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A Comparative Assessment of Redfish in NAFO Division 3M Based on Beaked Redfish (*S. mentella and S. fasciatus*) Commercial, By-catch and Survey Data

by

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Abstract

The present assessment evaluates the status of the 3M beaked redfish stock, regarded as a management unit composed of two populations from two very similar species (*Sebastes mentella* and *Sebastes fasciatus*). Survey bottom biomass and survey female spawning biomass was recalculated based on the abundance at length from Canadian (1979-85) and EU (1988-99) bottom trawl surveys and on the length weight relationships derived from EU survey data. The analytical assessment used a 1989-99 catch at age matrix starting at age 4 and incorporating the 1993-99 redfish by-catch in the shrimp fishery at age. A Separable analysis (Pope and Shepherd, 1982) coupled with a traditional VPA run was first performed, followed by an Extended Survivor Analysis (Shepherd, 1992), which included a 1999-94 Retrospective Analysis. Both models converge not only on the picture they gave of the biomass trend over the past eleven years but also on the order of magnitude of their annual estimates, ending up with an identical value for the 1999 biomass. A logistic surplus production model (ASPIC) which does not use the equilibrium assumption (Praguer, 1994 and 1995) was finally applied using the 1959-99 catch estimates with the STATLANT commercial catch and effort data (1959-1993) as well as the age 4 plus EU bottom biomass (1988-1999). These last results, as regards biomass and fishing mortality trends are identical to the VPA based ones though with a faster rate of biomass increase over the final years of 1998-99. Either VPA's and ASPIC analysis pointed out that the 3M beaked redfish stock experienced a steep decline during the second half of the eighties till 1991 and was kept at a low level during the first half of the nineties. During this former period fishing mortality was kept well above Fmsy, due to extremely high catches from the direct fishery (1989-93) followed by an extremely high level of redfish by-catch in numbers from the 3M shrimp fishery (1993-94), which primarily affected the above average year classes of 1989 and 1990 at age 4. From 1996 onwards fishing mortality dropped to values well below natural mortality allowing a discrete but continuous growth of the biomass and female spawning biomass. Meanwhile recruitment at age 4 has been stabilised contributing to a parallel increase in abundance. For the next coming years the recovery of the 3M beaked redfish stock will be dependent on the survival and maturation of fish from cohorts that are now reaching maturity as well as on the survival of pre-recruits at age 1. Based on the recent history of the 3M beaked redfish stock, female spawning biomass should reach a 40% proportion of the stock biomass. In order to predict when this goal can be achieve medium term projections for 2001-2010 redfish biomass, SSB and F were made, with three options of 2001-10 constant catch, corresponding to different assumptions of fishing mortality on the first year of the projection. All options allowed the continuation of the actual increase of biomass and female spawning biomass with an increasing proportion of female spawners, that for either options would represent 40% of the total biomass by the year 2007.

Introduction

There are three stocks of redfish in NAFO Division 3M: deep-sea redfish (*Sebastes mentella*) with a maximum abundance at depths greater than 300m, golden (*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. All stocks have both pelagic and demersal concentrations as well as a long recruitment process to the bottom, extending to lengths up to 30cm-32cm. Beaked redfish also presents wide geographical shifts of its density between the Flemish Cap bank and other 3M neighbouring grounds.

The Flemish Cap redfish species are long living and present a slow (and very similar) growth, with fish attaining a size around 20cm-22cm at 5 years old and reaching 30cm only at age 10 (Saborido-Rey, 1994). All species are viviparous with the larvae eclosion occurring right before or after birth. Mean age of female first maturation varies from 8 years (mean length of 26,5cm) for Acadian redfish, 10 years (mean length of 30.1cm) for deep-sea redfish, and 12 years (mean length of 33.8 cm) for golden redfish. Spawning on Flemish Cap has a peak in March - first half of April for deep-sea and golden redfish while for Acadian redfish spawning reach its maximum in July - August.

The main purpose of the present assessment is to update the status of the 3M beaked redfish stock, regarded as a management unit composed of two populations from two very similar species. The reasons for this approach were the dominance of this group in the 3M redfish commercial catches and respective CPUE series, corresponding also to the bulk of all redfish bottom biomass survey indices available for the Flemish Cap bank. Finally, and due to market demand reasons, any recovery of the 3M redfish fishery from its present minimum will be basically supported by the *S. mentella* plus *S. fasciatus* biomass.

The major critics raised by NAFO Scientific Council during last year assessment were taken into account, namely in what concerns the need of the use of a tuning analytical method to get an objective best estimate of terminal F's and abundance of cohorts at their last age, as well as the need to incorporate the available redfish data on by-catch in numbers from the 3M shrimp fishery in the assessment. In order to predict what would be the biomass, female spawning biomass (SSB) and fishing mortality trends under different constant catch levels, medium term projections are presented as well, based on the XSA survivors at the beginning of year 2000 and the average recruitment at age 4 observed on the second half of the nineties.

Description of the fishery

The 3M redfish stocks have been exploited over the past both by pelagic and bottom trawl. Due to the similarity of their external morphology the commercial catches of 3M redfish are reported together. The majority of the bottom commercial catches are composed of beaked redfish. The species composition of the pelagic redfish catches, which dominated the fishery in the early nineties, remains unknown. However, taking into account that from survey results, *S.mentella* and *S.fasciatus* together represent the major proportion of the abundance and biomass of 3M redfish it is assumed that these pelagic catches were also dominated by beaked redfish.

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, when a provisional catch of only 970 tons has been recorded (NAFO, 1999) most as by-catch of the Greenland halibut fishery. The drop of the 3M redfish catches from 1990 onwards is related both with the simultaneous quick decline of the stock biomass, namely of its pelagic component and with the abrupt decline of fishing effort deployed in this fishery, caused by the vanishing from the NAFO Regulatory Area of the fleets responsible for the high level of catches on the late eighties-early nineties (former USSR, former DDR and Korean crewed Non Contracting Party vessels). As for the remaining fleets, the EU (Portugal and Spain) and the Japanese trawlers are still the major partners of the present fishery, with 280 tons and 320 tons recorded in 1999, but for both fleets Greenland halibut has been for several years the priority species in all NAFO divisions. Also in 1999 Russia appeared again in Flemish Cap with a nominal catch of 168 tons, the same occurring with reflaged trawlers with an estimated 3M redfish catch of 300 tons.

The boom in 1993 and further settlement of a shrimp fishery in Flemish Cap lead to important levels of redfish by-catch in 1993-94. Despite the fact that since 1995 this by-catch fell to an apparent low level it is still accounting to an important portion of the age composition of the catch for the most recent years.

Recent catches and by-catch ('000 tons) are as follows:

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
TAC	20	20	20	20	50	50	43	30	26	26	26	26	20	13
Catch	28.9	44.4	23.2	58.1[1]	81.0[1]	48.5[1]	43.3[1]	29.0[1,2]	11.3[1,2]	13.5[1,2]	5.8[1,2]	1.3[2]	1.0[2]	1.1[1,2]
By-catch[3]								11.97	5.90	0.37	0.55	0.16	0.22	0.055
Total catch	28.9	44.4	23.2	58.1	81.0	48.5	43.3	41.0	17.2	13.9	6.4	1.5	1.2	1.2

[1] Includes estimates of non-reported catches from various sources
[2] Provisional
[3] Kulka, D. 1999

Input data

Length composition of the commercial catch and by-catch

Most of the commercial sampling data available for the 3M redfish stocks came, since 1989, from the Portuguese fisheries and has been annually included in the Portuguese research reports on the NAFO SCS Document series (Vargas *et al.*, 2000). Most of these data referred to beaked redfish, and, taking into account that the majority of the length sampling was from depths greater than 400m, they should represent *S. mentella* catches. The 1989-1999 per mille length composition of the 3M beaked redfish Portuguese trawl catch (both sexes combined) was used, together with the 3M beaked redfish length weight relationship from 1989-1998 EU survey data (Saborido-Rey *pers. comm.*, 1999), to get the absolute length frequencies of the 3M redfish commercial catch for the same period (Table 1a, 1999 catch from NAFO circular letter Ref.No.GF/00-092). Details of how the missing 1993-94 commercial catch length frequencies were generated can be found on last year assessment (Ávila de Melo *et al.*,1999).

Redfish by-catch in weight and in numbers at length for the 3M shrimp fishery were available for 1993-99 and 1993-97 respectively (Kulka, 1998 and *pers. comm.*, 2000), based on data collected on board of Canadian and Norwegian vessels. However using the EU survey 1993-97 length weight relationships to recalculate the by-catch in weight from the available by-catch numbers at length, would result in an average 25% overestimation. To abide the catch in numbers at length to both the estimated by-catch in weight and the length weight relationships, the length frequencies were recalculated. Using each year the mean weight in the catch given by the ratio of the by-catch in weight as the sum of products and the total by-catch in numbers, a new number for by-catch is generated by dividing the reported by-catch in weight to that "new" mean weight in the catch. Finally the by-catch in numbers at length results of the application of the per mile length frequency to this new figure of by-catch in number. No by-catch numbers at length were available for 1998 and 99. To calculate the length frequencies for those years, mean weights in the catch were calculated the same way but using at each length the sum of the 1996 and 97 observed absolute length frequencies with length weight relationship of the respective year of 1998 or 99. At the end the sum of products was divided by the sum of the 1996 and 1997 by-catch in numbers. After having mean weight and a by-catch in number for 1998 and 99, the permile length frequencies applied resulted of the junction of the 1996-97 absolute by-catch length frequencies. Length composition of redfish by-catch in the 3M shrimp fishery is presented on Table 1b.

The absolute length compositions of the 1989-99 commercial catch and 1993-99 by-catch were summed and used on this assessment as the 1989-99 3M redfish catch at length, presented on Table 1c.

Length composition of the stock and spawning stock survey abundance

The 1988-99 EU survey abundance and female mature abundance at length for 3M beaked redfish was updated as follows:

1) Juvenile *S. mentella* and *S. fasciatus* were calculated for each year of the 1992-99 period from the respective absolute length frequency files of the Flemish Cap survey data base. For each year of this interval there is a file for each species with the length frequencies for males, females and unsexed juveniles, and a file with the length frequencies of unidentified juveniles. The average proportion of each species found in the total of identified juveniles was then applied to the length frequencies of unidentified juveniles in order to split them by species. A

female ratio of 0.5 was finally applied to the juvenile length frequencies in order to have on an annual basis and for each one of the beaked redfish species separately numbers at length for females and total (both sexes combined) including juveniles. The same procedure was applied for the 1990-91 years when the survey redfish catches were split in golden redfish, beaked redfish and juveniles (on 1988-89 juveniles have not been considered a separate category in the survey catch and so total and female abundance at length including juveniles is given directly by the survey results).

2) As mentioned before all total and female abundance at length either for *S. mentella* and *S. fasciatus* (1992-99) or for beaked redfish (1988-99) was extracted directly from the database and processed in order to include juveniles in both sets. Mature female abundance at length for *S. mentella* and *S. fasciatus* was then given each year (1992-99) by the respective length maturity ogives (based on the histological analysis of gonads collected on the 1992 February-March cod tagging EU survey and on the 1992-93 June–July EU bottom trawl survey - Saborido-Rey, 1994). A combined maturity ogive was calculated next from the 1992-99 female and mature female abundance at length of *S. mentella* and *S. fasciatus* (Table 2) and applied to the 1988-91 beaked redfish female abundance at length, in order to derive the respective mature female abundance's. To avoid the appearance of mature females at unrealistic young ages the expected mature female proportions were set at zero for lengths smaller than 21cm.

Both beaked redfish total and mature female at length for the 1992-99 period are the sum of the respective *S. mentella* and *S. fasciatus* sets first calculated by species (Table 3, Fig.1). For the 1979-85 Canadian surveys (Power and Atkinson, 1986) beaked redfish total abundance at length is given directly by the survey results. A mature female proportion at length, given by the product of the 1988-99 EU survey female ratio and the combined beaked redfish maturity ogive at length (Table 2), was applied to the 1979-85 total abundance at length in order to obtain the correspondent mature female abundance at length for the Canadian survey series (Table 3, Fig.1).

Length weight relationships

Length weight relationships for each of the 3M beaked redfish species separately and for *S.mentella* and *S. fasciatus* combined were calculated with survey length/weight data from both sexes (Saborido Rey *pers. comm*., 1999) and used in this assessment on an annual basis (Table 4).

Survey stock biomass and spawning biomass

The annual *S.mentella* and *S. fasciatus* (1992-99) and beaked redfish (1988-91, and general) length weight relationships were used to calculate the respective survey biomass and survey female spawning biomass as sums of products of abundance and mature female abundance times mean weight at length, for the EU series (1988-99) and the Canadian series (1979-85) Table 3, Fig. 1). These survey bottom biomass sum of product results are comparable with the correspondent swept area biomass estimates (-4% on average for the 1989-99 assessment interval) for the EU surveys (Vazquez, 2000).

Age composition of the beaked redfish survey stock and mature female beaked redfish stock.

The EU survey abundance at age for the 1989-99 3M beaked redfish stock and mature female component (Table 5a and b) were obtained using the *S.mentella* age length keys from the 1990-98 EU surveys, with both sexes combined (due to the fact that the 1989 S.mentella age length key was based on scale readings, the 1990 *S. mentella* age length key was also used in 1989. The ageing criteria of 3M redfish otoliths has been first revised in 1995 by one of the authors (Saborido-Rey, 1995) and all survey age length keys were then standardised accordingly. However and due inconsistencies still found between the interannual shift of the *S. mentella* survey length distributions and the age assigned every year to each length modal group, the 1994 to 97 age length keys were revised in 1998 (Saborido Rey *pers. comm*., 1999). Details of this revision can be found on last year assessment (Ávila de Melo *et al*., 1999). Due to the scarcity of redfish larger than 40cm in the survey a plus group was considered at age 19.

Age composition of the catches

Age composition of the total catches, including the redfish by-catch on the shrimp fishery, were also obtained using the *S.mentella* age length keys from the 1990-99 EU surveys (Table 7).

Mean weights at age

The annual beaked redfish length weight relationships were used to calculate mean weights at age both in the 3M redfish total catches (commercial plus by-catch) (Table 7) as well as in the 3M beaked redfish stock and female spawning stock (Table 6).

Partial recruitment vector

In order to generate an observed partial recruitment vector a Findex was first derived from the 1989-99 ratios between the sums of the permile 3M redfish total catch (commercial plus by-catch) and the permile beaked redfish survey abundance at age, and then standardised to its highest value recorded at age 13. Assuming a flat top recruitment curve this observed partial recruitment vector was after adjusted to a general logistic curve (Table 8a, Fig. 2). The observed vector has been used in the VPA based methods to generate a first guess of fishing mortality at age in the last year, while the expected one was used in the yield per recruit analysis.

Maturity ogive

An observed maturity ogive for 3M beaked redfish was calculated as the mean proportion of mature females in the survey stock abundance at age (Table 5c). At each age this mean proportion is given by the ratio between the 1989-99 sum of mature females and the correspondent total stock abundance. This observed maturity ogive has been used as input file of the VPA based methods as well as on the medium term catch projections. These mean proportions of mature females at age were then fitted to a general logistic curve in order to give an expected maturity ogive that has been used in the yield per recruit analysis (Table 8b, Fig. 3).

Vectors used in yield per recruit analysis

A 3M beaked redfish yield per recruit analysis was conducted incorporating the following sets of vectors (Table 8c), all of them considered to be representative, in terms of growth and maturity, of beaked redfish as a whole:

1) Mean weights at age in the commercial catch for the whole assessment period (1989-1999).
2) Mean weights at age in the beaked redfish stock (as well as in the mature female component) from survey abundance (1989-1999).
3) Female beaked redfish maturity ogive at age, from the beaked redfish mature female and stock survey abundance at age (1989-1999).
4) Expected partial recruitment vector (though keeping the observed PR at age one in order to contemplate the actual high mortality on the first age group caused by the 3M shrimp fishery).
5) Natural mortality was set at 0.2 for ages 1 and 2 to allow a higher juvenile mortality and assumed to be constant at 0.1 for older ages.

Assessment results

Stock and spawning stock bottom biomass from EU bottom trawl surveys (1988-1999) and Canadian bottom trawl surveys (1979-1985)

The more recent period of 1988-1998, covered by EU surveys, started with a continuous decline of bottom biomass till 1991, followed by a period of biomass fluctuation with no apparent trend from 1992 till 1996, but further declining in 1997 and 1998, when the second lowest bottom biomass index was recorded (Table 3a, Fig.1). It is however difficult to associate this last apparent decline from 92,000 tons in 1996 to 56,000 tons in 1998 to fishing mortality, that at the time being has dropped already to very low levels. This decrease could in turn be related with an increasing proportion of beaked redfish biomass above the bottom, supported by the growth and maturation process of the survivals of the abundant cohorts from the turn of last decade. Survey bottom biomass increase again by 38% in 1999 being at 78,000 tons.

During the former period of 1979-1985, covered by the Canadian surveys, both bottom biomass and spawning biomass of beaked redfish were stabilised, with a female spawning bottom biomass (SSB) representing 40% of the survey bottom biomass. Bottom spawning biomass declined throughout the EU survey time series and for the last five years (1995-1999) spawning biomass represented on average just 10% of the bottom biomass (Table 3-A, Fig. 3)

Yield per recruit analysis

In order to get reference levels of fishing mortality taking into account the growth, maturity and exploitation pattern of the 3M beaked redfish stock an yield per recruit analysis was conducted, incorporating the sets of vectors already described .

From the yield, biomass and spawning biomass per recruit curves, different levels of reduction of spawning and total biomass were determined for corresponding levels of fishing mortality (Table 8d, Fig. 4). With the assumption of constant recruitment, the results indicated a reduction of 67% of the female spawning biomass from its unexploited level and a 34% proportion of female spawners in the stock biomass when fishing at $F_{0.1}$. If a logistic natural growth of the biomass is accepted, the fishing mortality associated with a long term equilibrium 50% reduction of total biomass is slightly below $F_{0.1}$. As for the fishing mortality corresponding to the average female spawning biomass proportion of 40% observed during the former period of 1979-85 covered by the Canadian series, its value should be at 0.057 and will lead to a female spawning biomass at a 50% reduction of its unexploited level.

A precautionary level of fishing mortality based on 3M *Sebastes mentella* growth

A growth based model (Beverton and Holt, 1957 from Die and Caddy, 1997) first applied on the 1998 assessment (Ávila de Melo *et al*.,1998) was updated in order to get a precautionary limit of Z, corresponding to a fishery where the mean length in the catch is above the mean length at maturity (Table 9). The F given by the Z "at maturity", assuming a natural mortality at 0.1, was equal to the SSB per recruit F associated with a long term 50% reduction on the female spawning stock biomass from its unexploited level and a 40% proportion of SSB on the stock biomass (0.057).

A survey index of fishing mortality trend, 1988-1999

The ratios between annual STACFIS estimates of 3M redfish catches and 3M beaked redfish survey bottom biomass (given by the EU survey series) were considered to be an index of the mean fishing mortality trend during the past 11 years (Table 10, Fig. 5). This approach assumes constant survey catchability over the recruited age groups and no changes in exploitation pattern. Both assumptions are difficult to sustain as regards any redfish stock, but the survey biomass can be considered representative of the mean annual biomass (EU survey is conducted around the middle of the year). Anyway the survey F index has shown a reasonable agreement with the mean F's from the VPA/SPA performed on last year assessment (Ávila de Melo et al., 1999). The 1989-99 survey Findex was used as a first guess of F on oldest age through the time interval on the VPA based methods. The same occurred with survey Findex for 1999 after multiplied by the observed partial recruitment vector, generating a first guess of F at age on the last year of the assessment.

The survey F index quickly rises to a peak in 1990 and gradually fell since then, reaching a very low level from 1997 onwards. In order to generate comparable fishing mortality trends the survey F index and analytical F's (from VPA/SPA and XSA) each series was transformed to F multipliers normalised to the respective average F (Table 10, Fig. 5)

VPA based methods: the Separable and Extended Survivor Analysis

The wide inter annual fluctuations of the 3M beaked redfish survey abundance at age have been considered a strong handicap on the performance of VPA tuning methods such as the Extended Survivor Analysis (XSA) (Shepherd, 1999), due to its reflection on the high variability through ages, years and cohorts of the catchabilities that relate CPUE's and abundance. Nevertheless the simple existence of an eleven years EU survey time series of abundance at age data urge us to proceed with an XSA after the update of the SPA analysis, as a further step of the analytical work started last year (Ávila de Melo *et al*., 1999).

The input files for both SPA and XSA analysis are presented in Table 11. Natural mortality was assumed constant at 0.1. The proportion mature at age is the one observed on the 1989-99 period (Table 8b) and the month with a peak of spawning for 3M *Sebastes mentella*, February (Saborido-Rey, 1994), was the one considered for the estimate of the proportion of F and M before spawning. The catch at age matrix includes the 1993-99 by-catch at age from the shrimp fishery. The first age group considered was age 4 (the first age in the 1989-99 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 an age 19 plus group has been considered throughout the assessment). The 1989-99 F_{survey} indices were used as the initial F's on oldest age by year (Table 10) while the observed exploitation pattern was used to derive a first guess of F at age in last year from the 99 F_{survey} index.

Taking into account the short time period available, in contrast with the wide range of ages considered and the slow progress on determinant processes for the stock such as recruitment, growth and female maturity, no year weights were used on both SPA and XSA analysis. The purpose is to give a full use and equal importance to the eleven years of input data, namely those from the first half of the time interval when a full scale redfish fishery occurred on Flemish Cap. The use of year weights can be justified on long time series where there is a high probability that the exploitation pattern has not been kept constant. However it has the disadvantage of imposing the most recent exploitation pattern to the biomass estimate from earlier years of the time interval (Flatman, *pers. com.*, 1999). Anyway, the underlying exploitation pattern assumed at the start of both models already incorporates the shifts observed during the nineties on the fishing mortality distribution through age as a consequence of the development and settlement of the 3M shrimp fishery, and therefore can be considered representative of the whole time interval.

The Separable Population Analysis

The assessment started with an Separable analysis, followed by a traditional VPA run (Cohort analysis) initialised, at the oldest cohort ages, with the Separable VPA terminal population abundance and the catch at those ages. The objective was to get a picture of the magnitude and patterns of the log catch residuals that could be useful on the following definition of the XSA recruiting ages, as well as preliminary estimates of biomass and SSB to be checked against the XSA outputs. The Separable VPA (Pope and Shepherd, 1982) doesn't require tuning data, though a previous notion about the trend in F and the exploitation pattern is needed. The model assumes that the exploitation pattern of the fishery remains unchanged, which, in the case of the 3M redfish is difficult to sustain due to impact that redfish by–catch in numbers caused in the length composition of the redfish removals since 1993 (Table 1c). However both the observed and the logit exploitation pattern in use already incorporate the changes observed during the last decade since they were derived from the total 1989-99 catch at age matrix, by-catch at age included (Table 7). The program used was based in the algorithm implemented by Shepherd and Stevens (1983) and is included in the Lowestoft VPA Suite (Darby and Flatman, 1994). The model algorithms are summarised in Appendix 6 of the respective user guide (Darby and Flatman, 1994).

The Separable VPA is based on the assumption that, for every year, fishing mortality at age is the product of a mean fishing mortality of the year (*Fo(y)*) and the selection at age (*S(a)*) given by the exploitation pattern

$$F(y,a) = Fo(y)S(a)$$

An observed log catch ratio *D(y,a)* matrix is generated through the catch at age matrix as follows

$$D(y,a) = Ln(C(y+1,a+1)/C(y,a))$$

The expected log catch ratio $\hat{D}(y,a)$ can be calculated as a function of $\hat{F}o(y)$ and $\hat{S}(a)$ and M

$$\hat{D}(y,a) = Ln\left[\frac{\hat{F}o(y+1)}{\hat{F}o(y)}\right] + Ln\left[\frac{\hat{S}(a+1)}{\hat{S}(a)}\right] - 0.4444\hat{F}o(y+1)\hat{S}(a+1) - 0.5556\hat{F}o(y)\hat{S}(a) - M$$

assuming the approximation (Gray, 1977)

$$\frac{F(1-e^{-Z})}{Z} \approx Fe^{(-Z/2.25)}$$

Being *R(y,a)* the residual between the observed and expected log catch ratios for each year and age

$$R(y,a) = D(y,a) - \hat{D}(y,a)$$

the Separable algorithm will iteratively find the vectors of *Fo*'s and *S*'s that will minimise both sums of year and age log catch ratio residuals

$$R(y,.) = \sum_{i=Firstage}^{i=Lastage-1} R(y,i) = 0 \quad \text{for each year (column) in log catch ratio residuals matrix}$$

$$R(.,a) = \sum_{i=Firstyear}^{i=Lastyear-1} R(i,a) = 0 \quad \text{for each age (row) in log catch ratio residuals matrix}$$

for a user defined *M* (which is allowed to be age dependent), a terminal *F* for the first age fully exploited and the selection value for the oldest true age. To calculate each new estimate of $\hat{Fo}(y)$ and $\hat{S}(a)$ the algorithm uses the approximations

$$\hat{Fo}(y)_{[new]} = \hat{Fo}(y)_{[old]} e^{(R(y,.)/2a)}$$

and

$$\hat{S}(a)_{[new]} = \hat{S}(a)_{[old]} e^{(R(.,a)/2y)}$$

where *a* is the number of ages and *y* is number of years considered in the analysis.

The Separable algorithm was further modified in order to incorporate year and age weights (Stevens, 1984). In this assessment the age weights have been calculated by the program as the reciprocal of the standard deviation of the log catch ratio residuals for each row of the log catch ratio residuals matrix.

$$Araw(a) = \sqrt{\frac{y-2}{\sum_{i=1}^{y-1}\left(\hat{D}(i,a) - D(i,a)\right)^2 - \frac{\left[\sum_{i=1}^{y-1}\left(\hat{D}(i,a) - D(i,a)\right)\right]^2}{y-1}}}$$

The age weights were then normalised to the largest reciprocal

$$A(a) = A_{raw}(a) / A_{maximum}$$

and incorporated in the sum of log catch ratio residuals for each year

$$\sum_{i=Firstage}^{i=Lastage-1} A(i) R(y,i) = 0$$

A Terminal F was "tuned" by hand under the following constraints:

- should not exceed the Findex for 1999 (0.013), taking into account that being this index given by the catch/survey bottom biomass ratio it is already an overestimate of fishing mortality
- should not generate unrealistic values of 4 plus biomass well bellow (20% or less) of the correspondent 4 plus survey bottom biomass. Most of the catches during the peak of the recent 3M redfish fishery were taken by pelagic trawl and to be consistent with this fact VPA stock biomass should be above or at the same level of the

correspondent survey bottom biomass estimate.

The first age fully exploited is age 13, given by both observed and logit exploitation patterns (Table 8-A) and the observed PR for age 18 of 0.95 was set as the selection at age for the last true age group. A terminal F of 0.0085 was adopted corresponding, under these constraints, to a minimum of the final sum of squared residuals and of number of iteractions.

The matrix of log catch ratio residuals (including the rows and columns totals, with the sum of year residuals incorporating the age weights), the fully exploited fishing mortality for each year (*Fo(y)*) and exploitation pattern (*S(a)*) from the Separable analysis are presented on Table 12a.

The totals for the rows are zero while the columns with totals differing from zero have very low sums of residuals. However some high positive and negative log catch residuals are observed on the younger ages namely on ages 4 and 5, consequence of the long and noisy recruitment process of beaked redfish to the bottom. High negative and positive residuals were observed as well in some older ages specially on the terminal year, reflecting not only the higher mobility of larger fish but also the sensitivity of the Separable analysis to the input terminal F. No patterns were however detected on the residuals down the columns (year effects), across the rows (age effects) or the cohort diagonals (year class effects).

The next step was to estimate the recruitment to each cohort that minimise the log difference between observed and expected catches throughout the cohort, using the Separable F at age matrix:

$$SS = \sum_{k=k\,min}^{k\,max}\left[LnC_{(i+k-k\,min,k)} - LnN_{(i,k\,min)}H_{(i+k-k\,min,k)}\right]^2$$

where

$$H_{(i+k-k\,min,k)} = \frac{F_{(i+k-k\,min,k)}}{Z_{(i+k-k\,min,k)}}(1-e^{-Z(i+k-k\,min,k)})e^{-\sum_{j=k\,min}^{k-1}Z(i+j-k\,min,k)}$$

i is the year, *k* the *kth* age in the cohort, *kmin* the recruitment age and *kmax* the last age of the cohort.

After a forward run of the Separable VPA, starting at the recruitment of each cohort and going down till the respective last age, a Cohort analysis was finally performed backwards, using the SPA terminal population abundance's and the catch at age matrix. The fishing mortality residuals from the traditional VPA (corresponding to the comparison between VPA and Separable F's) are presented on Table 12a. High F residuals are scattered trough years/ ages with no apparent pattern as well, which in part is the reflection of the fact that the Cohort analysis works with the true catch at age matrix while in the Separable VPA catch at age is derived from the recruitment of each cohort and the separable F's down the whole cohort, and so the SPA catch at age never match the observed one exactly. The results are presented on Table 12b as regards fishing mortality, stock and spawning stock abundance and biomass at the start of the year.

The Extended Survivor Analysis

The XSA program used was based in the algorithm implemented by Shepherd (1992) and is included in the Lowestoft VPA Suite (Darby and Flatman, 1994). The model algorithms are presented in Appendix 8 of the respective user guide (Darby and Flatman, 1994) and will be summarised and adapted to this case study next.

The XSA starts with the first estimates of abundance at the end of the year for the last age of each cohort using the catch equation, the respective catch at age and the initial value of *F* on oldest age by year or *F* at age in last year (Table 11). If *Ty* and *Ta* are the terminal year and last age of a cohort at that time and age

and if $Pt_{(Ty,Ta)}$ are the survivors at the end of the year, its first estimate is given by the survivor equation

$$Pt_{(Ty,Ta)} = N_{(Ty,Ta)} e^{-Z_{(Ty,Ta)}}$$

The Cohort analysis model is then rearranged so that, for each age *a* the cohort abundance at the start of year *y* is given by:

$$Nvpa_{(y,a)} = ECM_{(y,a)} Pt_{(Ty,Ta)} + Pc_{(y,a)}$$

where

$$ECM_{(y,a)} = e^{(M_{(y,a)} + M_{(y+1,a+1)} + \ldots + M_{(Ty,Ta)})}$$

is the exponential cumulative natural mortality, and

$$Pc_{(y,a)} = \sum_{i=a}^{i=Ta} (ECM_{(y,i)} C_{(y,i)} e^{-0.5M})$$

is the contribution from all cohort ages, since age *a* till *Ta* and from year *y* to T_y, of the raised accumulated catches to the age *a* cohort abundance at the start of year *y*.

The CPUE index *U* (in our case EU survey abundance at age) is first adjusted by an averaging factor (*A*) to the start of the year, in order to be directly related to population abundance. If catchability (*q*) is assumed constant with time:

$$U_{(y,a)} = q_{(a)} A_{(y,a)} N_{(y,a)}$$

and $U'_{(y,a)} = \dfrac{U_{(y,a)}}{A_{(y,a)}}$

where $A(y,a) = \dfrac{(e^{-\alpha Z_{(y,a)}} - e^{-\beta Z_{(y,a)}})}{(\beta - \alpha) Z_{(y,a)}}$

and α and β are the start and end of the survey period. The estimates of population abundance at age at the beginning of the year derived from the survey abundance at age would then be given by

$$Nest(y,a) = \frac{U'(y,a)}{q(a)}$$

In order to calculate $Nest_{(y,a)}$ from the EU survey abundance at age the survey catchabilities are first calculated by the power model (Shepherd, 1994)

$$U'_{(y,a)} = q_{(a)} Nvpa_{(y,a)}^{\ b}$$

through the linear regression of

$$LnNvpa_{(y,a)} = \frac{1}{b} LnU'_{(y,a)} - \frac{Lnq_{(a)}}{b}$$

The same linear equation will then be used during each iteration to derive survey estimates of population at age, calculating $LnNest_{(y,a)}$ from $Lnq_{(a)}$ and *b*. For ages where catchability is assumed to be constant with time $b = 1$.

For the younger recruiting ages, where b is different from 1 and the catchability $q_{(a)}$ is allowed to be dependent of the year class strength, the standard error of each $Nest_{(y,a)}$ is given by

$$\sigma_{(y,a)} = \sqrt{\frac{\sum_{i=1}^{i=ty}(Nest_{(i,a)} - \overline{N}est_{(a)})^2}{n_{(a)} - 2}} \sqrt{1 + \frac{1}{n_{(a)}} + \frac{(U'_{(y,a)} - \overline{U}'_{(a)})^2}{\sum_{i=1}^{i=ty}(U'_{(i,a)} - \overline{U}'_{(a)})}}$$

Where 1 and ty are the first and the last year with non zero survey data points at age *a*, and $n_{(a)}$ is the number of non zero survey data points at age *a*.

The catchabilities assumed to be constant with time are calculated by the program for each age through the log reciprocal catchability, given by the mean of the time series values:

$$Ln\left[\frac{1}{q_{(a)}}\right] = \frac{\sum_y \left[Ln(Nvpa_{(y,a)} - Ln(U'_{(y,a)}\right]}{n_{(a)}}$$

For those ages with constant catchbility the standard error of each $Nest_{(y,a)}$ is given by the standard error of the log reciprocal catchability and, since catchability is constant this standard error will be kept constant for all years.

$$\sigma(a) = \sqrt{\frac{\sum_y \left[Ln\left[\frac{Nvpa_{(y,a)}}{U'_{(y,a)}}\right] - Ln\left[\frac{1}{q_{(a)}}\right]\right]^2}{n_{(a)} - 1}} \sqrt{1 + \frac{1}{n_{(a)}}}$$

After all cohort's $Nest_{(y,a)}$ and associated standard errors are estimated, the terminal population of the cohort is then given by a weighted mean of each terminal cohort estimate at the end of the terminal year, derived from the estimated abundance of each age of the cohort

$$LnPt_{(Ty,Ta)} = \frac{\sum_{i=Fa}^{i=Ta}\left[w'_{(y,i)}(LnNest_{(y,i)} - LnECZ_{(y,i)}\right]}{\sum_{i=Fa}^{i=Ta}\left[w'_{(y,i)}\right]}$$

where

$$w'_{(y,i)} = \frac{1}{\sigma^2_{(y,i)} ECF_{(y,i)}},$$

Fa is the first age of the cohort, $ECZ_{(y,i)}$ and $ECF_{(y,i)}$ are the exponential cumulative total and fishing mortalities from *Ta* to each age i, and $\sigma_{(y,i)}$ are the standard errors of the $Nest_{(y,i)}$ values. This cohort's terminal population will then initialise the next iteration. The exponential cumulative fishing mortality enters in the weighting process of the mean terminal population as a second weighting factor that will reduce the influence of the terminal estimates from the younger ages of the cohort.

The XSA run ends when

$$\sum_a \left|(F_{(a,Ty,i)} - F_{(a,Ty,i-1)}\right| < 0.0001$$

in other words, when the sum of absolute fishing mortality residuals for all ages *a* in the terminal year *Ty*, between iteration *i* and the previous one, is less than 0.0001.

As justified earlier no tapered time weighting was applied. Final fishing mortality estimates were not shrunken towards a mean *F* either, taking into account the sharp declining trend of fishing mortality over the second half of the nineties and the overestimation of *F* that this process will cause under these circumstances. However, when catchability was considered to be dependent of the year class strength on one or more of the younger ages, the survivors estimates at the end of the final year for those ages are shrunken ($Pt_{Pshr(a)}$) to the mean VPA abundance of the next age at the start of year

$$Ln\overline{P}t_{Pshr(a)} = \frac{\sum_{i=1}^{i=Ty} LnNvpa_{(i,a+1)}}{n}$$

where *n* is the number of years of the time interval and the weight applied to this mean is the inverse of the variance of the log values, with a standard error given by:

$$\sigma_{Pshr(a)} = \sqrt{\frac{\sum_{i=1}^{i=Ty}\left[LnNvpa_{(i,a+1)} - Ln\overline{P}t_{Pshr(a)}\right]^2}{n-1}}$$

Under the above mentioned constraints several exploratory runs were performed in order to select the age at which catchability starts to be independent of year class strength and the one at which catchability is constant. On a first run catchability was set independent of age only at 17, the penultimate true age and all younger ages were treated as recruits. Despite the lack of convergence the results showed ages up to age 6 with high regression standard errors and high log catchability residuals namely on age 5, the age at which beaked redfish recruits to the bottom survey gear (Vazquez, 1999). High residuals were formerly observed on these same younger ages on the SPA log catch ratios. However an examination of the regression statistics of catchability for these "recruiting" ages show that the *t* values of the slopes, that linearly relate the log abundance at age with the log survey index at age adjusted to the start of the year, do not differ significantly from 1 (*Student's t* test with degrees of freedom = No. points – 2). This lack of a significant trend led us to treat the catchability as just age dependent also on the younger ages. On the opposite extreme the older ages show no stabilisation on the log catchabilities, that were in fact declining from ages 15 to 17. Fixing catchability and/or setting the plus group on younger ages (16 or even 15) didn't improve the fit of the model to the existing data and, as regards the second option, would shrunk the range of true ages involved on the assessment of a long living stock. The age at which catchability is independent of age was therefore kept at the oldest true age that the program allows which is age 17, the penultimate true age. Finally, and in order to avoid overweight by the last true age on the terminal population estimates, a minimum standard error of 0.5 was fixed to the log catchabilities for age 18.

The diagnostics of the XSA final run are presented on Table 13a and Fig. 6 and 7, while the fishing mortality, biomass and SSB results are presented in Table 13b and Fig.11 (the results of the different analysis will be discussed in conjunction afterwards). The diagnostics present high positive and negative log catchability residuals when recruiting to survey gear (ages 4 and 5), an increasing 94-96(97) residual trend on ages preceding commercial full recruitment (ages 11 and 12) coupled with declines on the most recent years. Through time most of the residuals were positive during the intermediate years (1994-96), while on 1991 and again on 1998 most ages had negative residuals.

Retrospective analysis

The variability observed on the catchability residuals is reflected on the 1999-94 retrospective analysis, performed with the same input data set and under the same constraints and specifications of the XSA final run (Table 14, Fig. 8 to 11). Despite the underestimation of the mean F's and the overestimation of biomass and recruits observed between most years when moving backwards on the 1994 direction, and despite the fact that the 1997-94 runs reached no convergence, the 1999-98 biases for the 1998-89 estimates of biomass, fishing mortality and recruits are the lowest biases observed when comparing the XSA results between any combination of years.

Comparison of the VPA/SPA and XSA results

Each VPA based model started with a different rational and input data (log catch ratios *versus* survey abundance at age) to get a "best" estimate of terminal populations and fishing mortalities at age and ended with a different quality of the diagnostics of the respective outputs. However both models converge not only on the picture they gave of the biomass trend over the past eleven years but also on the order of magnitude of their annual estimates, ending up with an identical value for the 1999 3M beaked redfish biomass: 105.990 tons from the VPA/SPA and 105.867 tons from the XSA (Tables 12b, 13b and 16; Fig. 12)

When comparing the VPA's stock biomass results and the EU survey bottom biomass each series started with a steep decline of the respective biomass but at two distinct levels (the VPA's biomass at an upper level) till 1993, indicating that although at the early years of the time period an important portion of the beaked redfish stock biomass was still above the bottom supporting a pelagic fishery at its peak, the stock declined fast as a whole. From 1994 till 1996 VPA stock biomass approaches and "entangles" with the survey bottom biomass reflecting a period of apparent stability at a low level, with most of the stock abundance composed of young age groups and most of the stock biomass concentrated near the bottom. Total biomass and female spawning biomass from the VPA's starts its recovery from 1996 onwards due to the survival and growth of the above average cohorts from the turn of the last decade (1989-90), but this increase was only reflected on the bottom biomass survey index from 1998 to 99, when the 1996-98 decline was finally inverted. As a consequence of this delay, coupled with a faster increase of the female spawning biomass as regards total biomass, the pelagic proportion of the beaked redfish stock biomass seems to be increasing again over the last couple of years, supported by an increasing proportion of larger and older fish with a higher level of mobility as regards the bottom and the swept area of the Flemish Cap EU survey.

In conclusion, the apparent poorer fit of the XSA model to the 3M beaked redfish data, provoked by sudden jumps and temporary trends in catchability through ages and time interval, is in our perspective more related with redfish own biology and behaviour than with poor quality data and is something this redfish assessment has to live with when using analytical models supported by any type of CPUE tuning.

Non-equilibrium stock production model incorporating covariates (ASPIC)

The ASPIC model (Praguer, 1994, 1995) fits a non-equilibrium logistic production model to several data series such as catch and effort, catch and CPUE, biomass indices and independent biomass estimates. Being K the carrying capacity stock biomass, r the intrinsic rate of stock biomass increase, C the catch biomass, MSY and Bmsy the long term yield and biomass associated with Fmsy, the same being applied to $Y_{0.1}$ and $B_{0.1}$ as regards $F_{0.1}$, the model basic assumptions are:

1) A logistic population growth over time of the unexploited stock (Schaefer, 1954)

$$dB_t / dt = rB_t - (r / K)B_t^2$$

2) For an exploited stock catch is also incorporated in the population growth

$$dB_t / dt = rB_t - (r / K)B_t^2 - C_t$$

3) The biological reference points are (Schaefer, 1954)

a. MSY = $r K / 4$ and $Y_{0.1}$ = 0.99 Ymsy

b. Bmsy = $K / 2$ and $B_{0.1}$ = 1.10 Bmsy

c. Fmsy = $r / 2$ and $F_{0.1}$ = 0.9 Fmsy

The model assumes that for each data series *q*, the catchability that relates each year fishing mortality (F) with fishing effort (*f*) or a biomass index with the stock biomass, is constant over time. The model requires from the user a set of inputs (Praguer, 1995) which were defined as follows

1) Maximum F when estimating effort. From the traditional VPA/SPA and XSA analysis the maximum level of the mean fishing mortality was between 0.4 and 0.6. In the ASPIC runs the maximum F was set 3 times higher than this level, at 1.5.

2) Penalty term for B1 (stock biomass at the first year of the time series) greater than *K*. The model fitted successfully without a penalty term.

3) Data series. On last years assessment the inclusion of all CPUE and survey series available in a first ASPIC run (Ávila de Melo *et al*., 1999) resulted in negative or very low correlations between most of them. The STATLANT commercial CPUE, built with STATLANT catch and effort data for most of the components of the fishery from 1959 to 1993 (Gorchinsky and Power,1994), is considered, due to its longevity, to be the backbone of the ASPIC runs. On the present assessment the EU bottom biomass (1988-1999) is recalculated as a sum of products of the age 4 plus biomass and runs with the STATLANT commercial CPUE, giving a high correlation on between the two series.

4) No series specific statistical weights were given.

5) The MSY was set at 20,000 tons as a starting guess corresponding to the upper level of catches during the former period of relative stability of this stock pointed out by the Canadian surveys between the late seventies and the first half of the eighties. Taking into account the recent history of the 3M redfish fishery the MSY was allowed to vary between 10,000 and 40,000 tons.

6) The starting guess for *r* was 0.212. This value was derived from the $F_{0.1}$ given by the yield per recruit analysis, using the model's assumptions as regards $F_{0.1,}$ Fmsy and *r*. Due to the slow growing and long living features of redfish species the lower limit for *r* was set at 0.05, but allowed to vary up to 1.0.

7) The starting guess for EU survey bottom biomass catchability was set at 0.82. This value corresponds to the mean survey bottom biomass/XSA stock biomass ratio for the 1992-99 period, when the survey biomass series starts to fluctuate with no apparent trend. This was the only parameter that was kept constant at the starting guess, since when the model is allowed to do this estimate by its own the run does not end normally, generating extremely high biomass estimates, which are kept almost undisturbed over large time intervals namely during the most recent period, as well as an unrealistically low catchability. Taking into account that the 3M redfish fishery has been dominated by its pelagic component at least during the period with the highest level of catches (1989-93), the EU survey catchability adopted is clearly an overestimate of the mean catchability occurring during the survey time interval, and would generate conservative stock biomass estimates.

Assuming catch (yield, Y) as exact and accumulating residuals in effort, and having user defined starting guesses for *r*, MSY, B1 (expressed as a ratio to MSY) and a program starting guess for the CPUE catchability (*q*), ASPIC started with the catch and CPUE series in order to generate starting and average biomass estimates going through an estimation procedure that is summarised next (Praguer, 1994; Azevedo, *pers. comm*. 1999):

1) Using the starting guesses r_0 , q_0 , K_0 and B_0 estimate effort *f* for the first year (1959) by solving iteratively

$$\hat{F}_t = \frac{\frac{r_0}{K_0} Y_t}{Ln\left[\frac{\frac{r_0}{K_0} B_0 e^{(r_0 - \tilde{F}_t) - 1}}{\left(r_0 - \tilde{F}_t\right)} + 1\right]}$$

with a starting guess for fishing mortality of $\tilde{F}_t = Y_t / B_0$ and seeking for convergence. Once estimated $\hat{F}_t$ than the estimated effort is computed as $\hat{f}_t = \hat{F}_t / q_0$ (the observed effort f_t is given by the catch/CPUE ratio).

3) Than estimate the biomass for the next year by solving

$$B_{t+1} = \frac{\left(r_0 - \hat{F}_t\right)\hat{B}_t e^{(r_0 - \hat{F}_t)}}{\left(r_0 - \hat{F}_t\right) + \left(\frac{r_0}{K_0}\right)\hat{B}_t\left(e^{-(r_0 - \hat{F}_t)} - 1\right)}$$

and compute $\hat{F}_{t+1}$ and $\hat{f}_{t+1}$ and f_{t+1} as described above.

3) The estimated average biomass for year t+1 will be given by

$$\hat{B}_{t+1average} = Y_{t+1} / \hat{F}_{t+1} \qquad \text{or} \qquad \left(\hat{B}_{t+1} + \hat{B}_t\right)/2$$

4) Using the input survey catchability q_{surv} the average biomass for year t+1 (the EU survey is carried out at the middle of the year) is transformed in the corresponding estimated survey biomass

$$\hat{B}_{t+1survey} = q_{survey}\hat{B}_{t+1average}$$

5) The process is repeated for each year in the analysis.

4) The objective function is computed as the sum of the sums of log squared residuals between the observed and expected effort and between the observed and expected survey biomass

$$Obj.function = \sum_{t=1959}^{T=1993}\left[Ln(f_t) - Ln(\hat{f}_t)\right]^2 + \sum_{t=1988}^{T=1999}\left[Ln(B_{tsurvey}) - Ln(\hat{B}_{tsurvey})\right]^2$$

This routine is repeated until the objective function is minimised.

After a first run on the FIT mode (Table 15), to have the conventional parameters estimate, effort and survey pattern of unweighted residuals as well as the biomass and fishing mortality trends expressed as ratios to Bmsy and Fmsy, ASPIC runned on BOT mode (Table 15). On the bootstrap procedure effort and survey residuals were resampled 1000 times in order to derive bias corrected estimates and probability distribution of the parameters. The program uses bias corrections based on medians and so, being P the fit estimate of a parameter and P_m its median value from the bootstrap, then the bias corrected estimate P_{bc} will be given as

$$P_{bc} = P - (P_m - P)$$

The results of the production model converge to a total biomass above the Bmsy level until 1990, though starting to decline in 1985 after a decade of apparent stability (1975-84) where the catches were within 14,000 and 20,000 tons. From 1989 till 1993 fishing mortality was well above Fmsy inducing a faster stock decline till 1994, when the biomass represented about 40% of the Bmsy. Between 1995 and 1996 fishing mortality dropped, being still declining in 1999, when its value was at 4.5% of the Fmsy. This drop gave room to stock recovery and biomass is gradually increasing from 1995 onwards, most likely being in 2000 at 90% of the Bmsy (bias corrected estimate). As for MSY for 3M beaked redfish stock, the ASPIC bias correct estimate is of 24,000tons with an inter quartile range for 50% confidence limits of 4,600tons. These results, as regards biomass and fishing mortality trends are identical to the ones given both the traditional VPA/SPA and XSA analysis, though with a faster rate of biomass increase over the final years of 1998-99.

State of the 3M redfish stocks and prognosis

Either VPA's and ASPIC analysis pointed out that the 3M beaked redfish stock experienced a steep decline during the second half of the eighties till 1993-1994 and is still at a low level. During the former period of the assessment fishing mortality was kept well above Fmsy, due to a period of extremely high catches from the direct fishery (1989-93) followed by an extremely high level of redfish by-catch in numbers from the 3M shrimp fishery (1993-94), which primarily affected the above average year classes of 1989 and 1990 at age 4. From 1996 onwards fishing mortality dropped to values well below natural mortality allowing the survival and growth of the remainders from all cohorts, namely from those most abundant ones and forcing a discrete growth of the biomass and female spawning biomass. Meanwhile recruitment at age 4 has been stabilised and, despite the fact that since 1990/89 no other pulse had occurred yet, it is also contributing to a parallel increase in abundance.

The observed 1989-1995 high level of fishing mortality affected primarily the larger length groups in the *S. mentella* and *S. fasciatus* populations, inducing a decline on the beaked redfish female spawning biomass to a very low level from which these stocks are now slowly recovering. From VPA results the female spawning biomass still represented in 1999 about 15%(XSA) the stock biomass, while back to the late seventies/early eighties, when there is evidence, from the Canadian survey bottom biomass series, that the stock experienced a period of relative stability, that proportion was at 40%. Also the by-catch component of the later high fishing mortalities had a major impact on the 1993-94 recruitments to the fishery, weakening the strength of what were abundant cohorts at age 4. Even at present this "unavoidable" part of fishing mortality is still responsible on average (1996-99) for the fact that 20% of the catch in numbers is coming from age 1 (6-10cm) redfish. Despite that no apparent relation is observed between spawning biomass and recruitment, in the NW Atlantic redfish stocks generally produce one or two strong years classes every 5 or 10 years. Taking into account that the last pulse of recruitment occurred in 1990, if a strong cohort appears in the near future its capacity to contribute to the present recovery of the 3M redfish stock will be hampered by the actual level of fishing effort to shrimp.

For the next coming years the recovery of the 3M beaked redfish will be dependent on the survival and maturation of fish from cohorts that are now reaching maturity. To allow the recovery of the female spawning biomass fishing mortality should be kept at a level below $F_{0.1}$, which on a long-term equilibrium would be sustained at a reduction of 67% of the female spawning biomass from its unexploited level and a 34% proportion of female spawners in the stock biomass. For long living, viviparous species like redfish this reduction might be too severe to guarantee the "normal" rhythm on the pulse of recruitment. As a precautionary rule of thumb based on the recent history of the 3M beaked redfish stock, female spawning biomass should reach a 40% proportion of the stock biomass. In order to predict when this goal can be achieved in a foreseen future medium term projections for redfish biomass, SSB and F were made, keeping a constant level of catch between 2001 and 2010. To reach the beginning of 2001 the average recruitment at age 4 was add to the XSA survivors at the beginning of year 2000, keeping catch equal to the previous year. Exploitation pattern was given by the average 1997-99 partial recruitment and recruitment at age 4 by the 1997-99 geometric mean. Weights at age in the catch, stock and female spawning stock were given by the correspondent 1997-99 arithmetic means. Three catch options were considered:

Option a. Catch in 2001 corresponding to F*status quo* (≅ 2.500 tons).

Option b. Catch in 2001 corresponding to Fssb given by the yield per recruit analysis (≅ 8.000 tons).

Option c. Catch in 2001 equal to actual TAC (5.000 tons).

All options allowed the continuation of the actual increase of biomass and female spawning biomass with an increasing proportion of female spawners, that for either options would represent 40% of the total biomass by the year 2007-8 (Table 17, Fig. 14-16). Taking into account the dependence on these projections of the maintenance of the more recent stable low level of recruitment for the next ten years and the incertitude on the magnitude and signal of the biases from the retrospective analysis, the TAC for the year 2001 should be nevertheless kept at 5.000 tons.

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Table 1a: Length composition (absolute frequencies in'000s) of the 3M redfish commercial catch, 1989-99.

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6											
7											
8											
9											
10	4				1						
11											
12	4				1						
13	16				9	1					
14	38	8			117	12					
15	12	141			395	44				4	
16	0	369			440	132		25			
17	0	675			167	391		25	1	3	
18	0	1083	356		101	843	116	25			
19	16	1546	1477	70	130	1030	235	84	7	15	
20	100	1452	3039	352	145	501	381	454	8	21	
21	283	1083	2818	1856	327	515	393	1217	16	52	
22	1096	1483	2511	3110	970	598	204	2779	44	103	1
23	3365	3186	1976	2376	1894	732	77	2066	112	192	
24	8176	8561	3063	1469	3372	1408	96	1648	284	236	9
25	13345	16817	7541	2760	3160	1999	610	932	351	453	119
26	12278	23000	13015	8656	3345	2005	1051	577	335	451	111
27	8715	22483	18893	13299	3277	1782	1332	904	213	416	222
28	5957	18174	16262	13405	4024	2439	1702	921	183	301	300
29	6036	15663	10928	9609	3530	2587	2203	1050	227	245	292
30	9754	13953	11854	8119	5261	2783	2227	1017	267	135	172
31	9188	12297	7551	5797	4611	2526	1770	1069	240	109	194
32	9573	10790	6812	5124	3629	2196	1860	889	268	106	237
33	8762	9268	4246	4535	3748	1456	1774	669	290	85	154
34	9031	8742	3921	4771	3079	931	1497	636	115	56	59
35	8689	7879	3833	4814	3308	994	1559	226	82	26	122
36	6606	6749	2825	3476	2903	623	1527	173	46	16	63
37	5172	4755	2397	2604	2777	354	1358	242	26	15	60
38	3052	3476	1382	1733	1536	303	1128	95	29	7	3
39	2010	2519	1104	1388	1318	152	736	152	12	4	31
40	1060	1342	714	974	695	100	706	51	4	2	1
41	554	926	289	583	392	78	521	30	13	1	4
42	377	518	187	233	339	26	247	40	6	1	
43	232	361	105	274	149	15	103	11	1		1
44	135	228	44	199	443	26	75	3	7		
45	147	141	32	45	55	16	52	3	1		2
46	90	63	19	10	45		11	4	1		
47	47	31			36		29	1	1		
48	42	24	18	20	499		6				
49	5	24									
50	16	8						34			
51	5	24									
52	5										
53	10	31									
54		16									
55		8									
56											
57											
58		8									
59											
60											
61									12		
no ('000)	134005	199902	129209	101663	60229	29599	25585	18054	3202	3057	2156
weight (tons)	**58100**	**81000**	**48500**	**43300**	**29000**	**11300**	**13500**	**5800**	**1300**	**971**	**930**
mean weight (kg)	0,434	0,405	0,375	0,426	0,481	0,382	0,528	0,321	0,406	0,318	0,431
mean length (cm)	30,8	29,8	29,1	30,2	31,0	28,6	32,4	27,1	29,5	27,4	30,7

Table 1b: Length composition (absolute frequencies in'000s) of the redfish by-catch in 3M shrimp fishery, 1993-99.

Length	1993	1994	1995	1996	1997	1998	1999
6				150	1	43	12
7			4	4408	96	1287	346
8			6	2469	116	740	199
9			5	216	65	81	22
10			3	426	235	193	52
11			14	1081	519	466	125
12	2	18	33	861	467	387	104
13	23	331	32	470	149	179	48
14	207	957	59	499	110	176	47
15	1792	2177	229	749	109	247	66
16	7171	7115	399	1733	590	673	181
17	27984	17018	703	1190	168	390	105
18	45217	20665	915	755	56	232	63
19	28682	10818	762	386	56	127	34
20	6435	2274	396	69	71	41	11
21	947	312	118	96	55	44	12
22	343	111	25	5	38	13	3
23	1		6		20	6	2
24			2		9	3	1
25			4		3	1	
26			4		1		
27			4				
28			6				
29			6				
30			2				
no ('000)	118805	61798	3739	15563	2933	5330	1434
weight (tons)	**11970**	**5903**	**374**	**550**	**157**	**216**	**55**
mean weight (kg)	0,101	0,096	0,100	0,035	0,054	0,041	0,038
mean length (cm)	18,5	18,1	18,3	11,9	14,0	12,2	12,2

Table 1c: Length composition (absolute frequencies in'000s) of the 3M redfish total annual catch, 1989-99.

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6								150	1	43	12
7							4	4408	96	1287	346
8							6	2469	116	740	199
9							5	216	65	81	22
10	4				1		3	426	235	193	52
11					0		14	1081	519	466	125
12	4				3	18	33	861	467	387	104
13	16				32	332	32	470	149	179	48
14	38	8			324	969	59	499	110	176	47
15	12	141			2187	2221	229	749	109	251	66
16		369			7611	7248	399	1758	590	673	181
17		675			28151	17409	703	1215	168	393	105
18		1083	356		45318	21508	1031	780	56	232	63
19	16	1546	1477	70	28812	11848	996	470	63	142	34
20	100	1452	3039	352	6580	2775	777	524	79	62	11
21	283	1083	2818	1856	1274	827	511	1313	70	96	12
22	1096	1483	2511	3110	1313	710	229	2784	82	116	5
23	3365	3186	1976	2376	1895	732	84	2066	132	198	2
24	8176	8561	3063	1469	3372	1408	98	1648	294	239	10
25	13345	16817	7541	2760	3160	1999	614	932	354	454	119
26	12278	23000	13015	8656	3345	2005	1055	577	336	452	111
27	8715	22483	18893	13299	3277	1782	1335	904	213	416	222
28	5957	18174	16262	13405	4024	2439	1708	921	183	301	300
29	6036	15663	10928	9609	3530	2587	2209	1050	227	245	292
30	9754	13953	11854	8119	5261	2783	2229	1017	267	135	172
31	9188	12297	7551	5797	4611	2526	1770	1069	240	109	194
32	9573	10790	6812	5124	3629	2196	1860	889	268	106	237
33	8762	9268	4246	4535	3748	1456	1774	669	290	85	154
34	9031	8742	3921	4771	3079	931	1497	636	115	56	59
35	8689	7879	3833	4814	3308	994	1559	226	82	26	122
36	6606	6749	2825	3476	2903	623	1527	173	46	16	63
37	5172	4755	2397	2604	2777	354	1358	242	26	15	60
38	3052	3476	1382	1733	1536	303	1128	95	29	7	3
39	2010	2519	1104	1388	1318	152	736	152	12	4	31
40	1060	1342	714	974	695	100	706	51	4	2	1
41	554	926	289	583	392	78	521	30	13	1	4
42	377	518	187	233	339	26	247	40	6	1	
43	232	361	105	274	149	15	103	11	1		1
44	135	228	44	199	443	26	75	3	7		
45	147	141	32	45	55	16	52	3	1		2
46	90	63	19	10	45		11	4	1		
47	47	31			36		29	1	1		
48	42	24	18	20	499		6				
49	5	24									
50	16	8						34			
51	5	24									
52	5										
53	10	31									
54		16									
no ('000)	134005	199887	129209	101663	179034	91397	29324	33617	6123	8387	3590
weight (tons)	**58100**	**81000**	**48500**	**43300**	**40970**	**17203**	**13874**	**6350**	**1457**	**1187**	**985**

Table 2: Female and mature female proportion in beaked redfish ,
EU surveys 1989-99 and 1992-99 respectively

Length	Female ratio	% Mature	**% Mature female**
<20	0,46		
20	0,46		
21	0,46	0,02	**0,01**
22	0,46	0,03	**0,01**
23	0,46	0,05	**0,02**
24	0,46	0,07	**0,03**
25	0,46	0,12	**0,06**
26	0,46	0,19	**0,09**
27	0,46	0,28	**0,13**
28	0,46	0,42	**0,20**
29	0,46	0,50	**0,23**
30	0,46	0,62	**0,29**
31	0,46	0,70	**0,32**
32	0,46	0,79	**0,37**
33	0,46	0,85	**0,40**
34	0,46	0,90	**0,42**
35	0,46	0,93	**0,43**
36	0,50	0,96	**0,48**
37	0,56	0,97	**0,54**
38	0,65	0,98	**0,64**
39	0,72	0,99	**0,71**
40	0,82	0,99	**0,81**
41	0,83	1,00	**0,82**
42	0,88	1,00	**0,88**
>42	0,88	1,00	**0,88**

Fig. 1: 3M Beaked redfish biomass, female spawning biomass and abundance (Canada survey, 1979/85; EU survey, 1988/99)

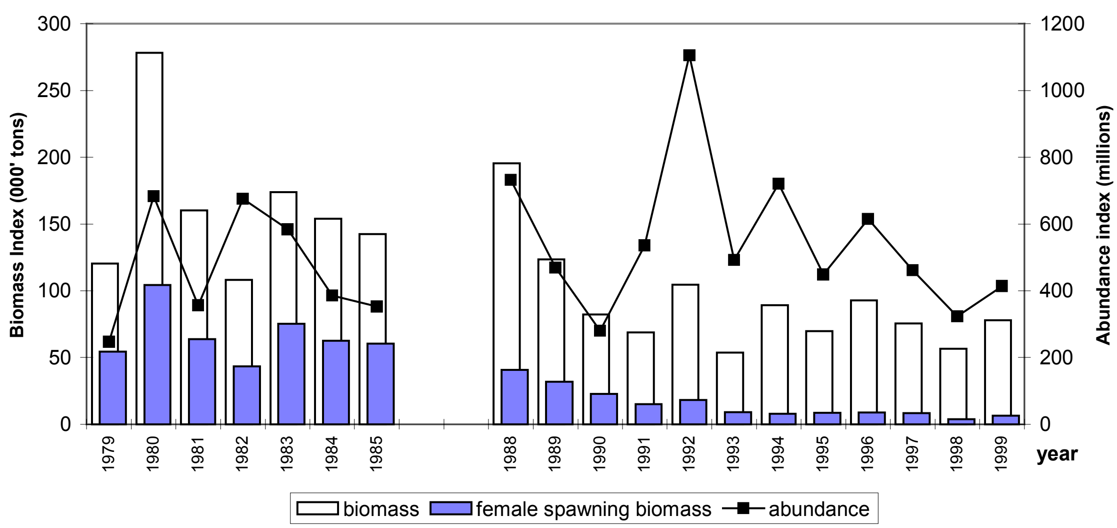


Table 3: 3M beaked redfish abundance at length ('000), biomass and spwanning biomass (tons)
from Canadian (1979-1985) and EU (1988-1999) bottom trawl surveys

Canadian series

length	1979	1980	1981	1982	1983	1984	1985
4							
5					109		
6	111	7	32	718	849		
7	1324	31	1203	42223	2638	34	12
8	1103	160	659	63441	1839	4015	6
9	143	129	55	9179	9423	2001	24
10	274	177	35	63966	37163	1565	174
11	1059	67	95	158442	41909	2470	567
12	529	81	152	115546	16896	2325	490
13	173	287	137	25360	23079	4035	907
14	390	232	114	1066	45144	7028	1901
15	685	187	75	353	69821	8906	2909
16	1279	191	183	321	23401	8131	5828
17	1915	377	178	360	6088	13438	10431
18	1630	1241	362	325	1336	15159	16987
19	1784	1936	200	510	1174	13987	25321
20	2488	3100	321	584	1059	6307	27476
21	4119	5177	811	709	1393	3893	20043
22	8190	15631	1735	1009	1651	3067	8182
23	13607	40695	3177	1285	2446	3071	1874
24	14554	87273	8900	2097	2721	3582	820
25	8174	100675	22222	4180	3391	4072	979
26	3279	78947	45081	6519	4229	6066	1558
27	882	30072	53109	13886	9660	8742	2766
28	2002	7463	31002	22404	19361	15467	7502
29	4793	7035	14374	19527	26191	28989	16887
30	9915	11480	9282	12581	24800	30685	21750
31	13635	19081	10988	9111	23497	35720	25132
32	19133	26240	15079	9563	21255	29280	19893
33	19992	33798	18861	10828	23609	22260	19161
34	22884	42205	22514	12709	25976	21772	21555
35	21054	42084	21497	14715	24070	18554	20830
36	19388	36351	21739	14251	22765	17724	20012
37	16247	32356	15632	12726	20789	15176	17851
38	11644	23151	14157	9185	16295	10365	12887
39	7992	16055	8858	6858	13188	7404	8091
40	4737	9070	5305	3303	6825	4667	5485
41	2741	4919	3545	2208	3202	2666	2768
42	1240	2574	2068	1979	2184	1772	1683
43	967	947	1301	725	962	863	739
44	384	585	660	458	606	367	380
45	169	177	331	214	315	181	179
46	32	313	101	89	227	90	138
47	41	73	93		134	43	28
48	5		26	18	39	24	18
49			22	11	34	6	
50	12	36		6			6
51					6		
52	6						
53							
54					11		
total	246706	682665	356270	675549	583761	385974	352233

	1979	1980	1981	1982	1983	1984	1985
spawning biomass	54345	104120	63816	43389	75112	62552	60452
biomass	120216	278287	160214	108200	173912	154124	142404
ssb proportion	45,2%	37,4%	39,8%	40,1%	43,2%	40,6%	42,5%

Table 3: cont.
EU series

	1988		1989		1990		1991		1992		1993	
length	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem
4												
5												
6			10		22		261					
7	300		30		376		14096		950		134	
8	2500		400		4068		95712		31275		535	
9	2800		490		4232		59863		27274		401	
10	2700		800		410		8005		27178		2348	
11	8700		2620		261		19838		206880		14178	
12	18700		6980		298		27836		306721		23675	
13	14400		8210		1090		10973		92559		19060	
14	2300		19280		2406		2295		21097		65615	
15	500		39630		4031		1945		44512		170339	
16	700		35080		6921		5861		41511		90359	
17	1100		11750		17117		16420		9601		20841	
18	900		2090		20705		30448		5884		6714	
19	3400		1330		12602		50563		9263		3714	
20	6700		2030		2830		60548		15981		2433	
21	15900	122	3120	37	768	9	31124	273	31905	234	2476	22
22	34700	448	7270	107	1566	25	8610	111	50785	629	4089	61
23	74000	1585	14590	353	3612	104	3230	96	39506	795	6189	175
24	117900	4082	27620	1002	9246	333	3520	134	19340	619	7391	327
25	131800	7396	44480	2378	20248	1073	7187	315	8638	459	5651	467
26	101400	9141	55920	4621	32819	2561	9800	675	11190	677	5587	506
27	45500	5996	48630	6121	34269	4076	10320	1199	15927	1199	4613	406
28	19700	3853	32350	6798	25550	5659	9450	1830	18072	2294	4935	523
29	10100	2361	18750	4751	15110	4330	6890	1767	13298	2892	3670	719
30	14200	4079	12110	2998	9550	2849	5980	1846	12040	4213	3615	1009
31	12300	3980	9720	2275	7340	1744	4550	1326	8662	3001	3108	852
32	15100	5500	11380	2639	7120	1971	4110	1363	5818	1810	2588	776
33	15200	6006	8890	3808	6340	2684	4650	2177	5570	1986	2912	884
34	13800	5759	8780	4355	7350	4040	4840	2564	5587	2407	2516	868
35	10900	4716	9170	4740	5210	3219	3950	2109	4732	2337	2419	759
36	9900	4731	7890	4050	5000	2843	3680	2326	3723	1983	2476	1091
37	7600	4122	5930	3111	4010	2440	3020	1789	2976	1847	2431	1271
38	6900	4383	3960	2594	3040	1955	2580	1827	2481	1680	1599	1092
39	3700	2642	3600	2809	1820	1266	1660	1276	1815	1417	1356	1035
40	2500	2026	2530	2185	1230	894	1030	814	1190	1053	808	678
41	1800	1479	1030	856	630	468	450	388	490	339	363	325
42	800	701	650	539	310	219	350	309	355	344	362	361
43	300	263	250	230	190	160	170	160	140	140	101	101
44	100	88	70	60	40	20	50	40	140	110	170	125
45	100	88	70	30	50	50	50	30	40	30	34	34
46			50	50	10	10	50	50	20	20	24	24
47			20	20	20	10	10	10			23	16
48			10	10							38	38
49												
50												
51												
52												
53												
54												
total	731900	85547	469570	63524	279817	45015	535977	26803	1105124	34515	491891	14544

	1988	1989	1990	1991	1992	1993
spawning biomass	40869	31852	22688	14977	18056	9046
biomass	195488	123424	82238	68798	104492	53804
ssb proportion	20,9%	25,8%	27,6%	21,8%	17,3%	16,8%

Table 3: cont.
EU series

length	1994 stock	1994 mat fem	1995 stock	1995 mat fem	1996 stock	1996 mat fem	1997 stock	1997 mat fem	1998 stock	1998 mat fem	1999 stock	1999 mat fem
4									10			
5									188			
6			28		44		9		47			
7			12		600				103		79	
8			176		4406		297		719		1126	
9			517		3172		784		1589		7822	
10	86		731		583		548		553		7377	
11	613		1553		1320		1988		1216		1557	
12	1385		4914		4452		7666		7951		1763	
13	3390		2946		4287		10480		15985		3343	
14	20783		2636		5137		5014		8054		2512	
15	59296		5562		9770		7795		8852		10116	
16	84806		14624		8962		13934		17535		21811	
17	154161		41775		15988		18639		13259		15808	
18	169625		76859		38991		20173		9575		21401	
19	92551		107204		83847		25914		10865		20686	
20	25753		79964		125875		52838		11213		15397	
21	13029	100	32884	270	118446	904	83129	627	15332	114	11960	105
22	7280	122	8965	130	77619	988	85180	1213	28529	329	14940	194
23	6862	199	3872	94	37487	778	57609	1468	50429	1052	26193	514
24	9043	395	3388	133	18134	713	23549	1113	53764	1912	57574	1725
25	10666	691	4017	266	8735	775	10041	937	33467	1997	74355	3940
26	9831	1002	5219	490	4814	716	6473	1495	15685	1397	59755	4966
27	7154	797	5085	620	7163	1030	4920	1548	6459	855	22027	3838
28	8858	1367	5776	742	5361	1298	4841	2506	3191	588	7653	2139
29	7762	1364	6134	1067	5864	1582	3524	1586	1557	338	2997	802
30	5589	1423	6137	1532	4251	1148	4238	2341	1062	279	1036	434
31	4907	1465	4976	1490	3697	1309	2731	1176	1279	422	940	404
32	4652	1865	4170	1314	3543	1643	2183	995	1066	301	912	331
33	3312	1033	3594	1172	3328	1341	1959	880	900	328	697	333
34	2253	624	3079	892	2374	1458	1543	825	796	266	601	228
35	2134	789	2688	909	1659	787	977	460	467	175	542	215
36	1580	754	2540	889	1397	891	921	453	510	162	359	231
37	920	563	2206	851	1088	719	541	312	340	165	225	186
38	918	648	1365	774	785	486	390	196	260	108	137	119
39	470	297	978	661	512	348	210	129	170	89	70	61
40	340	268	520	397	290	189	146	105	60	30	44	34
41	200	159	450	418	260	199	130	110	70	60	20	20
42	80	80	330	279	180	130	40	30	30	26	30	10
43	30	20	160	130	70	50			60	40	10	10
44	20	20	40	20	20	20	20	10	30	20		
45	30	20	40	20	20	20			10	10	20	10
46			40	40					10	10		
47			10	10								
48					10	10						
49												
50												
51												
52												
53												
54												
total	720368	16066	448164	15610	614540	19530	461374	20514	323247	11074	413895	20849

	1994	1995	1996	1997	1998	1999
spawning biomass	7900	8682	8821	8288	3665	6453
biomass	89152	69646	92656	75575	56469	77926
ssb proportion	8,9%	12,5%	9,5%	11,0%	6,5%	8,3%

Table 4: Length weight relationships of 3M beaked redfish (Saborido Rey, *pers. comm*. 2000)

	S. mentella		*S. fasciatus*		*Sebastes sp.*	
Year	A	B	A	B	A	B
1989					0,016	2,964
1990					0,023	2,857
1991	0,022	2,861	0,030	2,816	0,031	2,774
1992	0,016	2,968	0,015	3,025	0,025	2,848
1993	0,018	2,938	0,021	2,918	0,023	2,874
1994	0,017	2,951	0,018	2,967	0,023	2,868
1995	0,018	2,937	0,014	3,034	0,024	2,863
1996	0,012	3,046	0,019	2,947	0,018	2,941
1997	0,015	2,983	0,015	3,029	0,025	2,844
1998	0,021	2,891	0,018	2,952	0,026	2,835
1999	0,016	2,958	0,017	2,973	0,020	2,900
All period	0,018	2,940	0,018	2,968	0,023	2,859

Table 5a: Stock abundance at age (' 000) of 3M beaked redfish from EU surveys, 1989-99.

Year/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989	930	18610	101981	11311	5961	28885	80756	85753	44097	22942	14552	9129	8803	8158	7468	4344	3351	3110	9429
1990	8697	2059	39137	27953	1472	9873	41729	55111	31331	16675	10277	6150	6192	5683	4876	2881	2218	2147	5354
1991	169931	66830	5403	105510	93181	15719	20771	15002	9739	5561	5428	4988	4617	3796	1456	1999	1623	926	3498
1992	59499	641604	65635	62451	103409	55934	27966	26574	17983	10987	7403	5599	5337	4086	3722	2450	1484	1016	1989
1993	1070	87870	75709	253241	8113	19398	10942	7535	2660	3812	3590	3535	2917	3205	2596	1157	1156	1740	1643
1994		15021	57871	498187	61409	20396	22182	12328	8563	6091	4988	3685	2806	1626	1837	861	661	797	1061
1995	733	9798	39623	82435	250396	8639	10341	11110	6321	5614	6103	3576	2705	2386	2648	1751	1023	1054	1909
1996	8222	12812	21025	16661	159816	343885	13670	11043	7853	4110	3129	3157	1668	1912	1581	1169	779	702	1348
1997	1638	18015	22083	56738	73641	71026	194508	6070	4841	3819	2143	1935	1080	1325	388	514	614	175	822
1998	3208	25230	39166	24068	26522	45918	29057	119235	4719	620	541	2872	394	403	126	275	502	46	346
1999	16404	7309	27721	49921	33821	32990	44043	39713	150810	6637	353	498	1215	161	358	368	278	611	684
total	270333	905156	495353	1188475	817742	652662	495966	389473	288916	86868	58505	45125	37735	32741	27056	17769	13688	12324	28081

Table 5b: Mature female abundance at age (' 000) of 3M beaked redfish from EU surveys, 1989-99.

Year/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989				29	105	1096	6384	11204	7605	4634	4094	3349	3968	3929	3835	2263	1922	1745	7363
1990				7	29	443	3840	8240	6091	3736	3133	2510	3120	3023	2810	1682	1332	1279	3739
1991				39	357	681	2144	2935	2615	1934	2312	2476	2512	2225	907	1356	1070	612	2628
1992				12	1196	1491	2174	4489	4709	3630	2767	2308	2602	2188	2103	1610	921	778	1536
1993					100	905	958	1191	570	988	1072	1094	1093	1352	1114	1098	766	1164	1078
1994				15	213	1004	2022	1928	1754	1880	1604	1196	919	696	767	448	413	513	694
1995				75	370	382	1079	1736	1367	1575	1909	1110	870	844	972	803	478	579	1460
1996					1232	2489	1797	2283	2130	1459	1315	1450	878	1020	884	698	497	451	946
1997					133	2684	6216	2817	2414	1752	1013	928	524	642	187	271	333	94	508
1998					113	843	1638	5309	987	159	166	950	133	159	42	108	221	15	230
1999					73	589	1983	3710	10961	1398	146	238	506	63	154	151	140	292	444
total	0	0	0	177	3921	12607	30234	45843	41202	23147	19531	17609	17125	16141	13776	10488	8094	7522	20626

Table 5c: Maturity ogive at age for 3M beaked reddish as the average proportion of mature females at age, from the EU survey abundance at age 1989-99.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
Maturrity ogive	0,000	0,000	0,000	0,000	0,005	0,019	0,061	0,118	0,143	0,266	0,334	0,390	0,454	0,493	0,509	0,590	0,591	0,610	0,735

Table 6a: Weights at age of the 3M beaked redfish stock (Kg) from EU surveys, 1989-99.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989	0,011	0,030	0,057	0,100	0,161	0,204	0,248	0,287	0,322	0,357	0,445	0,523	0,577	0,602	0,646	0,661	0,719	0,723	0,897
1990	0,012	0,033	0,086	0,101	0,174	0,226	0,272	0,309	0,341	0,374	0,456	0,531	0,587	0,608	0,654	0,670	0,727	0,728	0,894
1991	0,013	0,032	0,064	0,112	0,139	0,222	0,284	0,342	0,391	0,468	0,518	0,573	0,620	0,648	0,694	0,754	0,742	0,770	0,862
1992	0,013	0,031	0,066	0,081	0,169	0,207	0,292	0,354	0,398	0,456	0,531	0,575	0,640	0,681	0,703	0,793	0,754	0,874	0,922
1993	0,012	0,040	0,055	0,068	0,162	0,219	0,292	0,368	0,398	0,436	0,514	0,554	0,623	0,682	0,706	0,830	0,823	0,835	1,061
1994		0,049	0,076	0,092	0,133	0,229	0,280	0,352	0,398	0,468	0,498	0,537	0,558	0,674	0,664	0,708	0,801	0,827	0,876
1995	0,013	0,033	0,079	0,111	0,122	0,225	0,293	0,359	0,404	0,452	0,507	0,537	0,615	0,673	0,699	0,768	0,774	0,812	0,993
1996	0,011	0,034	0,061	0,078	0,141	0,143	0,273	0,332	0,390	0,450	0,488	0,543	0,593	0,614	0,666	0,710	0,766	0,799	0,956
1997	0,016	0,037	0,064	0,098	0,135	0,200	0,184	0,357	0,405	0,462	0,499	0,562	0,598	0,608	0,662	0,721	0,752	0,708	0,855
1998	0,014	0,039	0,067	0,097	0,145	0,187	0,236	0,227	0,367	0,415	0,475	0,531	0,598	0,657	0,674	0,762	0,765	0,688	0,997
1999	0,016	0,035	0,066	0,090	0,125	0,180	0,226	0,264	0,249	0,328	0,470	0,565	0,514	0,548	0,538	0,551	0,618	0,595	0,730
mean	0,013	0,036	0,067	0,093	0,146	0,204	0,262	0,323	0,369	0,424	0,491	0,548	0,593	0,636	0,664	0,721	0,749	0,760	0,913

Table 6b: Weights at age of the 3M mature female beaked redfish stock (Kg) from EU surveys, 1989-99.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989				0,154	0,171	0,219	0,272	0,315	0,344	0,387	0,473	0,551	0,590	0,612	0,651	0,665	0,739	0,741	0,906
1990				0,164	0,185	0,238	0,298	0,336	0,363	0,404	0,484	0,558	0,598	0,619	0,659	0,674	0,741	0,743	0,900
1991				0,154	0,166	0,260	0,312	0,359	0,412	0,476	0,531	0,589	0,632	0,659	0,705	0,766	0,754	0,782	0,880
1992				0,153	0,182	0,224	0,310	0,372	0,414	0,463	0,541	0,595	0,659	0,705	0,727	0,814	0,783	0,887	0,939
1993					0,189	0,232	0,293	0,378	0,413	0,440	0,519	0,558	0,645	0,699	0,719	0,889	0,835	0,844	1,116
1994				0,155	0,172	0,250	0,290	0,360	0,404	0,473	0,506	0,544	0,576	0,700	0,689	0,737	0,808	0,847	0,920
1995				0,161	0,165	0,234	0,304	0,367	0,411	0,455	0,508	0,537	0,621	0,686	0,709	0,786	0,797	0,831	1,008
1996					0,176	0,190	0,285	0,342	0,396	0,457	0,491	0,546	0,596	0,620	0,675	0,715	0,767	0,803	0,968
1997					0,196	0,234	0,254	0,359	0,408	0,461	0,497	0,564	0,601	0,611	0,664	0,722	0,754	0,714	0,881
1998					0,165	0,201	0,270	0,248	0,379	0,428	0,477	0,535	0,600	0,674	0,673	0,766	0,775	0,688	1,030
1999					0,156	0,198	0,249	0,289	0,276	0,357	0,470	0,585	0,526	0,549	0,543	0,555	0,652	0,634	0,757
mean				0,157	0,175	0,225	0,285	0,339	0,384	0,436	0,500	0,560	0,604	0,649	0,674	0,735	0,764	0,774	0,937

Table 7a: Catch in numbers at age (' 000) of 3M redfish, 1989-99, including redfish by-catch in the shrimp fishery.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989		25	78	358	937	7214	20422	21950	15079	11186	10979	8014	8284	7690	6793	3883	2733	2520	5858
1990			2460	3354	1641	8396	32330	43476	28836	17848	13689	8652	8320	7685	6550	3783	2852	2640	7388
1991				2807	7871	13330	29058	25239	16633	8477	6619	5121	4274	2990	1100	1450	1187	669	2385
1992				259	5725	7676	18580	19850	12776	8118	6134	4873	4687	3611	3229	2136	1301	815	1892
1993		300	3749	106451	10847	8312	6997	7081	3247	5116	4983	4735	3592	3852	3193	1515	1169	1792	2104
1994		746	5093	53387	6637	3094	4624	3633	3311	3000	2314	1639	1196	658	783	344	235	290	413
1995	15	78	907	1084	2981	609	2332	3516	2288	2123	2687	1651	1436	1381	1589	1242	718	821	1866
1996	7243	3037	2346	1676	4256	5694	1651	1705	1662	1080	791	713	367	371	260	187	135	143	300
1997	513	1109	447	632	136	636	847	294	308	347	236	209	106	129	29	30	32	11	70
1998	2344	1020	1226	590	172	222	529	1312	524	61	53	246	27	23	5	8	16	1	7
1999	631	287	225	230	45	14	69	260	595	352	78	101	243	36	71	71	63	90	129
total	10747	6602	16531	170828	41247	55198	117440	128318	85261	57708	48563	35954	32531	28427	23603	14649	10442	9792	22411

Table 7b: Weights at age in the catch (Kg) of 3M redfish, 1989-99.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989		0,031	0,071	0,146	0,171	0,207	0,245	0,299	0,358	0,406	0,475	0,532	0,576	0,598	0,641	0,656	0,708	0,719	0,921
1990			0,098	0,122	0,170	0,223	0,270	0,316	0,359	0,398	0,471	0,534	0,584	0,604	0,650	0,667	0,717	0,722	0,937
1991				0,129	0,159	0,252	0,299	0,344	0,385	0,458	0,501	0,554	0,602	0,637	0,677	0,744	0,730	0,762	0,852
1992				0,137	0,173	0,240	0,303	0,352	0,397	0,460	0,537	0,578	0,642	0,679	0,697	0,794	0,748	0,874	0,956
1993		0,055	0,080	0,098	0,138	0,225	0,294	0,373	0,408	0,440	0,511	0,552	0,617	0,678	0,702	0,844	0,818	0,831	1,231
1994		0,048	0,085	0,095	0,130	0,239	0,285	0,359	0,404	0,466	0,499	0,537	0,566	0,667	0,658	0,690	0,795	0,819	0,888
1995	0,011	0,034	0,073	0,108	0,124	0,241	0,302	0,362	0,404	0,455	0,512	0,542	0,621	0,679	0,705	0,782	0,788	0,826	1,000
1996	0,008	0,028	0,062	0,075	0,159	0,180	0,279	0,338	0,398	0,452	0,486	0,544	0,588	0,602	0,662	0,709	0,768	0,805	1,045
1997	0,015	0,031	0,064	0,080	0,137	0,242	0,260	0,362	0,408	0,471	0,509	0,555	0,580	0,585	0,630	0,716	0,748	0,697	0,930
1998	0,010	0,032	0,068	0,093	0,139	0,185	0,284	0,263	0,373	0,415	0,473	0,522	0,572	0,625	0,668	0,743	0,754	0,688	0,872
1999	0,009	0,030	0,064	0,081	0,115	0,169	0,295	0,328	0,316	0,396	0,474	0,560	0,515	0,541	0,529	0,543	0,646	0,570	0,700
mean	0,011	0,036	0,074	0,106	0,147	0,218	0,283	0,336	0,383	0,438	0,495	0,546	0,588	0,627	0,656	0,717	0,747	0,756	0,939

Table 8a: Beaked redfish exploitaion pattern given by the generalized logit of the 1989-99 observed partial recruitment.

Age	F at age index	Observed PR	Logit PR	Squared difference
1	1,59	0,35	0,03	0,098
2	0,43	0,09	0,05	0,002
3	0,46	0,10	0,07	0,001
4	0,73	0,16	0,09	0,005
5	0,36	0,08	0,13	0,002
6	0,57	0,12	0,17	0,003
7	1,05	0,23	0,24	0,000
8	1,32	0,29	0,33	0,002
9	1,44	0,31	0,46	0,021
10	3,39	0,74	0,63	0,012
11	3,99	0,87	0,84	0,001
12	4,23	0,92	0,97	0,002
13	4,58	1,00	1,00	0,000
14	3,92	0,86	1,00	0,021
15	4,10	0,90	1,00	0,011
16	4,40	0,96	1,00	0,002
17	4,00	0,87	1,00	0,016
18	4,34	0,95	1,00	0,003
19+	4,03	0,88	1,00	0,015
		Minimum sum of squares		0,216

Curve parameters	*a*	*b*	*m*
	-27,055	2,372	0,136

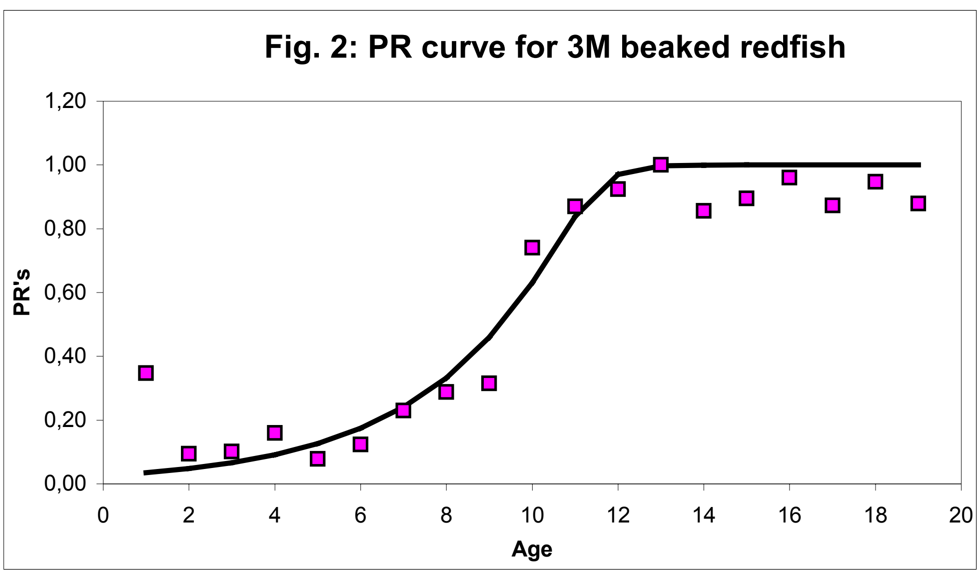


Table 8b: Female maturity ogive at age for 3M beaked redfish given by by a general logit of the 1989-99 observed maturiry at age.

Age	Obs. Mat	Mat. ogive	Squared difference
1			
2			
3			
4	0,00	0,06	0,003
5	0,00	0,07	0,005
6	0,02	0,09	0,006
7	0,06	0,12	0,003
8	0,12	0,15	0,001
9	0,14	0,18	0,002
10	0,27	0,23	0,002
11	0,33	0,27	0,004
12	0,39	0,33	0,004
13	0,45	0,39	0,005
14	0,49	0,45	0,002
15	0,51	0,51	0,000
16	0,59	0,58	0,000
17	0,59	0,64	0,002
18	0,61	0,70	0,007
19+	0,73	0,75	0,000
Minimum sum of squares			0,045

Curve parameters	*a*	*b*	*m*
	-3,814	0,258	1,000

Fig. 3: Maturity ogive for 3M beaked redfish

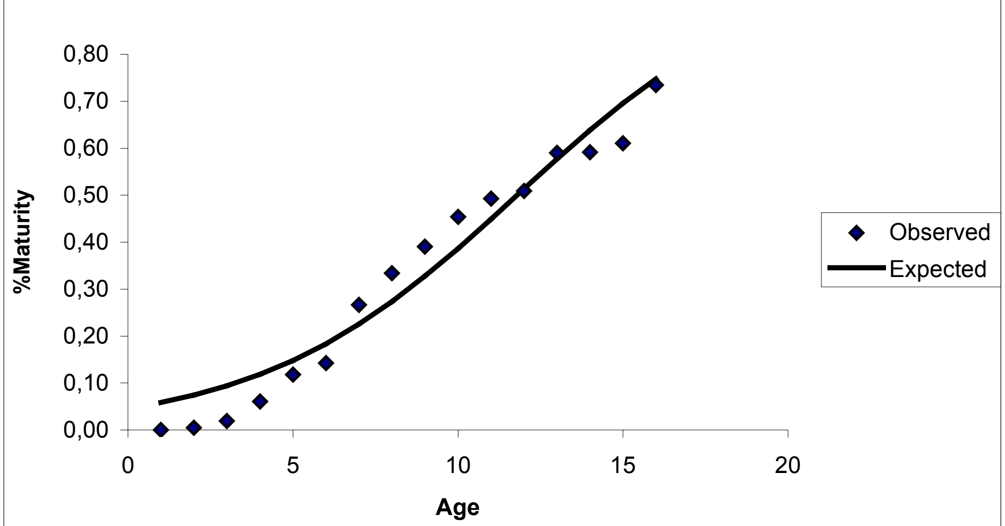


Table 8c: Yield per recruit parameters for 3M beaked redfish

	mean weights 1989-99					
Age	stock	catch	stock mat f	% mat females	PR 89-99	Ref. M
1	0,013	0,011			0,348	0,20
2	0,036	0,036			0,048	0,20
3	0,067	0,074			0,066	0,10
4	0,093	0,106	0,157	0,058	0,091	0,10
5	0,146	0,147	0,175	0,074	0,126	0,10
6	0,204	0,218	0,225	0,094	0,174	0,10
7	0,262	0,283	0,285	0,118	0,241	0,10
8	0,323	0,336	0,339	0,148	0,333	0,10
9	0,369	0,383	0,384	0,183	0,459	0,10
10	0,424	0,438	0,436	0,225	0,632	0,10
11	0,491	0,495	0,500	0,273	0,839	0,10
12	0,548	0,546	0,560	0,328	0,970	0,10
13	0,593	0,588	0,604	0,387	0,997	0,10
14	0,636	0,627	0,649	0,449	1,000	0,10
15	0,664	0,656	0,674	0,514	1,000	0,10
16	0,721	0,717	0,735	0,577	1,000	0,10
17	0,749	0,747	0,764	0,639	1,000	0,10
18	0,760	0,756	0,774	0,696	1,000	0,10
19+	0,913	0,939	0,937	0,748	1,000	0,10

Table 8d: Fishing mortalities associated with different levels of reduction of spawning and total biomass of 3M beaked redfish.

	% SSB	% B	%SSB/B	Ref. F	Yield	SSB	B	Slope
	100,0%	100,0%	50,6%	0,00	0	1808	3575	2550
	90,0%	92,9%	49,1%	0,01	19	1628	3319	2082
	80,0%	85,6%	47,3%	0,02	37	1449	3061	1651
	70,0%	78,3%	45,4%	0,03	54	1269	2798	1257
	60,0%	70,8%	43,1%	0,04	71	1089	2529	903
Fssb	**50,0%**	**63,0%**	**40,3%**	**0,057**	86	909	2254	671
	45,0%	59,1%	38,8%	0,07	93	819	2112	527
	40,0%	55,0%	37,0%	0,08	100	728	1967	396
F"msy"	**35,0%**	**50,8%**	**35,1%**	**0,095**	106	638	1818	311
F0.1	**32,8%**	**48,9%**	**34,2%**	**0,103**	108	598	1750	255
	30,0%	46,5%	32,9%	0,11	111	548	1663	174
	25,0%	42,0%	30,5%	0,14	116	457	1501	86
	20,0%	37,1%	27,6%	0,17	118	366	1327	30
Fmax	**16,2%**	**34,2%**	**25,8%**	**0,199**	119	315	1222	0
	15,0%	31,8%	24,2%	0,23	119	276	1136	-35
	10,0%	25,5%	20,2%	0,32	116	184	911	-52
	9,0%	24,0%	19,3%	0,35	114	166	859	-56
	8,0%	22,5%	18,3%	0,39	112	147	804	-59
	7,0%	20,8%	17,3%	0,43	110	129	745	-60
	6,0%	19,0%	16,2%	0,49	106	110	680	-60
	5,0%	17,0%	15,1%	0,57	102	92	609	-58
	4,0%	14,8%	13,9%	0,68	95	74	529	-53
	3,0%	12,2%	12,6%	0,84	86	55	438	-46

Fig 4:Yield, SSB and B per recruit curve for 3M redfish.

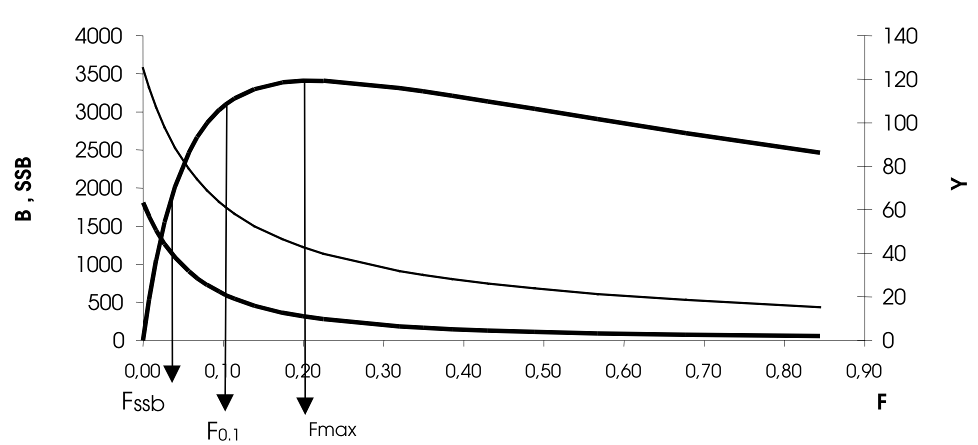


Table 9 : Computation of Z's using female *S. mentella* length data
(Beverton and Holt, 1957 from Die, D.J. and J.F. Caddy 1997)

1) Mean length in the catch

	95	96	97	98	99	mean
$\overline{L}$	32,7	27,9	30,9	27,4	30,4	29,9

2) Mean length of age of first capture (age 5)

	95	96	97	98	99	mean
Lc	19,9	21,9	20,5	20,7	19,6	20,5

3) von Bertalanfy growth parameters

L_∞	51,07
K	0,072

4) Length at maturity

L_m	30,14

$$Z = \frac{(L_\infty - \overline{L})K}{(\overline{L} - L_c)}$$

$$Z^* < \frac{(L_\infty - L_m)K}{(L_m - L_c)}$$

Z mean 95-98 =	0,164
$Z^*(\overline{L} > L_m) <$	0,157
Assuming M =	0,100
$F^*(\overline{L} > L_m) <$	**0,057**

Table 10: Trends in 1988-99 3M beaked redfish fishing mortality, derived from the Catch/survey bottom biomass ratios, XSA and VPA/SPA.
All series standardized to the respective means

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3M beaked redfish survey biomass	195488	123424	82238	68798	104492	53804	89152	69646	92656	75575	56469	77926
3M redfish catches	23200	58100	81000	48500	43300	40970	17203	13874	6350	1457	1187	985
F survey index	0,119	0,471	0,985	0,705	0,528	0,500	0,210	0,169	0,077	0,019	0,021	0,013
Fmultiplier survey	0,373	1,480	3,096	2,216	1,661	1,572	0,660	0,532	0,244	0,061	0,066	0,040
Fmultiplier VPA/SPA		1,050	1,901	1,651	1,864	2,092	1,048	0,807	0,410	0,092	0,049	0,035
Fmultiplier XSA		0,776	1,457	1,348	1,655	2,238	1,221	1,233	0,730	0,190	0,085	0,068

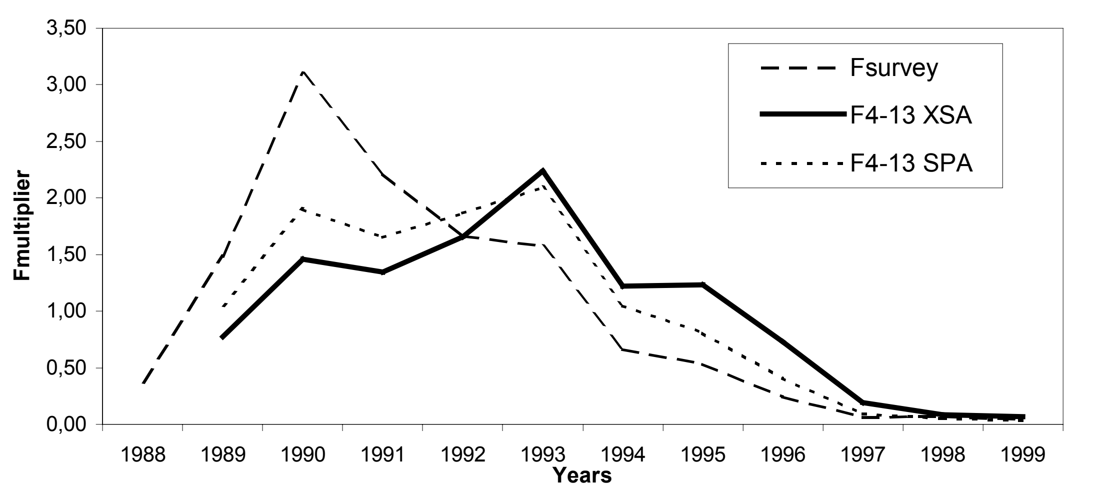


Fig. 5: Fishing mortality trends 1988-99

Table 11: Lowestoft VPA input files for 3M beaked redfish (2000 assessment)

REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES APRIL 2000

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	1999
4	19
5	
58094	
80758	
48500	
43300	
40654	
16735	
13805	
6061	
1349	
1047	
956	

REDFISH NAFO 3M CATCH NUMBERS thousands

1	2														
1989	1999														
4	19														
1															
358	937	7214	20422	21950	15079	11186	10979	8014	8284	7690	6793	3883	2733	2520	5858
3354	1641	8396	32330	43476	28836	17848	13689	8652	8320	7685	6550	3783	2852	2640	7388
2807	7871	13330	29058	25239	16633	8477	6619	5121	4274	2990	1100	1450	1187	669	2385
259	5725	7676	18580	19850	12776	8118	6134	4873	4687	3611	3229	2136	1301	815	1892
106451	10847	8312	6997	7081	3247	5116	4983	4735	3592	3852	3193	1515	1169	1792	2104
53387	6637	3094	4624	3633	3311	3000	2314	1639	1196	658	783	344	235	290	413
1084	2981	609	2332	3516	2288	2123	2687	1651	1436	1381	1589	1242	718	821	1866
1676	4256	5694	1651	1705	1662	1080	791	713	367	371	260	187	135	143	300
632	136	636	847	294	308	347	236	209	106	129	29	30	32	11	70
590	172	222	529	1312	524	61	53	246	27	23	5	8	16	1	7
230	45	14	69	260	595	352	78	101	243	36	71	71	63	90	129

REDFISH NAFO 3M CATCH WEIGHT AT AGE kg

1	3														
1989	1999														
4	19														
1															
0,146	0,171	0,207	0,245	0,299	0,358	0,406	0,475	0,532	0,576	0,598	0,641	0,656	0,708	0,719	0,921
0,122	0,170	0,223	0,270	0,316	0,359	0,398	0,471	0,534	0,584	0,604	0,650	0,667	0,717	0,722	0,937
0,129	0,159	0,252	0,299	0,344	0,385	0,458	0,501	0,554	0,602	0,637	0,677	0,744	0,730	0,762	0,852
0,137	0,173	0,240	0,303	0,352	0,397	0,460	0,537	0,578	0,642	0,679	0,697	0,794	0,748	0,874	0,956
0,098	0,138	0,225	0,294	0,373	0,408	0,440	0,511	0,552	0,617	0,678	0,702	0,844	0,818	0,831	1,231
0,095	0,130	0,239	0,285	0,359	0,404	0,466	0,499	0,537	0,566	0,667	0,658	0,690	0,795	0,819	0,888
0,108	0,124	0,241	0,302	0,362	0,404	0,455	0,512	0,542	0,621	0,679	0,705	0,782	0,788	0,826	1,000
0,075	0,159	0,180	0,279	0,338	0,398	0,452	0,486	0,544	0,588	0,602	0,662	0,709	0,768	0,805	1,045
0,080	0,137	0,242	0,260	0,362	0,408	0,471	0,509	0,555	0,580	0,585	0,630	0,716	0,748	0,697	0,930
0,093	0,139	0,185	0,284	0,263	0,373	0,415	0,473	0,522	0,572	0,625	0,668	0,743	0,754	0,688	0,872
0,081	0,115	0,169	0,295	0,328	0,316	0,396	0,474	0,560	0,515	0,541	0,529	0,543	0,646	0,570	0,700

REDFISH NAFO 3M STOCK WEIGHT AT AGE kg

1	4														
1989	1999														
4	19														
1															
0,100	0,161	0,204	0,248	0,287	0,322	0,357	0,445	0,523	0,577	0,602	0,646	0,661	0,719	0,723	0,897
0,101	0,174	0,226	0,272	0,309	0,341	0,374	0,456	0,531	0,587	0,608	0,654	0,670	0,727	0,728	0,894
0,112	0,139	0,222	0,284	0,342	0,391	0,468	0,518	0,573	0,620	0,648	0,694	0,754	0,742	0,770	0,862
0,081	0,169	0,207	0,292	0,354	0,398	0,456	0,531	0,575	0,640	0,681	0,703	0,793	0,754	0,874	0,922
0,068	0,162	0,219	0,292	0,368	0,398	0,436	0,514	0,554	0,623	0,682	0,706	0,830	0,823	0,835	1,061
0,092	0,133	0,229	0,280	0,352	0,398	0,468	0,498	0,537	0,558	0,674	0,664	0,708	0,801	0,827	0,876
0,111	0,122	0,225	0,293	0,359	0,404	0,452	0,507	0,537	0,615	0,673	0,699	0,768	0,774	0,812	0,993
0,078	0,141	0,143	0,273	0,332	0,390	0,450	0,488	0,543	0,593	0,614	0,666	0,710	0,766	0,799	0,956
0,098	0,135	0,200	0,184	0,357	0,405	0,462	0,499	0,562	0,598	0,608	0,662	0,721	0,752	0,708	0,855
0,097	0,145	0,187	0,236	0,227	0,367	0,415	0,475	0,531	0,598	0,657	0,674	0,762	0,765	0,688	0,997
0,090	0,125	0,180	0,226	0,264	0,249	0,328	0,470	0,565	0,514	0,548	0,538	0,551	0,618	0,595	0,730

Table 11: cont.

REDFISH NAFO 3M NATURAL MORTALITY

1 5
1989 1999
4 19
2

0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1

REDFISH NAFO 3M PROPORTION MATURE AT AGE

1 6
1989 1999
4 19
2

0,00	0,00	0,02	0,06	0,12	0,14	0,27	0,33	0,39	0,45	0,49	0,51	0,59	0,59	0,61	0,73

REDFISH NAFO 3M PROPORTION OF F BEFORE SPAWNING

1 7
1989 1999
4 19
3
0,08

REDFISH NAFO 3M PROPORTION OF M BEFORE SPAWNING

1 8
1989 1999
4 19
3
0,08

REDFISH NAFO 3M F ON OLDEST AGE GROUP BY YEAR

1 9
1989 1999
4 19
5
0,471
0,985
0,705
0,528
0,500
0,210
0,169
0,077
0,019
0,021
0,013

REDFISH NAFO 3M F AT AGE IN LAST YEAR

1 10
1989 1999
4 19
2

0,002	0,001	0,002	0,003	0,004	0,004	0,009	0,011	0,012	0,013	0,011	0,011	0,012	0,011	0,012	0,011

REDFISH NAFO 3M SURVEY TUNNING DATA

101

EU BOTTOM TRAWL SURVEY

1989 1999
1 1 0,5 0,6
4 18

10555	11311	5961	28885	80756	85753	44097	22942	14552	9129	8803	8158	7468	4344	3351	3110
10555	27953	1472	9873	41729	55111	31331	16675	10277	6150	6192	5683	4876	2881	2218	2147
10555	105510	93181	15719	20771	15002	9739	5561	5428	4988	4617	3796	1456	1999	1623	926
10555	62451	103409	55934	27966	26574	17983	10987	7403	5599	5337	4086	3722	2450	1484	1016
10555	253241	8113	19398	10942	7535	2660	3812	3590	3535	2917	3205	2596	1157	1156	1740
10555	498187	61409	20396	22182	12328	8563	6091	4988	3685	2806	1626	1837	861	661	797
10555	82435	250396	8639	10341	11110	6321	5614	6103	3576	2705	2386	2648	1751	1023	1054
10555	16661	159816	343885	13670	11043	7853	4110	3129	3157	1668	1912	1581	1169	779	702
10555	56738	73641	71026	194508	6070	4841	3819	2143	1935	1080	1325	388	514	614	175
10555	24068	26522	45918	29057	119235	4719	620	541	2872	394	403	126	275	502	46
10555	49921	33821	32990	44043	39713	150810	6637	353	498	1215	161	358	368	278	611

Table 12a: Separable VPA diognostics (Lowestoft Version 3.1)

Title : REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES APRIL 2000

Separable analysis
from 1989 to 1999 on ages 4 to 18
with Terminal F of .009 on age 13 and Terminal S of .950

Initial sum of squared residuals was 236.441 and
final sum of squared residuals is 137.867 after 124 iterations

Matrix of Residuals

Years	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	TOT	WTS
4/ 5	-1,006	-1,293	-0,566	-3,719	1,926	3,024	-2,23	0,943	0,066	2,855	0,000	0,112
5/ 6	-1,533	-2,388	0,318	-0,216	0,559	2,684	-1,345	0,505	-1,55	2,966	0,000	0,137
6/ 7	-0,668	-1,354	0,138	0,415	0,094	0,791	-1,461	0,766	-0,611	1,89	0,000	0,236
7/ 8	-0,345	-0,311	0,424	0,839	-0,267	0,396	-0,529	0,243	-1,559	1,109	0,000	0,319
8/ 9	-0,162	0,073	0,415	1,365	-0,489	0,291	-0,391	-0,052	-1,97	0,921	0,000	0,273
9/10	-0,099	0,293	0,409	0,429	-1,217	0,226	-0,44	-0,25	0,173	0,474	0,000	0,467
10/11	-0,044	0,157	0,106	0,095	-0,406	-0,02	-0,113	-0,208	0,518	-0,085	0,000	1
11/12	0,517	0,279	0,214	-0,014	0,055	0,35	0,382	-0,232	-1,234	-0,316	0,000	0,482
12/13	-0,034	-0,305	-0,289	-0,262	0,012	-0,132	0,273	0,07	0,589	0,078	0,000	0,883
13/14	0,208	0,158	-0,074	-0,233	0,481	-0,273	0,265	-0,652	0,207	-0,087	0,000	0,745
14/15	0,062	0,824	-0,559	-0,546	0,112	-1,261	0,315	0,582	1,662	-1,192	0,000	0,269
15/16	0,72	0,647	-0,905	0,339	1,003	-0,615	1,016	0,407	-0,096	-2,515	0,000	0,224
16/17	0,532	0,395	-0,041	0,275	0,742	-0,788	1,205	0,128	-0,639	-1,81	0,000	0,282
17/18	0,094	0,504	0,056	-0,823	0,09	-1,468	0,429	0,707	2,041	-1,63	0,000	0,226
TOT	-0,001	-0,001	-0,001	0,000	0,000	0,001	0,001	0,001	0,001	0,000	-0,002	
WTS	1	1	1	1	1	1	1	1	1	1		

Fishing Mortalities (F)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
F-values	0,2962	0,5329	0,3714	0,4619	0,513	0,2324	0,2741	0,1169	0,0238	0,0067	0,0085

Selection-at-age (S)

	4	5	6	7	8
S-values	0,2493	0,2871	0,3944	0,707	0,9192

	9	10	11	12	13	14	15	16	17	18
S-values	0,914	0,861	0,8824	1,0711	1	1,0689	0,8749	0,8767	0,9867	0,95

Traditional vpa Terminal populations from weighted Separable populations

Fishing mortality residuals

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE											
4	-0,0692	-0,0845	-0,0419	-0,1088	0,8029	0,2346	-0,0548	0,0192	0,0169	0,0058	0
5	-0,0756	-0,1292	0,0307	-0,008	0,1987	0,046	-0,0575	0,0273	-0,0024	0,0051	-0,0018
6	-0,052	-0,1118	0,0962	-0,0094	0,0369	0,0482	-0,0959	0,0003	0,001	0,0055	-0,0027
7	-0,0232	0,0249	0,2386	0,2218	-0,1521	0,0175	-0,0602	-0,0453	-0,009	0,005	-0,0032
8	0,0057	0,1633	0,2135	0,2498	-0,1033	-0,0691	-0,0686	0,0152	-0,0143	0,0074	-0,0025
9	0,0041	0,1362	0,1551	0,1141	-0,2768	0,0493	-0,1359	0,0043	0,0047	0,0089	-0,0009
10	-0,0111	0,0735	0,0111	0,0259	-0,0642	0,0434	0,0023	-0,0352	0,007	0,0001	0,004
11	0,0581	-0,0037	0,0127	-0,0314	-0,01	0,0556	0,0765	0,0144	-0,0045	-0,0012	0,0009
12	-0,0252	-0,1739	-0,1152	-0,0945	-0,0564	-0,0222	-0,026	-0,0085	0,0116	0,0122	0,0009
13	0,094	-0,041	-0,062	-0,0614	-0,0012	-0,0359	0,0086	-0,0384	-0,0032	-0,0013	0,013
14	0,0687	0,1001	-0,1056	-0,0807	0,0434	-0,1025	0,031	-0,0269	0,0068	-0,0021	-0,001
15	0,2675	0,1167	-0,1607	0,1117	0,2413	-0,0025	0,3008	-0,0192	-0,0119	-0,0044	0,0098
16	0,1688	0,089	-0,1097	0,0765	-0,0187	-0,0771	0,2522	-0,0042	-0,0097	-0,0031	0,0149
17	0,016	0,0428	-0,0673	-0,1828	-0,0377	-0,1321	0,1015	-0,0356	-0,0037	0	0,0158
18	-0,0002	-0,0204	-0,1308	-0,1315	0,1592	-0,0413	0,2387	-0,0064	-0,0151	-0,0056	0,034

Table 12b: Traditional VPA results from separably generated population numbers.

Traditional vpa Terminal populations from weighted Separable populations

Fishing mortality (F) at age

Age\YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	FBAR 97-99
4	0,005	0,048	0,051	0,006	0,931	0,293	0,014	0,048	0,023	0,008	0,002	0,011
5	0,009	0,024	0,137	0,125	0,346	0,113	0,021	0,061	0,005	0,007	0,001	0,004
6	0,065	0,098	0,243	0,173	0,239	0,140	0,012	0,046	0,010	0,008	0,001	0,006
7	0,186	0,402	0,501	0,548	0,211	0,182	0,134	0,037	0,008	0,010	0,003	0,007
8	0,278	0,653	0,555	0,674	0,368	0,145	0,183	0,123	0,008	0,014	0,005	0,009
9	0,275	0,623	0,495	0,536	0,192	0,262	0,115	0,111	0,026	0,015	0,007	0,016
10	0,244	0,532	0,331	0,424	0,378	0,244	0,238	0,066	0,028	0,006	0,011	0,015
11	0,319	0,467	0,340	0,376	0,443	0,261	0,318	0,118	0,017	0,005	0,008	0,010
12	0,292	0,397	0,283	0,400	0,493	0,227	0,268	0,117	0,037	0,019	0,010	0,022
13	0,390	0,492	0,309	0,401	0,512	0,196	0,283	0,079	0,021	0,005	0,022	0,016
14	0,385	0,670	0,291	0,413	0,592	0,146	0,324	0,098	0,032	0,005	0,008	0,015
15	0,527	0,583	0,164	0,516	0,690	0,201	0,541	0,083	0,009	0,001	0,017	0,009
16	0,429	0,556	0,216	0,481	0,431	0,127	0,493	0,098	0,011	0,003	0,022	0,012
17	0,308	0,569	0,299	0,273	0,469	0,097	0,372	0,080	0,020	0,007	0,024	0,017
18	0,281	0,486	0,222	0,307	0,647	0,179	0,499	0,105	0,008	0,001	0,042	0,017
+gp	0,281	0,486	0,222	0,307	0,647	0,179	0,499	0,105	0,008	0,001	0,042	
0 FBAR 4-13	0,206	0,374	0,324	0,366	0,411	0,206	0,159	0,081	0,018	0,010	0,007	

Relative F at age

Age\YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	MEAN 97-99
4	0,022	0,129	0,156	0,017	2,264	1,420	0,085	0,600	1,259	0,780	0,302	0,780
5	0,046	0,064	0,423	0,340	0,841	0,547	0,134	0,756	0,248	0,728	0,086	0,354
6	0,314	0,263	0,748	0,471	0,582	0,679	0,077	0,576	0,574	0,842	0,086	0,501
7	0,903	1,075	1,544	1,497	0,512	0,882	0,843	0,465	0,431	1,008	0,403	0,614
8	1,347	1,748	1,710	1,841	0,895	0,701	1,156	1,524	0,414	1,414	0,763	0,863
9	1,332	1,668	1,524	1,464	0,467	1,270	0,723	1,380	1,458	1,559	0,993	1,337
10	1,182	1,425	1,020	1,156	0,918	1,182	1,503	0,814	1,518	0,613	1,626	1,253
11	1,548	1,249	1,049	1,027	1,077	1,265	2,008	1,461	0,911	0,489	1,209	0,869
12	1,415	1,062	0,871	1,093	1,199	1,100	1,688	1,450	2,049	2,006	1,439	1,831
13	1,891	1,316	0,954	1,093	1,245	0,953	1,783	0,975	1,137	0,561	3,094	1,597
14	1,868	1,793	0,898	1,127	1,439	0,708	2,044	1,218	1,784	0,520	1,151	1,151
15	2,553	1,560	0,506	1,408	1,678	0,975	3,410	1,032	0,491	0,146	2,475	1,037
16	2,077	1,489	0,665	1,314	1,048	0,614	3,106	1,221	0,613	0,281	3,209	1,367
17	1,494	1,522	0,922	0,745	1,139	0,472	2,346	0,991	1,088	0,686	3,482	1,752
18	1,363	1,300	0,684	0,839	1,572	0,871	3,148	1,300	0,414	0,073	6,058	2,181
+gp	1,363	1,300	0,684	0,839	1,572	0,871	3,148	1,300	0,414	0,073	6,058	
0 REFMEAN	0,206	0,374	0,324	0,366	0,411	0,206	0,159	0,081	0,018	0,010	0,007	

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

Age\YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	GMST 89-97	AMST 89-97
4	81517	74670	59639	43223	183256	220652	84782	37320	29416	83210	114161	0	73025	90497
5	104955	73420	64376	51296	38864	65369	149015	75683	32175	26016	74730	103079	65906	72795
6	120715	94076	64873	50774	40976	24881	52844	132000	64436	28984	23376	67576	63648	71731
7	126139	102372	77147	46050	38655	29189	19575	47236	114027	57700	26015	21139	56047	66710
8	94845	94748	61991	42291	24082	28335	22022	15497	41172	102371	51706	23474	39344	47220
9	65805	64996	44615	32204	19497	15078	22188	16588	12403	36974	91381	46538	27236	32597
10	54205	45238	31534	24619	17045	14559	10501	17903	13431	10930	32957	82120	21971	25448
11	42082	38432	24037	20495	14585	10574	10327	7487	15173	11823	9832	29486	17373	20355
12	33171	27666	21809	15474	12730	8476	7372	6796	6024	13505	10647	8822	12928	15502
13	26860	22413	16834	14876	9383	7035	6114	5104	5472	5252	11986	9538	10607	12677
14	25193	16453	12401	11178	9018	5090	5230	4170	4270	4850	4726	10614	8556	10334
15	17359	15507	7620	8385	6693	4515	3980	3423	3421	3741	4367	4242	6614	7878
16	11667	9276	7833	5851	4530	3037	3343	2097	2850	3068	3380	3884	4804	5609
17	10800	6878	4813	5712	3271	2663	2421	1848	1720	2550	2768	2991	3722	4458
18	10780	7180	3524	3229	3934	1853	2187	1510	1544	1526	2292	2445	3174	3971
+gp	25059	20093	12564	7496	4619	2638	4970	3169	9826	10682	3286	4839		
TOTAL	851151	713417	515611	383152	431138	443945	406871	377834	357360	403181	467613	420787		

Table 12b: cont.

Spawning stock number at age (spawning time) Numbers*10**-3

Age\YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	2383	1852	1262	994	798	488	1047	2609	1277	575	464
7	7397	5901	4411	2623	2262	1712	1153	2803	6783	3432	1548
8	11042	10705	7059	4770	2784	3334	2583	1827	4898	12173	6153
9	8941	8588	5956	4285	2667	2051	3053	2283	1719	5129	12684
10	14238	11612	8226	6374	4430	3824	2760	4770	3589	2926	8820
11	13429	12121	7658	6510	4608	3390	3296	2428	4961	3869	3217
12	12537	10369	8249	5798	4735	3220	2792	2605	2324	5217	4116
13	11622	9619	7331	6431	4021	3092	2668	2264	2439	2343	5341
14	11874	7581	5889	5257	4181	2445	2477	2011	2070	2357	2296
15	8420	7488	3805	4071	3204	2248	1929	1720	1729	1893	2206
16	6599	5193	4506	3295	2561	1760	1881	1218	1667	1795	1975
17	6167	3847	2750	3271	1844	1547	1376	1075	1005	1492	1617
18	6378	4179	2095	1906	2261	1105	1271	906	934	923	1383
+gp	17743	13997	8938	5296	3176	1883	3458	2276	7112	7735	2372
TOTAL	138770	113052	78135	60881	43532	32099	31744	30795	42507	51859	54192

Stock biomass at age (start of year) Tonnes

Age\YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	8152	7542	6680	3501	12461	20300	9411	2911	2883	8071	10275
5	16898	12775	8948	8669	6296	8694	18180	10671	4344	3772	9341
6	24626	21261	14402	10510	8974	5698	11890	18876	12887	5420	4208
7	31283	27845	21910	13447	11287	8173	5736	12895	20981	13617	5879
8	27220	29277	21201	14971	8862	9974	7906	5145	14698	23238	13650
9	21189	22164	17445	12817	7760	6001	8964	6469	5023	13569	22754
10	19351	16919	14758	11226	7432	6814	4747	8056	6205	4536	10810
11	18727	17525	12451	10883	7496	5266	5236	3654	7571	5616	4621
12	17348	14691	12497	8898	7053	4552	3959	3690	3385	7171	6016
13	15498	13156	10437	9521	5846	3926	3760	3027	3272	3140	6161
14	15166	10003	8036	7613	6151	3430	3520	2560	2596	3187	2590
15	11214	10142	5289	5895	4725	2998	2782	2280	2264	2521	2349
16	7712	6215	5906	4640	3760	2150	2567	1489	2055	2337	1863
17	7765	5000	3571	4307	2692	2133	1874	1416	1294	1951	1711
18	7794	5227	2714	2822	3285	1532	1776	1207	1093	1050	1364
+gp	22478	17964	10830	6911	4901	2311	4935	3029	8402	10650	2399
0 TOTALBIO	272420	237705	177073	136629	108980	93952	97241	87377	98954	109849	105990

Spawning stock biomass at age (spawning time) Tonnes

Age\YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	486	419	280	206	175	112	236	373	255	107	83
7	1834	1605	1253	766	661	479	338	765	1248	810	350
8	3169	3308	2414	1689	1024	1174	927	607	1749	2763	1624
9	2879	2928	2329	1705	1061	816	1234	891	696	1882	3158
10	5083	4343	3850	2907	1931	1790	1247	2147	1658	1214	2893
11	5976	5527	3967	3457	2369	1688	1671	1185	2475	1838	1512
12	6557	5506	4727	3334	2623	1729	1499	1414	1306	2770	2326
13	6706	5647	4545	4116	2505	1725	1641	1343	1458	1401	2746
14	7148	4609	3816	3580	2852	1648	1667	1235	1259	1548	1258
15	5439	4897	2641	2862	2262	1493	1348	1146	1145	1276	1187
16	4362	3479	3398	2613	2126	1246	1444	865	1202	1368	1088
17	4434	2796	2041	2466	1518	1239	1065	823	756	1141	999
18	4611	3043	1613	1666	1888	914	1032	724	661	635	823
+gp	15916	12513	7705	4883	3370	1650	3434	2176	6081	7712	1731
0 TOTSPBIO	74601	60620	44578	36250	26364	17703	18784	15693	21949	26467	21778

Table 12b: cont.

Summary (without SOP correction)

Traditional vpa Terminal populations from weighted Separable populations

	RECRUITS Age 4	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4-13
1989	81517	272420	74601	58094	0,779	0,206
1990	74670	237705	60620	80758	1,332	0,374
1991	59639	177073	44578	48500	1,088	0,324
1992	43223	136629	36250	43300	1,195	0,366
1993	183256	108980	26364	40654	1,542	0,411
1994	220652	93952	17703	16735	0,945	0,206
1995	84782	97241	18784	13805	0,735	0,159
1996	37320	87377	15693	6061	0,386	0,081
1997	29416	98954	21949	1349	0,062	0,018
1998	83210	109849	26467	1047	0,040	0,010
1999	114161	105990	21778	956	0,044	0,007
Arith. Mean	91986	138743	33163	28296	0,741	0,236
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 13a: Extended Survivors Analysis dignostics (Lowestoft VPA Version 3.1).

REDFISH NAFO DIVISION 3M

Catch data for 11 years. 1989 to 1999. Ages 4 to 19.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU BOTTOM TRAWL SURV	1989	1999	4	18	.500	.600

Time series weights :
  Tapered time weighting not applied

Catchability analysis :
  Catchability independent of stock size for all ages
  Catchability independent of age for ages >= 17

Terminal population estimation :
  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 182 iterations

Regression weights

1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Estimated population abundance at 1st Jan 2000

AGE	4	5	6	7	8	9	10	11	12	13
	0.00E+00	4.87E+04	2.58E+04	4.30E+04	4.34E+04	4.32E+04	1.81E+05	7.10E+03	3.76E+03	4.03E+03

AGE	14	15	16	17	18
	3.19E+03	6.86E+02	1.14E+03	1.29E+03	1.20E+03

Taper weighted geometric mean of the VPA populations:

AGE	4	5	6	7	8	9	10	11	12	13
	6.92E+04	5.56E+04	5.11E+04	4.48E+04	3.33E+04	2.19E+04	1.29E+04	1.01E+04	8.00E+03	6.45E+03

AGE	14	15	16	17	18
	5.40E+03	5.10E+03	4.45E+03	4.06E+03	3.88E+03

Standard error of the weighted Log(VPA populations) :

AGE	4	5	6	7	8	9	10	11	12	13
	.7131	.7127	.8421	.9617	10.715	11.391	.9033	.9886	10.640	11.352

AGE	14	15	16	17	18
	11.396	.9320	.7834	.7147	.6701

Tab 13a: cont.

Log catchability residuals.
Fleet : EU BOTTOM TRAWL SURV

Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	-1.76	-.55	.94	.75	1.57	.38	.12	-1.30	.05	-.20	.00
5	-2.40	-3.37	1.19	1.45	-.60	1.48	.17	1.23	.60	-.30	.55
6	-.94	-1.71	-.71	1.05	.17	.80	-.18	.63	.59	.26	.05
7	-.05	-.36	-.65	.34	-.31	.57	.31	.32	.02	-.35	.17
8	.27	.08	-.81	.37	-.28	.19	.24	.68	-.36	-.41	.02
9	.14	.03	-.75	.29	-1.10	.68	.10	.47	.30	-.28	.12
10	-.12	-.08	-.88	.23	-.35	.42	1.20	.24	.23	-1.38	.46
11	-.05	-.23	-.44	.11	-.02	.70	1.30	1.51	.04	-1.35	-1.59
12	-.45	-.65	-.70	-.14	-.25	.36	.72	1.04	1.27	.30	-1.50
13	-.21	-.26	-.42	-.12	-.16	.07	.64	.45	.34	-.02	-.30
14	-.10	.01	-.19	-.03	-.01	-.27	.39	.79	.52	-.42	-.69
15	.35	.16	-.70	.50	.31	.07	.86	.51	-.39	-1.48	-.18
16	.17	.04	-.18	.29	-.03	-.28	.50	.52	-.35	-.52	-.17
17	.02	.07	-.03	-.06	.07	-.16	.29	.09	.13	-.16	-.27
18	.00	-.05	-.47	-.21	.58	-.01	.68	.16	-1.27	-2.35	.17

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
Mean Log q	-92.874	-95.923	-96.196	-94.690	-94.214	-96.132	-98.606	-100.980	-99.113	-100.024
S.E(Log q)	.9599	15.982	.8313	.3801	.4250	.5255	.6933	.9527	.8289	.3405

Age	14	15	16	17	18
Mean Log q	-100.886	-103.066	-104.181	-105.278	-105.278
S.E(Log q)	.4275	.6602	.3414	.1553	.9092

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

Age	Slope	t-value	Intercept	RSquare	NoPts	Regs.e	MeanQ
4	.82	.484	9.62	.46	11	.82	-9.29
5	2.54	-.844	7.53	.03	11	4.13	-9.59
6	1.35	-.810	9.20	.38	11	1.14	-9.62
7	1.24	-1.698	9.17	.85	11	.43	-9.47
8	1.16	-1.124	9.26	.84	11	.49	-9.42
9	1.07	-.409	9.59	.81	11	.59	-9.61
10	1.22	-.714	9.95	.55	11	.86	-9.86
11	1.21	-.545	10.28	.43	11	1.19	-10.10
12	2.05	-2.607	10.88	.41	11	1.35	-9.91
13	1.21	-2.090	10.26	.92	11	.36	-10.00
14	.98	.168	10.06	.88	11	.44	-10.09
15	.77	1.382	9.90	.80	11	.49	-10.31
16	.87	1.071	10.16	.89	11	.30	-10.42
17	.95	.789	10.41	.96	11	.15	-10.53
18	.72	.956	10.07	.56	11	.63	-10.78

Terminal year survivor and F summaries :

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 1995

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	48736.	1.003	.000	.00	1	1.000	.004

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
48736.	1.00	.00	1	.000	.004

Age 5 Catchability constant w.r.t. time and dependent on age
Year class = 1994

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	25828.	.860	.335	.39	2	1.000	.002

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
25828.	.86	.33	2	.389	.002

Table 13a: cont.

Age 6 Catchability constant w.r.t. time and dependent on age
Year class = 1993

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	42957.	.611	.084	.14	3	1.000	.000

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
42957.	.61	.08	3	.137	.000

Age 7 Catchability constant w.r.t. time and dependent on age
Year class = 1992

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	43447.	.387	.314	.81	4	1.000	.002

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
43447.	.39	.31	4	.812	.002

Age 8 Catchability constant w.r.t. time and dependent on age
Year class = 1991

Fleet	Estimated	Int	Ext	Var	N	Scaled	Estimated
EU BOTTOM TRAWL SURV	43223.	.306	.185	.61	5	1.000	.006

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
43223.	.31	.19	5	.606	.006

Age 9 Catchability constant w.r.t. time and dependent on age
Year class = 1990

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	181300.	.268	.141	.53	6	1.000	.003

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
181300.	.27	.14	6	.526	.003

Age 10 Catchability constant w.r.t. time and dependent on age
Year class = 1989

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	7096.	.258	.166	.64	7	1.000	.046

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7096.	.26	.17	7	.643	.046

Age 11 Catchability constant w.r.t. time and dependent on age
Year class = 1988

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	3760.	.255	.317	1.25	8	1.000	.020

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3760.	.25	.32	8	1.246	.020

Age 12 Catchability constant w.r.t. time and dependent on age
Year class = 1987

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	4030.	.254	.272	1.07	9	1.000	.024

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4030.	.25	.27	9	1.072	.024

Table 13a: cont.

Age 13 Catchability constant w.r.t. time and dependent on age
Year class = 1986

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	3186.	.237	.103	.43	10	1.000	.070

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3186.	.24	.10	10	.435	.070

Age 14 Catchability constant w.r.t. time and dependent on age
Year class = 1985

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	686.	.274	.233	.85	11	1.000	.049

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
686.	.27	.23	11	.852	.049

Age 15 Catchability constant w.r.t. time and dependent on age
Year class = 1984

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	1137.	.257	.176	.68	11	1.000	.058

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1137.	.26	.18	11	.683	.058

Age 16 Catchability constant w.r.t. time and dependent on age
Year class = 1983

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	1286.	.235	.217	.93	11	1.000	.051

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1286.	.23	.22	11	.926	.051

Age 17 Catchability constant w.r.t. time and dependent on age
Year class = 1982

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	1200.	.222	.168	.76	11	1.000	.049

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1200.	.22	.17	11	.756	.049

Age 18 Catchability constant w.r.t. time and age (fixed at the value for age) 17
Year class = 1981

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	1703.	.219	.102	.47	11	1.000	.049

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1703.	.22	.10	11	.466	.049

Fig. 6: XSA log catchability residuals for ages 4 to 17, 1989-99.

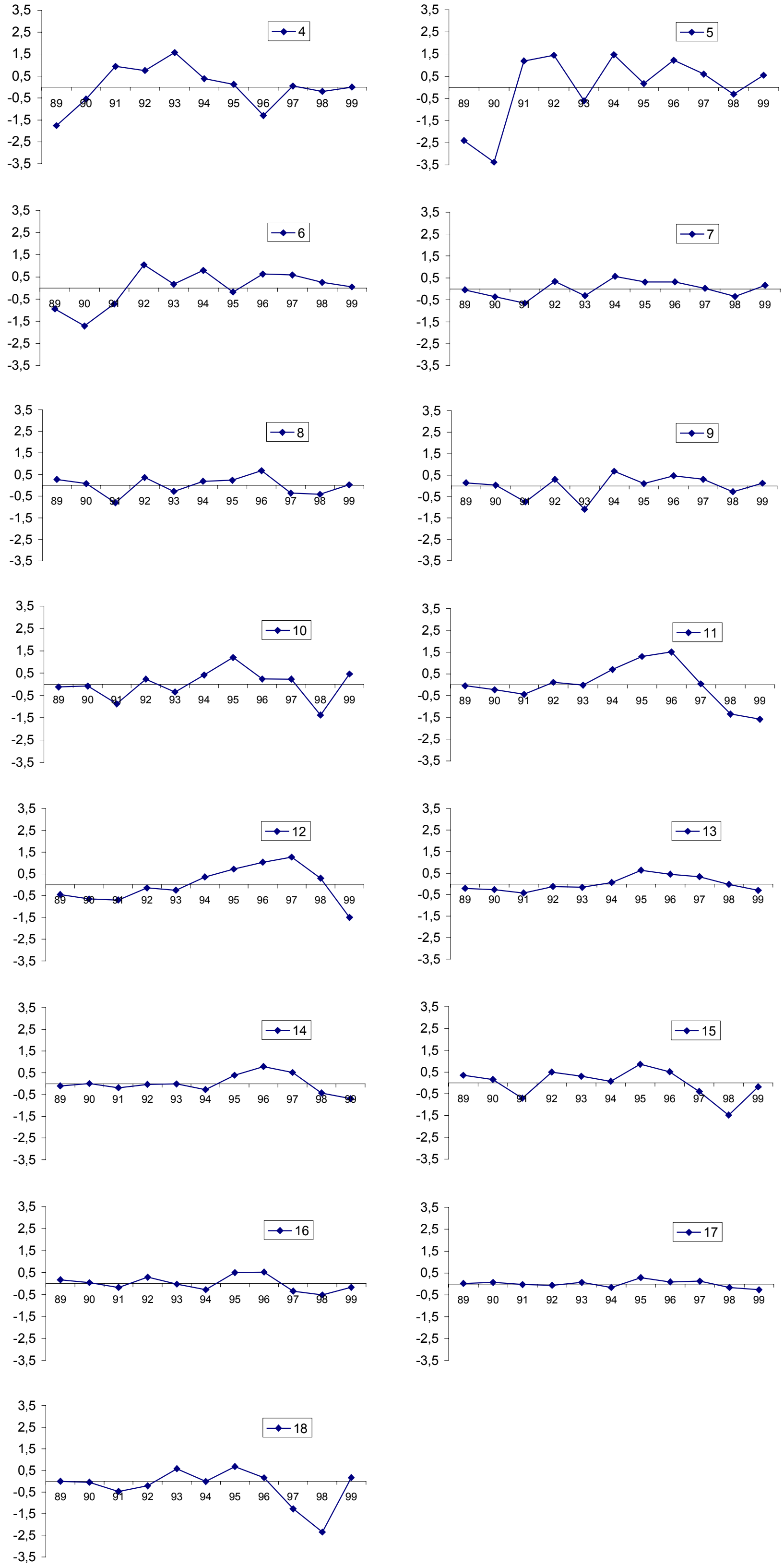


Fig. 7: XSA log catchability residuals by year (1989-99), for ages 4 to 17.

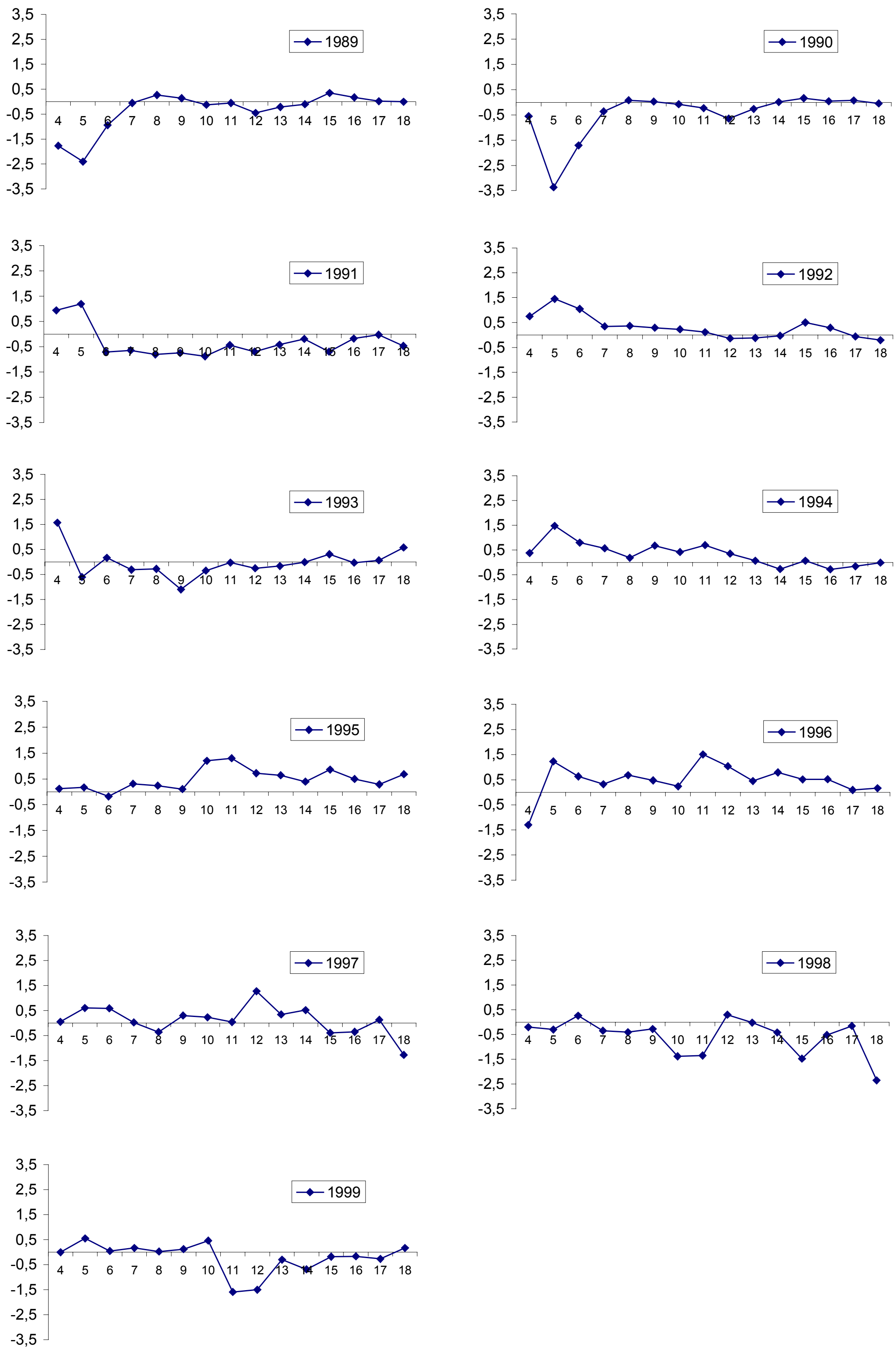


Table 13b :Extended Survivors Analysis results (Lowestoft VPA Version 3.1)

REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES APRIL 2000
Terminal Fs derived using XSA (Without F shrinkage)
Fishing mortality (F) at age

AGE/YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	FBAR 97-99
4	0,005	0,067	0,066	0,009	1,633	0,151	0,015	0,027	0,011	0,019	0,005	0,012
5	0,010	0,027	0,198	0,167	0,506	0,334	0,010	0,065	0,002	0,003	0,002	0,003
6	0,068	0,107	0,286	0,268	0,345	0,233	0,041	0,022	0,011	0,004	0,000	0,005
7	0,192	0,425	0,566	0,714	0,371	0,292	0,246	0,134	0,004	0,010	0,002	0,005
8	0,281	0,689	0,611	0,854	0,578	0,298	0,336	0,256	0,029	0,006	0,006	0,014
9	0,271	0,635	0,543	0,637	0,280	0,518	0,277	0,234	0,060	0,059	0,003	0,041
10	0,235	0,524	0,340	0,493	0,501	0,400	0,655	0,182	0,063	0,014	0,046	0,041
11	0,306	0,443	0,331	0,391	0,567	0,394	0,667	0,479	0,049	0,011	0,020	0,027
12	0,286	0,373	0,262	0,385	0,525	0,325	0,478	0,326	0,198	0,060	0,024	0,094
13	0,355	0,478	0,283	0,361	0,482	0,214	0,464	0,163	0,065	0,032	0,070	0,056
14	0,363	0,574	0,279	0,365	0,503	0,134	0,364	0,185	0,071	0,016	0,049	0,045
15	0,440	0,531	0,131	0,483	0,562	0,159	0,483	0,096	0,018	0,003	0,058	0,026
16	0,327	0,416	0,188	0,357	0,389	0,094	0,359	0,084	0,013	0,006	0,051	0,023
17	0,230	0,377	0,197	0,230	0,300	0,085	0,259	0,053	0,017	0,008	0,049	0,024
18	0,225	0,323	0,126	0,181	0,500	0,101	0,420	0,067	0,005	0,001	0,049	0,018
+gp	0,225	0,323	0,126	0,181	0,500	0,101	0,420	0,067	0,005	0,001	0,049	
FBAR 4-13	0,201	0,377	0,349	0,428	0,579	0,316	0,319	0,189	0,049	0,022	0,018	0,030

Relative F at age

AGE/YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	MEAN 97-99
4	0,026	0,177	0,190	0,020	2,821	0,477	0,045	0,141	0,231	0,885	0,256	0,457
5	0,051	0,072	0,566	0,391	0,874	1,057	0,032	0,346	0,049	0,155	0,097	0,100
6	0,337	0,284	0,821	0,627	0,597	0,737	0,129	0,114	0,227	0,201	0,017	0,148
7	0,956	1,129	1,623	1,668	0,641	0,926	0,772	0,711	0,073	0,474	0,085	0,211
8	1,397	1,829	1,752	1,996	0,998	0,944	1,054	1,354	0,581	0,283	0,324	0,396
9	1,351	1,686	1,559	1,488	0,483	1,639	0,868	1,240	1,216	2,687	0,176	1,360
10	1,170	1,390	0,975	1,153	0,866	1,266	2,054	0,964	1,275	0,620	2,619	1,505
11	1,521	1,177	0,950	0,914	0,979	1,246	2,090	2,540	1,003	0,502	1,108	0,871
12	1,424	0,989	0,752	0,900	0,907	1,028	1,500	1,725	4,018	2,742	1,341	2,700
13	1,768	1,268	0,812	0,844	0,833	0,678	1,456	0,865	1,326	1,451	3,977	2,251
14	1,808	1,524	0,799	0,852	0,869	0,424	1,140	0,979	1,450	0,744	2,767	1,653
15	2,193	1,410	0,375	1,129	0,972	0,503	1,513	0,507	0,359	0,146	3,278	1,261
16	1,628	1,105	0,540	0,834	0,672	0,298	1,127	0,446	0,262	0,251	2,909	1,141
17	1,146	1,000	0,566	0,537	0,519	0,269	0,811	0,282	0,339	0,351	2,773	1,154
18	1,120	0,858	0,362	0,422	0,863	0,320	1,316	0,356	0,099	0,027	2,790	0,972
+gp	1,120	0,858	0,362	0,422	0,863	0,320	1,316	0,356	0,099	0,027	2,790	
0 REFMEAN	0,201	0,377	0,349	0,428	0,579	0,316	0,319	0,189	0,049	0,022	0,018	

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

AGE/YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	GMST 89-97	AMST 89-97
4	71073	54552	46156	32015	139076	401528	79320	67117	58866	32218	54103	0	77449	105523
5	97092	63969	46170	39094	28722	24582	312534	70741	59136	52663	28591	48736	60177	82449
6	116037	86961	56321	34289	29928	15671	15930	279957	59961	53379	47488	25828	51261	77228
7	122922	98132	70699	38281	23724	19173	11237	13834	247899	53650	48088	42957	43625	71767
8	94344	91798	58040	36330	16965	14811	12950	7949	10947	223503	48041	43447	25859	38237
9	66729	64487	41707	28509	13991	8614	9946	8373	5571	9626	200986	43223	18748	27547
10	56173	46035	30920	21916	13643	9571	4645	6823	5996	4748	8211	181300	15207	21747
11	43848	40187	24677	19914	12108	7478	5807	2184	5146	5095	4238	7096	11989	17928
12	33886	29232	23341	16032	12184	6216	4566	2698	1223	4432	4560	3760	9089	14375
13	29146	23038	18220	16249	9871	6521	4065	2561	1763	908	3776	4030	8513	12382
14	26551	18493	12931	12421	10244	5515	4763	2313	1968	1494	796	3186	7713	10578
15	20052	16709	9423	8856	7804	5605	4364	2996	1740	1658	1330	686	6717	8617
16	14638	11682	8889	7480	4942	4024	4327	2438	2463	1547	1495	1137	5651	6765
17	13973	9551	6972	6663	4736	3031	3314	2734	2028	2200	1392	1286	4902	5889
18	13148	10043	5929	5179	4792	3173	2519	2315	2345	1804	1976	1200	4555	5494
+gp	30494	28019	21107	12001	5600	4514	5703	4853	14916	12624	2830	4141		
0 TOTAL	850105	692889	481503	335231	338332	540028	485989	479885	481968	461550	457901	412013		

Table 13b: cont.

Spawning stock number at age (spawning time) Numbers*10**-3

AGE/YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	2290	1711	1092	666	578	305	315	5545	1189	1059	942
7	7205	5646	4022	2152	1371	1115	656	815	14751	3191	2862
8	10982	10342	6580	4039	1928	1722	1501	927	1300	26593	5716
9	9069	8513	5546	3763	1900	1148	1351	1141	770	1331	27907
10	14766	11825	8060	5643	3511	2483	1181	1801	1598	1270	2191
11	14008	12697	7867	6318	3788	2372	1802	688	1678	1666	1385
12	12814	10977	8843	6015	4520	2343	1700	1017	466	1706	1761
13	12647	9899	7952	7047	4240	2862	1749	1128	783	404	1676
14	12537	8586	6147	5864	4783	2652	2249	1108	951	726	385
15	9794	8102	4718	4311	3775	2800	2125	1504	879	839	670
16	8346	6614	5125	4255	2804	2338	2461	1417	1440	905	872
17	8029	5424	4017	3829	2706	1762	1900	1593	1185	1287	811
18	7814	5922	3552	3089	2786	1905	1474	1394	1418	1092	1191
+gp	21689	19773	15132	8566	3897	3242	3993	3496	10797	9142	2041
TOTAL											

Stock biomass at age (start of year) Tonnes

AGE/YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	7107	5510	5170	2593	9457	36941	8805	5235	5769	3125	4869
5	15632	11131	6418	6607	4653	3269	38129	9974	7983	7636	3574
6	23671	19653	12503	7098	6554	3589	3584	40034	11992	9982	8548
7	30485	26692	20079	11178	6928	5369	3292	3777	45613	12661	10868
8	27077	28366	19850	12861	6243	5213	4649	2639	3908	50735	12683
9	21487	21990	16307	11347	5568	3429	4018	3266	2256	3533	50045
10	20054	17217	14471	9994	5948	4479	2100	3070	2770	1970	2693
11	19512	18325	12783	10575	6224	3724	2944	1066	2568	2420	1992
12	17722	15522	13374	9219	6750	3338	2452	1465	688	2353	2576
13	16817	13523	11297	10399	6150	3639	2500	1518	1054	543	1941
14	15984	11244	8379	8459	6986	3717	3205	1420	1196	982	436
15	12954	10928	6539	6226	5510	3722	3051	1995	1152	1117	716
16	9675	7827	6702	5931	4102	2849	3323	1731	1776	1178	824
17	10046	6944	5173	5024	3898	2428	2565	2094	1525	1683	860
18	9506	7312	4566	4527	4001	2624	2045	1850	1660	1241	1176
+gp	27353	25049	18194	11065	5942	3954	5663	4639	12753	12586	2066
0 TOTALBIO	285082	247232	181804	133101	94915	92283	92325	85774	104664	113748	105867

Spawning stock biomass at age (spawning time) Tonnes

AGE/YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	467	387	242	138	126	70	71	793	238	198	170
7	1787	1536	1142	628	400	312	192	222	2714	753	647
8	3152	3196	2250	1430	710	606	539	308	464	6037	1509
9	2920	2903	2168	1498	756	457	546	445	312	488	6949
10	5271	4422	3772	2573	1531	1162	534	810	738	527	719
11	6234	5790	4075	3355	1947	1181	914	336	837	792	651
12	6702	5829	5067	3458	2504	1258	913	552	262	906	995
13	7297	5811	4930	4510	2642	1597	1075	669	468	242	862
14	7547	5220	3983	3993	3262	1788	1513	680	578	477	211
15	6327	5299	3274	3031	2665	1859	1485	1002	582	565	360
16	5517	4431	3864	3374	2327	1655	1890	1006	1038	689	480
17	5773	3943	2980	2887	2227	1411	1470	1220	891	985	501
18	5650	4312	2735	2700	2326	1575	1197	1114	1004	751	709
+gp	19455	17677	13043	7898	4135	2840	3965	3342	9232	9114	1490
0 TOTSPBIO	84098	70755	53528	41473	27559	17772	16304	12499	19360	22524	16253

Table 13b: cont.

Summary (without SOP correction)

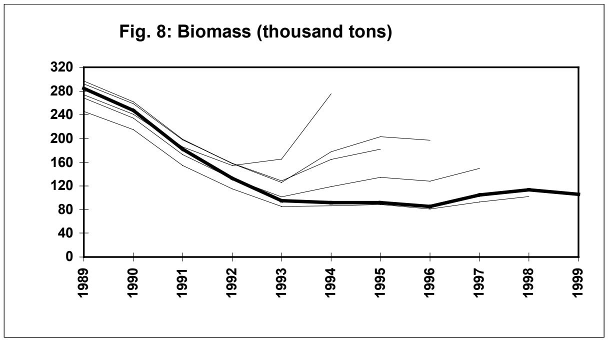
Terminal Fs derived using XSA (Without F shrinkage)

	RECRUITS Age 4	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR4-13
1989	71073	285082	84098	58094	0,6908	0,201
1990	54552	247232	70755	80758	1,1414	0,377
1991	46156	181804	53528	48500	0,9061	0,349
1992	32015	133101	41473	43300	1,044	0,428
1993	139076	94915	27559	40654	1,4752	0,579
1994	401528	92283	17772	16735	0,9416	0,316
1995	79320	92325	16304	13805	0,8467	0,319
1996	67117	85774	12499	6061	0,4849	0,189
1997	58866	104664	19360	1349	0,0697	0,049
1998	32218	113748	22524	1047	0,0465	0,022
1999	54103	105867	16253	956	0,0588	0,018
Arith. Mean	94184	139709	34739	28296	0,7005	0,2586
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Table 14: retrospective analysis for 3M beaked redfish biomass, SSB, F and age 4 recruits, based on 1999-94 XSA runs back to 1989.

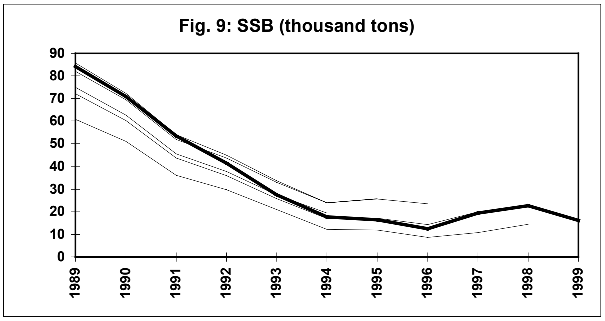
Biomass

	1999	1998	1997	1996	1995	1994
1989	285,082	245,766	268,225	297,013	292,238	274,210
1990	247,232	215,149	234,677	261,991	258,798	241,116
1991	181,804	154,373	172,616	198,798	197,893	185,656
1992	133,101	115,354	132,532	157,566	158,343	154,401
1993	94,915	85,654	101,273	125,63	129,008	165,145
1994	92,283	85,935	118,971	177,963	164,474	275,505
1995	92,325	88,377	134,647	203,136	181,975	
1996	85,774	81,418	128,221	196,806		
1997	104,664	93,014	149,642			
1998	113,748	101,795				
1999	105,867					



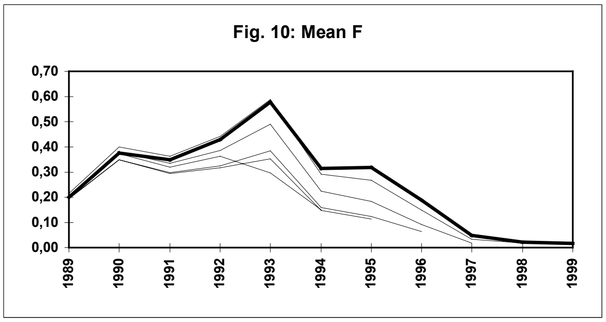
SSB

	1999	1998	1997	1996	1995	1994
1989	84,098	60,861	72,167	85,624	82,112	74,990
1990	70,755	50,946	60,247	72,378	69,441	62,682
1991	53,528	36,088	43,706	53,981	51,954	45,632
1992	41,473	29,716	36,031	45,081	43,754	37,809
1993	27,559	20,888	25,760	33,611	33,028	27,535
1994	17,772	12,237	16,856	23,826	23,819	19,336
1995	16,304	11,856	17,109	25,514	25,871	
1996	12,499	8,598	14,383	23,457		
1997	19,360	10,676	19,987			
1998	22,524	14,543				
1999	16,253					



F4-13

	1999	1998	1997	1996	1995	1994
1989	0,201	0,215	0,206	0,194	0,195	0,205
1990	0,377	0,399	0,380	0,349	0,349	0,372
1991	0,349	0,362	0,335	0,299	0,295	0,321
1992	0,428	0,442	0,387	0,326	0,317	0,362
1993	0,579	0,588	0,490	0,385	0,353	0,297
1994	0,316	0,292	0,224	0,160	0,147	0,152
1995	0,319	0,268	0,184	0,124	0,114	
1996	0,189	0,149	0,091	0,065		
1997	0,049	0,034	0,019			
1998	0,022	0,019				
1999	0,018					



REC

	1999	1998	1997	1996	1995	1994
1989	71073	73630	81616	86561	88400	78812
1990	54552	57130	59147	67017	69959	71141
1991	46156	50259	58975	71814	78178	121781
1992	32015	35198	44556	53280	55887	124099
1993	139076	138994	144217	161046	178844	665465
1994	401528	407839	601213	990671	786734	1262650
1995	79320	80774	163697	165563	116367	
1996	67117	51237	34500	24969		
1997	58866	56380	72031			
1998	32218	25730				
1999	54103					

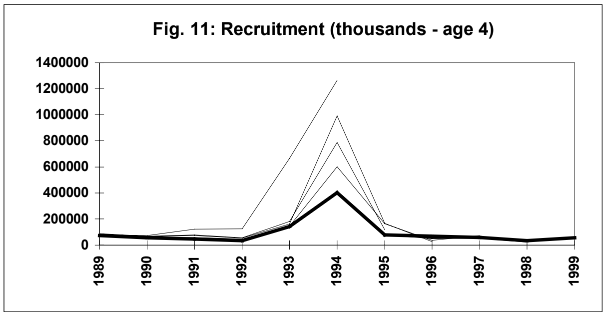


Tabela 15: Aspic results

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3M redfish                                                                                                 Page 1
                                                                                                05 May 2000 at 14:45

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.65)                                         BOT Mode

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        Southwest Fisheries Science Center
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        Tiburon, California 94920  USA


CONTROL PARAMETERS USED (FROM INPUT FILE)
---------------------------------------------------------------------------------------------------------------------
Number of years analyzed:                        41          Number of bootstrap trials:                         1000
Number of data series:                            2          Lower bound on MSY:                            1.000E+04
Objective function computed:              in EFFORT          Upper bound on MSY:                            4.000E+04
Relative conv. criterion (simplex):       1.000E-08          Lower bound on r:                              5.000E-02
Relative conv. criterion (restart):       3.000E-08          Upper bound on r:                              1.000E+00
Relative conv. criterion (effort):        1.000E-04          Random number seed:                              9126738
Maximum F allowed in fitting:                 1.500          Monte Carlo search trials:                             0

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                         code  0
---------------------------------------------------------------------------------------------------------------------
Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
----------------------------------------------------------------------------------------------------------------------
                                      |
 1  EU survey                         |   1.000
                                      |      12
                                      |
 2  Statlant CPUE                     |   0.808   1.000
                                      |       6      35
                                      -------------------------------------------------
                                              1       2


GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS
---------------------------------------------------------------------------------------------------------------------
                                                     Weighted           Weighted       Current      Suggested     R-squared
Loss component number and title                           SSE    N          MSE         weight         weight       in CPUE

Loss(-1)  SSE in yield                              0.000E+00
Loss( 0)  Penalty for B1R > 2                       0.000E+00    1          N/A      0.000E+00          N/A
Loss( 1)  EU survey                                 1.430E+00   12    1.430E-01      1.000E+00    8.171E-01         0.285
Loss( 2)  Statlant CPUE                             3.627E+00   35    1.099E-01      1.000E+00    1.063E+00         0.293

TOTAL OBJECTIVE FUNCTION:                      5.05696924E+00
```

Number of restarts required for convergence: 8
Est. B-ratio coverage index (0 worst, 2 best): 1.5934
Est. B-ratio nearness index (0 worst, 1 best): 1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1959	2.264E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	2.460E+04	2.000E+04	1	1
r	Intrinsic rate of increase	2.895E-01	2.120E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	EU survey	8.200E-01	8.200E-01	0	1
q(2)	Statlant CPUE	1.052E-05	3.881E-05	1	0

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	2.460E+04	Kr/4	
K	Maximum stock biomass	3.399E+05		
Bmsy	Stock biomass at MSY	1.699E+05	K/2	
Fmsy	Fishing mortality at MSY	1.447E-01	r/2	
F(0.1)	Management benchmark	1.303E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	2.435E+04	0.99*MSY	
B-ratio	Ratio of B(2000) to Bmsy	9.042E-01		
F-ratio	Ratio of F(1999) to Fmsy	4.522E-02		
Y-ratio	Proportion of MSY avail in 2000	9.908E-01	2*Br-Br^2	Ye(2000) = 2.437E+04
....	Fishing effort at MSY in units of each fishery:			
fmsy(2)	Statlant CPUE	1.376E+04	r/2q(2)	f(0.1) = 1.238E+04

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1959	0.147	3.847E+05	3.543E+05	5.198E+04	5.198E+04	-4.559E+03	1.014E+00	2.264E+00
2	1960	0.026	3.282E+05	3.258E+05	8.388E+03	8.388E+03	3.906E+03	1.779E-01	1.931E+00
3	1961	0.049	3.237E+05	3.186E+05	1.552E+04	1.552E+04	5.779E+03	3.365E-01	1.905E+00
4	1962	0.022	3.140E+05	3.139E+05	6.958E+03	6.958E+03	6.940E+03	1.531E-01	1.847E+00
5	1963	0.022	3.139E+05	3.139E+05	7.035E+03	7.035E+03	6.953E+03	1.549E-01	1.847E+00
6	1964	0.057	3.139E+05	3.089E+05	1.765E+04	1.765E+04	8.155E+03	3.947E-01	1.847E+00
7	1965	0.114	3.044E+05	2.929E+05	3.343E+04	3.343E+04	1.169E+04	7.885E-01	1.791E+00
8	1966	0.025	2.826E+05	2.857E+05	7.241E+03	7.241E+03	1.318E+04	1.751E-01	1.663E+00
9	1967	0.002	2.886E+05	2.941E+05	7.290E+02	7.290E+02	1.146E+04	1.713E-02	1.698E+00
10	1968	0.016	2.993E+05	3.018E+05	4.963E+03	4.963E+03	9.790E+03	1.136E-01	1.761E+00
11	1969	0.009	3.041E+05	3.071E+05	2.801E+03	2.801E+03	8.571E+03	6.301E-02	1.790E+00
12	1970	0.010	3.099E+05	3.121E+05	3.168E+03	3.168E+03	7.390E+03	7.014E-02	1.824E+00
13	1971	0.026	3.141E+05	3.136E+05	8.033E+03	8.033E+03	7.027E+03	1.770E-01	1.848E+00
14	1972	0.141	3.131E+05	2.966E+05	4.195E+04	4.195E+04	1.086E+04	9.770E-01	1.842E+00
15	1973	0.080	2.820E+05	2.780E+05	2.235E+04	2.235E+04	1.465E+04	5.555E-01	1.660E+00
16	1974	0.131	2.743E+05	2.650E+05	3.467E+04	3.467E+04	1.688E+04	9.040E-01	1.614E+00
17	1975	0.062	2.565E+05	2.576E+05	1.608E+04	1.608E+04	1.806E+04	4.312E-01	1.510E+00
18	1976	0.066	2.585E+05	2.590E+05	1.700E+04	1.700E+04	1.785E+04	4.535E-01	1.521E+00
19	1977	0.079	2.594E+05	2.582E+05	2.027E+04	2.027E+04	1.797E+04	5.424E-01	1.526E+00
20	1978	0.065	2.571E+05	2.577E+05	1.676E+04	1.676E+04	1.803E+04	4.494E-01	1.513E+00
21	1979	0.078	2.583E+05	2.573E+05	2.007E+04	2.007E+04	1.810E+04	5.390E-01	1.520E+00
22	1980	0.062	2.564E+05	2.575E+05	1.596E+04	1.596E+04	1.807E+04	4.282E-01	1.509E+00
23	1981	0.053	2.585E+05	2.604E+05	1.389E+04	1.389E+04	1.763E+04	3.686E-01	1.521E+00
24	1982	0.056	2.622E+05	2.635E+05	1.468E+04	1.468E+04	1.714E+04	3.851E-01	1.543E+00
25	1983	0.074	2.647E+05	2.634E+05	1.953E+04	1.953E+04	1.715E+04	5.121E-01	1.557E+00
26	1984	0.078	2.623E+05	2.609E+05	2.023E+04	2.023E+04	1.755E+04	5.357E-01	1.543E+00
27	1985	0.078	2.596E+05	2.584E+05	2.028E+04	2.028E+04	1.793E+04	5.423E-01	1.528E+00
28	1986	0.115	2.573E+05	2.520E+05	2.887E+04	2.887E+04	1.885E+04	7.915E-01	1.514E+00
29	1987	0.189	2.472E+05	2.349E+05	4.441E+04	4.441E+04	2.096E+04	1.306E+00	1.455E+00
30	1988	0.104	2.238E+05	2.233E+05	2.319E+04	2.319E+04	2.217E+04	7.176E-01	1.317E+00
31	1989	0.284	2.228E+05	2.045E+05	5.810E+04	5.810E+04	2.349E+04	1.963E+00	1.311E+00
32	1990	0.515	1.882E+05	1.574E+05	8.105E+04	8.105E+04	2.423E+04	3.557E+00	1.107E+00
33	1991	0.413	1.314E+05	1.175E+05	4.849E+04	4.849E+04	2.220E+04	2.851E+00	7.730E-01
34	1992	0.468	1.051E+05	9.247E+04	4.332E+04	4.332E+04	1.944E+04	3.237E+00	6.183E-01
35	1993	0.387	8.120E+04	7.492E+04	2.899E+04	2.899E+04	1.689E+04	2.674E+00	4.778E-01
36	1994	0.158	6.910E+04	7.161E+04	1.132E+04	1.132E+04	1.636E+04	1.092E+00	4.066E-01
37	1995	0.178	7.414E+04	7.593E+04	1.350E+04	1.350E+04	1.707E+04	1.228E+00	4.363E-01
38	1996	0.069	7.771E+04	8.387E+04	5.789E+03	5.789E+03	1.827E+04	4.769E-01	4.573E-01
39	1997	0.013	9.019E+04	9.955E+04	1.300E+03	1.300E+03	2.035E+04	9.023E-02	5.307E-01
40	1998	0.008	1.092E+05	1.198E+05	9.710E+02	9.710E+02	2.242E+04	5.599E-02	6.428E-01
41	1999	0.007	1.307E+05	1.421E+05	9.300E+02	9.300E+02	2.390E+04	4.522E-02	7.690E-01
42	2000		1.537E+05						9.042E-01

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) EU survey

Data type I1: Year-average biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1959	0.000E+00	0.000E+00	0.0	*	2.905E+05	0.00000	0.0
2	1960	0.000E+00	0.000E+00	0.0	*	2.672E+05	0.00000	0.0
3	1961	0.000E+00	0.000E+00	0.0	*	2.612E+05	0.00000	0.0
4	1962	0.000E+00	0.000E+00	0.0	*	2.574E+05	0.00000	0.0
5	1963	0.000E+00	0.000E+00	0.0	*	2.574E+05	0.00000	0.0
6	1964	0.000E+00	0.000E+00	0.0	*	2.533E+05	0.00000	0.0
7	1965	0.000E+00	0.000E+00	0.0	*	2.402E+05	0.00000	0.0
8	1966	0.000E+00	0.000E+00	0.0	*	2.343E+05	0.00000	0.0
9	1967	0.000E+00	0.000E+00	0.0	*	2.412E+05	0.00000	0.0
10	1968	0.000E+00	0.000E+00	0.0	*	2.475E+05	0.00000	0.0
11	1969	0.000E+00	0.000E+00	0.0	*	2.518E+05	0.00000	0.0
12	1970	0.000E+00	0.000E+00	0.0	*	2.559E+05	0.00000	0.0
13	1971	0.000E+00	0.000E+00	0.0	*	2.571E+05	0.00000	0.0
14	1972	0.000E+00	0.000E+00	0.0	*	2.432E+05	0.00000	0.0
15	1973	0.000E+00	0.000E+00	0.0	*	2.280E+05	0.00000	0.0
16	1974	0.000E+00	0.000E+00	0.0	*	2.173E+05	0.00000	0.0
17	1975	0.000E+00	0.000E+00	0.0	*	2.112E+05	0.00000	0.0
18	1976	0.000E+00	0.000E+00	0.0	*	2.123E+05	0.00000	0.0
19	1977	0.000E+00	0.000E+00	0.0	*	2.117E+05	0.00000	0.0
20	1978	0.000E+00	0.000E+00	0.0	*	2.113E+05	0.00000	0.0
21	1979	0.000E+00	0.000E+00	0.0	*	2.110E+05	0.00000	0.0
22	1980	0.000E+00	0.000E+00	0.0	*	2.111E+05	0.00000	0.0
23	1981	0.000E+00	0.000E+00	0.0	*	2.135E+05	0.00000	0.0
24	1982	0.000E+00	0.000E+00	0.0	*	2.161E+05	0.00000	0.0
25	1983	0.000E+00	0.000E+00	0.0	*	2.160E+05	0.00000	0.0
26	1984	0.000E+00	0.000E+00	0.0	*	2.139E+05	0.00000	0.0
27	1985	0.000E+00	0.000E+00	0.0	*	2.119E+05	0.00000	0.0
28	1986	0.000E+00	0.000E+00	0.0	*	2.067E+05	0.00000	0.0
29	1987	0.000E+00	0.000E+00	0.0	*	1.926E+05	0.00000	0.0
30	1988	1.000E+00	1.000E+00	0.0	1.936E+05	1.831E+05	0.05568	1.048E+04
31	1989	1.000E+00	1.000E+00	0.0	1.170E+05	1.677E+05	-0.35976	-5.067E+04
32	1990	1.000E+00	1.000E+00	0.0	7.870E+04	1.291E+05	-0.49487	-5.039E+04
33	1991	1.000E+00	1.000E+00	0.0	6.413E+04	9.636E+04	-0.40719	-3.223E+04
34	1992	1.000E+00	1.000E+00	0.0	8.562E+04	7.582E+04	0.12154	9.798E+03
35	1993	1.000E+00	1.000E+00	0.0	4.622E+04	6.143E+04	-0.28459	-1.522E+04
36	1994	1.000E+00	1.000E+00	0.0	8.636E+04	5.872E+04	0.38567	2.764E+04
37	1995	1.000E+00	1.000E+00	0.0	6.880E+04	6.226E+04	0.09990	6.541E+03
38	1996	1.000E+00	1.000E+00	0.0	9.496E+04	6.877E+04	0.32257	2.618E+04
39	1997	1.000E+00	1.000E+00	0.0	7.678E+04	8.163E+04	-0.06119	-4.845E+03
40	1998	1.000E+00	1.000E+00	0.0	5.404E+04	9.826E+04	-0.59791	-4.422E+04
41	1999	1.000E+00	1.000E+00	0.0	7.747E+04	1.165E+05	-0.40820	-3.905E+04

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                   -1       -0.75     -0.5      -0.25       0         0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -----------------------------------------------------------------------------------
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0557                                             |==
1989    -0.3598                               ==============|
1990    -0.4949                         ====================|
1991    -0.4072                             ================|
1992     0.1215                                             |=====
1993    -0.2846                                  ===========|
1994     0.3857                                             |===============
1995     0.0999                                             |====
1996     0.3226                                             |=============
1997    -0.0612                                           ==|
1998    -0.5979                     ========================|
1999    -0.4082                             ================|
                   -----------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) Statlant CPUE

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1959	1.934E+04	1.395E+04	0.1467	5.198E+04	5.198E+04	0.32651	0.000E+00
2	1960	2.007E+03	2.448E+03	0.0257	8.388E+03	8.388E+03	-0.19848	0.000E+00
3	1961	2.911E+03	4.631E+03	0.0487	1.552E+04	1.552E+04	-0.46444	0.000E+00
4	1962	1.885E+03	2.107E+03	0.0222	6.958E+03	6.958E+03	-0.11144	0.000E+00
5	1963	1.870E+03	2.131E+03	0.0224	7.035E+03	7.035E+03	-0.13066	0.000E+00
6	1964	7.861E+03	5.432E+03	0.0571	1.765E+04	1.765E+04	0.36947	0.000E+00
7	1965	1.020E+04	1.085E+04	0.1141	3.343E+04	3.343E+04	-0.06214	0.000E+00
8	1966	4.089E+03	2.410E+03	0.0253	7.241E+03	7.241E+03	0.52865	0.000E+00
9	1967	4.010E+02	2.357E+02	0.0025	7.290E+02	7.290E+02	0.53149	0.000E+00
10	1968	1.442E+03	1.564E+03	0.0164	4.963E+03	4.963E+03	-0.08074	0.000E+00
11	1969	9.579E+02	8.672E+02	0.0091	2.801E+03	2.801E+03	0.09953	0.000E+00
12	1970	4.355E+02	9.652E+02	0.0102	3.168E+03	3.168E+03	-0.79577	0.000E+00
13	1971	1.600E+03	2.436E+03	0.0256	8.033E+03	8.033E+03	-0.42011	0.000E+00
14	1972	1.427E+04	1.345E+04	0.1414	4.195E+04	4.195E+04	0.05935	0.000E+00
15	1973	8.721E+03	7.645E+03	0.0804	2.235E+04	2.235E+04	0.13169	0.000E+00
16	1974	1.084E+04	1.244E+04	0.1308	3.467E+04	3.467E+04	-0.13790	0.000E+00
17	1975	5.123E+03	5.935E+03	0.0624	1.608E+04	1.608E+04	-0.14710	0.000E+00
18	1976	7.151E+03	6.241E+03	0.0656	1.700E+04	1.700E+04	0.13606	0.000E+00
19	1977	9.524E+03	7.464E+03	0.0785	2.027E+04	2.027E+04	0.24368	0.000E+00
20	1978	6.646E+03	6.184E+03	0.0650	1.676E+04	1.676E+04	0.07208	0.000E+00
21	1979	1.154E+04	7.418E+03	0.0780	2.007E+04	2.007E+04	0.44222	0.000E+00
22	1980	7.181E+03	5.893E+03	0.0620	1.596E+04	1.596E+04	0.19768	0.000E+00
23	1981	5.491E+03	5.072E+03	0.0533	1.389E+04	1.389E+04	0.07927	0.000E+00
24	1982	6.225E+03	5.299E+03	0.0557	1.468E+04	1.468E+04	0.16100	0.000E+00
25	1983	9.150E+03	7.048E+03	0.0741	1.953E+04	1.953E+04	0.26106	0.000E+00
26	1984	9.537E+03	7.372E+03	0.0775	2.023E+04	2.023E+04	0.25752	0.000E+00
27	1985	9.270E+03	7.463E+03	0.0785	2.028E+04	2.028E+04	0.21676	0.000E+00
28	1986	9.017E+03	1.089E+04	0.1146	2.887E+04	2.887E+04	-0.18892	0.000E+00
29	1987	1.240E+04	1.797E+04	0.1890	4.441E+04	4.441E+04	-0.37137	0.000E+00
30	1988	1.100E+04	9.875E+03	0.1039	2.319E+04	2.319E+04	0.10788	0.000E+00
31	1989	3.504E+04	2.702E+04	0.2841	5.810E+04	5.810E+04	0.26013	0.000E+00
32	1990	5.149E+04	4.895E+04	0.5148	8.105E+04	8.105E+04	0.05062	0.000E+00
33	1991	3.267E+04	3.924E+04	0.4126	4.849E+04	4.849E+04	-0.18302	0.000E+00
34	1992	2.831E+04	4.454E+04	0.4685	4.332E+04	4.332E+04	-0.45320	0.000E+00
35	1993	1.674E+04	3.680E+04	0.3870	2.899E+04	2.899E+04	-0.78764	0.000E+00
36	1994	*	1.502E+04	0.1580	1.132E+04	1.132E+04	0.00000	0.000E+00
37	1995	*	1.690E+04	0.1777	1.350E+04	1.350E+04	0.00000	0.000E+00
38	1996	*	6.563E+03	0.0690	5.789E+03	5.789E+03	0.00000	0.000E+00
39	1997	*	1.242E+03	0.0131	1.300E+03	1.300E+03	0.00000	0.000E+00
40	1998	*	7.705E+02	0.0081	9.710E+02	9.710E+02	0.00000	0.000E+00
41	1999	*	6.223E+02	0.0065	9.300E+02	9.300E+02	0.00000	0.000E+00

* Asterisk indicates missing value(s).

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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -1       -0.75     -0.5      -0.25       0       0.25      0.5       0.75      1
                   |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year    Residual   ----------------------------------------------------------------------------------
1959      0.3265                                           |=============
1960     -0.1985                                   ========|
1961     -0.4644                        ===================|
1962     -0.1114                                       ====|
1963     -0.1307                                      =====|
1964      0.3695                                           |===============
1965     -0.0621                                         ==|
1966      0.5287                                           |=====================
1967      0.5315                                           |=====================
1968     -0.0807                                        ===|
1969      0.0995                                           |====
1970     -0.7958           ================================|
1971     -0.4201                          =================|
1972      0.0594                                           |==
1973      0.1317                                           |=====
1974     -0.1379                                     ======|
1975     -0.1471                                     ======|
1976      0.1361                                           |=====
1977      0.2437                                           |==========
1978      0.0721                                           |===
1979      0.4422                                           |==================
1980      0.1977                                           |========
1981      0.0793                                           |===
1982      0.1610                                           |======
1983      0.2611                                           |==========
1984      0.2575                                           |==========
1985      0.2168                                           |=========
1986     -0.1889                                   ========|
1987     -0.3714                            ===============|
1988      0.1079                                           |====
1989      0.2601                                           |==========
1990      0.0506                                           |==
1991     -0.1830                                    =======|
1992     -0.4532                         ==================|
1993     -0.7876           ================================|
1994      0.0000                                           |
1995      0.0000                                           |
1996      0.0000                                           |
1997      0.0000                                           |
1998      0.0000                                           |
1999      0.0000                                           |
                   ----------------------------------------------------------------------------------
```

RESULTS OF BOOTSTRAPPED ANALYSIS

Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1ratio	2.234E+00	2.264E+00	1.35%	1.593E+00	3.315E+00	1.850E+00	2.653E+00	8.026E-01	0.359
K	3.452E+05	3.399E+05	-1.54%	2.849E+05	4.178E+05	3.069E+05	3.810E+05	7.406E+04	0.215
r	2.828E-01	2.895E-01	2.34%	1.966E-01	3.985E-01	2.336E-01	3.483E-01	1.147E-01	0.405
q(1)	8.200E-01	8.200E-01	0.00%	8.200E-01	8.200E-01	8.200E-01	8.200E-01	6.715E-13	0.000
q(2)	9.949E-06	1.052E-05	5.71%	8.334E-06	1.187E-05	9.041E-06	1.093E-05	1.889E-06	0.190
MSY	2.438E+04	2.460E+04	0.87%	2.039E+04	2.847E+04	2.221E+04	2.684E+04	4.633E+03	0.190
Ye(2000)	2.468E+04	2.437E+04	-1.27%	1.801E+04	2.711E+04	2.162E+04	2.640E+04	4.779E+03	0.194
Bmsy	1.726E+05	1.699E+05	-1.54%	1.425E+05	2.089E+05	1.535E+05	1.905E+05	3.703E+04	0.215
Fmsy	1.414E-01	1.447E-01	2.34%	9.828E-02	1.993E-01	1.168E-01	1.741E-01	5.735E-02	0.405
fmsy(1)	1.725E-01	1.765E-01	2.34%	1.199E-01	2.430E-01	1.424E-01	2.124E-01	6.993E-02	0.405
fmsy(2)	1.419E+04	1.376E+04	-3.00%	1.135E+04	1.716E+04	1.254E+04	1.584E+04	3.300E+03	0.233
F(0.1)	1.273E-01	1.303E-01	2.11%	8.845E-02	1.793E-01	1.051E-01	1.567E-01	5.161E-02	0.405
Y(0.1)	2.414E+04	2.435E+04	0.86%	2.019E+04	2.818E+04	2.199E+04	2.658E+04	4.586E+03	0.190
B-ratio	9.057E-01	9.042E-01	-0.17%	6.054E-01	1.291E+00	7.389E-01	1.104E+00	3.654E-01	0.403
F-ratio	4.543E-02	4.522E-02	-0.46%	2.711E-02	7.967E-02	3.416E-02	6.089E-02	2.673E-02	0.588
Y-ratio	1.021E+00	9.908E-01	-2.97%	9.672E-01	1.000E+00	9.917E-01	1.000E+00	8.281E-03	0.008
f0.1(1)	1.552E-01	1.589E-01	2.11%	1.079E-01	2.187E-01	1.282E-01	1.911E-01	6.294E-02	0.405
f0.1(2)	1.277E+04	1.238E+04	-2.70%	1.022E+04	1.544E+04	1.128E+04	1.425E+04	2.970E+03	0.233
q2/q1	1.213E-05	1.283E-05	5.71%	1.016E-05	1.448E-05	1.103E-05	1.333E-05	2.304E-06	0.190

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 1000 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- The bias corrections used here are based on medians. This is an accepted statistical procedure, but may estimate nonzero bias for unbiased, skewed estimators.

Trials replaced for lack of convergence:	0
Trials replaced for MSY out-of-bounds:	2
Trials replaced for r out-of-bounds:	0
Residual-adjustment factor:	1.0455

Table 16: The 4 plus biomass summary table.

Year	EU survey	SPA	XSA	ASPIC
1988	193567			223800
1989	117015		285082	222800
1990	78703	237705	247232	188200
1991	64126	177073	181804	131400
1992	85620	136629	133101	105100
1993	46218	108980	94915	81200
1994	86359	93952	92283	69100
1995	68804	97241	92325	74140
1996	94955	87377	85774	77710
1997	76785	98954	104664	90190
1998	54039	109849	113748	109200
1999	77468	105990	105867	130700

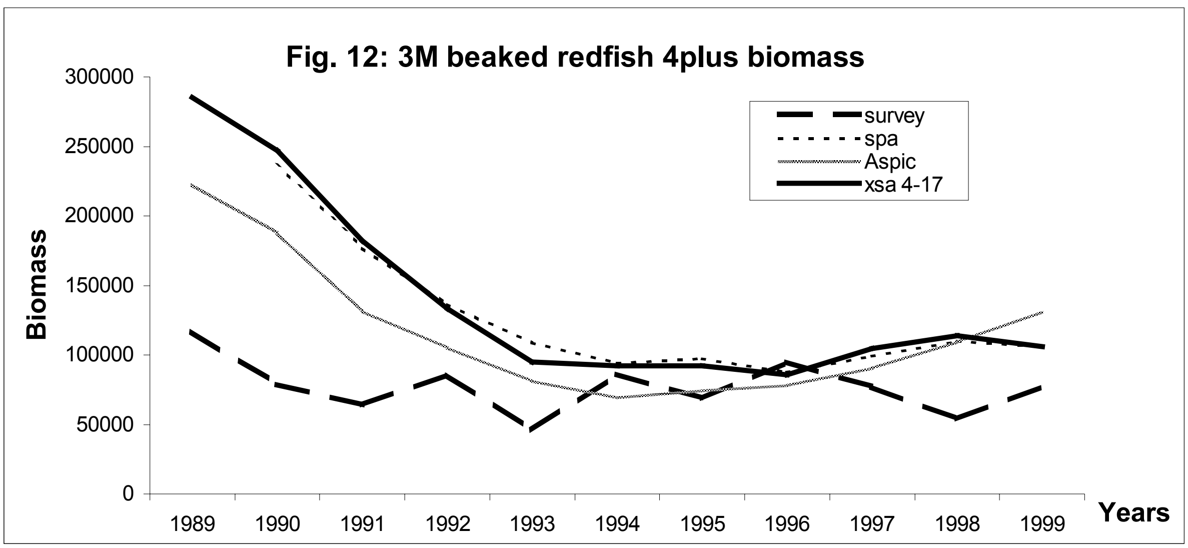

Table 17: Medium term projections for 3M beaked redfish biomass, SSB and mean F4-13 fishing mortality. Catch in 2000 equal to previous year.
For all options constant 2001-10 catch, constant recruitment equal to 1997-99 geometric mean and PR equal to average 1997-99 PR.
Average 1997-99 mean weights at age in the catch, stock and female spawning stock

Option a: Catch in 2001 corresponding to F staus quo.

Option b: Catch for 2001 corresponding to Fssb.

Option c: Catch for 2001 corresponding to actual TAC (5000 tons)

	F4-13			Biomass			SSB					
Year	Option a	Option b	Option c	Option a	Option b	Option c	Option a	(SSB/B)a	Option b	(SSB/B)b	Option c	(SSB/B)c
2000	0,007	0,007	0,007	141999	141999	141999	32119	23%	32119	23%	32119	23%
2001	0,018	0,057	0,035	158918	158918	158918	39770	25%	39770	25%	39770	25%
2002	0,009	0,030	0,018	171335	165377	168652	48475	28%	46533	28%	47600	28%
2003	0,009	0,033	0,019	176233	164584	170987	54824	31%	50492	31%	52871	31%
2004	0,010	0,038	0,022	182094	165030	174411	61891	34%	54709	33%	58652	34%
2005	0,011	0,041	0,023	186178	164201	176288	68045	37%	57865	35%	63449	36%
2006	0,012	0,045	0,025	192849	165657	180617	75715	39%	62014	37%	69521	38%
2007	0,011	0,044	0,024	198082	166193	183749	82838	42%	65492	39%	74986	41%
2008	0,011	0,046	0,025	197370	162478	181710	85196	43%	65256	40%	76162	42%
2009	0,011	0,044	0,024	211416	169509	192598	98399	47%	72733	43%	86747	45%
2010	0,011	0,044	0,023	214019	168631	193663	100325	47%	72176	43%	87542	45%

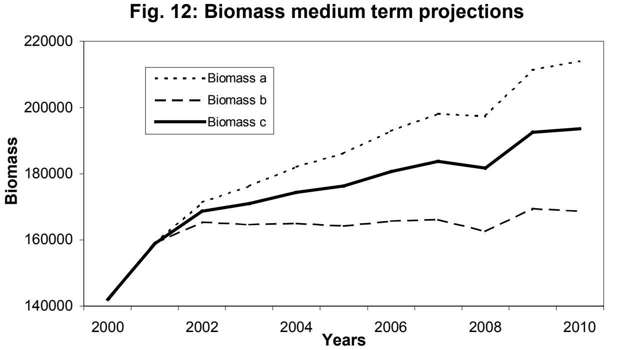

Fig. 12: Biomass medium term projections

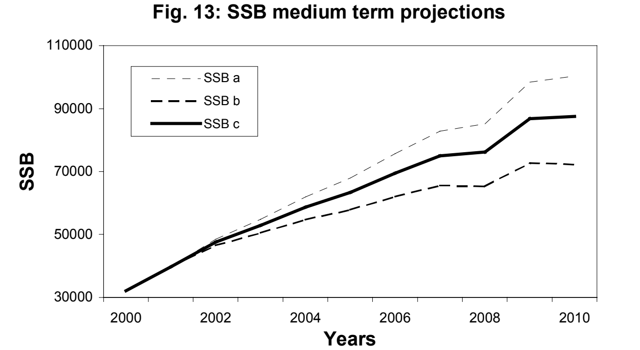

Fig. 13: SSB medium term projections

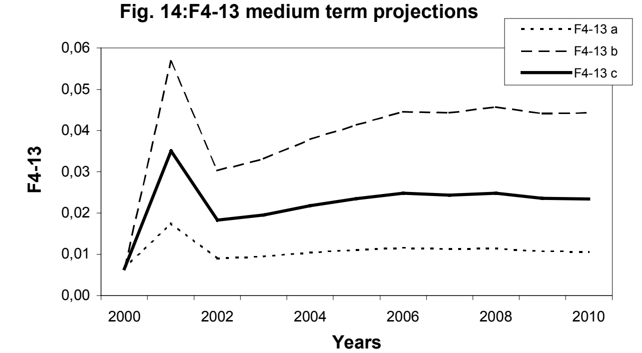

Fig. 14:F4-13 medium term projections