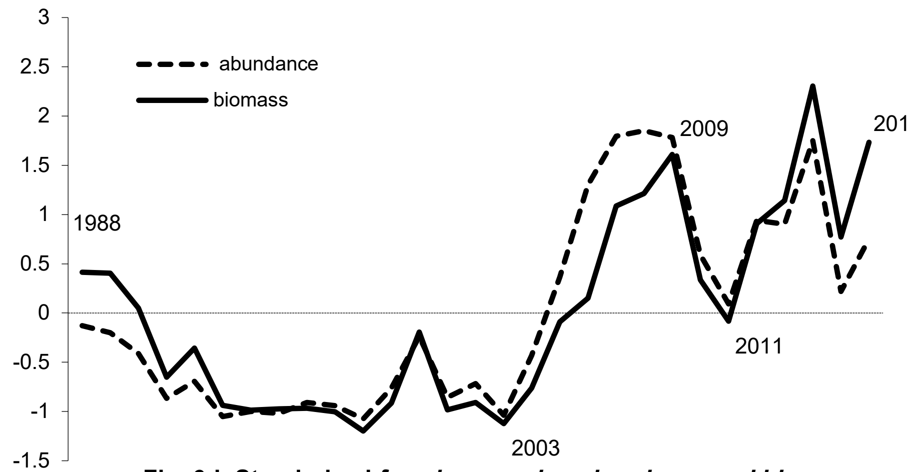


Fig 6d: Standarized *female spawning abundance and biomass* given by EU surveys, 1988-2016

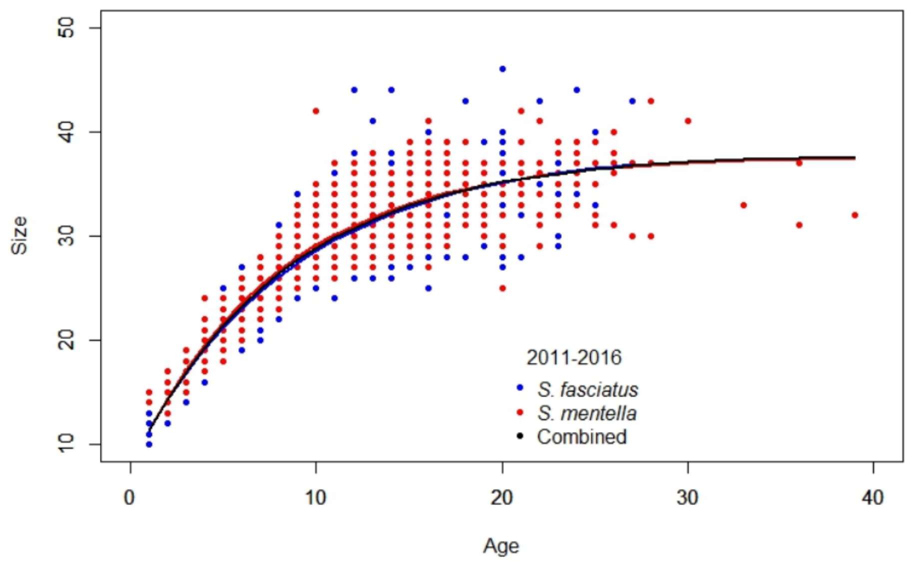


Fig. 7a: Von Bertalanfy age-length growth for 3M beaked redfish and by species (both sexes, 2011-2016)

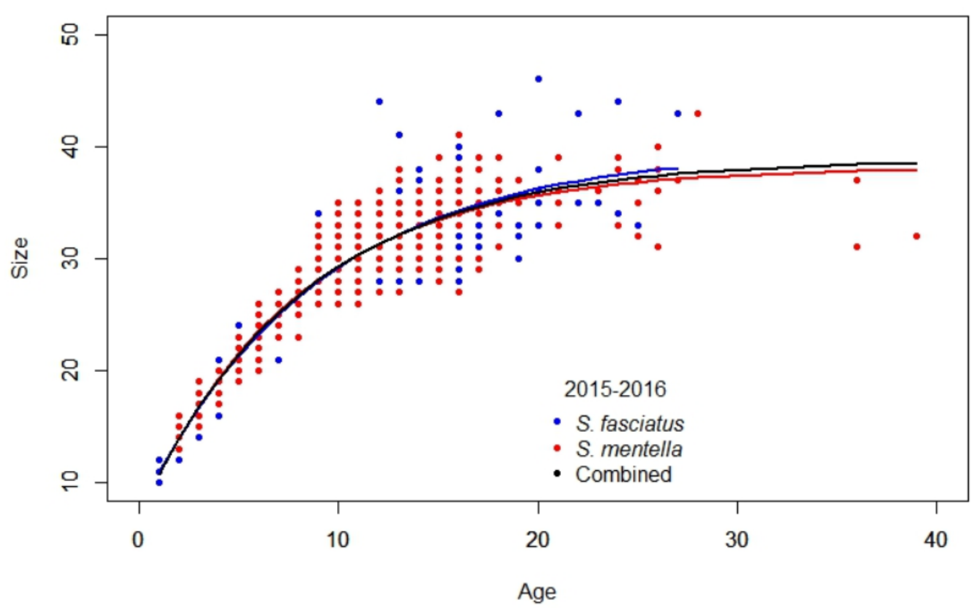


Fig. 7b: Von Bertalanfy age-length growth for 3M beaked redfish and by species (both sexes, 2015-2016)

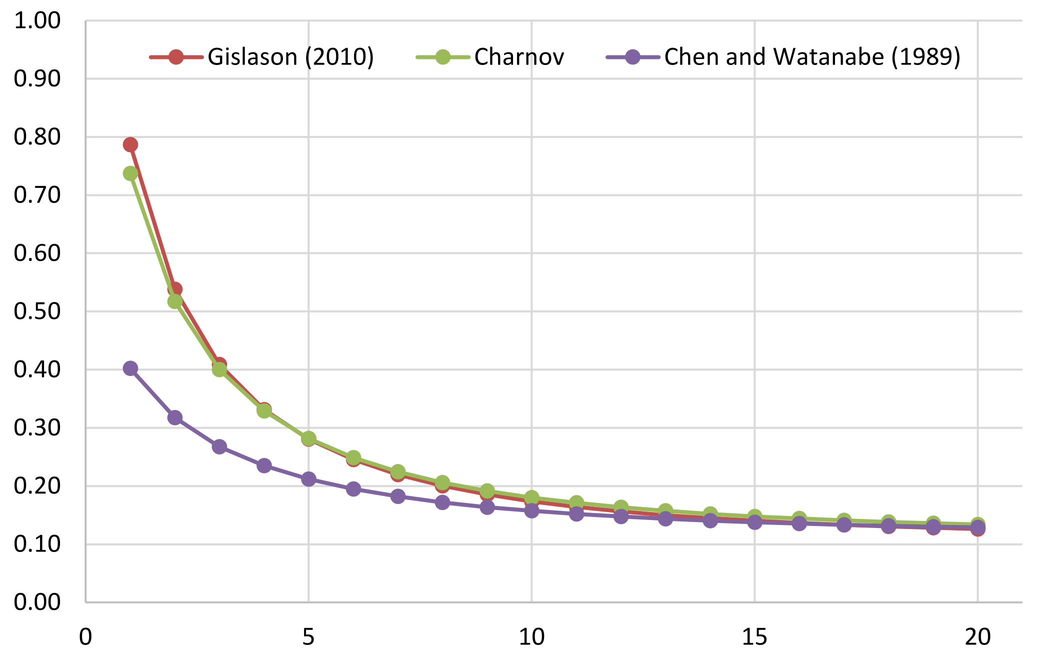


Fig. 8a: 3M beaked redfish size dependent M (2011-2016)

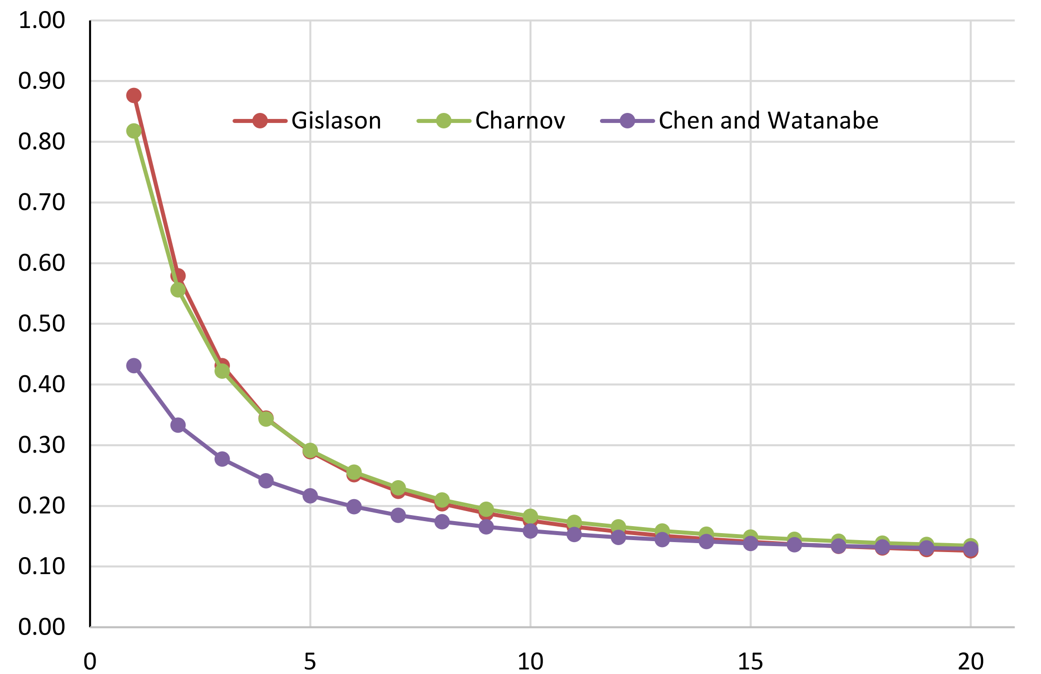


Fig. 8b: 3M beaked redfish size dependent M (2015-2016)

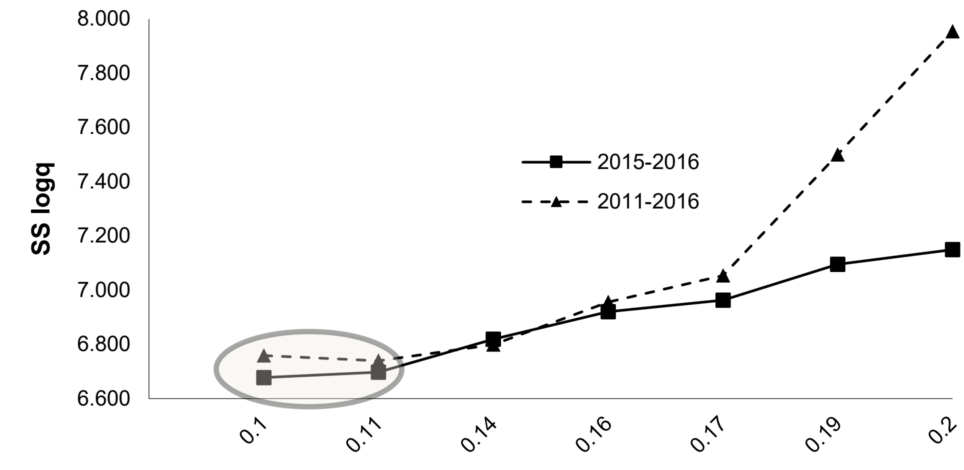


Fig 9a: XSA_{2017} $SS_{2015\text{-}2016}$ log q residuals for a set of 2015-2016 and 2011-2016 "biological" M candidates

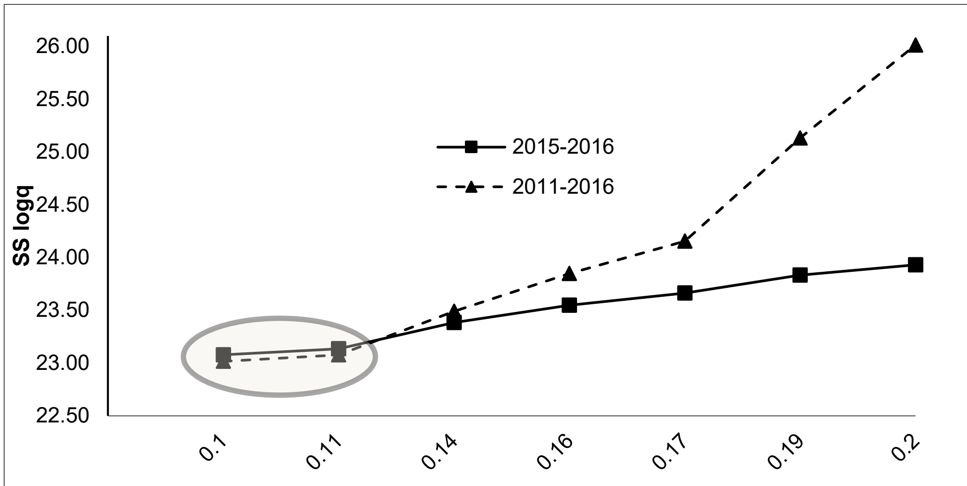


Fig 9b: XSA_{2017} $SS_{2011\text{-}2016}$ log q residuals for a set of 2015-2016 and 2011-2016 "biological" M candidates

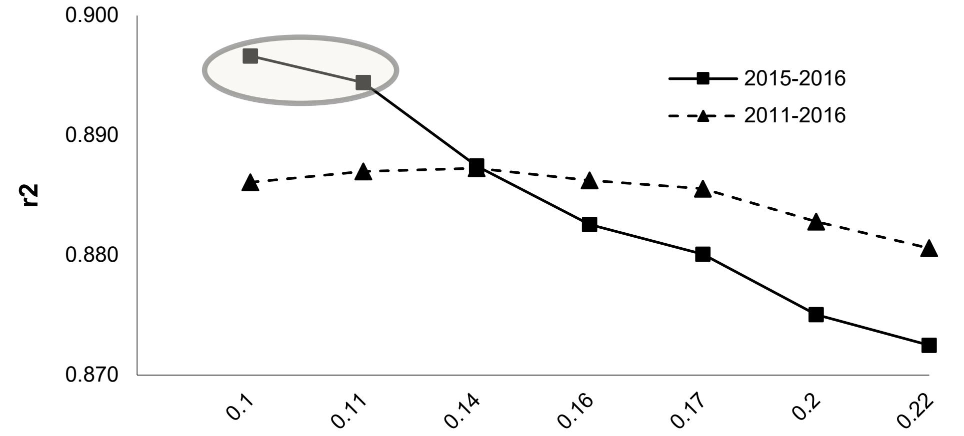
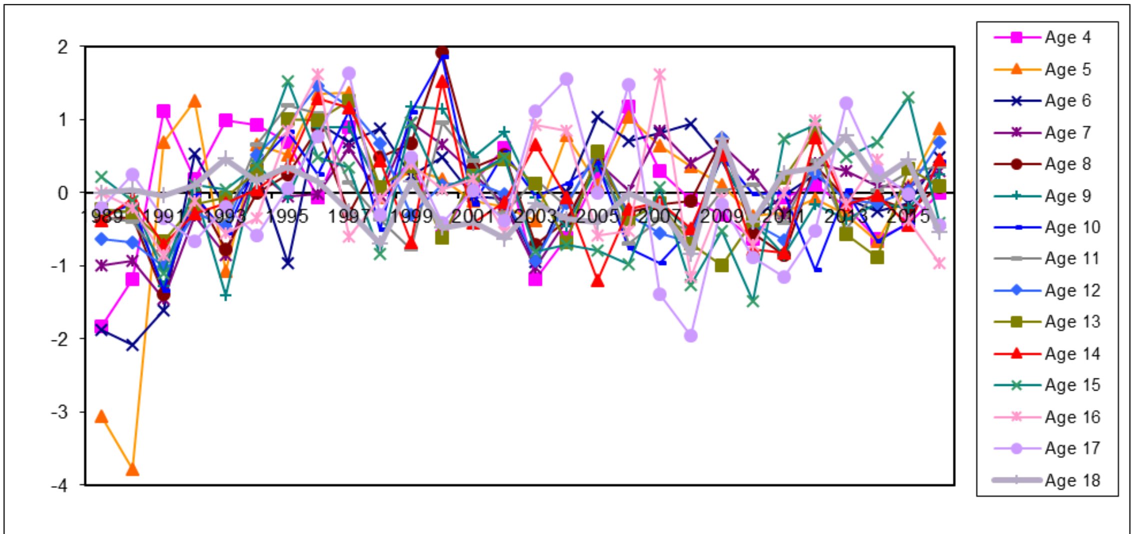


Fig 9c: 2011-2016 correlation between XSA_{2017} versus Survey 4+abundance for a set of 2015-2016 and 2011-2016 "biological" M candidates



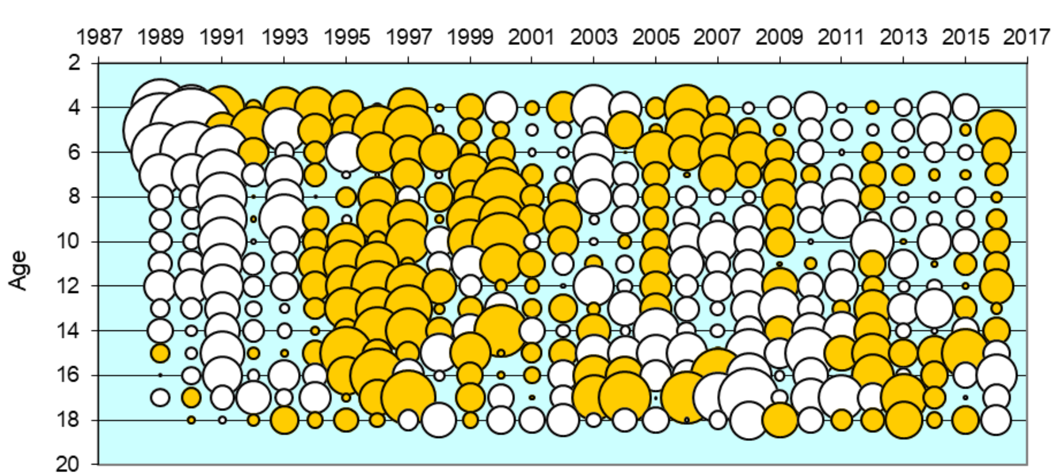


Fig 10: EU survey log q residuals 1989-2016 (XSA 2017 $M_{2015\text{-}2016}$ 0.10)

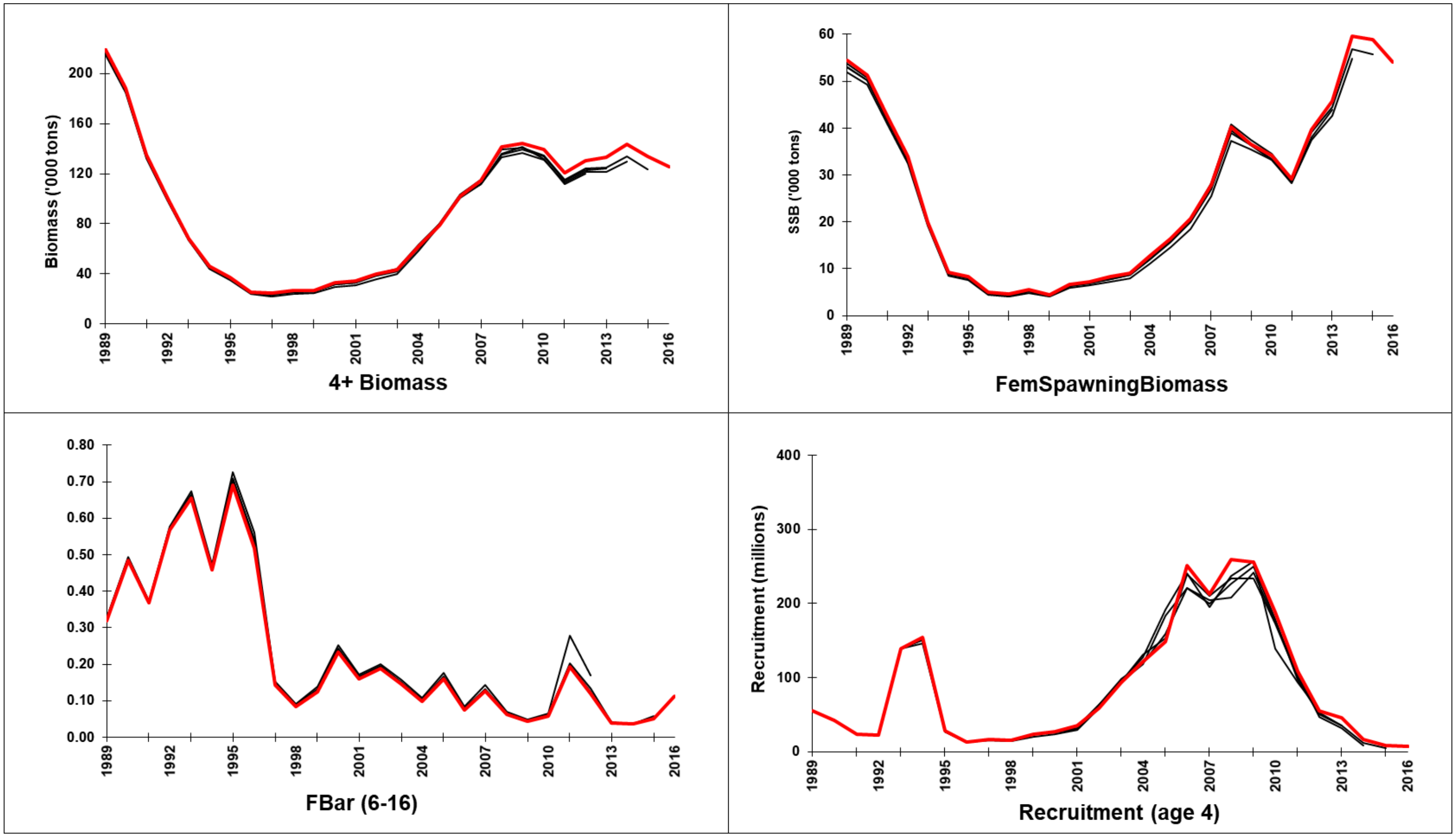


Fig. 11: Main results of retrospective 2017 XSA$_{2016\text{-}2012}$

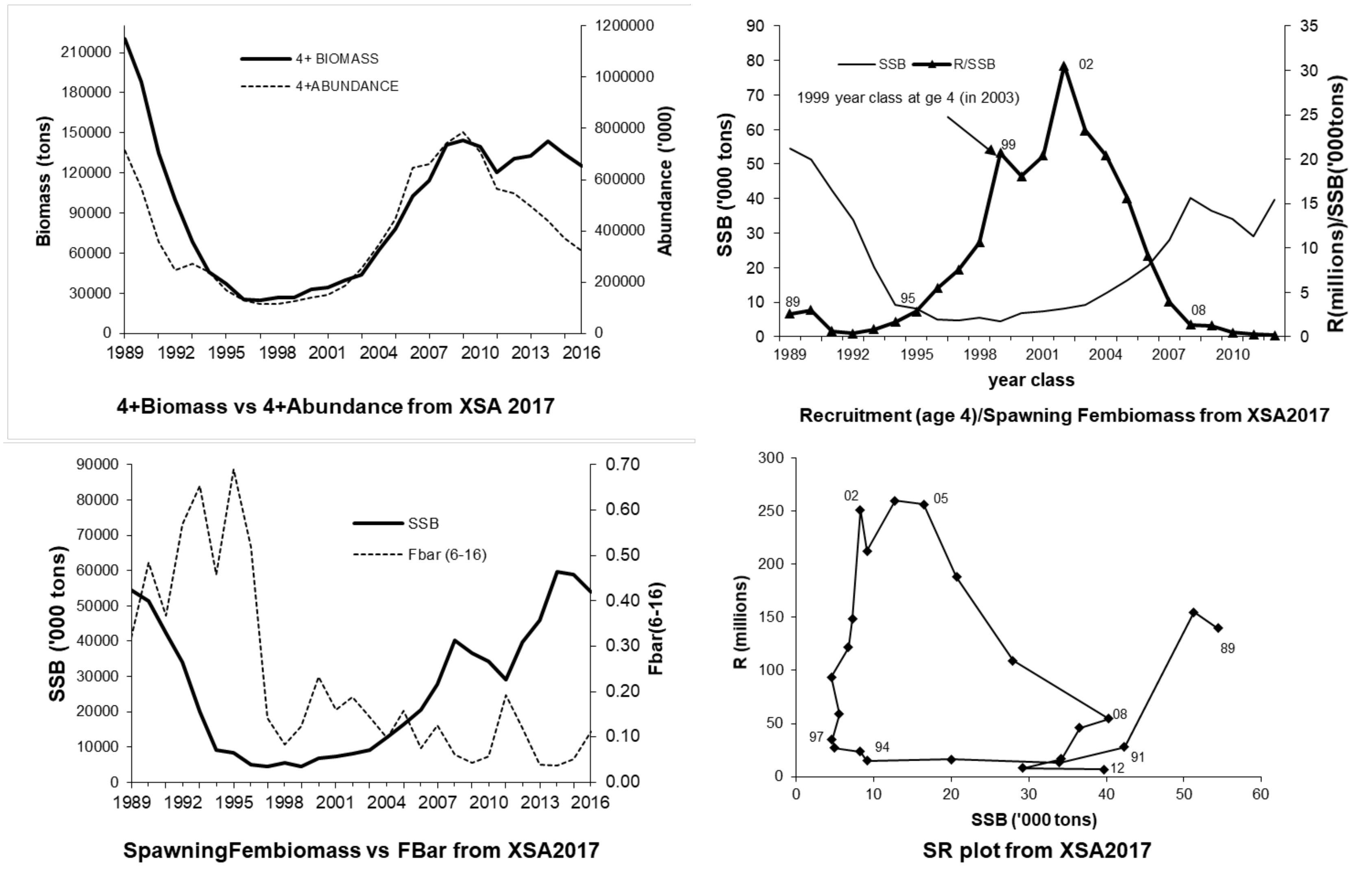


Fig. 12a: XSA results for 2017 assessment.