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A Comparative Assessment and Medium Term Projections of Redfish (*S. mentella and S. fasciatus*) in NAFO Division 3M

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 were calculated based on the abundance at length from Canadian (1979-1985) and EU (1988-2000) bottom trawl surveys, and on the length weight relationships derived from EU survey data. The analytical assessment used a 1989-00 catch at age matrix starting at age 4 and incorporating the 1993-2000 redfish by-catch in the shrimp fishery at age. An Extended Survivor Analysis (Shepherd, 1999), including a 2000-1994 Retrospective Analysis, was first performed and complemented further by a Separable/Cohort analysis (Pope and Shepherd, 1982). Both models gave similar trends of stock biomass, spawning stock biomass and fishing mortality over the past twelve years. However the full weight of the former high catches of adult beaked redfish (greater than 30cm) on the SPA fit of the correspondent fishing mortalities lead to higher 1989-1993 F's from the Cohort analysis and lower 1989-1998 SSB's than those from XSA. A logistic surplus production model (ASPIC) which does not use the equilibrium assumption (Praguer, 1994 and 1995) was also applied using the 1959-2000 catch coupled with the STATLANT standardised CPUE series (1959-1993) and the age 4 plus EU bottom biomass (1988-2000). 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 1998-2000. Either VPA's and ASPIC analysis pointed out that the 3M beaked redfish stock experienced a steep decline from the second half of the eighties till 1994-1996. Biomass is increasing since then but is still well bellow the level estimated by each model for the beginning of the time series (1989). Till 1996 fishing mortality was kept well above Fmsy, due to a period of extremely high commercial catches from the direct fishery (1989-93) followed by an extremely high level of redfish by-catch in numbers from beginning of the 3M shrimp fishery (1993-94). From 1997 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, no new pulse of recruitment has occurred since 1990-1989. With the XSA survivors and recruitment randomly resampled from the 1998-00 geometric mean, short and medium term projections, under F and TAC *status quo*, were made for several probability levels. The underlying assumption of these projections was that no pulse of recruitment would be foreseen in the next coming years. Maintaining in the short term the catches at the TAC level will represent a 50% reduction on F*status quo*. Under this scenario, and considering a high probability given by the 20% percentile profiles, catches will be anchored to levels between 4,000 tons and 5,000 tons till the end of this decade but female spawning stock biomass should reach in 2010 the vicinity of the 1990 SSB, that generated the last abundant cohort seen in this stock. Until 3M beaked redfish stock returns to a "normal" rhythm on the pulse of recruitment, the future increase of the female stock biomass will continue to be dependent on keeping fishing mortality well below F0.1. At the present magnitude of the exploitable stock biomass, and at least in the short term, this will correspond to an annual catch not going beyond 5,000 tons.

Introduction

There are three stocks of redfish in NAFO Division 3M: deep-sea redfish (*Sebastes mentella*) with a maximum abundance at depths greater than 300m, golden (*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 present assessment 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 are the dominance of this group in the 3M redfish commercial catches, 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 will be basically supported by the *S. mentella* plus *S. fasciatus* biomass.

An extended survivor analysis (XSA) was used to tune the terminal F's with the EU survey abundance's and estimate the survivors at age by the end of 2000. This analysis was then compared with a separable analysis (SPA) and a non-equilibrium surplus production model (ASPIC) for checking the fitness of the respective biomass trends. With the XSA survivors and recruitment randomly resampled from the 1998-00 geometric mean, short and medium term projections, under F and TAC status quo, were made for several probability levels.

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 1998-99, when a minimum catch around 1,000 tons has been recorded 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 and with the abrupt decline of fishing effort deployed in this fishery, caused by the vanishing from 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 were the major partners of the catch till 1999, but for both fleets Greenland halibut has been for several years the priority species in all NAFO divisions (NAFO circular letters with monthly provisional catches, 1995-00).

However in 1999 Russian vessels appeared again in Flemish Cap and their nominal catch raised from 168 tons to 1,808 tons in 2000. Estonians vessels joined the fishery in 2000 recording 632 tons, while the EU catches increased from 505 tons in 1999 to 1349tons in 2000 due to a jump in the catches from Portugal: 96 tons to 916 tons (NAFO circular letter Ref.No.GF/01-109). Despite the almost null presence of the Japanese fleet in 2000 (31 tons against 321 tons in 1999) the fact is that the overall increase of the redfish catches from 1,068 tons in 1999 to 3,825 tons in 2000 reflects the rebirth of a redfish directed fishery in Div. 3M.

The boom in 1993 and further settlement of a shrimp fishery in Flemish Cap lead to high levels of redfish by-catch in 1993-94. Despite the fact that since 1995 this by-catch in weight fell to an apparent low level it is still accounting to a very important portion of the age composition of the catch for the most recent years. In 1998-2000 the by-catch (ages 1 to 3) represented on average 42% of the total 3M redfish catch in numbers (26% just for age 2).

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

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
TAC	20	20	20	50	50	43	30	26	26	26	26	20	13	5
Catch	4.4	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[2]	3.8[2]
By-catch[3]							11.97	5.90	0.37	0.55	0.16	0.19	0.10	0.10
Total catch	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	3.9

[1] Includes estimates of non-reported catches from various sources
[2] Provisional
[3] Kulka, D. *pers. comm*. 2000 and 2001

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*., 2001). 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. Length sampling data from Russia (1989-91, 1995, 1998-2000; Vaskov, A. *pers. comm*. 2000 and 2001) and from the Japan (1996 and 98; Ichii,T. *pers. comm*. 2001) were used to estimate the length composition of the commercial catches for those fleets and time periods. The 1989-2000 per mille length composition of the Portuguese trawl catch was applied to the rest of the commercial catches. In all cases the 3M beaked redfish length weight relationships from 1989-2000 EU surveys (Saborido-Rey *pers. comm*., 2000) were used to get each absolute length frequency vector of the 3M redfish commercial catches (Table 1a, 2000 catch from NAFO circular letter Ref.No.GF/01-109).

Redfish by-catch in weight and in numbers at length for the 3M shrimp fishery was available for 1993-97, based on data collected on board of Canadian and Norwegian vessels (Kulka, 1998 and *pers. comm*., 2000). To abide the by-catch in numbers at length to both the estimated by-catch in weight and the adopted length weight relationships those length frequencies were recalculated (Ávila de Melo *et al*. 2000). The 1998-00 by-catch in numbers at length was derived from the 1998 Norwegian and 1999-00 Canadian length sampling applied to the estimates of the overall by-catch in weight (Kulka, *pers. comm*., 2001). Length composition of redfish by-catch in the 3M shrimp fishery is presented on Table 1b.

The sum of the absolute length compositions of the 1989-00 commercial catch with the 1993-00 by-catch is the 3M redfish catch at length input of this assessment (Table 1c).

Length composition of the stock and spawning stock survey abundance

The 1988-00 EU survey abundance and female mature abundance at length for 3M beaked redfish was updated with the results from 2000 survey (Saborido-Rey and Vazquez, 2001) following the steps described in last assessments (Ávila de Melo *et al*. 1999 and 2000). From 1992 till 2000 mature female abundance at length for *S. mentella* and *S. fasciatus* is given each year by the respective length maturity ogives. These ogives are 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), with the exception of the *S. mentella* length maturity ogive adopted for 1999 and 2000 which is based in the histological analysis of gonads collected during the 1999 EU survey (Saborido-Rey, *pers. comm*. 2000) 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 1992-00 period are the sum of the respective *S. mentella* and *S. fasciatus* sets first calculated by species.

A combined maturity ogive was calculated from the 1992-00 female and mature female abundance at length of *S. mentella* and *S. fasciatus* (Table 2). This ogive was applied to the 1988-91 beaked redfish female abundance at length, in order to derive the respective mature female abundance's (Table 3, Fig.1).

For the 1979-85 Canadian surveys beaked redfish total abundance at length is given directly by the survey results (Power and Atkinson, 1986). The correspondent biomass and spawning stock biomass were revised according to the procedure used in previous assessments (Table 3, Fig.1).

Length weight relationships

Length weight relationships for each of the 3M beaked redfish species separately (1992-00) and for *S.mentella* and *S. fasciatus* combined (1989-91) were calculated with survey length/weight data from both sexes (Saborido Rey *pers. comm.*, 2000) and used in this assessment on an annual basis (Table 4).

Survey stock biomass and spawning biomass

The annual *S.mentella* and *S. fasciatus* (1992-00) 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 at length times mean weight at length, for the EU series (1988-00) and the Canadian series (1979-85) (Table 3, Fig. 1).

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

The EU survey abundance at age for the 1989-00 3M beaked redfish stock and mature female component (Table 5a and b) were obtained using the *S.mentella* age length keys from the 1990-00 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 the 1999 assessment (Ávila de Melo *et al*., 1999). Due to the scarcity of redfish larger than 40cm in the EU surveys 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 1990-00 EU surveys (Table 6).

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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 6) as well as in the 3M beaked redfish stock and female spawning stock (Table 7).

Partial recruitment vector

In order to generate an observed partial recruitment vector a Findex was first derived from the 1989-00 ratios between the sums of the permile 3M redfish total catch (commercial plus by-catch) and the permile beaked redfish survey abundance at age. Those indicators of F at age were then standardised to its highest value recorded at age 14. Assuming a flat top recruitment curve this observed partial recruitment vector was adjusted to a general logistic curve (Table 8a, Fig. 2). The expected vector has been used in the yield per recruit analysis, while the observed one was used in the SPA/Cohort analysis to generate a first guess of fishing mortality at age in 2000. Due to the impact of the shrimp fishery on the mortality of the prerecruited age groups the observed PR for age 1 was kept as the expected one for this age.

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 1989-00 sum of mature females and the correspondent total stock abundance. These mean proportions of mature females at age have been used both as input file of the VPA based methods and 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 throughout the assessment period (1989-00):

1) Mean weights at age in the commercial catch.
2) Mean weights at age in the stock (as well as in the mature female component) from length weight relationships from stock survey abundances.
3) Female maturity ogive at age, from the mature female and stock survey abundance at age.
4) Expected partial recruitment vector (though keeping the observed PR at age one).
5) Natural mortality, 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 (1988-2000) and Canadian bottom trawl surveys (1979-1985)

The more recent period of 1988-2000 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. A further decline occurred in 1997 and 1998, when the second lowest bottom biomass index was recorded (Table 3, Fig.1). It is however difficult to associate this last apparent decline from 93,000 tons in 1996 to 56,000 tons in 1998 to fishing mortality, that have already dropped to very low levels. Survey bottom biomass increase since then by 96% being in 2000 at 110,000 tons, the highest index observed since 1989. Those drastic shifts in bottom biomass survey indices, on opposite directions and at relatively short and consecutive time intervals, should be also influenced by changes on the redfish concentration near the bottom, that will cause “year” (=time interval) effects of alternate sign on survey catchability.

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 more than 40% of the survey bottom biomass on most of the years. This proportion varied between 22% and 28% during the first years of the EU survey time series and gradually declined since 1991 till 1998 when a minimum of 7% was reached. Survey spawning biomass is steadily increasing since then both in absolute and relative magnitude (18%), but was still in 2000 bellow its former level (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 64% of the female spawning biomass from its unexploited level and a 36% proportion of female spawners in the stock biomass when fishing at $F_{0.1}$ (0.10). 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 above $F_{0.1}$ (F”msy”=0.11). As for the fishing mortality which, under a constant recruitment assumption, will lead to a long term female spawning biomass at a 50% reduction from its unexploited level, its value should be of 0.062 corresponding to a spawning biomass proportion of 39%. This value is near the average SSB proportion observed during the former period of 1979-85 covered by the Canadian series (42%).

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" (0.065), assuming a natural mortality at 0.1, is very similar to the F associated with a long term 50% reduction on the female spawning stock biomass from its unexploited level and a 39% proportion of SSB on the stock biomass.

VPA based methods: the Extended Survivors Analysis and Separable Cohort Analysis

This assessment updates the Extended Survivor Analysis (XSA) (Shepherd, 1999), first carried out last year using the EU survey abundance at age data as the tuning file (Ávila de Melo *et al*., 2000). A Separable Cohort Analysis (SPA) was runned next and the respective trends of F and SSB were compared. The purpose of this procedure is to check if the expected year effects on the residuals of the log catchabilities that relate survey and vpa abundances at age (due to fluctuations on the concentration of beaked redfish near the bottom) have a major impact on the XSA results.

The input files for both XSA and SPA analysis are presented in Table 10. Natural mortality was assumed constant at 0.1. The proportion mature at age is the one observed on the 1989-00 period (Table 5 and 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 1993-00 by-catch at age from the shrimp fishery. The first age group considered was age 4 (the first age in the catch at age matrix with catches assigned every year) and age 18 was the last true age (from age 19 onwards both survey and commercial sampling data are scarce and so a plus group on age 19 has been considered). The F's from the 2000 XSA were used as the initial guess for F's on oldest age and the F's at age in last year.

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). 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 XSA and SPA analysis. The purpose is to give a full use and equal importance to the twelve years of input data, namely those from the beginning of the time interval when a full scale redfish fishery occurred on Flemish Cap.

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

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

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 $A(y,a) = \dfrac{(e^{-aZ_{(y,a)}} - e^{-bZ_{(y,a)}})}{(b-a)Z_{(y,a)}}$

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 $b = 1$.

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 at each age and, since catchability is constant with time this standard error will be kept constant for all years:

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

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, given by the forward estimated abundance from each age of the cohort

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

where

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

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 back to each age i, and $s^2_{(i)}$ is the variance of each $Nest_{(y,i)}$ value. 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 internal standard error of the cohort´s terminal population is given by the standard errors of the $Nest_{(y,a)}$ that contributed (with a terminal estimate from each age) to its calculation:

$$s\ int(Ty,Ta)^2 = \frac{\sum_{i=Fa}^{i=Ta} \left(\frac{1}{s^2_{(i)} ECF_{(y,i)}^2} \right)}{\left(\sum_{i=Fa}^{i=Ta} \frac{1}{s^2_{(i)} ECF(y,i)} \right)^2}$$

The external standard error of the cohort´s terminal population is given by the standard error of the terminal estimates, $Ptest_{(y,a)}$, obtained from each cohort age

$$s\,ext(Ty,Ta) = \sqrt{\frac{1}{n-1}} \sqrt{\frac{\sum_{i=Fa}^{i=Ta} w'_{(y,i)} \left[Ptest_{(y,i)} - Pt(Ty,Ta) \right]^2}{\sum_{i=Fa}^{i=Ta} w'_{(y,i)}}}$$

where

$$Ptest_{(y,a)} = LnNest_{(y,a)} - LnECZ_{(y,a)}$$

and $w'_{(y,,i)}$ are the weighting factors used in the computation of the terminal population mean $Pt(Ty,Ta)$

The XSA run ends when

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

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 most likely increase of F on the last year of the assessment, following the increase of the catches in 2000. Under these circumstances the shrinkage will flat the changes occurring on F over the most recent years, masking its impact on the stock status.

A first run, with catchability independent of year-class strength on younger ages and independent of age at the penultimate true age (17), showed ages up to age 6 with high regression standard errors and high log catchability residuals. However the regression statistics of catchability for these "recruiting" ages present *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, not differing significantly from 1 (*Student's t* test with degrees of freedom = No. points – 2) (Table 11a). This lack of a significant trend led us to treat the catchability as just age dependent also on the younger ages.

With the above mentioned constraint, and taking into account that cathability declines on older ages, four exploratory runs were performed in order to 1) select the age at which catchability starts to be "constant", the second or third oldest true age (17 or 16), and 2) select a minimum standard error (0.3 or 0.5) for the log catchability of the last true age (18), in order to avoid overweight of the cohort's terminal population estimates by the last true age. Under the four options considered, for age of constant catchability/ last age minimum standard error, all retrospective runs converged. A 2000-94 retrospective analysis was carried out as well under each of the four hypothesis, to compare the patterns on the fishing mortality (average F, ages 6-16) and female spawning stock biomass (SSB) estimates, from the assessments back in time. The four matrices with the log catchability residuals are presented on Table 11b and Fig. 5, and the retrospective analysis on Fig 6. The results of this exercise point out that fixing catchability on age 16 doesn't improve the fitness of the model to the existing data (and besides will shrunk the range of true ages involved on the assessment of a long living stock). However keeping the minimum standard error of the log catchability of age 18 at 0.5 (instead of adopting a lower minimum) will reduce the magnitude of the majority of the residuals on the full recruited age groups, giving the lowest final sum of squared residuals when coupled with a fixed catchability since age 17. The "constant catchability since age17/ last age minimum standard error of 0.5" option was also the only one that did not produce consistent under-estimation bias of F and over-estimation bias of SSB (Fig. 6), while the 2000 and 1999 assessments for the 1989-1999 time interval showed the closest results of the four options (Table 12a). This preliminary analysis confirm last year's XSA framework, consisting of no recruiting ages with catchability dependent of year-class strength, constant catchability just at the penultimate age and a minimum standard error of the log catchability for the lat true age of 0.5. The diagnostics and results of the adopted XSA are presented on Table 11a and Table 12b respectively.

Extended Survivor Analysis converged after a high number of iterations. The diagnostics present high positive and negative log catchability residuals at recruitment to survey gear (ages 4 to 6), namely during the first half of the period. Most of the residuals were positive during the intermediate years of 1994 to 1996, while on the former years till 1991 and again on 1998 most ages had negative residuals (Table 11a and Fig. 5). Very low fishing mortalities over the last three years, on average less than 50% of the assumed level of natural mortality, changes of opposite sign on beaked redfish concentration near the bottom amplifying the noise around the log catchabilities at age and introducing year effects, and a declining trend of catchabilties on older ages, all these factors contributed at some extent to this long process of convergence. The poor fit, on the XSA model, of survey data to the catch at age matrix of 3M beaked redfish, provoked by recent low fishing mortalities and fluctuations on availability to the bottom trawl survey gear, seems related with redfish own biology and behaviour, and is something a redfish assessment has to live with when using vpa based models supported by tuning.

The Separable VPA

A Separable analysis, followed by a traditional VPA run (Cohort analysis), has been performed afterwards. The purpose is not to get an alternate assessment to be regarded as a potential substitue of the adopted XSA, but to evaluate how well the survey abundance at age used in tunning fits with the catch at age matrix. In other words if an analytical model "free" from a noisy survey tuning and just dependent of commercial catch data is telling the same history of the 3M beaked redfish stock., with a better, or worse, fitness of the input data. The procedure will be to check the level of agreement of the F's and SSB's time series from both models.

The Separable VPA (Pope and Shepherd, 1982) doesn't require tuning data, though a previous notion about fishing mortality (F for the first fully exploited age on last year) and exploitation pattern (selection value for last true age) is required. 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 1989-00 catch at age matrix, by-catch at age included (Table 6). 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

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

$$R(.,a) = \sum_{i=Firstyear}^{i=Lastyear-1} R(i,a) = 0$$ 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 $\hat{F}o(y)$ and $\hat{S}(a)$ the algorithm uses the approximations

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

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

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

From the observed exploitation pattern (Table 8a and Fig. 2) a reference age of 12 and a terminal selection value of 0.95 at age 18 was adopted for the Separable Analysis. An approach to the fishing mortality on the reference age in the last year by the correlation between survey and VPA spawning stock biomass proved to be unsuccessful: correlation was still slowly increasing for levels of fishing mortality resulting on VPA stock biomass well bellow the survey estimate for several years. Since, as stated above, the purpose was not to produce a second assessment but just to check the consistency of the adopted XSA results, several exploratory runs were made in order to iteractively reach a terminal reference F that would generate a stock biomass in 2000 identical to the one given by the XSA. The terminal F was set at 0.029.

The diagnostics of the Separable analysis are presented on Table 13a and Fig. 7. Both the columns (years) and rows (ages) have very low sums of residuals. However some high positive and negative residuals are observed on the log catch ratios between the younger ages, consequence of the long recruitment process of beaked redfish. High negative and positive residuals were observed as well on some older ages specially for the 1997/98 and 1999/00 log catch ratios, 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 better diagnostics provided by the SPA analysis can be interpreted as a much lower impact of redfish biology and behaviour on the commercial fisheries than on the survey series.

The Separable Analysis was concluded with a traditional VPA (Cohort analysis). Recruitment to each cohort was estimated first minimising 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 Cohort analysis (corresponding to the comparison between VPA and Separable F's) are presented on Table 13a and Fig. 8. These F residuals are a consequence 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. That's why the SPA catch at age never matches the observed one exactly. Despite the general small magnitude of these residuals they are higher on the first half of the time interval till 1995, diminishing to very low values afterwards. This pattern reflects an improving match between SPA estimated and observed catches over time. The Cohort analysis results are presented on Table 13b.

Comparison of the XSA and Cohort/SPA results

The VPA based models are compared on tables 14 and figures 9. Both models gave similar trends of stock biomass, spawning stock biomass and fishing mortality over the past twelve years. However the full weight of the former high catches of adult beaked redfish (greater than 30cm) on the SPA fit of the correspondent fishing mortalities, lead to higher 1989-93 F's from the Cohort analysis and lower 1989-98 SSB's than those from XSA. The different constraints on each model background can also be used to justify the different impact of the fall of the catches and fishing mortality since 1993 on the more recent SSB estimates from both models: conditioned by the tuning, where the response of the survey abundance's at age to this drop is not straightforward in time and magnitude, the XSA outputs higher estimates of F since 1994 and lower SSB's on the last couple of years. From both VPA based models an important fishing mortality increase is detected from 1998 to 1999 on several older cohorts (1988 and 1987, and from 1984 to 1981), causing in 1999 a break on the SSB recovery (Table 12b and 13b). However the recruitment to maturity of the above average 1990 cohort, in progress in 2000, returns the spawning stock biomass back to its increasing trend.

A 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 XSA and Cohort/SPA analysis the maximum level of the mean fishing mortality was 0.5. 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 the 1999 assessments the inclusion of all CPUE and survey series available in a first ASPIC run resulted in negative or very low correlations between most of them (Ávila de Melo *et al*., 1999). 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 (1988-2000) is recalculated as a sum of products of the age 4 plus biomass and runs with the STATLANT commercial CPUE, gaving a high correlation 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 tons and 55,000 tons.

6) The starting guess for r was 0.200. This value was derived from the $F_{0.1}$ given by the yield per recruit analysis, using the model's assumptions as regards $F_{0.1,}$ F_{msy} 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 0.7. This value corresponds to the geometric mean of the survey bottom biomass/XSA stock biomass ratio for the 1992-2000 interval, after a former period, between 1989 and 1991, when this bottom survey ratio was at a much lower level (Table 16). A geometric mean is justified due to a better goodness-of –fit (than the correspondent arithmetic mean) of the survey series to the non-bootstrapped surplus production model. Biomass survey catchability was the only parameter that was fixed, 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.

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

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

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

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

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

$$P_{\text{bc}} = P - (P_{\text{m}} - P)$$

The results of the production model converge to a total biomass above the Bmsy level until 1990, though starting to decline in 1984 after almost a decade of apparent stability (1975-83) where the catches were within 14,000 and

20,000 tons. From 1989 till 1993 fishing mortality was well above Fmsy inducing a fast stock decline till 1994, when the biomass represented about 45% of the Bms y. Between 1995 and 1996 fishing mortality dropped, and continued to decline till 1999 when its value was 5.5% of the Fmsy. Fishing mortality increased in 2000 to 17% of the Fmsy, which in turn, is a bias-corrected estimate very much consistent with the correspondent proxy estimate from the yield per recruit analysis (0.12 from ASPIC versus 0.11 from Y/R). This decline of fishing mortality during the second half of the nineties gave room to stock recovery and biomass is gradually increasing from 1995 onwards, most likely being in 2001 at 99% of the Bmsy (bias corrected estimate). As for MSY for 3M beaked redfish stock, the ASPIC bias correct estimate is of 23,000tons with an inter quartile range for 80% confidence limits of 3,900tons. 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 1998-2000.

State of the 3M beaked redfish stock

Either VPA's and ASPIC analysis pointed out that the 3M beaked redfish stock experienced a steep decline from the second half of the eighties till 1994-96. Biomass is increasing since then but is still well bellow the level estimated by each model for the beginning of the time series (1989). Till 1996 fishing mortality was kept well above Fmsy, due to a period of extremely high commercial catches from the direct fishery (1989-93) followed by an extremely high level of redfish by-catch in numbers from beginning of the 3M shrimp fishery (1993-94). From 1997 onwards fishing mortality dropped to values well below natural mortality allowing the survival and growth of the remainders from all cohorts, namely from the most abundant one (1990), and forcing a discrete growth of the biomass and female spawning biomass. Meanwhile since 1990-89 no other pulse of recruitment had occurred yet and abundance at age 4 has been fluctuating over the more recent years at a low level, when compared to the average recruitment of the whole series (even without the couple of peaks from the turn of last decade).

This low level of recruitment at age 4 is in part a result of a depressed spawning stock biomass that only started to recover recently. The female spawning biomass still represented in 2000 only 22% of the stock biomass (from the XSA), while back to the late seventies/early eighties that proportion was at 40% (from the Canadian survey bottom biomass series) and the stock sustained catches between 16,000 tons and 20,000 tons. Associated with low spawning stock biomass, the 1993-94 high by-catch in numbers at age 4 depressed the most abundant cohorts at that time (1989 and 1990), reducing their potential contribution on the rate of growth of the female spawning biomass. By-catch mortality continued to act as a buffer on recruitment in recent years, and in 2000 was still responsible for a by-catch of 3 million prerecruits (ages 1 to 3), corresponding to 24% of the total catch in numbers (19% just for age 2). This is a much lower level than the one observed at the beginning of the 3M shrimp fishery, but is also reflection of the weakness of the more recent year-classes. In addition, backcalculation of 1996-1999 cohorts at age 1, from the respective XSA abundance's at age 4 (Table 12b) and 1996-2000 by-catch at age (Table 6), indicates that by-catch rate increases with year-class strength (for those cohorts, from 3% to 8%). Taking into account that the last pulse of recruitment occurred more than a decade ago, if a strong cohort appears in the near future its capacity to contribute to the present recovery of the 3M redfish stock may be prevented by the actual level of fishing effort to shrimp.

Prognosis

In order evaluate what will be stock response, in terms of spawning stock biomass and yield, to different levels of fishing mortality, regarded as a range of multipliers centred on a reference fishing mortality, a medium term projection program (Mterm) has been used. This program has first been applied in a NAFO stock last year (Mahe and Darby, 2000), and recently adjusted at the CEFAS laboratory in Lowestoft/UK to allow projections for long living stocks with a large number of ages included in the analytical assessment (Smith and Darby, *pers. comm.* 2001). The input data are agregated in two files:

1. A ". sen" (sensitivity) file (Table 17a) including the usual vectors needed to forward projections but with uncertainty associated to the population at age on the beginning of the first year of the projection (given by the XSA survivors at age by the end of 2000, plus the geometric mean of the 1998-2000 XSA recruitment's at age 4). Being the internal and external standard errors two measures of the uncertainty around the survivors estimates, the correspondent average of these standard errors were adopted as the coefficients of variation associated with the initial populations at age in the red.sen file. Fishing mortality at age in last year from the XSA was the "exploitation pattern for human comsumption" adopted on the first run of Mterm.

2. A ".srr" (stock recruitment relationship) file (Table 17b), adopting as 3M redfish SRR model a fluctuation of recruitment around the geometric mean of recruitment for the more recent years (but eliminating the the 1989 and 1990 peaks). Residuals in this file were used to randomly resample recruitment. Details as regards the inputs of the red.srr file are included in the file as text coments.

The results are presented as probabilities profiles for 5, 10, 20, 50 and 95 percentiles for:

1. Short (3 years) and medium term (10 years) female spawning stock biomass projections for a range of F multipliers around a reference F, taken from the "exploitation pattern for human consumption" of the red.sen file as an average for a range of ages predetermined by the user at the beginning of each Mterm run. These projections are presented on Table 18a and Fig. 11a and 11b for the short term (with the range of F's represented as multipliers around 1) and on Table 18b and Fig. 12a and 12b for the medium term (with the range of F's represented as F bar's around the refence F).

2. Female spawning stock biomass and yield trajectories for the next ten years for a reference F. These trajectories are presented on Table 19 and Fig. 13a to 14b.

The first short and medium term projections were made with the XSA fishing mortality at age for 2000, corresponding to a reference F at F*status quo*. There is a high probability (corresponding to the 20% percentile profiles) that on the short term (2003) catches will raise to 8,000 tons, but in 2010 they will be lowered to 6,500 tons (Table 19, Fig. 14a). At the same time female spawning stock biomass will rise in the short term to 52,500 tons (Table 18a, Fig 11a) but in the medium term will be kept at that same level, increasing till 2010 just to 54,500 (Table 18b and 19, Fig. 12a and 13a) . This seems a rather poor perspective in terms of stock recovery, taking into account that under the present low productivity regime, with no cyclic pulse of recruitment occurring, most likely female spawning stock biomass will stay in the medium term future still far away from the former level of 78,000 tons (XSA results) that in 1990 generated the last abundant cohort seen in this stock. For a second projection several exploratory runs were made in order to check what will be the reduction on F*status quo* necessary to achieve a 50% probability that in the near future (till 2003) catches would be kept around the actual TAC of 5,000 tons. Maintaining in the short term the catches at the TAC level will represent a 50% reduction on F*status quo* and so the second short and medium term projections were made with the "exploitation pattern for human consumption" of the red.sen file corresponding to half of the XSA fishing mortality at age for 2000. Under this scenario, and again considering a high probability given by the 20% percentile profiles, catches will be anchored to levels between 4,000 tons and 5,000 tons till the end of this decade (Table 19, Fig. 14b) but female spawning stock biomass, that in 2003 will be already at 57,000 tons, should reach in 2010 the vicinity of the 1990 SSB with 71,000 tons (Table 18a, 18b and 19, Fig. 11b, 12b and 13b).

Even associated with a gradient of probability levels, short and medium term projections should be taken with caution. They depend on the similarity between the near future and the recent past, namely as regards the amount of variability associated with recruitment and population at age estimates at the end of each last year on future assessments. The underlying assumption of these projections, that no pulse of recruitment will be foreseen in the next coming years, can fall with appearance of one or two year-classes strong enough to be still well above average when reaching age 4. And, if the 3M beaked redfish stock returns to a "normal" rhythm on the pulse of recruitment, the perspective of a faster rate of stock recovery sustaining a higher level of catch will certainly increase. But until then the future increase of the female stock biomass will continue to be dependent on keeping fishing mortality well below F0.1. At the present magnitude of the exploitable stock biomass and at least in the short term this will correspond to an annual catch not going beyond 5,000 tons.

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Table 1a: Length composition (absolute frequencies in'000s) of the 3M redfish commercial catch, 1989-00.

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
10	3				1							
11												
12	3				1							9
13	12				9	1						17
14	29	4			117	12						1
15	9	81			395	44				2		9
16	34	211			440	132		22				1
17	69	808			167	391		22	1	2		9
18	34	2787	175		101	843	129	22		1		26
19	12	6470	726	70	130	1030	291	74	7	9	1	40
20	128	6925	1494	352	145	501	1273	400	8	14	2	68
21	440	3253	1385	1856	327	515	3222	1073	16	31	1	52
22	1316	1344	1323	3110	970	598	6630	2464	44	57	2	120
23	4317	2146	1060	2376	1894	732	6431	1825	112	104	1	121
24	9628	6157	1904	1469	3372	1408	1901	1472	284	128	10	244
25	16884	13302	4193	2760	3160	1999	1282	872	351	246	122	348
26	16970	22298	7061	8656	3345	2005	858	569	335	247	116	732
27	12796	28705	11632	13299	3277	1782	1028	822	213	229	228	1278
28	8096	29130	14411	13405	4024	2439	1276	842	183	191	317	1604
29	6605	22485	16923	9609	3530	2587	1588	951	227	185	319	1397
30	8465	16982	14634	8119	5261	2783	1621	998	267	178	210	957
31	7949	11308	8359	5797	4611	2526	1356	1058	240	188	218	662
32	8432	9266	7907	5124	3629	2196	1405	985	268	172	255	465
33	8022	7303	3946	4535	3748	1456	1312	761	290	123	185	357
34	7899	7133	4361	4771	3079	931	1084	742	115	81	89	322
35	7432	6115	3477	4814	3308	994	1113	310	82	59	150	203
36	5607	4900	2938	3476	2903	623	1121	218	46	51	81	160
37	4655	3394	2683	2604	2777	354	985	244	26	50	71	151
38	2786	2458	1874	1733	1536	303	805	114	29	36	9	128
39	1787	1734	1959	1388	1318	152	525	139	12	32	31	54
40	1082	856	1148	974	695	100	504	50	4	17	2	35
41	577	647	717	583	392	78	372	42	13	12	5	24
42	390	384	225	233	339	26	176	50	6	9	1	16
43	332	294	317	274	149	15	74	20	1	3	2	22
44	155	145	22	199	443	26	54	3	7	2		15
45	163	81	16	45	55	16	37	2	1		2	3
46	85	36	9	10	45		8	4	1	1		7
47	53	18			36		20	1	1			4
48	32	13	9	20	65		5					
49	4	13										
50	12	4						30				
51	4	13										
52	4											
53	8	18										
54		9										
55		4										
56												
57												
58		4										
59												
60												
61									12			
no ('000)	143320	219243	116888	101663	61265	29599	38484	17202	3202	2461	2429	9662
weight (tons)	**58100**	**81000**	**48500**	**43300**	**29000**	**11300**	**13500**	**5789**	**1300**	**971**	**1068**	**3825**
mean weight	405	369	415	426	473	382	351	337	406	395	440	396
mean length	30.1	28.8	30.2	30.2	30.9	28.6	27.5	27.5	29.5	29.4	30.9	29.6

Table 1b: Length composition (absolute frequencies in'000s) of the redfish by-catch in the 3M shrimp fishery, 1993-00.

Length	1993	1994	1995	1996	1997	1998	1999	2000
5								3
6				150	1	3	14	5
7			4	4408	96	97	111	58
8			6	2469	116	222	531	121
9			5	216	65	36	784	55
10			3	426	235	40	816	191
11			14	1081	519	350	377	588
12	2	18	33	861	467	1638	302	997
13	23	331	32	470	149	1540	276	743
14	207	957	59	499	110	304	93	179
15	1792	2177	229	749	109	54	87	84
16	7171	7115	399	1733	590	104	83	48
17	27984	17018	703	1190	168	75	59	16
18	45217	20665	915	755	56	28	40	10
19	28682	10818	762	386	56	23	37	9
20	6435	2274	396	69	71	5	12	10
21	947	312	118	96	55	10	6	4
22	343	111	25	5	38	12	7	2
23	1		6		20	7	5	2
24			2		9	17	2	2
25			4		3	14	4	
26			4		1	18		2
27			4			9	3	
28			6			1		
29			6			1		
30			2					
31								
32						1		
33								
34						1		
no ('000)	118805	61798	3739	15563	2933	4609	3651	3126
weight (tons)	11970	5903	374	550	157	191	96	106
mean weight	0.101	0.096	0.100	0.035	0.054	0.041	0.026	0.034
mean length	18.5	18.1	18.3	11.9	14.0	13.1	11.2	12.5

Table 1c: Length composition (absolute frequencies in'000s) of the 3M redfish total annual catch, 1989-00.

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
5												3
6								150	1	3	14	5
7							4	4408	96	97	111	58
8							6	2469	116	222	531	121
9							5	216	65	36	784	55
10	3				1		3	426	235	40	816	191
11							14	1081	519	350	377	588
12	3				3	18	33	861	467	1638	302	1006
13	12				32	332	32	470	149	1540	276	761
14	29	4			324	969	59	499	110	304	93	180
15	9	81			2187	2221	229	749	109	57	87	93
16	34	211			7611	7248	399	1755	590	104	83	49
17	69	808			28151	17409	703	1212	168	76	59	25
18	34	2787	175		45318	21508	1044	777	56	29	40	36
19	12	6470	726	70	28812	11848	1052	460	63	32	38	49
20	128	6925	1494	352	6580	2775	1669	470	79	20	14	78
21	440	3253	1385	1856	1274	827	3340	1168	70	41	7	56
22	1316	1344	1323	3110	1313	710	6655	2469	82	69	9	122
23	4317	2146	1060	2376	1895	732	6438	1825	132	111	6	123
24	9628	6157	1904	1469	3372	1408	1903	1472	294	146	12	246
25	16884	13302	4193	2760	3160	1999	1286	872	354	260	126	348
26	16970	22298	7061	8656	3345	2005	862	569	336	265	116	734
27	12796	28705	11632	13299	3277	1782	1031	822	213	238	231	1278
28	8096	29130	14411	13405	4024	2439	1283	842	183	192	317	1604
29	6605	22485	16923	9609	3530	2587	1594	951	227	186	319	1397
30	8465	16982	14634	8119	5261	2783	1623	998	267	178	210	957
31	7949	11308	8359	5797	4611	2526	1356	1058	240	188	218	662
32	8432	9266	7907	5124	3629	2196	1405	985	268	173	255	465
33	8022	7303	3946	4535	3748	1456	1312	761	290	123	185	357
34	7899	7133	4361	4771	3079	931	1084	742	115	82	89	322
35	7432	6115	3477	4814	3308	994	1113	310	82	59	150	203
36	5607	4900	2938	3476	2903	623	1121	218	46	51	81	160
37	4655	3394	2683	2604	2777	354	985	244	26	50	71	151
38	2786	2458	1874	1733	1536	303	805	114	29	36	9	128
39	1787	1734	1959	1388	1318	152	525	139	12	32	31	54
40	1082	856	1148	974	695	100	504	50	4	17	2	35
41	577	647	717	583	392	78	372	42	13	12	5	24
42	390	384	225	233	339	26	176	50	6	9	1	16
43	332	294	317	274	149	15	74	20	1	3	2	22
44	155	145	22	199	443	26	54	3	7	2		15
45	163	81	16	45	55	16	37	2	1	0	2	3
46	85	36	9	10	45		8	4	1	1		7
47	53	18			36		20	1	1			4
48	32	13	9	20	65		5					
49	4	13										
50	12	4						30				
51	4	13										
52	4											
53	8	18										
54		9										
55		4										
56												
57												
58		4										
59												
60												
61									12			
no ('000)	143320	219243	116888	101663	180070	91397	42223	32765	6123	7070	6080	12788
weight (tons)	58100	81000	48500	43300	40970	17203	13874	6339	1457	1162	1164	3931

Table 2: Female and mature female proportion in beaked redfish , EU surveys 1989-00 and 1992-00 respectively

Length	Female ratio	Mature proportion	Mature fem. prop.
<20	0.47	0.00	
20	0.47	0.00	
21	0.47	0.02	**0.01**
22	0.47	0.03	**0.01**
23	0.47	0.05	**0.02**
24	0.47	0.09	**0.04**
25	0.47	0.16	**0.07**
26	0.47	0.23	**0.11**
27	0.47	0.30	**0.14**
28	0.47	0.40	**0.19**
29	0.47	0.50	**0.23**
30	0.47	0.62	**0.29**
31	0.47	0.70	**0.33**
32	0.47	0.79	**0.37**
33	0.47	0.85	**0.40**
34	0.47	0.90	**0.42**
35	0.47	0.93	**0.43**
36	0.47	0.96	**0.44**
37	0.52	0.97	**0.50**
38	0.52	0.98	**0.51**
39	0.55	0.99	**0.54**
40	0.57	0.99	**0.57**
41	0.66	1.00	**0.66**
42	0.74	1.00	**0.74**
43	0.82	1.00	**0.81**
44	0.82	1.00	**0.82**
45	0.85	1.00	**0.85**
46	0.88	1.00	**0.88**
>46	0.88	1.00	**0.88**

Fig. 1: 3M Beaked redfish biomass,spawning biomass and abundance (Canada survey, 1979/85; EU survey, 1988/00)

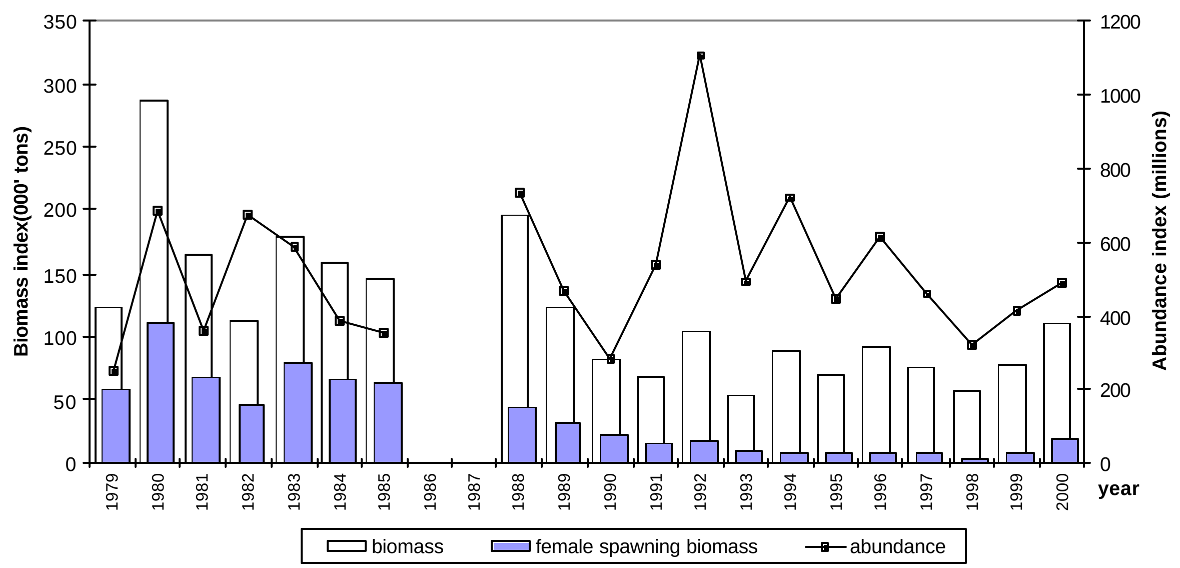

Table 3: 3M beaked redfish abundance at length ('000), biomass and spwanning biomass (tons)
Canadian (1979-1985) and EU (1988-2000) bottom trawl surveys

	Canadian series						
	1979	1980	1981	1982	1983	1984	1985
length	stock	stock	stock	stock	stock	stock	stock
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	**57782**	**111684**	**67885**	**45806**	**79349**	**66131**	**63985**
biomass	**123144**	**286971**	**164797**	**112229**	**179117**	**158663**	**146467**
ssb proportion	**46.9%**	**38.9%**	**41.2%**	**40.8%**	**44.3%**	**41.7%**	**43.7%**

Table 3 (cont.): 3M beaked redfish abundance at length ('000), biomass and spwanning biomass (tons) from Canadian (1979-1985) and EU (1988-2000) bottom trawl surveys

	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	133	3120	40	768	10	31124	296	31905	234	2476	22
22	34700	488	7270	116	1566	27	8610	120	50785	629	4089	61
23	74000	1784	14590	396	3612	117	3230	107	39506	795	6189	175
24	117900	5057	27620	1236	9246	411	3520	165	19340	619	7391	327
25	131800	9552	44480	3057	20248	1379	7187	405	8638	459	5651	467
26	101400	10943	55920	5507	32819	3052	9800	804	11190	677	5587	506
27	45500	6449	48630	6555	34269	4365	10320	1284	15927	1199	4613	406
28	19700	3681	32350	6467	25550	5383	9450	1741	18072	2294	4935	523
29	10100	2343	18750	4694	15110	4279	6890	1746	13298	2892	3670	719
30	14200	4076	12110	2983	9550	2835	5980	1836	12040	4213	3615	1009
31	12300	4037	9720	2297	7340	1762	4550	1339	8662	3001	3108	852
32	15100	5582	11380	2666	7120	1992	4110	1377	5818	1810	2588	776
33	15200	6031	8890	3808	6340	2683	4650	2177	5570	1986	2912	884
34	13800	6441	8780	4353	7350	4038	4840	2563	5587	2407	2516	868
35	10900	5298	9170	4733	5210	3214	3950	2106	4732	2337	2419	759
36	9900	5162	7890	4040	5000	2836	3680	2321	3723	1983	2476	1091
37	7600	4238	5930	3104	4010	2434	3020	1785	2976	1847	2431	1271
38	6900	4478	3960	2592	3040	1954	2580	1826	2481	1680	1599	1092
39	3700	2720	3600	2807	1820	1265	1660	1275	1815	1417	1356	1035
40	2500	2024	2530	2185	1230	894	1030	814	1190	1053	808	678
41	1800	1471	1030	856	630	468	450	388	490	339	363	325
42	800	677	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	93104	469570	65429	279817	45869	535977	27073	1105124	34515	491891	14544

	1988	1989	1990	1991	1992	1993
spawning biomass	**43458**	**32292**	**22890**	**15034**	**18056**	**9046**
biomass	**195488**	**123424**	**82238**	**68798**	**104492**	**53804**
ssb proportion	**22.2%**	**26.2%**	**27.8%**	**21.9%**	**17.3%**	**16.8%**

Table 3 (cont.): 3M beaked redfish abundance at length ('000), biomass and spwanning biomass (tons) from Canadian (1979-1985) and EU (1988-2000) bottom trawl surveys

	EU series													
	1994		1995		1996		1997		1998		1999		2000	
length	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem
4									10					
5									188					
6			28		44		9		47					
7			12		600				103		79		29	
8			176		4406		297		719		1126		392	
9			517		3172		784		1589		7822		1972	
10	86		731		583		548		553		7377		1930	
11	613		1553		1320		1988		1216		1557		2181	
12	1385		4914		4452		7666		7951		1763		9871	
13	3390		2946		4287		10480		15985		3343		24448	
14	20783		2636		5137		5014		8054		2512		18261	
15	59296		5562		9770		7795		8852		10116		6123	
16	84806		14624		8962		13934		17535		21811		2431	
17	154161		41775		15988		18639		13259		15808		4776	
18	169625		76859		38991		20173		9575		21401		11863	
19	92551		107204		83847		25914		10865		20686		18079	
20	25753		79964		125875		52838		11213		15397		20578	
21	13029	100	32884	270	118446	904	83129	627	15332	114	11960	187	18149	253
22	7280	122	8965	130	77619	988	85180	1213	28529	329	14940	327	17309	419
23	6862	199	3872	94	37487	778	57609	1468	50429	1052	26193	907	15587	531
24	9043	395	3388	133	18134	713	23549	1113	53764	1912	57574	3009	25380	1003
25	10666	691	4017	266	8735	775	10041	937	33467	1997	74355	6267	48243	2252
26	9831	1002	5219	490	4814	716	6473	1495	15685	1397	59755	7030	71071	6628
27	7154	797	5085	620	7163	1030	4920	1548	6459	855	22027	4883	76814	15057
28	8858	1367	5776	742	5361	1298	4841	2506	3191	588	7653	2436	55720	16179
29	7762	1364	6134	1067	5864	1582	3524	1586	1557	338	2997	851	23367	8946
30	5589	1423	6137	1532	4251	1148	4238	2341	1062	279	1036	436	5273	2699
31	4907	1465	4976	1490	3697	1309	2731	1176	1279	422	940	399	2126	1225
32	4652	1865	4170	1314	3543	1643	2183	995	1066	301	912	321	1199	785
33	3312	1033	3594	1172	3328	1341	1959	880	900	328	697	324	1480	306
34	2253	624	3079	892	2374	1458	1543	825	796	266	601	218	816	408
35	2134	789	2688	909	1659	787	977	460	467	175	542	207	559	295
36	1580	754	2540	889	1397	891	921	453	510	162	359	225	582	336
37	920	563	2206	851	1088	719	541	312	340	165	225	182	548	466
38	918	648	1365	774	785	486	390	196	260	108	137	117	105	91
39	470	297	978	661	512	348	210	129	170	89	70	60	110	94
40	340	268	520	397	290	189	146	105	60	30	44	34	70	39
41	200	159	450	418	260	199	130	110	70	60	20	20	40	30
42	80	80	330	279	180	130	40	30	30	26	30	10		
43	30	20	160	130	70	50			60	40	10	10	20	
44	20	20	40	20	20	20	20	10	30	20			10	10
45	30	20	40	20	20	20			10	10	20	10		
46			40	40	0				10	10				
47			10	10	0									
48					10									
49														
50														
51														
52														
53														
54														
total	720368	16066	448164	15610	614540	19520	461374	20514	323247	11074	413895	28467	487511	58050

	1994	1995	1996	1997	1998	1999	2000
spawning biomass	**7900**	**8682**	**8821**	**8288**	**3665**	**8314**	**19490**
biomass	**89152**	**69646**	**92656**	**75575**	**56469**	**77926**	**110438**
ssb proportion	**8.9%**	**12.5%**	**9.5%**	**11.0%**	**6.5%**	**10.7%**	**17.6%**

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

	S. mentella		S. fasciatus		S. spp	
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
2000	0.018	2.937	0.018	2.957	0.023	2.870
1989-00	0.017	2.940	0.018	2.970	0.024	2.849

Table 5-A: Stock abundance at age (' 000) of 3M beaked redfish from EU surveys, 1989-00.

year\age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+	Total
1989	930	18610	101981	11311	5961	28885	80756	85753	44097	22942	14552	9129	8803	8158	7468	4344	3351	3110	9429	469570
1990	8697	2059	39137	27953	1472	9873	41729	55111	31331	16675	10277	6150	6192	5683	4876	2881	2218	2147	5354	279817
1991	169931	66830	5403	105510	93181	15719	20771	15002	9739	5561	5428	4988	4617	3796	1456	1999	1623	926	3498	535977
1992	59499	641604	65635	62451	103409	55934	27966	26574	17983	10987	7403	5599	5337	4086	3722	2450	1484	1016	1989	1105124
1993	1070	87870	75709	253241	8113	19398	10942	7535	2660	3812	3590	3535	2917	3205	2596	1157	1156	1740	1643	491891
1994		15021	57871	498187	61409	20396	22182	12328	8563	6091	4988	3685	2806	1626	1837	861	661	797	1061	720368
1995	733	9798	39623	82435	250396	8639	10341	11110	6321	5614	6103	3576	2705	2386	2648	1751	1023	1054	1909	448164
1996	8222	12812	21025	16661	159816	343885	13670	11043	7853	4110	3129	3157	1668	1912	1581	1169	779	702	1348	614540
1997	1638	18015	22083	56738	73641	71026	194508	6070	4841	3819	2143	1935	1080	1325	388	514	614	175	822	461374
1998	3208	25230	39166	24068	26522	45918	29057	119235	4719	620	541	2872	394	403	126	275	502	46	346	323247
1999	16404	7309	27721	49921	33821	32990	44043	39713	150810	6637	353	498	1215	161	358	368	278	611	684	413895
2000	4324	39981	23787	20508	43429	37089	41931	67567	36332	164361	3451	612	234	2123	198	120	127	79	1260	486251
total	274657	945137	519140	1208983	861170	689751	537897	457040	325248	251229	61956	45737	37969	34864	27254	17889	13814	12403	29341	

Table 5-B: Mature female abundance at age (' 000) of 3M beaked redfish from EU surveys, 1989-00.

year\age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+	Total
1989				31	119	1324	7287	11793	7735	4676	4109	3351	3968	3925	3829	2259	1920	1742	7359	65429
1990				8	33	539	4275	8504	6139	3750	3141	2511	3119	3020	2806	1679	1330	1276	3737	45869
1991				42	391	796	2273	2929	2606	1943	2318	2477	2510	2222	906	1354	1069	611	2626	27073
1992				12	1196	1491	2174	4489	4709	3630	2767	2308	2602	2188	2103	1610	921	778	1536	34515
1993				0	100	905	958	1191	570	988	1072	1094	1093	1352	1114	1098	766	1164	1078	14544
1994				15	213	1004	2022	1928	1754	1880	1604	1196	919	696	767	448	413	513	694	16066
1995				75	370	382	1079	1736	1367	1575	1909	1110	870	844	972	803	478	579	1460	15610
1996					1232	2489	1797	2283	2130	1459	1315	1450	878	1020	884	698	497	451	936	19520
1997					133	2684	6216	2817	2414	1752	1013	928	524	642	187	271	333	94	508	20514
1998					113	843	1638	5309	987	159	166	950	133	159	42	108	221	15	230	11074
1999					127	1016	3075	5031	15546	1589	144	232	495	61	150	146	136	287	434	28467
2000					258	882	2898	9871	9648	30429	1642	224	147	920	111	84	92	52	792	58050
total				183	4284	14355	35692	57883	55605	53832	21199	17831	17258	17050	13871	10558	8177	7562	21389	

Table 5-C: Maturity ogive at age for 3M beaked redfish as the average proportion of mature females at age, from the EU survey abundance at age 1989-00.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
Ogive				0.000	0.005	0.021	0.066	0.127	0.171	0.214	0.342	0.390	0.455	0.489	0.509	0.590	0.592	0.610	0.729

Table 6-A: Catch in numbers at age (' 000) of 3M redfish, 1989-00, including redfish by-catch in the shrimp fishery.

year\age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+	Total
1989		19	156	509	1212	9042	26340	27565	16599	11100	10033	7086	7260	6708	5928	3381	2420	2246	5715	143320
1990			6715	11630	3102	6532	32081	52517	36082	20570	12993	7377	6622	6054	4958	2833	2103	1993	5081	219243
1991				1380	4032	7775	20348	25477	18908	9518	7290	5390	4448	3238	1236	1848	1423	874	3704	116888
1992				259	5725	7676	18580	19850	12776	8118	6134	4873	4687	3611	3229	2136	1301	815	1892	101663
1993		302	3753	106478	10881	8511	7170	7255	3327	5242	5105	4852	3680	3947	3271	1552	1197	1836	1709	180070
1994		746	5093	53387	6637	3094	4624	3633	3311	3000	2314	1639	1196	658	783	344	235	290	413	91397
1995	15	78	910	2931	14563	6056	2046	2607	1671	1584	2014	1224	1039	997	1151	896	519	589	1333	42223
1996	7243	3037	2343	1673	3870	5116	1557	1555	1588	1090	849	811	434	447	313	223	149	147	320	32765
1997	513	1109	447	632	136	636	847	294	308	347	236	209	106	129	29	30	32	11	82	6135
1998	398	3291	725	99	61	116	312	771	464	75	83	389	49	54	13	36	72	5	57	7070
1999	2256	963	220	146	42	16	75	277	638	396	88	122	283	42	84	85	74	113	159	6080
2000	434	2389	256	103	161	233	415	1009	1379	4105	650	181	75	649	64	39	35	42	572	12791
total	10860	11933	20619	179226	50422	54804	114394	142810	97054	65145	47790	34152	29879	26534	21061	13404	9560	8960	21036	

Table 6-B: Weights at age in the catch (Kg) of 3M redfish, 1989-00.

year\age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989		0.031	0.076	0.139	0.169	0.207	0.246	0.292	0.345	0.393	0.471	0.530	0.575	0.597	0.641	0.657	0.710	0.720	0.931
1990			0.110	0.123	0.158	0.225	0.281	0.323	0.357	0.388	0.458	0.524	0.581	0.599	0.647	0.664	0.709	0.704	0.933
1991				0.129	0.160	0.255	0.309	0.357	0.391	0.456	0.499	0.551	0.602	0.646	0.693	0.766	0.747	0.779	0.867
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	1.135
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	0.147	0.164	0.213	0.296	0.362	0.405	0.456	0.511	0.541	0.621	0.679	0.705	0.781	0.787	0.825	1.000
1996	0.008	0.028	0.062	0.075	0.157	0.180	0.279	0.338	0.399	0.454	0.487	0.544	0.590	0.605	0.660	0.703	0.762	0.801	1.040
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	1.248
1998	0.011	0.036	0.049	0.093	0.145	0.190	0.286	0.264	0.387	0.437	0.474	0.524	0.588	0.657	0.672	0.767	0.779	0.688	0.958
1999	0.014	0.031	0.057	0.083	0.117	0.174	0.293	0.330	0.317	0.398	0.473	0.564	0.519	0.546	0.534	0.549	0.640	0.579	0.708
2000	0.014	0.033	0.056	0.086	0.140	0.188	0.255	0.305	0.370	0.352	0.460	0.536	0.664	0.571	0.512	0.666	0.722	0.763	0.796
mean	0.012	0.036	0.071	0.107	0.149	0.215	0.282	0.335	0.382	0.431	0.491	0.545	0.595	0.626	0.646	0.716	0.747	0.757	0.955

Table 7-A: Weights at age of the 3M beaked redfish stock (Kg) from EU surveys, 1989-00.

year\age	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
2000	0.016	0.038	0.057	0.098	0.135	0.177	0.238	0.288	0.333	0.302	0.424	0.533	0.673	0.571	0.506	0.680	0.722	0.722	0.725
mean	0.013	0.036	0.067	0.094	0.145	0.201	0.260	0.320	0.366	0.414	0.485	0.547	0.600	0.630	0.651	0.717	0.747	0.757	0.898

Table 7-B: Weights at age of the 3M mature female beaked redfish stock (Kg) from EU surveys, 1989-00.

year\age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989				0.154	0.172	0.219	0.269	0.311	0.342	0.386	0.473	0.551	0.590	0.612	0.651	0.665	0.739	0.741	0.906
1990				0.164	0.187	0.239	0.294	0.333	0.361	0.403	0.484	0.558	0.598	0.619	0.659	0.674	0.741	0.743	0.900
1991				0.154	0.167	0.257	0.309	0.358	0.412	0.476	0.531	0.588	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	0.961
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					0.155	0.198	0.244	0.284	0.270	0.351	0.470	0.585	0.525	0.549	0.543	0.554	0.652	0.633	0.758
2000					0.164	0.195	0.275	0.307	0.348	0.332	0.432	0.525	0.686	0.581	0.503	0.699	0.727	0.732	0.747
mean				0.157	0.174	0.223	0.283	0.335	0.380	0.427	0.494	0.557	0.611	0.643	0.660	0.732	0.761	0.770	0.921

Table 8a: beaked redfish exploitaion pattern given by the generalized logit of the 1989-00 observed partial recruitment (See text).

Age	F at age index	Observed PR	Logit PR	Squared difference
1	1.71	0.382	0.017	0.133
2	0.43	0.096	0.025	0.005
3	0.49	0.109	0.036	0.005
4	0.75	0.167	0.054	0.013
5	0.35	0.078	0.080	0.000
6	0.53	0.119	0.118	0.000
7	1.00	0.223	0.175	0.002
8	1.21	0.270	0.259	0.000
9	1.49	0.331	0.383	0.003
10	1.87	0.416	0.566	0.023
11	4.19	0.934	0.837	0.009
12	4.45	0.991	1.000	0.000
13	4.48	0.999	1.000	0.000
14	4.49	1.000	1.000	0.000
15	3.92	0.873	1.000	0.016
16	4.35	0.968	1.000	0.001
17	4.10	0.913	1.000	0.008
18	4.28	0.953	1.000	0.002
19	4.68	1.042	1.000	0.002
		Minimum sum of squares		0.089

Curve parameters	*a*	*b*	*m*
	-105.042	9.173	0.043

Fig. 2: PR curve for 3M beaked redfish

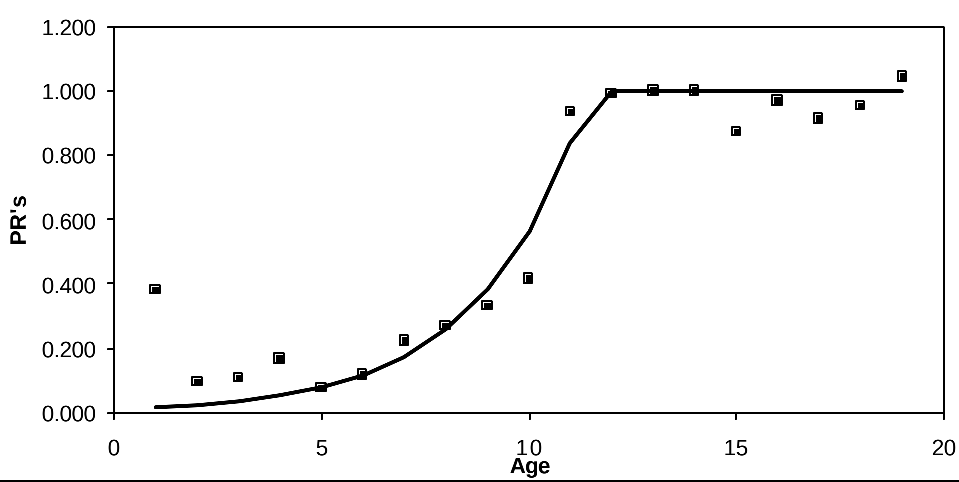

Table 8-B: Female maturity ogive at age for 3M beaked redfish given by
a general logit of the 1989-00 observed maturiry at age.

Age	Obs. Mat	Mat ogive	Squared difference
1	0.0	0.0	0.000
2	0.0	0.0	0.000
3	0.0	0.0	0.000
4	0.0	0.0	0.000
5	0.0	0.0	0.001
6	0.0	0.1	0.002
7	0.1	0.1	0.001
8	0.1	0.1	0.000
9	0.2	0.2	0.000
10	0.2	0.2	0.000
11	0.3	0.3	0.003
12	0.4	0.3	0.002
13	0.5	0.4	0.002
14	0.5	0.5	0.000
15	0.5	0.5	0.000
16	0.6	0.6	0.000
17	0.6	0.6	0.001
18	0.6	0.7	0.004
19	0.7	0.7	0.000
Minimum sum of squares			0.017

Curve parameters	*a*	*b*	*m*
	5.314	0.163	1509.175

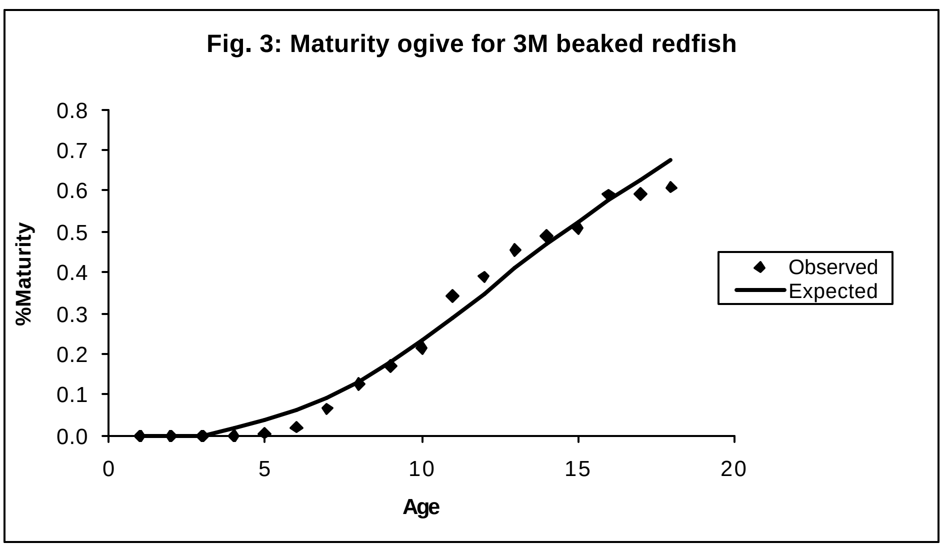

Table 8-C: Yield per recruit parameters for 3M beaked redfish

	mean weights 1989-00					
Age	stock	catch	stock mat f	% mat females	PR 89-00	Ref. M
1	0.013	0.012		0.000	0.382	0.20
2	0.036	0.036		0.000	0.025	0.20
3	0.067	0.071		0.000	0.036	0.10
4	0.094	0.107	0.157	0.020	0.054	0.10
5	0.145	0.149	0.175	0.036	0.080	0.10
6	0.201	0.215	0.225	0.060	0.118	0.10
7	0.260	0.282	0.285	0.092	0.175	0.10
8	0.320	0.335	0.339	0.132	0.259	0.10
9	0.366	0.382	0.384	0.179	0.383	0.10
10	0.414	0.431	0.436	0.233	0.566	0.10
11	0.485	0.491	0.500	0.290	0.837	0.10
12	0.547	0.545	0.560	0.350	1.000	0.10
13	0.600	0.595	0.604	0.410	1.000	0.10
14	0.630	0.626	0.649	0.469	1.000	0.10
15	0.651	0.646	0.674	0.526	1.000	0.10
16	0.717	0.716	0.735	0.580	1.000	0.10
17	0.747	0.747	0.764	0.630	1.000	0.10
18	0.757	0.757	0.774	0.676	1.000	0.10
19+	0.898	0.955	0.937	0.717	1.000	0.10

Table 8-D: Fishing mortalities associated with different levels of reduction of spawning and total biomass of 3M beaked reddish.

	% SSB	% B	%SSB/B	Ref. F	Yield	SSB	B	Slope
	100.0%	100.0%	49.0%	0.00	0	1734	3535	2,509
	90.0%	92.7%	47.5%	0.01	20	1557	3276	2,023
	80.0%	85.3%	45.8%	0.02	39	1380	3015	1.691
	75.0%	81.5%	44.8%	0.02	48	1292	2883	1.481
	70.0%	77.8%	43.8%	0.03	57	1204	2750	1.281
	65.0%	74.0%	42.7%	0.04	66	1116	2616	1,093
	60.0%	70.2%	41.4%	0.04	74	1028	2481	917
	55.0%	66.3%	40.1%	0.05	82	940	2344	753
Fssb	**50.0%**	**62.4%**	**38.7%**	**0.06**	90	853	2206	602
	45.0%	58.4%	37.1%	0.07	97	766	2066	463
	40.0%	54.4%	35.3%	0.09	103	679	1922	366
F0.1	**36.4%**	**52.1%**	**34.2%**	**0.10**	106	630	1841	251
F"msy"	**30.0%**	**50.0%**	**33.2%**	**0.11**	109	587	1768	174
	25.0%	41.5%	28.6%	0.15	118	420	1467	59
Fmax	**20.0%**	**36.8%**	**25.7%**	**0.19**	120	334	1300	0
	15.0%	31.6%	22.4%	0.25	120	250	1118	-38
	10.0%	25.7%	18.5%	0.36	116	168	908	-51
	9.0%	24.3%	17.6%	0.39	114	151	860	-53

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

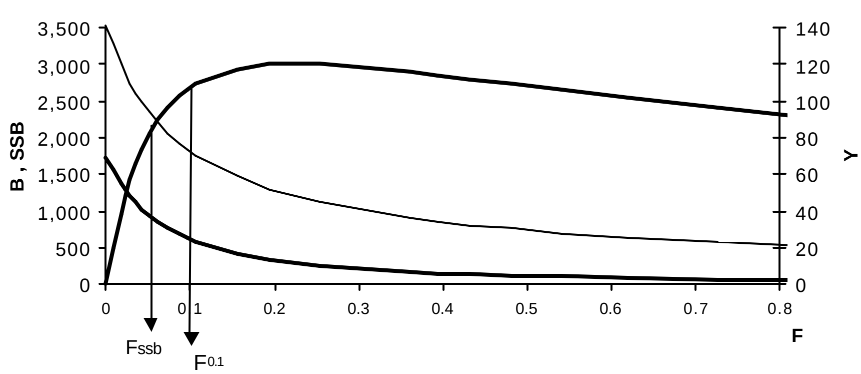

Table 9 : Computation of Z's using female *S. mentella* length data
(Beverton and Holt, 1957 from Die, D.J. and J.F. Caddy 1997)

1) Mean length in the catch

	95	96	97	98	99	00	mean
$\bar{L}$	32.7	27.9	30.9	27.4	30.4	30.4	30.0

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

	95	96	97	98	99	00	mean
Lc	21.9	21.8	20.5	21.0	19.8	20.9	21.0

3) von Bertalanfy growth parameters

L_∞	51.07
K	0.072

4) Length at maturity

L_m	30.14

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

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

Z mean 95-00 =	0.169
$Z^*(\bar{L} > L_m) <$	0.165
Assuming M =	0.100
$F^*(\bar{L} > L_m) <$	**0.065**

Table 10: Lowestoft VPA input files for 3M beaked redfish (2001 assessment)

REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2001

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	2000
4	19
5	
58100	
81000	
48500	
43300	
40970	
17203	
13874	
5789	
1300	
971	
1068	
3825	

REDFISH NAFO 3M CATCH NUMBERS thousands

1	2														
1989	2000														
4	19														
1															
509	1212	9042	26340	27565	16599	11100	10033	7086	7260	6708	5928	3381	2420	2246	5715
11630	3102	6532	32081	52517	36082	20570	12993	7377	6622	6054	4958	2833	2103	1993	5081
1380	4032	7775	20348	25477	18908	9518	7290	5390	4448	3238	1236	1848	1423	874	3704
259	5725	7676	18580	19850	12776	8118	6134	4873	4687	3611	3229	2136	1301	815	1892
106478	10881	8511	7170	7255	3327	5242	5105	4852	3680	3947	3271	1552	1197	1836	1709
53387	6637	3094	4624	3633	3311	3000	2314	1639	1196	658	783	344	235	290	413
2931	14563	6056	2046	2607	1671	1584	2014	1224	1039	997	1151	896	519	589	1333
1673	3870	5116	1557	1555	1588	1090	849	811	434	447	313	223	149	147	320
632	136	636	847	294	308	347	236	209	106	129	29	30	32	11	82
99	61	116	312	771	464	75	83	389	49	54	13	36	72	5	57
146	42	16	75	277	638	396	88	122	283	42	84	85	74	113	159
103	161	233	415	1009	1379	4105	650	181	75	649	64	39	35	42	572

REDFISH NAFO 3M CATCH WEIGHT AT AGE kg

1	3														
1989	2000														
4	19														
1															
0.139	0.169	0.207	0.246	0.292	0.345	0.393	0.471	0.530	0.575	0.597	0.641	0.657	0.710	0.720	0.931
0.123	0.158	0.225	0.281	0.323	0.357	0.388	0.458	0.524	0.581	0.599	0.647	0.664	0.709	0.704	0.933
0.129	0.160	0.255	0.309	0.357	0.391	0.456	0.499	0.551	0.602	0.646	0.693	0.766	0.747	0.779	0.867
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	1.135
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
0.147	0.164	0.213	0.296	0.362	0.405	0.456	0.511	0.541	0.621	0.679	0.705	0.781	0.787	0.825	1.000
0.075	0.157	0.180	0.279	0.338	0.399	0.454	0.487	0.544	0.590	0.605	0.660	0.703	0.762	0.801	1.040
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	1.248
0.093	0.145	0.190	0.286	0.264	0.387	0.437	0.474	0.524	0.588	0.657	0.672	0.767	0.779	0.688	0.958
0.083	0.117	0.174	0.293	0.330	0.317	0.398	0.473	0.564	0.519	0.546	0.534	0.549	0.640	0.579	0.708
0.086	0.140	0.188	0.255	0.305	0.370	0.352	0.460	0.536	0.664	0.571	0.512	0.666	0.722	0.763	0.796

REDFISH NAFO 3M STOCK WEIGHT AT AGE kg

1	4														
1989	2000														
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
0.098	0.135	0.177	0.238	0.288	0.333	0.302	0.424	0.533	0.673	0.571	0.506	0.680	0.722	0.722	0.725

Table 10: cont.

REDFISH NAFO 3M NATURAL MORTALITY

1	5														
1989	2000														
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	2000														
4	19														
2															
0.00	0.00	0.02	0.07	0.13	0.17	0.21	0.34	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	2000
4	19
3	
0.08	

REDFISH NAFO 3M PROPORTION OF M BEFORE SPAWNING

1	8
1989	2000
4	19
3	
0.08	

REDFISH NAFO 3M F ON OLDEST AGE GROUP BY YEAR

1	9
1989	2000
4	19
5	
0.225	
0.323	
0.126	
0.181	
0.500	
0.101	
0.420	
0.067	
0.005	
0.001	
0.049	
0.049	

REDFISH NAFO 3M F AT AGE IN LAST YEAR

1	10														
1989	2000														
4	19														
2															
0.0045	0.0017	0.0003	0.0015	0.0057	0.0031	0.0461	0.0195	0.0236	0.07	0.0487	0.0577	0.0512	0.0488	0.0491	0.0491

REDFISH NAFO 3M SURVEY TUNNING DATA

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EU BOTTOM TRAWL SURVEY

1989	2000															
1	1	0.5	0.6													
4	19															
10555	11311	5961	28885	80756	85753	44097	22942	14552	9129	8803	8158	7468	4344	3351	3110	9429
10555	27953	1472	9873	41729	55111	31331	16675	10277	6150	6192	5683	4876	2881	2218	2147	5354
10555	105510	93181	15719	20771	15002	9739	5561	5428	4988	4617	3796	1456	1999	1623	926	3498
10555	62451	103409	55934	27966	26574	17983	10987	7403	5599	5337	4086	3722	2450	1484	1016	1989
10555	253241	8113	19398	10942	7535	2660	3812	3590	3535	2917	3205	2596	1157	1156	1740	1643
10555	498187	61409	20396	22182	12328	8563	6091	4988	3685	2806	1626	1837	861	661	797	1061
10555	82435	250396	8639	10341	11110	6321	5614	6103	3576	2705	2386	2648	1751	1023	1054	1909
10555	16661	159816	343885	13670	11043	7853	4110	3129	3157	1668	1912	1581	1169	779	702	1348
10555	56738	73641	71026	194508	6070	4841	3819	2143	1935	1080	1325	388	514	614	175	822
10555	24068	26522	45918	29057	119235	4719	620	541	2872	394	403	126	275	502	46	346
10555	49921	33821	32990	44043	39713	150810	6637	353	498	1215	161	358	368	278	611	684
10555	20508	43429	37089	41931	67567	36332	164361	3451	612	234	2123	198	120	127	79	1260

Table 11a: Extended Survivors Analysis diagnostics (Lowestoft VPA Version 3.1)

REDFISH NAFO DIVISION 3M

Catch data for 12 years. 1989 to 2000. Ages 4 to 19.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU BOTTOM TRAWL SURV	1989	2000	4	18	0.5	0.6

Time series weights :
Tapered time weighting not applied

Catchability analysis :
Catchability independent of stock size for all ages
Catchability independent of age for ages >= 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 334 iterations

Regression weights

1	1	1	1	1	1	1	1	1	1

Estimated population abundance at 1st Jan 2001

AGE	4	5	6	7	8	9	10	11	12	13
	0	20500	48200	33100	41500	43200	36100	158000	5360	1660

AGE	14	15	16	17	18
	997	2590	588	790	907

Taper weighted geometric mean of the VPA populations:

AGE	4	5	6	7	8	9	10	11	12	13
	64500	55500	48100	42200	31900	20900	14000	8400	6440	5560

AGE	14	15	16	17	18
	5210	4420	4250	4230	4320

Standard error of the weighted Log(VPA populations) :

AGE	4	5	6	7	8	9	10	11	12	13
	0.763	0.6619	0.8224	1.0181	1.1702	1.2706	1.3331	1.1159	1.1799	1.1981

AGE	14	15	16	17	18
	1.1214	1.1083	0.9309	0.8357	0.7723

Log catchability residuals.
Fleet : EU BOTTOM TRAWL SURV

Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4	-1.65	-0.52	1.19	0.92	1.47	0.38	0.19	-1.39	0	-0.53	-0.07	0
5	-2.25	-3.29	1.21	1.67	-0.41	1.23	0.15	1.27	0.47	-0.39	0.18	0.16
6	-1.03	-1.63	-0.74	0.94	0.41	1.02	-0.35	0.55	0.55	0.06	-0.12	0.33
7	-0.27	-0.44	-0.65	0.27	-0.41	0.98	0.61	0.3	-0.05	-0.39	-0.03	0.08
8	-0.01	-0.14	-0.92	0.28	-0.38	0.03	0.75	1.03	-0.44	-0.54	-0.07	0.41
9	-0.09	-0.2	-0.91	0.19	-1.15	0.61	-0.11	1.19	0.71	-0.36	-0.02	0.15
10	-0.31	-0.33	-1.1	0.05	-0.45	0.37	1.01	-0.07	1.1	-0.98	0.34	0.38
11	-0.2	-0.43	-0.65	-0.08	-0.15	0.68	1.24	1.28	-0.27	-0.38	-1.15	0.12
12	-0.48	-0.74	-0.8	-0.23	-0.34	0.35	0.79	1.08	1.14	0.11	-0.37	-0.51
13	-0.1	-0.23	-0.41	-0.1	-0.13	0.1	0.71	0.66	0.56	-0.02	-0.34	-0.72
14	-0.13	-0.06	-0.31	-0.13	-0.09	-0.34	0.25	0.72	0.67	-0.27	-0.77	0.45
15	0.34	0.1	-0.75	0.44	0.26	0.05	0.78	0.4	-0.36	-1.24	0.07	-0.08
16	0.2	0.02	-0.18	0.34	-0.02	-0.24	0.52	0.47	-0.34	-0.36	0.21	-0.62
17	0.04	0.03	-0.06	-0.01	0.15	-0.11	0.33	0.11	0.15	-0.07	-0.03	-0.53
18	0	-0.13	-0.58	-0.28	0.55	0.04	0.61	0.15	-1.26	-2.34	0.27	-1.14

Table 11a: (cont.) Extended Survivors Analysis diagnostics (Lowestoft VPA Version 3.1)

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	-9.3121	-9.5764	-9.5317	-9.3843	-9.2822	-9.4671	-9.6664	-9.9238	-9.8446	-10.0698
S.E(Log q)	0.9444	1.4724	0.8105	0.4773	0.554	0.655	0.6899	0.73	0.6894	0.4437

Age	14	15	16	17	18
Mean Log q	-10.0588	-10.3592	-10.5894	-10.7634	-10.7634
S.E(Log q)	0.4434	0.5548	0.3598	0.2068	0.9314

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
4	0.93	0.187	9.43	0.43	12	0.92	-9.31
5	1.87	-0.676	8.4	0.06	12	2.82	-9.58
6	1.47	-1.088	8.94	0.35	12	1.18	-9.53
7	1.43	-2.641	8.84	0.79	12	0.55	-9.38
8	1.34	-2.023	8.91	0.78	12	0.66	-9.28
9	1.28	-1.459	9.33	0.74	12	0.8	-9.47
10	1.16	-0.878	9.69	0.75	12	0.81	-9.67
11	1.19	-0.786	10.09	0.64	12	0.88	-9.92
12	1.57	-2.516	10.46	0.66	12	0.89	-9.84
13	1.1	-0.838	10.22	0.86	12	0.5	-10.07
14	1.04	-0.298	10.12	0.86	12	0.48	-10.06
15	0.86	1.136	10.07	0.86	12	0.47	-10.36
16	0.87	1.303	10.3	0.91	12	0.3	-10.59
17	0.91	1.38	10.55	0.96	12	0.18	-10.76
18	0.72	1.18	10.34	0.64	12	0.61	-11.1

Terminal year survivor and F summaries :

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 1996

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	20520	0.983	0	0	1	1	0.005

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
20520	0.98	0	1	0	0.005

Age 5 Catchability constant w.r.t. time and dependent on age
Year class = 1995

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	48201	0.827	0.104	0.13	2	1	0.003

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
48201	0.83	0.1	2	0.125	0.003

Age 6 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	33146	0.591	0.282	0.48	3	1	0.007

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
33146	0.59	0.28	3	0.477	0.007

Table 11a: (cont.) Extended Survivors Analysis diagnostics (Lowestoft VPA Version 3.1)

Age 7 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	41460	0.382	0.073	0.19	4	1	0.009

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
41460	0.38	0.07	4	0.192	0.009

Age 8 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	43236	0.318	0.254	0.8	5	1	0.022

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
43236	0.32	0.25	5	0.8	0.022

Age 9 Catchability constant w.r.t. time and dependent on age
Year class = 1991

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	36077	0.289	0.171	0.59	6	1	0.036

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
36077	0.29	0.17	6	0.593	0.036

Age 10 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	158497	0.268	0.145	0.54	7	1	0.024

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
158497	0.27	0.14	7	0.541	0.024

Age 11 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	5362	0.263	0.146	0.55	8	1	0.109

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
5362	0.26	0.15	8	0.555	0.109

Age 12 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	1659	0.26	0.305	1.17	9	1	0.099

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1659	0.26	0.31	9	1.175	0.099

Table 11a: (cont.) Extended Survivors Analysis diagnostics (Lowestoft VPA Version 3.1)

Age 13 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	997	0.26	0.26	1	10	1	0.069

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
997	0.26	0.26	10	0.999	0.069

Age 14 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	2589	0.217	0.112	0.52	11	1	0.214

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2589	0.22	0.11	11	0.517	0.214

Age 15 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	588	0.242	0.204	0.84	12	1	0.099

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
588	0.24	0.2	12	0.845	0.099

Age 16 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	790	0.224	0.178	0.8	12	1	0.046

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
790	0.22	0.18	12	0.796	0.046

Age 17 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	907	0.209	0.212	1.01	12	1	0.036

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
907	0.21	0.21	12	1.014	0.036

Age 18 Catchability constant w.r.t. time and age (fixed at the value for age) 17
Year class = 1982

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU BOTTOM TRAWL SURV	1041	0.21	0.16	0.76	12	1	0.038

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1041	0.21	0.16	12	0.763	0.038

Table 11b: Log catchability residuals.
REDFISH NAFO DIVISION 3M
Catchability independent of stock size for all ages
Final estimates not shrunk towards mean F
Prior weighting not applied

Run 1 Catchability independent of age for ages >= 16 Minimum standard error for population estimates derived from each fleet = .300

Ages	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
4	-1.68	-0.51	1.15	0.91	1.45	0.4	0.21	-1.37	0.01	-0.51	-0.06	0	
5	-2.29	-3.32	1.23	1.63	-0.41	1.23	0.17	1.29	0.49	-0.39	0.19	0.16	
6	-1.06	-1.67	-0.78	0.98	0.38	1.05	-0.33	0.57	0.57	0.08	-0.11	0.34	
7	-0.31	-0.47	-0.69	0.23	-0.35	0.95	0.66	0.33	-0.04	-0.37	-0.02	0.08	
8	-0.05	-0.17	-0.96	0.26	-0.41	0.13	0.73	1.1	-0.42	-0.54	-0.07	0.41	
9	-0.11	-0.23	-0.93	0.17	-1.18	0.59	0.01	1.17	0.79	-0.36	-0.05	0.12	
10	-0.33	-0.33	-1.13	0.06	-0.45	0.34	1.01	0.06	1.08	-0.93	0.3	0.31	
11	-0.3	-0.45	-0.62	-0.11	-0.07	0.72	1.25	1.31	-0.17	-0.46	-1.15	0.03	
12	-0.68	-0.88	-0.83	-0.16	-0.32	0.56	0.92	1.16	1.19	0.15	-0.52	-0.57	
13	-0.3	-0.49	-0.6	-0.12	0.12	0.15	1.11	0.87	0.63	-0.03	-0.38	-0.97	
14	-0.49	-0.29	-0.67	-0.38	0.05	0.05	0.32	1.43	0.86	-0.32	-0.9	0.34	
15	0.11	-0.35	-1.05	-0.01	0.06	0.35	1.64	0.44	0.43	-1.18	-0.1	-0.35	
16	0.05	-0.2	-0.79	-0.04	-0.55	-0.47	1.12	2.03	-0.5	0.27	0.08	-1	
17	-0.17	0.11	-0.15	-0.69	-0.1	-0.71	0.08	1.07	2.06	-0.37	0.62	-0.76	SSquares
18	0	0.01	-0.01	0.02	0.15	0.06	0.16	0.06	-0.13	-0.28	0.03	-0.23	100.92

Run 2 Catchability independent of age for ages >= 16 Minimum standard error for population estimates derived from each fleet = .500

Ages	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
4	-1.66	-0.51	1.16	0.9	1.47	0.4	0.2	-1.38	0.01	-0.52	-0.07	0	
5	-2.27	-3.31	1.22	1.64	-0.42	1.24	0.17	1.28	0.48	-0.39	0.19	0.16	
6	-1.05	-1.65	-0.76	0.97	0.38	1.01	-0.33	0.58	0.56	0.06	-0.11	0.34	
7	-0.29	-0.45	-0.67	0.25	-0.37	0.95	0.61	0.33	-0.03	-0.38	-0.03	0.08	
8	-0.03	-0.16	-0.93	0.28	-0.39	0.1	0.72	1.02	-0.41	-0.53	-0.07	0.4	
9	-0.12	-0.21	-0.93	0.2	-1.14	0.63	-0.03	1.16	0.7	-0.35	-0.03	0.13	
10	-0.34	-0.36	-1.1	0.05	-0.41	0.39	1.06	0.02	1.05	-1.02	0.32	0.34	
11	-0.26	-0.47	-0.68	-0.08	-0.12	0.77	1.32	1.39	-0.21	-0.48	-1.24	0.07	
12	-0.59	-0.83	-0.87	-0.28	-0.3	0.43	0.97	1.26	1.28	0.12	-0.53	-0.66	
13	-0.21	-0.36	-0.54	-0.19	-0.15	0.17	0.86	0.93	0.77	0.09	-0.41	-0.97	
14	-0.28	-0.17	-0.48	-0.28	-0.15	-0.37	0.34	0.95	0.96	-0.13	-0.73	0.33	
15	0.23	-0.02	-0.87	0.29	0.19	0.03	0.78	0.5	-0.15	-1.02	0.16	-0.11	
16	0.15	-0.02	-0.27	0.25	-0.05	-0.26	0.54	0.48	-0.32	-0.24	0.36	-0.61	
17	-0.02	0.03	-0.05	-0.1	0.16	-0.14	0.26	0.08	0.02	-0.21	-0.04	-0.48	SSquares
18	0	0.06	-0.34	-0.03	1.08	0.29	0.83	0.2	-1.27	-2.46	0.18	-1.09	93.54

Run 3 Catchability independent of age for ages >= 17 Minimum standard error for population estimates derived from each fleet = .300

Ages	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
4	-1.68	-0.51	1.15	0.91	1.46	0.4	0.21	-1.37	0.01	-0.51	-0.06	0	
5	-2.28	-3.32	1.23	1.63	-0.41	1.24	0.17	1.29	0.49	-0.39	0.19	0.16	
6	-1.06	-1.67	-0.78	0.98	0.37	1.04	-0.33	0.58	0.57	0.07	-0.12	0.34	
7	-0.31	-0.47	-0.68	0.24	-0.34	0.94	0.64	0.33	-0.03	-0.37	-0.02	0.08	
8	-0.04	-0.17	-0.95	0.26	-0.41	0.14	0.71	1.08	-0.41	-0.54	-0.07	0.4	
9	-0.11	-0.22	-0.93	0.18	-1.17	0.6	0.02	1.14	0.77	-0.36	-0.04	0.12	
10	-0.33	-0.33	-1.11	0.06	-0.43	0.36	1.03	0.08	1.03	-0.96	0.3	0.31	
11	-0.3	-0.46	-0.63	-0.09	-0.06	0.75	1.28	1.34	-0.16	-0.52	-1.19	0.03	
12	-0.69	-0.89	-0.85	-0.18	-0.29	0.56	0.98	1.21	1.22	0.15	-0.6	-0.63	
13	-0.32	-0.51	-0.62	-0.15	0.09	0.2	1.12	0.96	0.69	0	-0.4	-1.07	
14	-0.52	-0.32	-0.7	-0.41	0	-0.01	0.39	1.47	0.97	-0.28	-0.9	0.31	
15	0.06	-0.39	-1.09	-0.03	0.06	0.3	1.59	0.53	0.48	-1.08	-0.07	-0.37	
16	-0.03	-0.25	-0.83	-0.09	-0.55	-0.46	1.12	2.05	-0.42	0.3	0.16	-1	
17	-0.31	-0.04	-0.27	-0.84	-0.2	-0.8	0.01	1.04	2.05	-0.42	0.56	-0.78	SSquares
18	0	0.02	0	0.02	0.15	0.06	0.15	0.05	-0.1	-0.23	0.01	-0.19	102.75

Run 4 Catchability independent of age for ages >= 17 Minimum standard error for population estimates derived from each fleet = .500

Ages	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
4	-1.65	-0.52	1.19	0.92	1.47	0.38	0.19	-1.39	0	-0.53	-0.07	0	
5	-2.25	-3.29	1.21	1.67	-0.41	1.23	0.15	1.27	0.47	-0.39	0.18	0.16	
6	-1.03	-1.63	-0.74	0.94	0.41	1.02	-0.35	0.55	0.55	0.06	-0.12	0.33	
7	-0.27	-0.44	-0.65	0.27	-0.41	0.98	0.61	0.3	-0.05	-0.39	-0.03	0.08	
8	-0.01	-0.14	-0.92	0.28	-0.38	0.03	0.75	1.03	-0.44	-0.54	-0.07	0.41	
9	-0.09	-0.2	-0.91	0.19	-1.15	0.61	-0.11	1.19	0.71	-0.36	-0.02	0.15	
10	-0.31	-0.33	-1.1	0.05	-0.45	0.37	1.01	-0.07	1.1	-0.98	0.34	0.38	
11	-0.2	-0.43	-0.65	-0.08	-0.15	0.68	1.24	1.28	-0.27	-0.38	-1.15	0.12	
12	-0.48	-0.74	-0.8	-0.23	-0.34	0.35	0.79	1.08	1.14	0.11	-0.37	-0.51	
13	-0.1	-0.23	-0.41	-0.1	-0.13	0.1	0.71	0.66	0.56	-0.02	-0.34	-0.72	
14	-0.13	-0.06	-0.31	-0.13	-0.09	-0.34	0.25	0.72	0.67	-0.27	-0.77	0.45	
15	0.34	0.1	-0.75	0.44	0.26	0.05	0.78	0.4	-0.36	-1.24	0.07	-0.08	
16	0.2	0.02	-0.18	0.34	-0.02	-0.24	0.52	0.47	-0.34	-0.36	0.21	-0.62	
17	0.04	0.03	-0.06	-0.01	0.15	-0.11	0.33	0.11	0.15	-0.07	-0.03	-0.53	SSquares
18	0	-0.13	-0.58	-0.28	0.55	0.04	0.61	0.15	-1.26	-2.34	0.27	-1.14	86.94

Fig. 5: residual patterns for 3M beaked redfish 1989-00 XSA assuming different upper limits for age dependent catchability associated with two levels of minimum standard error of the log catchability estimates for age 18. (dark bubbles are positive residuals)

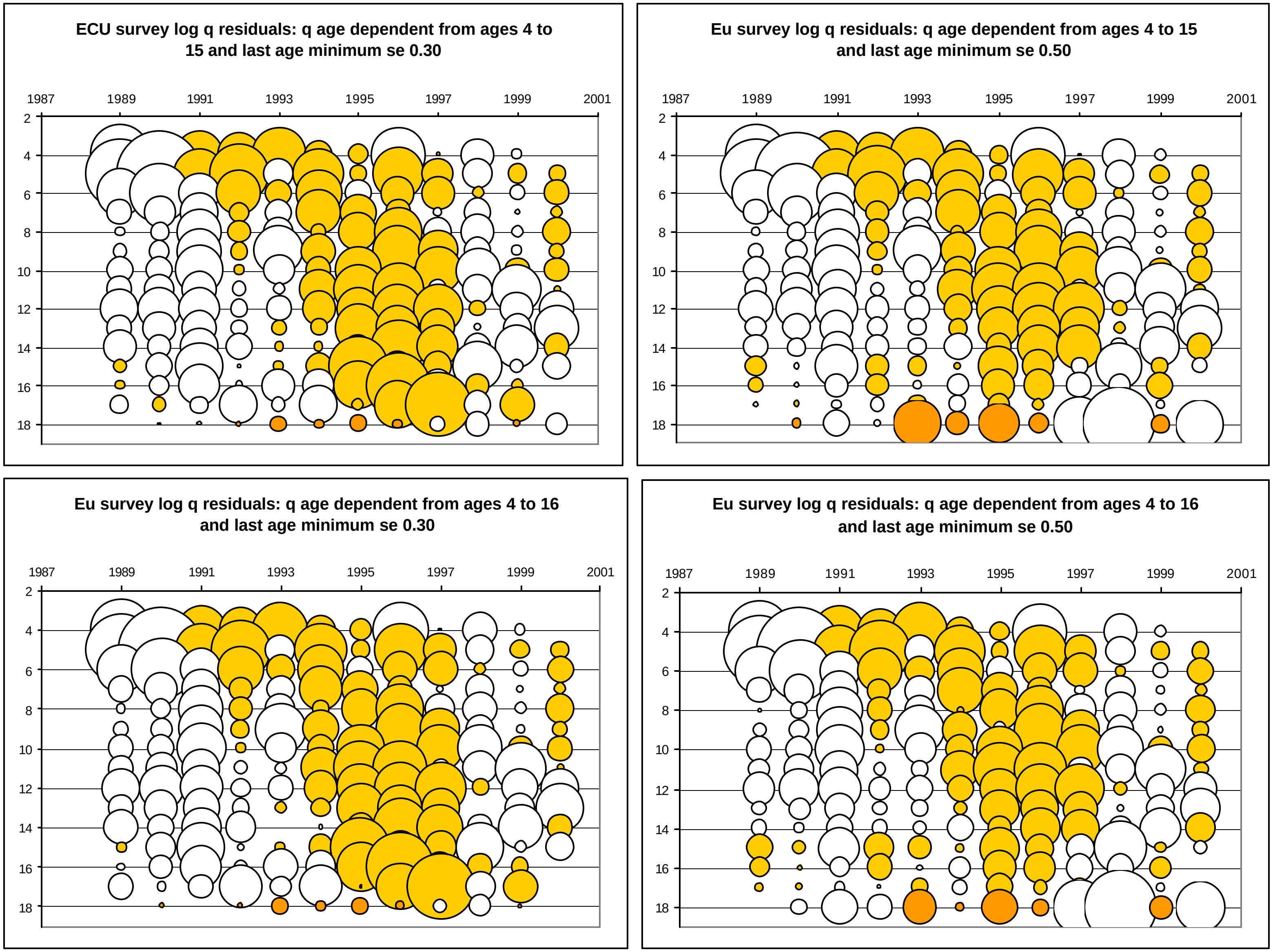

Fig. 6: retrospective analysis for 3M beaked redfish assuming different upper limits for age dependent catchability associated with two levels of minimum standard error of the log catchability estimates for age 18.

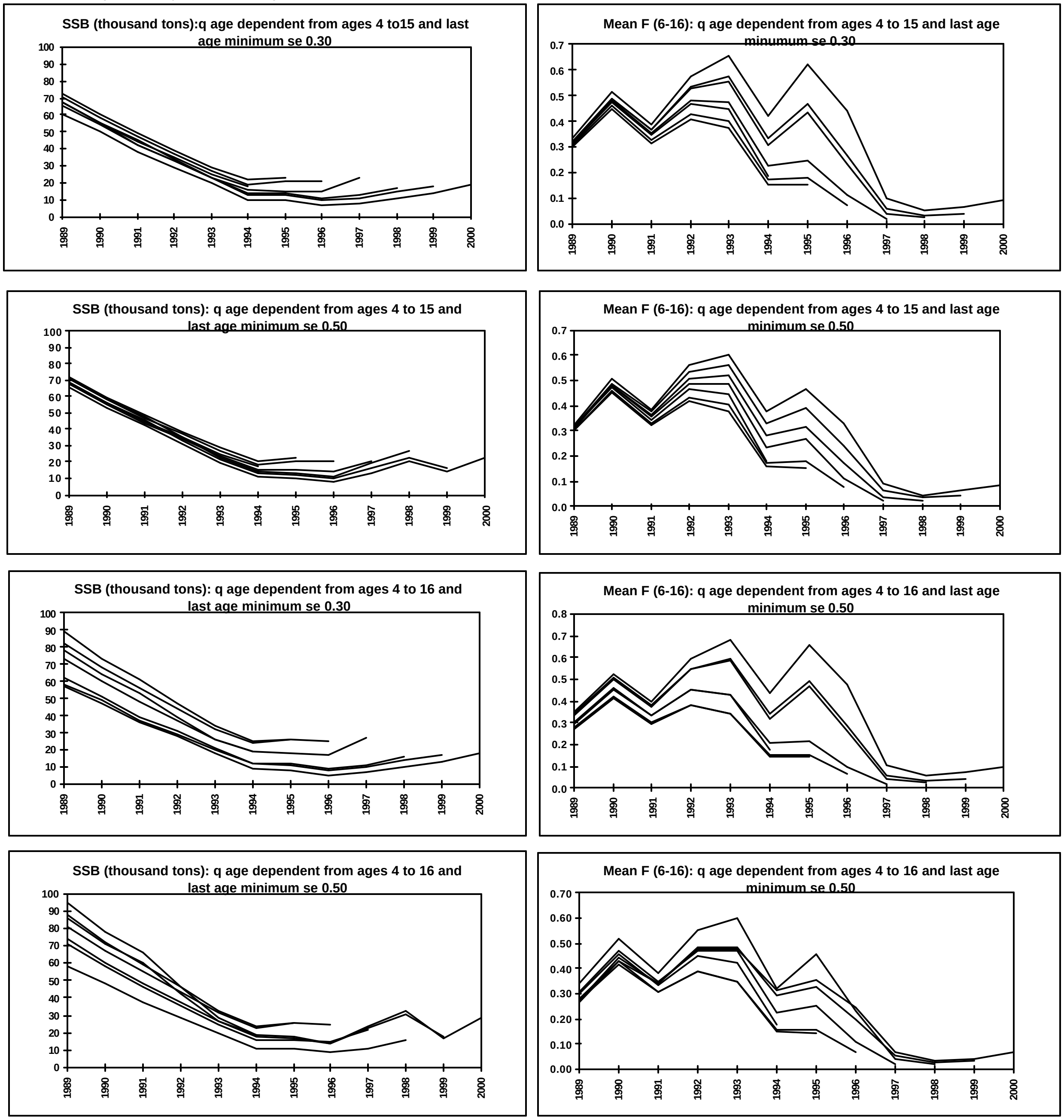

Table 12a: retrospective 3M beaked redfish assessment for an age dependent catchability from 4 to 16 and a minimum standard error of 0.50 associated with the log catchability estimates for age 18.

Biomass

	2000	1999	1998	1997	1996	1995	1994
1989	306	292	245	269	303	294	276
1990	260	248	211	231	262	256	239
1991	197	188	152	172	203	199	188
1992	139	134	113	130	159	157	155
1993	96	94	83	99	125	126	165
1994	93	94	85	118	178	161	275
1995	93	94	88	134	204	178	
1996	86	88	82	128	198		
1997	109	110	94	151			
1998	127	124	103				
1999	106	107					
2000	130						

SSB	2000	1999	1998	1997	1996	1995	1994
1989	94.4	86.1	58.3	70.7	87.4	81.1	73.8
1990	77.9	70.9	48.5	58.0	71.9	67.0	60.6
1991	66.5	59.9	37.2	46.1	59.3	55.2	48.5
1992	46.6	42.5	28.9	35.5	46.0	43.4	37.6
1993	29.1	27.1	19.4	24.4	33.0	31.6	26.6
1994	18.9	17.7	11.1	16.0	23.7	23.1	19.2
1995	17.5	16.3	10.7	16.2	25.5	25.2	
1996	14.1	13.5	8.5	14.7	24.6		
1997	24.0	22.8	11.2	21.5			
1998	32.1	30.4	15.6				
1999	17.0	18.2					
2000	29.0						

FBAR	2000	1999	1998	1997	1996	1995	1994
1989	0.26	0.28	0.34	0.31	0.27	0.28	0.30
1990	0.43	0.44	0.52	0.47	0.42	0.43	0.46
1991	0.34	0.35	0.39	0.35	0.30	0.31	0.34
1992	0.48	0.49	0.55	0.47	0.39	0.39	0.45
1993	0.48	0.48	0.60	0.47	0.35	0.35	0.42
1994	0.31	0.29	0.32	0.23	0.16	0.15	0.18
1995	0.36	0.33	0.46	0.26	0.15	0.15	
1996	0.25	0.20	0.23	0.11	0.07		
1997	0.07	0.05	0.04	0.02			
1998	0.03	0.03	0.02				
1999	0.04	0.03					
2000	0.07						

REC	2000	1999	1998	1997	1996	1995	1994
1989	65	65	67	76	81	83	74
1990	59	58	61	63	72	75	78
1991	36	44	49	57	71	76	124
1992	28	32	35	44	54	56	123
1993	145	146	146	151	167	178	661
1994	410	418	423	614	994	773	1255
1995	77	82	83	163	166	116	
1996	75	66	51	34	25		
1997	63	59	57	72			
1998	45	32	26				
1999	59	54					
2000	23						

Table 12b: Extended Survey Analysis results (Lowestoft VPA Version 3.1)

Run title : REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2000
Terminal Fs derived using XSA (Without F shrinkage)

(Table 8) Fishing mortality (F) at age

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	FBAR 98-**
AGE													
4	0.008	0.231	0.041	0.010	1.479	0.147	0.041	0.024	0.011	0.002	0.003	0.005	0.003
5	0.016	0.057	0.105	0.211	0.621	0.266	0.049	0.062	0.002	0.001	0.001	0.003	0.002
6	0.085	0.098	0.178	0.264	0.487	0.316	0.367	0.020	0.012	0.002	0.000	0.007	0.003
7	0.217	0.427	0.438	0.723	0.374	0.472	0.316	0.135	0.004	0.006	0.002	0.010	0.006
8	0.304	0.761	0.629	0.898	0.613	0.293	0.472	0.375	0.031	0.004	0.006	0.022	0.011
9	0.274	0.722	0.604	0.665	0.314	0.556	0.190	0.521	0.105	0.056	0.003	0.036	0.032
10	0.232	0.565	0.369	0.500	0.559	0.458	0.499	0.163	0.180	0.030	0.055	0.024	0.037
11	0.285	0.412	0.353	0.382	0.600	0.455	0.564	0.484	0.043	0.054	0.041	0.109	0.068
12	0.262	0.311	0.266	0.375	0.522	0.345	0.411	0.411	0.185	0.084	0.094	0.099	0.092
13	0.326	0.371	0.279	0.347	0.477	0.207	0.340	0.222	0.076	0.054	0.073	0.069	0.066
14	0.319	0.440	0.278	0.341	0.487	0.129	0.238	0.214	0.085	0.046	0.054	0.214	0.105
15	0.361	0.366	0.133	0.435	0.522	0.148	0.309	0.098	0.017	0.010	0.084	0.099	0.064
16	0.248	0.261	0.201	0.317	0.342	0.083	0.225	0.081	0.011	0.024	0.075	0.046	0.048
17	0.166	0.215	0.181	0.190	0.263	0.071	0.156	0.048	0.013	0.030	0.057	0.036	0.041
18	0.159	0.179	0.117	0.134	0.395	0.084	0.226	0.054	0.004	0.002	0.054	0.038	0.031
+gp	0.159	0.179	0.117	0.134	0.395	0.084	0.226	0.054	0.004	0.002	0.054	0.038	
0 FBAR 6-16	0.265	0.430	0.339	0.477	0.481	0.315	0.357	0.248	0.068	0.034	0.044	0.067	0.048

(Table 9) Relative F at age

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	MEAN 98-**
AGE													
4	0.031	0.536	0.120	0.021	3.073	0.468	0.114	0.096	0.155	0.069	0.059	0.071	0.066
5	0.059	0.133	0.309	0.442	1.290	0.845	0.137	0.252	0.032	0.034	0.024	0.048	0.035
6	0.321	0.228	0.526	0.553	1.011	1.003	1.027	0.080	0.173	0.061	0.007	0.100	0.056
7	0.818	0.992	1.293	1.517	0.776	1.501	0.885	0.544	0.054	0.192	0.033	0.142	0.122
8	1.148	1.768	1.857	1.883	1.273	0.930	1.320	1.514	0.448	0.109	0.143	0.329	0.194
9	1.035	1.677	1.783	1.394	0.652	1.767	0.531	2.104	1.538	1.654	0.076	0.536	0.755
10	0.876	1.313	1.088	1.049	1.162	1.456	1.397	0.660	2.646	0.898	1.251	0.365	0.838
11	1.075	0.957	1.041	0.801	1.246	1.446	1.579	1.954	0.637	1.596	0.915	1.637	1.382
12	0.990	0.724	0.785	0.786	1.085	1.096	1.149	1.662	2.721	2.504	2.116	1.481	2.034
13	1.233	0.861	0.823	0.727	0.991	0.657	0.953	0.896	1.121	1.613	1.653	1.037	1.434
14	1.203	1.022	0.819	0.714	1.011	0.409	0.665	0.865	1.249	1.360	1.224	3.208	1.930
15	1.365	0.851	0.393	0.912	1.084	0.470	0.864	0.395	0.254	0.296	1.891	1.478	1.222
16	0.937	0.607	0.593	0.665	0.709	0.264	0.630	0.326	0.161	0.720	1.691	0.688	1.033
17	0.626	0.500	0.535	0.398	0.546	0.224	0.436	0.192	0.197	0.880	1.292	0.541	0.904
18	0.601	0.417	0.345	0.282	0.821	0.267	0.633	0.219	0.058	0.069	1.207	0.565	0.614
+gp	0.601	0.417	0.345	0.282	0.821	0.267	0.633	0.219	0.058	0.069	1.207	0.565	
0 REFMEAN	0.265	0.430	0.339	0.477	0.481	0.315	0.357	0.248	0.068	0.034	0.044	0.067	

Table 12b: Extended Survey Analysis results (Lowestoft VPA Version 3.1)

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

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	GMST 89-98	AMST 89-98
AGE															
4	65327	59395	36463	27596	144968	410157	77395	75036	63194	45194	59212	22786	0	72202	100472
5	82525	58626	42680	31680	24723	29887	320343	67242	66304	56579	40799	53438	20520	57435	78059
6	116817	73519	50096	34783	23219	12020	20730	276005	57162	59865	51137	36876	48201	49121	72422
7	142250	97099	60309	37933	24172	12914	7933	12996	244873	51117	54058	46255	33146	40783	69160
8	110535	103658	57342	35214	16650	15051	7286	5232	10278	220765	45956	48842	41460	29514	58201
9	72834	73795	43838	27651	12981	8164	10163	4113	3255	9021	199023	41319	43236	15589	26582
10	56399	50113	32450	21680	12867	8581	4238	7606	2211	2652	7721	179476	36077	11529	19880
11	42576	40473	25777	20309	11895	6656	4911	2328	5846	1671	2329	6609	158497	9776	16244
12	32296	28981	24262	16390	12541	5907	3822	2528	1299	5065	1433	2023	5362	8401	13309
13	27409	22482	19206	16826	10195	6732	3786	2294	1516	976	4213	1180	1659	6675	11142
14	25852	17895	14044	13147	10767	5724	4954	2437	1662	1271	837	3543	997	6498	9775
15	20550	17011	10433	9627	8461	5988	4554	3534	1780	1382	1098	717	2589	6092	8332
16	16172	12955	10676	8265	5640	4544	4673	3025	2900	1583	1238	914	588	5608	7043
17	16660	11417	9028	7902	5446	3627	3785	3376	2525	2596	1398	1039	790	5434	6636
18	16053	12772	8330	6815	5913	3789	3058	2931	2913	2255	2280	1195	907	5231	6483
+gp	40775	32500	35254	15796	5484	5391	6905	6374	21705	25690	3205	16261	15211		
0 TOTAL	885029	712692	480189	331615	335920	545133	488533	477058	489424	487681	475936	462476	409240		

(Table 11) Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE												
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	2302	1447	980	676	443	233	399	5468	1133	1188	1015	731
7	9709	6516	4044	2486	1629	864	537	893	17000	3548	3753	3210
8	13912	12579	7032	4227	2045	1896	905	655	1322	28462	5924	6288
9	12017	11747	7044	4422	2135	1317	1688	665	544	1515	33555	6948
10	11533	9979	6564	4339	2563	1723	848	1564	454	551	1601	37317
11	14037	13209	8452	6644	3824	2165	1583	755	1965	561	783	2210
12	12236	10937	9189	6154	4654	2223	1431	946	495	1946	550	777
13	11920	9743	8384	7306	4381	2956	1645	1006	673	434	1870	524
14	12251	8398	6677	6219	5034	2754	2363	1165	803	615	405	1693
15	10101	8358	5223	4704	4106	2994	2248	1774	899	698	552	360
16	9279	7426	6149	4716	3212	2642	2686	1759	1696	925	720	533
17	9622	6568	5208	4556	3121	2111	2188	1968	1476	1516	815	606
18	9591	7619	4994	4080	3467	2278	1817	1766	1762	1364	1374	721
+gp	29155	23201	25293	11317	3848	3878	4911	4596	15713	18601	2311	11741

Table 12b: Extended Survey Analysis results (Lowestoft VPA Version 3.1)

(Table 12) Stock biomass at age (start of year) Tonnes

	YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE												
	4	6533	5999	4084	2235	9858	37734	8591	5853	6193	4384	5329	2233
	5	13286	10201	5933	5354	4005	3975	39082	9481	8951	8204	5100	7214
	6	23831	16615	11121	7200	5085	2753	4664	39469	11432	11195	9205	6527
	7	35278	26411	17128	11077	7058	3616	2324	3548	45057	12064	12217	11009
	8	31723	32030	19611	12466	6127	5298	2616	1737	3669	50114	12132	14067
	9	23452	25164	17141	11005	5167	3249	4106	1604	1318	3311	49557	13759
	10	20134	18742	15187	9886	5610	4016	1915	3423	1022	1101	2532	54202
	11	18946	18456	13353	10784	6114	3315	2490	1136	2917	794	1094	2802
	12	16891	15389	13902	9424	6948	3172	2052	1373	730	2689	810	1078
	13	15815	13197	11907	10769	6351	3757	2328	1360	906	584	2165	794
	14	15563	10880	9100	8953	7343	3858	3334	1497	1011	835	458	2023
	15	13275	11125	7241	6768	5973	3976	3183	2354	1179	931	591	363
	16	10690	8680	8050	6554	4681	3217	3589	2148	2091	1206	682	621
	17	11978	8300	6699	5958	4482	2905	2929	2586	1899	1986	864	750
	18	11606	9298	6414	5956	4937	3134	2483	2342	2062	1551	1357	863
	+gp	36575	29055	30389	14564	5818	4722	6856	6094	18558	25613	2340	11789
0	TOTALBIO	305578	259543	197259	138954	95558	92697	92543	86003	108995	126560	106434	130096

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

	YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE												
	4	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0
	6	470	327	218	140	97	53	90	782	227	222	183	129
	7	2408	1772	1148	726	476	242	157	244	3128	837	848	764
	8	3993	3887	2405	1496	752	667	325	217	472	6461	1564	1811
	9	3869	4006	2754	1760	850	524	682	259	220	556	8355	2314
	10	4117	3732	3072	1979	1118	807	383	704	210	229	525	11270
	11	6247	6023	4378	3528	1966	1078	803	369	980	267	368	937
	12	6399	5807	5265	3538	2578	1194	768	514	278	1034	311	414
	13	6878	5719	5198	4676	2729	1649	1012	596	402	259	961	353
	14	7375	5106	4326	4235	3433	1856	1590	715	488	404	222	967
	15	6525	5466	3624	3307	2899	1988	1571	1182	595	471	297	182
	16	6134	4975	4637	3740	2666	1871	2063	1249	1223	705	397	362
	17	6919	4775	3864	3435	2569	1691	1693	1508	1110	1159	503	438
	18	6934	5547	3845	3566	2895	1884	1476	1411	1248	938	817	520
	+gp	26152	20742	21802	10434	4082	3397	4876	4394	13435	18545	1687	8512
0	TOTSPBIO	94420	77885	66539	46560	29109	18900	17489	14144	24017	32087	17039	28973

Table 12b:(count.) Extended Survey Analysis results (Lowestoft VPA Version 3.1)

(Table 16) Summary (without SOP correction)
Terminal Fs derived using XSA (Without F shrinkage)

	RECRUITS Age 4	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR6-16
1989	65327	305578	94420	58100	0.6153	0.2648
1990	59395	259543	77885	81000	1.04	0.4302
1991	36463	197259	66539	48500	0.7289	0.3389
1992	27596	138954	46560	43300	0.93	0.477
1993	144968	95558	29109	40970	1.4075	0.4814
1994	410157	92697	18900	17203	0.9102	0.3146
1995	77395	92543	17489	13874	0.7933	0.3573
1996	75036	86003	14144	5789	0.4093	0.2475
1997	63194	108995	24017	1300	0.0541	0.0681
1998	45194	126560	32087	971	0.0303	0.0336
1999	59212	106434	17039	1068	0.0627	0.0443
2000	22786	130096	28973	3825	0.132	0.0667
Arith. Mean	90560	145018	38930	26325	0.5928	0.2604
0 Units	(Thousands	(Tonnes)	(Tonnes)	(Tonnes)		

Fig. 7: SPA Log catch ratio residuals

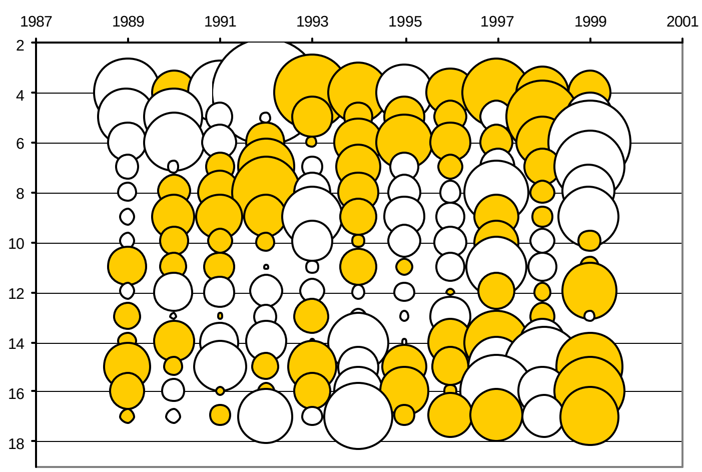

Fig. 8: Cohort analysis/SPA F residuals

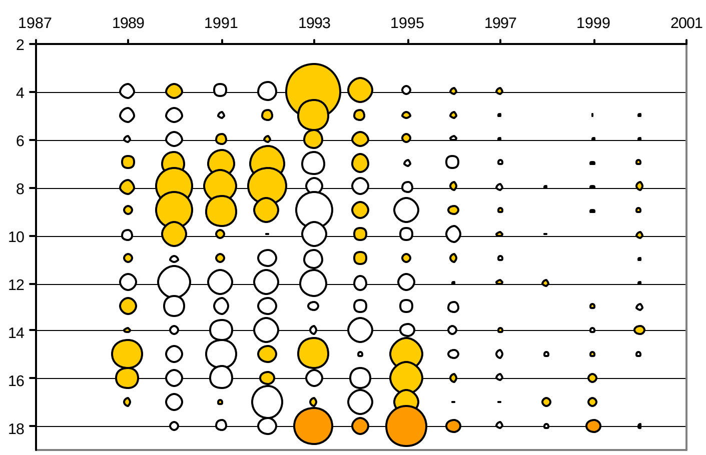

Table 13a : Separable VPA diagonostics (Lowestoft VPA Version 3.1)

Separable analysis
from 1989 to 2000 on ages 4 to 18
with Terminal F of .029 on age 12 and Terminal S of .950

Initial sum of squared residuals was 199.116 and
final sum of squared residuals is 91.648 after 97 iterations

Matrix of Residuals of Log catch ratios

Years / Ages	1989/9	1990/9	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/**	TOT	WTS
4/ 5	-1.422	0.661	-1.293	-3.651	1.808	1.2	-1.062	0.755	1.548	0.846	0.61	0	0.15
5/ 6	-1.025	-1.039	-0.239	-0.042	0.573	0.278	0.555	0.35	-0.331	1.627	-0.706	0.001	0.312
6/ 7	-0.501	-1.148	-0.364	0.507	0.04	0.733	1.014	0.508	0.394	0.897	-2.077	0.001	0.26
7/ 8	-0.18	-0.047	0.269	1.088	-0.158	0.668	-0.278	0.197	-0.389	0.416	-1.586	0.002	0.36
8/ 9	-0.109	0.371	0.574	1.554	-0.44	0.534	-0.389	-0.162	-1.236	0.192	-0.887	0.002	0.322
9/10	-0.092	0.639	0.689	0.61	-1.166	0.465	-0.483	-0.276	0.621	0.149	-1.156	0.002	0.354
10/11	-0.093	0.28	0.222	0.116	-0.518	0.074	-0.336	-0.31	0.6	-0.207	0.172	0.002	0.758
11/12	0.493	0.251	0.305	-0.008	-0.062	0.458	0.11	-0.263	-1.151	-0.254	0.124	0.002	0.54
12/13	-0.088	-0.498	-0.31	-0.324	-0.197	-0.072	-0.119	0.025	0.466	0.118	1.001	0.002	0.592
13/14	0.274	-0.017	0.013	-0.179	0.415	-0.082	-0.037	-0.521	-0.04	0.224	-0.048	0.002	1
14/15	0.122	0.555	-0.474	-0.539	-0.011	-1.105	-0.013	0.717	1.307	-0.645	0.089	0.002	0.361
15/16	0.71	0.123	-0.866	0.26	0.804	-0.529	0.624	0.472	-1.067	-1.944	1.414	0.002	0.25
16/17	0.449	-0.174	0.034	0.104	0.442	-0.797	0.787	0.084	-1.709	-0.77	1.551	0.002	0.284
17/18	0.081	-0.08	0.151	-0.909	-0.13	-1.397	0.159	0.653	0.93	-0.593	1.138	0.002	0.325
TOT	-0.003	-0.003	-0.003	-0.001	0	0.003	0.005	0.005	0.004	0.002	0.001	0.025	
WTS	1	1	1	1	1	1	1	1	1	1	1		

FishingMortalities(F)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
F-values	0.3677	0.6071	0.4616	0.5949	0.7527	0.3243	0.3207	0.1576	0.0286	0.0135	0.0138	0.029

Selection-at-age(S)

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S-values	0.1674	0.1792	0.2589	0.4455	0.6524	0.7127	0.7704	0.802	1	0.896	1.0509	0.9387	0.9607	1.0008	0.95

CohortanalysisTerminalpopulationsfromweightedSeparablepopulations

Fishingmortalityresiduals

YEAR / AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
4	-0.0543	0.0644	-0.0483	-0.0929	0.716	0.1666	-0.0207	0.0148	0.0196	0.001	0.001	0
5	-0.0515	-0.0584	-0.011	0.0383	0.2407	0.0373	0.02	0.022	-0.0013	0.0002	-0.001	-0.0011
6	-0.0133	-0.0667	0.0349	0.0161	0.1011	0.0706	0.0234	-0.0091	0.002	0.0001	-0.0028	0.0018
7	0.0491	0.1372	0.1891	0.3169	-0.1228	0.0873	-0.0126	-0.0378	-0.0068	-0.0009	-0.0036	0.0093
8	0.0686	0.3439	0.2817	0.3494	-0.0746	-0.0693	-0.0319	0.0215	-0.0118	-0.0028	-0.0039	0.02
9	0.0261	0.3071	0.2439	0.1532	-0.3107	0.0708	-0.1477	0.0277	0.009	0.0026	-0.0043	0.0076
10	-0.0279	0.1436	0.0291	-0.0011	-0.1428	0.041	-0.0409	-0.0588	0.0149	-0.0023	0.001	0.0178
11	0.0267	-0.0148	0.0305	-0.0704	-0.0882	0.0511	0.031	0.0194	-0.0074	-0.0008	-0.0005	-0.0019
12	-0.0706	-0.2386	-0.1378	-0.1421	-0.1751	-0.0507	-0.0806	0.0033	0.015	0.0156	0.0027	-0.0046
13	0.0787	-0.1019	-0.0612	-0.0749	-0.0245	-0.051	-0.0383	-0.0288	-0.0001	-0.0004	0.0116	-0.0146
14	0.0132	-0.0136	-0.1278	-0.1488	-0.013	-0.1413	-0.0503	-0.0213	0.0098	0.0005	-0.0033	0.033
15	0.2231	-0.057	-0.2155	0.0826	0.2374	-0.0059	0.2557	-0.0255	-0.0157	-0.0081	0.0128	-0.0082
16	0.1263	-0.0655	-0.1204	0.0532	-0.0745	-0.11	0.2717	0.0223	-0.0136	0.0026	0.0202	-0.0144
17	0.0182	-0.0576	0.0105	-0.2435	0.0177	-0.1587	0.1446	-0.0018	0.0019	0.0243	0.0225	-0.0134
18	0.0006	-0.0164	-0.0279	-0.0836	0.357	0.0646	0.3875	0.0556	-0.0133	-0.0074	0.0561	-0.0041

Table 13b : Cohort analysis results from SPA (Lowestoft VPA Version 3.1)

Cohort analysis Terminal populations from weighted Separable populations

(Table 8) Fishing mortality (F) at age

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	FBAR 98-**
AGE													
4	0.0073	0.1661	0.029	0.0067	0.842	0.2209	0.033	0.0412	0.0244	0.0032	0.0033	0.0049	0.0038
5	0.0144	0.0504	0.0717	0.1449	0.3755	0.0954	0.0774	0.0502	0.0038	0.0026	0.0015	0.0041	0.0027
6	0.0819	0.0905	0.1545	0.1701	0.2961	0.1546	0.1064	0.0318	0.0094	0.0036	0.0008	0.0093	0.0045
7	0.2129	0.4076	0.3947	0.5819	0.2125	0.2318	0.1303	0.0324	0.0059	0.0051	0.0026	0.0222	0.01
8	0.3085	0.74	0.5829	0.7375	0.4165	0.1423	0.1774	0.1243	0.0069	0.006	0.0051	0.039	0.0167
9	0.2882	0.7398	0.5728	0.5771	0.2257	0.3019	0.0809	0.14	0.0294	0.0122	0.0055	0.0283	0.0153
10	0.2553	0.6114	0.3847	0.4572	0.4371	0.2908	0.2062	0.0627	0.037	0.0081	0.0116	0.0401	0.0199
11	0.3216	0.4721	0.4007	0.4067	0.5155	0.3112	0.2882	0.1458	0.0156	0.01	0.0106	0.0214	0.014
12	0.2971	0.3686	0.3238	0.4527	0.5776	0.2736	0.2401	0.161	0.0436	0.029	0.0165	0.0244	0.0233
13	0.4081	0.4421	0.3523	0.4581	0.6499	0.2395	0.249	0.1124	0.0255	0.0116	0.024	0.0113	0.0157
14	0.3996	0.6244	0.3573	0.4764	0.7781	0.1995	0.2868	0.1444	0.0399	0.0147	0.0111	0.0635	0.0298
15	0.5682	0.5128	0.2177	0.641	0.944	0.2986	0.5567	0.1224	0.0112	0.0045	0.0257	0.019	0.0164
16	0.4796	0.5177	0.323	0.6248	0.6487	0.2015	0.5798	0.1738	0.0139	0.0156	0.0334	0.0135	0.0208
17	0.3862	0.5499	0.4724	0.3519	0.771	0.1658	0.4656	0.156	0.0306	0.0378	0.0363	0.0156	0.0299
18	0.3499	0.5604	0.4106	0.4816	1.0721	0.3727	0.6922	0.2053	0.0139	0.0054	0.0692	0.0235	0.0327
+gp	0.3489	0.5582	0.4093	0.4799	1.0661	0.3716	0.6891	0.2049	0.0139	0.0054	0.0691	0.0234	
0 FBAR 6-16	0.3292	0.5025	0.3695	0.5076	0.5183	0.2405	0.2638	0.1137	0.0217	0.0109	0.0133	0.0265	

(Table 9) Relative F at age

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	MEAN 98-**
AGE													
4	0.0221	0.3305	0.0785	0.0132	1.6245	0.9185	0.1251	0.3621	1.127	0.293	0.2506	0.183	0.2422
5	0.0438	0.1003	0.1941	0.2855	0.7245	0.3968	0.2936	0.4414	0.1746	0.2412	0.1129	0.1541	0.1694
6	0.2489	0.1801	0.418	0.3352	0.5712	0.6428	0.4035	0.2793	0.4336	0.3271	0.0574	0.3499	0.2448
7	0.6468	0.8113	1.0682	1.1463	0.41	0.9639	0.494	0.2852	0.2733	0.4687	0.1922	0.8374	0.4994
8	0.9371	1.4728	1.5775	1.453	0.8035	0.5916	0.6724	1.0932	0.3186	0.5476	0.379	1.4671	0.7979
9	0.8754	1.4723	1.5503	1.137	0.4355	1.2554	0.3066	1.2312	1.3572	1.1105	0.413	1.0661	0.8632
10	0.7756	1.2168	1.0412	0.9007	0.8433	1.2093	0.7816	0.551	1.7062	0.7368	0.8691	1.5104	1.0388
11	0.977	0.9396	1.0845	0.8013	0.9946	1.2943	1.0926	1.2819	0.7198	0.9142	0.7906	0.8059	0.8369
12	0.9025	0.7335	0.8764	0.8919	1.1144	1.1376	0.9101	1.4154	2.0139	2.6543	1.2338	0.9196	1.6025
13	1.2397	0.8798	0.9536	0.9024	1.2538	0.996	0.9439	0.9886	1.1792	1.062	1.7967	0.4274	1.0954
14	1.2138	1.2427	0.9669	0.9385	1.5011	0.8297	1.0871	1.2696	1.8403	1.341	0.8343	2.3916	1.5223
15	1.7262	1.0207	0.5893	1.2629	1.8212	1.2415	2.1104	1.0766	0.5169	0.4149	1.9288	0.7172	1.0203
16	1.4568	1.0304	0.8741	1.2308	1.2514	0.8379	2.1979	1.528	0.6412	1.4228	2.5051	0.5075	1.4785
17	1.1731	1.0945	1.2785	0.6932	1.4874	0.6894	1.7649	1.3714	1.4104	3.4548	2.7196	0.5874	2.2539
18	1.0628	1.1152	1.1112	0.9488	2.0683	1.5497	2.6238	1.8054	0.64	0.4909	5.1822	0.8838	2.1856
+gp	1.0599	1.1109	1.1078	0.9455	2.0568	1.5451	2.6123	1.802	0.6396	0.4907	5.1772	0.8832	
0 REFMEAN	0.3292	0.5025	0.3695	0.5076	0.5183	0.2405	0.2638	0.1137	0.0217	0.0109	0.0133	0.0265	

Table 13b : Cohort analysis results from SPA (Lowestoft VPA Version 3.1)

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

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	GMST 89-98	AMST 89-98
AGE															
4	73890	79911	50748	40651	196666	283179	94922	43595	27542	32507	45957	22343	0	69187	92361
5	88983	66374	61243	44606	36537	76666	205447	83101	37855	24320	29319	41444	20119	60974	72513
6	120838	79362	57107	51580	34916	22709	63057	172044	71511	34123	21948	26489	37347	59883	70725
7	144381	100738	65596	44277	39370	23497	17605	51296	150805	64101	30765	19844	23747	56662	70167
8	109168	105586	60635	39998	22390	28803	16862	13984	44933	135648	57704	27766	17561	43787	57801
9	69701	72559	45582	30630	17310	13358	22606	12778	11174	40378	122006	51949	24164	27089	33608
10	51785	47279	31332	23259	15563	12498	8937	18865	10051	9817	36094	109789	45694	18886	22939
11	38351	36298	23213	19296	13323	9095	8455	6580	16033	8765	8812	32282	95436	15036	17941
12	28983	25158	20485	14069	11625	7199	6029	5735	5146	14283	7852	7890	28592	11615	13871
13	22777	19484	15746	13408	8095	5903	4955	4291	4418	4458	12554	6989	6967	8458	10354
14	21409	13704	11331	10017	7674	3824	4204	3495	3469	3896	3987	11090	6252	6742	8302
15	14377	12991	6641	7173	5629	3189	2834	2856	2737	3017	3474	3567	9417	5045	6144
16	9330	7370	7039	4833	3419	1982	2141	1470	2286	2449	2717	3064	3167	3504	4232
17	7942	5226	3973	4611	2341	1617	1466	1085	1118	2040	2182	2378	2735	2523	3142
18	7998	4884	2729	2242	2935	980	1240	833	840	981	1777	1904	2118	1891	2566
+gp	20331	12424	11549	5195	2715	1394	2797	1812	6260	11183	2501	25930	24601		
0 TOTAL	830244	689347	474949	355846	420506	495894	463557	423816	396179	391965	389648	394718	347917		

(Table 11) Spawning stock number at age (spawning time) Numbers*10**-3

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE												
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	2382	1563	1119	1010	677	445	1240	3405	1418	677	435	525
7	9857	6771	4414	2935	2688	1602	1210	3553	10467	4449	2136	1376
8	13736	12834	7463	4863	2793	3673	2144	1786	5792	17485	7439	3570
9	11487	11534	7343	4933	2867	2199	3788	2131	1880	6803	20567	8741
10	10570	9379	6329	4671	3131	2544	1831	3911	2088	2044	7512	22799
11	12607	11789	7582	6300	4312	2992	2787	2194	5401	2954	2970	10870
12	10950	9450	7723	5250	4295	2725	2288	2190	1984	5513	3034	3046
13	9841	8396	6834	5770	3431	2585	2168	1898	1968	1988	5593	3117
14	10080	6337	5353	4687	3505	1829	1997	1680	1681	1892	1936	5363
15	6950	6308	3302	3448	2641	1575	1372	1431	1384	1526	1754	1802
16	5255	4138	4015	2691	1900	1141	1196	848	1337	1432	1586	1791
17	4507	2927	2239	2624	1288	934	827	627	653	1190	1273	1390
18	4706	2826	1598	1305	1630	576	710	496	508	593	1070	1150
+gp	14318	8605	8094	3621	1806	980	1917	1291	4529	8095	1801	18743

Table 13b : Cohort analysis results from SPA (Lowestoft VPA Version 3.1)

(Table 12) Stock biomass at age (start of year) Tonnes

	YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE												
	4	7389	8071	5684	3293	13373	26052	10536	3400	2699	3153	4136	2190
	5	14326	11549	8513	7538	5919	10197	25065	11717	5110	3526	3665	5595
	6	24651	17936	12678	10677	7646	5200	14188	24602	14302	6381	3951	4689
	7	35806	27401	18629	12929	11496	6579	5158	14004	27748	15128	6953	4723
	8	31331	32626	20737	14159	8239	10139	6054	4643	16041	30792	15234	7997
	9	22444	24743	17823	12191	6889	5316	9133	4983	4525	14819	30380	17299
	10	18487	17682	14663	10606	6785	5849	4040	8489	4644	4074	11839	33156
	11	17066	16552	12024	10246	6848	4529	4287	3211	8001	4163	4142	13688
	12	15158	13359	11738	8090	6440	3866	3237	3114	2892	7584	4436	4205
	13	13142	11437	9763	8581	5043	3294	3047	2544	2642	2666	6453	4703
	14	12888	8332	7343	6821	5234	2577	2829	2146	2109	2560	2185	6332
	15	9287	8496	4609	5042	3974	2118	1981	1902	1812	2033	1869	1805
	16	6167	4938	5307	3833	2837	1403	1644	1044	1648	1866	1497	2083
	17	5710	3800	2948	3477	1927	1295	1135	831	841	1561	1348	1717
	18	5783	3556	2101	1959	2450	810	1007	665	595	675	1058	1375
	+gp	18237	11107	9955	4790	2881	1221	2777	1732	5353	11149	1826	18799
0	TOTALBIO	257874	221583	164514	124233	97984	90447	96118	89028	100962	112131	100970	130356

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

	YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE												
	4	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0
	6	486	353	248	209	148	102	279	487	284	127	78	93
	7	2444	1842	1253	857	785	448	354	970	1926	1050	483	327
	8	3942	3966	2553	1721	1028	1293	770	593	2068	3969	1964	1028
	9	3699	3933	2871	1963	1141	875	1530	831	761	2497	5121	2911
	10	3774	3508	2962	2130	1365	1191	828	1760	965	848	2464	6885
	11	5610	5376	3928	3345	2216	1490	1413	1070	2695	1403	1396	4609
	12	5727	5018	4425	3019	2379	1463	1229	1189	1115	2927	1714	1624
	13	5679	4928	4237	3693	2137	1443	1334	1126	1177	1189	2875	2098
	14	6068	3853	3469	3192	2390	1233	1344	1031	1022	1243	1061	3063
	15	4490	4126	2291	2424	1864	1046	959	953	916	1028	944	912
	16	3474	2773	3027	2134	1577	808	919	602	964	1091	874	1218
	17	3240	2128	1662	1978	1060	748	640	480	491	911	787	1004
	18	3403	2057	1230	1141	1361	476	576	396	359	408	636	830
	+gp	12844	7692	6977	3338	1916	858	1903	1234	3872	8070	1315	13589
0	TOTSPBIO	64879	51553	41133	31144	21368	13475	14077	12722	18614	26762	21712	40190

Table 13b : Cohort analysis results from SPA (Lowestoft VPA Version 3.1)

(Table 16) Summary (without SOP correction)
Cohort analysis Terminal populations from weighted Separable populations

	RECRUITS Age 4	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR6-16
1989	73890	257874	64879	58100	0.8955	0.3292
1990	79911	221583	51553	81000	1.5712	0.5025
1991	50748	164514	41133	48500	1.1791	0.3695
1992	40651	124233	31144	43300	1.3903	0.5076
1993	196666	97984	21368	40970	1.9173	0.5183
1994	283179	90447	13475	17203	1.2767	0.2405
1995	94922	96118	14077	13874	0.9855	0.2638
1996	43595	89028	12722	5789	0.455	0.1137
1997	27542	100962	18614	1300	0.0698	0.0217
1998	32507	112131	26762	971	0.0363	0.0109
1999	45957	100970	21712	1068	0.0492	0.0133
2000	22343	130356	40190	3825	0.0952	0.0265
Arith. Mean	82659	132183	29802	26325	0.8268	0.2431
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

1

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(Table 17) Summary (with SOP correction)
Cohort analysis Terminal populations from weighted Separable populations

	RECRUITS Age 4	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR6-16
1989	73890	257864	64876	58100	0.8956	1	0.3292
1990	79911	223671	52039	81000	1.5565	1.0094	0.5025
1991	50748	164425	41111	48500	1.1797	0.9995	0.3695
1992	40651	124223	31142	43300	1.3904	0.9999	0.5076
1993	196666	98843	21556	40970	1.9006	1.0088	0.5183
1994	283179	93026	13859	17203	1.2413	1.0285	0.2405
1995	94922	96565	14143	13874	0.981	1.0047	0.2638
1996	43595	85173	12172	5789	0.4756	0.9567	0.1137
1997	27542	94724	17464	1300	0.0744	0.9382	0.0217
1998	32507	108536	25904	971	0.0375	0.9679	0.0109
1999	45957	98916	21270	1068	0.0502	0.9797	0.0133
2000	22343	130127	40119	3825	0.0953	0.9982	0.0265
Arith. Mean	82659	131341	29638	26325	.8232	.2431	
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

1

Table 14a: The VPA 4 plus biomass.

Year	XSA	Cohort
1989	305578	257874
1990	259543	221583
1991	197259	164514
1992	138954	124233
1993	95558	97984
1994	92697	90447
1995	92543	96118
1996	86003	89028
1997	108995	100962
1998	126560	112131
1999	106434	100970
2000	130096	130356

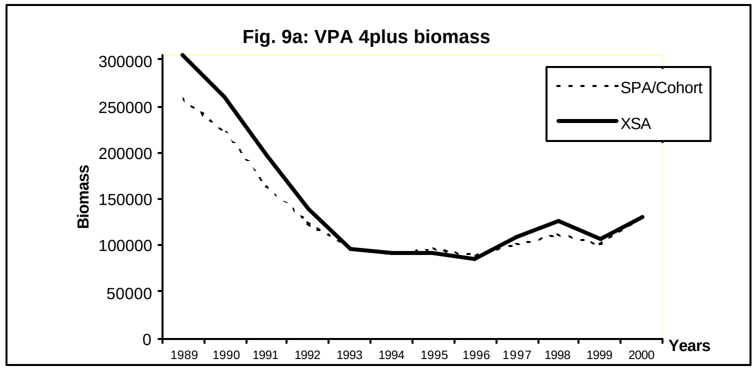

Table 14b: The VPA spawnning stock biomass.

Year	XSA	Cohort
1989	94420	64879
1990	77885	51553
1991	66539	41133
1992	46560	31144
1993	29109	21368
1994	18900	13475
1995	17489	14077
1996	14144	12722
1997	24017	18614
1998	32087	26762
1999	17039	21712
2000	28973	40190

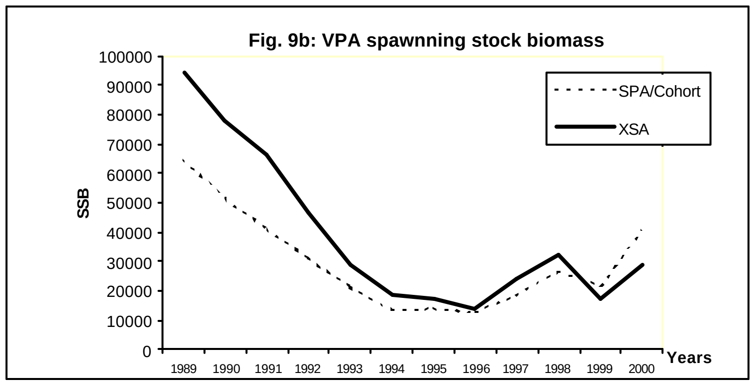

Table 14c: The VPA fishing mortalities (6-16).

Year	XSA	Cohort
1989	0.2648	0.3292
1990	0.4302	0.5025
1991	0.3389	0.3695
1992	0.477	0.5076
1993	0.4814	0.5183
1994	0.3146	0.2405
1995	0.3573	0.2638
1996	0.2475	0.1137
1997	0.0681	0.0217
1998	0.0336	0.0109
1999	0.0443	0.0133
2000	0.0667	0.0265

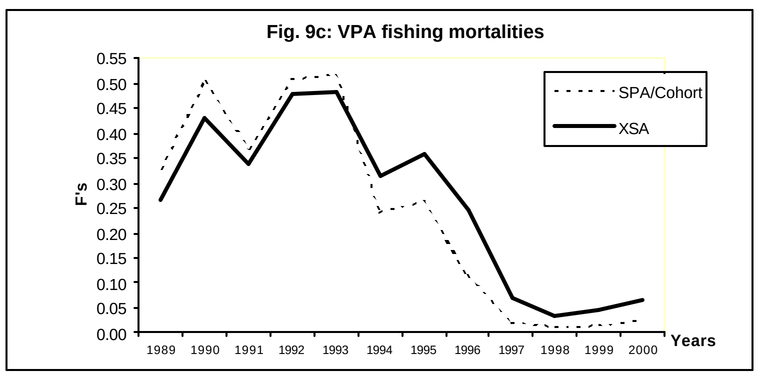

Table 15a: ASPIC input file on bootstrapped mode

```
'BOT'                   ## Mode (FIT, IRF, BOT)
'3M redfish'
'EFF'                   ## Error type ('EFF' = condition on yield)
 2                      ## Verbosity (0 to 4)
 1000                    ## Number of bootstrap trials, <= 1000
 0 10000                ## Monte Carlo search enable (0,1,2), N trials
 1.0E-8                 ## Convergence crit. for simplex
 3.0E-8                 ## Convergence crit. for restarts
 1.0d-4                 ## Convergence crit. for estimating effort
 1.5d0                  ## Maximum F when estimating effort
 0.0d0                 ## Statistical weight for B1 > K as residual
 2                      ## Number of data series (fisheries)
1.0d0 1.0d0                ## Statistical weights for fisheries
1.0d0                   ## B1-ratio (starting guess)
2.0d4                   ## MSY (starting guess)
0.20d0                   ## r (starting guess)
0.70d0 0.0d0           ## q (starting guess)
1 1 1 0 1             ## Flags to estimate parameters
1.0d4  5.5d4            ## Min and max allowable MSY
0.05d0  1.0d0          ## Min and max allowable r
9126738                 ## Random number seed
42                      ## Number of years of data.
'EU survey'             ## Title for first series
'I1'                    ## Type of series ('CE' = effort, catch)
 1959   -0.001
 1960   -0.001
 1961   -0.001
 1962   -0.001
 1963   -0.001
 1964   -0.001
 1965   -0.001
 1966   -0.001
 1967   -0.001
 1968   -0.001
 1969   -0.001
 1970   -0.001
 1971   -0.001
 1972   -0.001
 1973   -0.001
 1974   -0.001
 1975   -0.001
 1976   -0.001
 1977   -0.001
 1978   -0.001
 1979   -0.001
 1980   -0.001
 1981   -0.001
 1982   -0.001
 1983   -0.001
 1984   -0.001
 1985   -0.001
 1986   -0.001
 1987   -0.001
 1988      193567.0
 1989      117015.0
 1990       78703.0
 1991       64126.0
 1992       85620.0
 1993       46218.0
 1994       86359.0
 1995       68804.0
```

```
 1996       94955.0
 1997       76785.0
 1998       54039.0
 1999       77468.0
 2000      110019.0
'Statlant CPUE'
'CC'
 1959   2.688   51977.0
 1960   4.179    8388.0
 1961   5.331   15517.0
 1962   3.691    6958.0
 1963   3.762    7035.0
 1964   2.245   17647.0
 1965   3.278   33427.0
 1966   1.771    7241.0
 1967   1.818     729.0
 1968   3.441    4963.0
 1969   2.924    2801.0
 1970   7.274    3168.0
 1971   5.020    8033.0
 1972   2.940   41946.0
 1973   2.563   22352.0
 1974   3.199   34671.0
 1975   3.138   16075.0
 1976   2.377   16998.0
 1977   2.128   20267.0
 1978   2.522   16762.0
 1979   1.739   20074.0
 1980   2.222   15957.0
 1981   2.530   13891.0
 1982   2.359   14684.0
 1983   2.134   19527.0
 1984   2.121   20228.0
 1985   2.188   20282.0
 1986   3.202   28873.0
 1987   3.582   44411.0
 1988   2.108   23189.0
 1989   1.658   58102.0
 1990   1.574   81046.0
 1991   1.484   48489.0
 1992   1.530   43317.0
 1993   1.732   28993.0
 1994  -0.001   11315.0
 1995  -0.001   13495.0
 1996  -0.001    5789.0
 1997  -0.001    1300.0
 1998  -0.001     971.0
 1999  -0.001    1068.0
 2000  -0.001    3825.0
```

Table 15b: ASPIC results

3M redfish

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

BOT Mode

Author: Michael H. Prager
National Marine Fisheries Service
Southwest Fisheries Science Center
3150 Paradise Drive
Tiburon, California 94920 USA

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	42	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:	5.500E+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	2
1	EU survey	1.000 13	
2	Statlant CPUE	0.808 6	1.000 35

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared 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	1.185E+00	13	1.077E-01	1.000E+00	9.741E-01	0.459
Loss(2) Statlant CPUE	3.429E+00	35	1.039E-01	1.000E+00	1.010E+00	0.297

TOTAL OBJECTIVE FUNCTION: 4.61410708E+00

Number of restarts required for convergence: 2
Est. B-ratio coverage index (0 worst, 2 best): 1.5540
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	2.226E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	2.339E+04	2.000E+04	1	1
r	Intrinsic rate of increase	2.523E-01	2.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	EU survey	7.000E-01	7.000E-01	0	1
q(2)	Statlant CPUE	9.647E-06	3.958E-05	1	0

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	2.339E+04	Kr/4	
K	Maximum stock biomass	3.709E+05		
Bmsy	Stock biomass at MSY	1.855E+05	K/2	
Fmsy	Fishing mortality at MSY	1.261E-01	r/2	
F(0.1)	Management benchmark	1.135E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	2.316E+04	0.99*MSY	
B-ratio	Ratio of B(2001) to Bmsy	9.928E-01		
F-ratio	Ratio of F(2000) to Fmsy	1.739E-01		
Y-ratio	Proportion of MSY avail in 2001	9.999E-01	2*Br-Br^2	Ye(2001) = 2.339E+04
....	Fishing effort at MSY in units of each fishery:			
fmsy(2)	Statlant CPUE	1.307E+04	r/2q(2)	f(0.1) = 1.177E+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	0.136	4.128E+05	3.832E+05	5.198E+04	5.198E+04	-3.375E+03	1.075E+00	2.226E+00
2	1960	0.024	3.574E+05	3.550E+05	8.388E+03	8.388E+03	3.837E+03	1.873E-01	1.927E+00
3	1961	0.045	3.528E+05	3.476E+05	1.552E+04	1.552E+04	5.503E+03	3.539E-01	1.903E+00
4	1962	0.020	3.428E+05	3.426E+05	6.958E+03	6.958E+03	6.590E+03	1.610E-01	1.849E+00
5	1963	0.021	3.425E+05	3.423E+05	7.035E+03	7.035E+03	6.668E+03	1.630E-01	1.847E+00
6	1964	0.052	3.421E+05	3.370E+05	1.765E+04	1.765E+04	7.779E+03	4.152E-01	1.845E+00
7	1965	0.104	3.322E+05	3.205E+05	3.343E+04	3.343E+04	1.097E+04	8.270E-01	1.791E+00
8	1966	0.023	3.098E+05	3.124E+05	7.241E+03	7.241E+03	1.242E+04	1.837E-01	1.670E+00
9	1967	0.002	3.150E+05	3.203E+05	7.290E+02	7.290E+02	1.103E+04	1.805E-02	1.698E+00
10	1968	0.015	3.253E+05	3.277E+05	4.963E+03	4.963E+03	9.637E+03	1.201E-01	1.754E+00
11	1969	0.008	3.299E+05	3.329E+05	2.801E+03	2.801E+03	8.601E+03	6.670E-02	1.779E+00
12	1970	0.009	3.357E+05	3.380E+05	3.168E+03	3.168E+03	7.566E+03	7.431E-02	1.810E+00
13	1971	0.024	3.401E+05	3.397E+05	8.033E+03	8.033E+03	7.213E+03	1.875E-01	1.834E+00
14	1972	0.130	3.393E+05	3.228E+05	4.195E+04	4.195E+04	1.052E+04	1.030E+00	1.830E+00
15	1973	0.074	3.079E+05	3.035E+05	2.235E+04	2.235E+04	1.391E+04	5.839E-01	1.660E+00
16	1974	0.120	2.994E+05	2.897E+05	3.467E+04	3.467E+04	1.598E+04	9.489E-01	1.615E+00
17	1975	0.057	2.808E+05	2.813E+05	1.608E+04	1.608E+04	1.715E+04	4.531E-01	1.514E+00
18	1976	0.060	2.818E+05	2.819E+05	1.700E+04	1.700E+04	1.707E+04	4.781E-01	1.520E+00
19	1977	0.072	2.819E+05	2.803E+05	2.027E+04	2.027E+04	1.727E+04	5.732E-01	1.520E+00
20	1978	0.060	2.789E+05	2.792E+05	1.676E+04	1.676E+04	1.741E+04	4.759E-01	1.504E+00
21	1979	0.072	2.795E+05	2.782E+05	2.007E+04	2.007E+04	1.754E+04	5.720E-01	1.507E+00
22	1980	0.057	2.770E+05	2.779E+05	1.596E+04	1.596E+04	1.759E+04	4.553E-01	1.494E+00
23	1981	0.050	2.786E+05	2.804E+05	1.389E+04	1.389E+04	1.726E+04	3.928E-01	1.502E+00
24	1982	0.052	2.820E+05	2.832E+05	1.468E+04	1.468E+04	1.690E+04	4.112E-01	1.521E+00
25	1983	0.069	2.842E+05	2.829E+05	1.953E+04	1.953E+04	1.694E+04	5.473E-01	1.533E+00
26	1984	0.072	2.816E+05	2.801E+05	2.023E+04	2.023E+04	1.730E+04	5.725E-01	1.519E+00
27	1985	0.073	2.787E+05	2.773E+05	2.028E+04	2.028E+04	1.765E+04	5.798E-01	1.503E+00
28	1986	0.107	2.761E+05	2.707E+05	2.887E+04	2.887E+04	1.845E+04	8.458E-01	1.489E+00
29	1987	0.176	2.657E+05	2.530E+05	4.441E+04	4.441E+04	2.025E+04	1.392E+00	1.432E+00
30	1988	0.096	2.415E+05	2.405E+05	2.319E+04	2.319E+04	2.133E+04	7.644E-01	1.302E+00
31	1989	0.263	2.396E+05	2.209E+05	5.810E+04	5.810E+04	2.247E+04	2.085E+00	1.292E+00
32	1990	0.469	2.040E+05	1.728E+05	8.105E+04	8.105E+04	2.309E+04	3.718E+00	1.100E+00
33	1991	0.368	1.460E+05	1.318E+05	4.849E+04	4.849E+04	2.139E+04	2.916E+00	7.875E-01
34	1992	0.408	1.189E+05	1.062E+05	4.332E+04	4.332E+04	1.909E+04	3.233E+00	6.414E-01
35	1993	0.328	9.472E+04	8.853E+04	2.899E+04	2.899E+04	1.699E+04	2.597E+00	5.107E-01
36	1994	0.133	8.272E+04	8.535E+04	1.132E+04	1.132E+04	1.657E+04	1.051E+00	4.460E-01
37	1995	0.150	8.798E+04	8.983E+04	1.350E+04	1.350E+04	1.717E+04	1.191E+00	4.744E-01
38	1996	0.059	9.166E+04	9.778E+04	5.789E+03	5.789E+03	1.815E+04	4.694E-01	4.942E-01
39	1997	0.011	1.040E+05	1.131E+05	1.300E+03	1.300E+03	1.982E+04	9.109E-02	5.609E-01
40	1998	0.007	1.225E+05	1.327E+05	9.710E+02	9.710E+02	2.147E+04	5.802E-02	6.607E-01
41	1999	0.007	1.430E+05	1.538E+05	1.068E+03	1.068E+03	2.268E+04	5.506E-02	7.713E-01
42	2000	0.022	1.647E+05	1.744E+05	3.825E+03	3.825E+03	2.329E+04	1.739E-01	8.878E-01
43	2001		1.841E+05						9.928E-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	*	2.682E+05	0.00000	0.0
2	1960	0.000E+00	0.000E+00	0.0	*	2.485E+05	0.00000	0.0
3	1961	0.000E+00	0.000E+00	0.0	*	2.433E+05	0.00000	0.0
4	1962	0.000E+00	0.000E+00	0.0	*	2.399E+05	0.00000	0.0
5	1963	0.000E+00	0.000E+00	0.0	*	2.396E+05	0.00000	0.0
6	1964	0.000E+00	0.000E+00	0.0	*	2.359E+05	0.00000	0.0
7	1965	0.000E+00	0.000E+00	0.0	*	2.243E+05	0.00000	0.0
8	1966	0.000E+00	0.000E+00	0.0	*	2.187E+05	0.00000	0.0
9	1967	0.000E+00	0.000E+00	0.0	*	2.242E+05	0.00000	0.0
10	1968	0.000E+00	0.000E+00	0.0	*	2.294E+05	0.00000	0.0
11	1969	0.000E+00	0.000E+00	0.0	*	2.331E+05	0.00000	0.0
12	1970	0.000E+00	0.000E+00	0.0	*	2.366E+05	0.00000	0.0
13	1971	0.000E+00	0.000E+00	0.0	*	2.378E+05	0.00000	0.0
14	1972	0.000E+00	0.000E+00	0.0	*	2.259E+05	0.00000	0.0
15	1973	0.000E+00	0.000E+00	0.0	*	2.124E+05	0.00000	0.0
16	1974	0.000E+00	0.000E+00	0.0	*	2.028E+05	0.00000	0.0
17	1975	0.000E+00	0.000E+00	0.0	*	1.969E+05	0.00000	0.0
18	1976	0.000E+00	0.000E+00	0.0	*	1.973E+05	0.00000	0.0
19	1977	0.000E+00	0.000E+00	0.0	*	1.962E+05	0.00000	0.0
20	1978	0.000E+00	0.000E+00	0.0	*	1.955E+05	0.00000	0.0
21	1979	0.000E+00	0.000E+00	0.0	*	1.948E+05	0.00000	0.0
22	1980	0.000E+00	0.000E+00	0.0	*	1.945E+05	0.00000	0.0
23	1981	0.000E+00	0.000E+00	0.0	*	1.963E+05	0.00000	0.0
24	1982	0.000E+00	0.000E+00	0.0	*	1.982E+05	0.00000	0.0
25	1983	0.000E+00	0.000E+00	0.0	*	1.980E+05	0.00000	0.0
26	1984	0.000E+00	0.000E+00	0.0	*	1.961E+05	0.00000	0.0
27	1985	0.000E+00	0.000E+00	0.0	*	1.941E+05	0.00000	0.0
28	1986	0.000E+00	0.000E+00	0.0	*	1.895E+05	0.00000	0.0
29	1987	0.000E+00	0.000E+00	0.0	*	1.771E+05	0.00000	0.0
30	1988	1.000E+00	1.000E+00	0.0	1.936E+05	1.684E+05	0.13943	2.519E+04
31	1989	1.000E+00	1.000E+00	0.0	1.170E+05	1.546E+05	-0.27869	-3.761E+04
32	1990	1.000E+00	1.000E+00	0.0	7.870E+04	1.210E+05	-0.43003	-4.229E+04
33	1991	1.000E+00	1.000E+00	0.0	6.413E+04	9.228E+04	-0.36400	-2.816E+04
34	1992	1.000E+00	1.000E+00	0.0	8.562E+04	7.436E+04	0.14099	1.126E+04
35	1993	1.000E+00	1.000E+00	0.0	4.622E+04	6.197E+04	-0.29325	-1.575E+04
36	1994	1.000E+00	1.000E+00	0.0	8.636E+04	5.974E+04	0.36843	2.661E+04
37	1995	1.000E+00	1.000E+00	0.0	6.880E+04	6.288E+04	0.09007	5.926E+03
38	1996	1.000E+00	1.000E+00	0.0	9.496E+04	6.844E+04	0.32738	2.651E+04
39	1997	1.000E+00	1.000E+00	0.0	7.678E+04	7.920E+04	-0.03100	-2.417E+03
40	1998	1.000E+00	1.000E+00	0.0	5.404E+04	9.288E+04	-0.54155	-3.884E+04
41	1999	1.000E+00	1.000E+00	0.0	7.747E+04	1.076E+05	-0.32900	-3.018E+04
42	2000	1.000E+00	1.000E+00	0.0	1.100E+05	1.221E+05	-0.10401	-1.206E+04

* Asterisk indicates missing value(s).

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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     0.1394                                             |======
1989    -0.2787                                  ===========|
1990    -0.4300                            =================|
1991    -0.3640                              ===============|
1992     0.1410                                             |======
1993    -0.2933                                 ============|
1994     0.3684                                             |===============
1995     0.0901                                             |====
1996     0.3274                                             |=============
1997    -0.0310                                            =|
1998    -0.5416                       ======================|
1999    -0.3290                                =============|
2000    -0.1040                                         ====|
                   ------------------------------------------------------------------------------------
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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	1.406E+04	0.1356	5.198E+04	5.198E+04	0.31870	0.000E+00
2	1960	2.007E+03	2.449E+03	0.0236	8.388E+03	8.388E+03	-0.19896	0.000E+00
3	1961	2.911E+03	4.627E+03	0.0446	1.552E+04	1.552E+04	-0.46351	0.000E+00
4	1962	1.885E+03	2.105E+03	0.0203	6.958E+03	6.958E+03	-0.11029	0.000E+00
5	1963	1.870E+03	2.131E+03	0.0206	7.035E+03	7.035E+03	-0.13042	0.000E+00
6	1964	7.861E+03	5.429E+03	0.0524	1.765E+04	1.765E+04	0.37015	0.000E+00
7	1965	1.020E+04	1.081E+04	0.1043	3.343E+04	3.343E+04	-0.05855	0.000E+00
8	1966	4.089E+03	2.402E+03	0.0232	7.241E+03	7.241E+03	0.53181	0.000E+00
9	1967	4.010E+02	2.359E+02	0.0023	7.290E+02	7.290E+02	0.53033	0.000E+00
10	1968	1.442E+03	1.570E+03	0.0151	4.963E+03	4.963E+03	-0.08483	0.000E+00
11	1969	9.579E+02	8.721E+02	0.0084	2.801E+03	2.801E+03	0.09389	0.000E+00
12	1970	4.355E+02	9.715E+02	0.0094	3.168E+03	3.168E+03	-0.80233	0.000E+00
13	1971	1.600E+03	2.451E+03	0.0236	8.033E+03	8.033E+03	-0.42645	0.000E+00
14	1972	1.427E+04	1.347E+04	0.1300	4.195E+04	4.195E+04	0.05742	0.000E+00
15	1973	8.721E+03	7.634E+03	0.0736	2.235E+04	2.235E+04	0.13309	0.000E+00
16	1974	1.084E+04	1.241E+04	0.1197	3.467E+04	3.467E+04	-0.13512	0.000E+00
17	1975	5.123E+03	5.923E+03	0.0571	1.608E+04	1.608E+04	-0.14524	0.000E+00
18	1976	7.151E+03	6.251E+03	0.0603	1.700E+04	1.700E+04	0.13448	0.000E+00
19	1977	9.524E+03	7.494E+03	0.0723	2.027E+04	2.027E+04	0.23976	0.000E+00
20	1978	6.646E+03	6.222E+03	0.0600	1.676E+04	1.676E+04	0.06590	0.000E+00
21	1979	1.154E+04	7.479E+03	0.0721	2.007E+04	2.007E+04	0.43408	0.000E+00
22	1980	7.181E+03	5.953E+03	0.0574	1.596E+04	1.596E+04	0.18759	0.000E+00
23	1981	5.491E+03	5.136E+03	0.0495	1.389E+04	1.389E+04	0.06683	0.000E+00
24	1982	6.225E+03	5.375E+03	0.0519	1.468E+04	1.468E+04	0.14667	0.000E+00
25	1983	9.150E+03	7.155E+03	0.0690	1.953E+04	1.953E+04	0.24598	0.000E+00
26	1984	9.537E+03	7.485E+03	0.0722	2.023E+04	2.023E+04	0.24226	0.000E+00
27	1985	9.270E+03	7.580E+03	0.0731	2.028E+04	2.028E+04	0.20120	0.000E+00
28	1986	9.017E+03	1.106E+04	0.1067	2.887E+04	2.887E+04	-0.20396	0.000E+00
29	1987	1.240E+04	1.819E+04	0.1755	4.441E+04	4.441E+04	-0.38348	0.000E+00
30	1988	1.100E+04	9.993E+03	0.0964	2.319E+04	2.319E+04	0.09605	0.000E+00
31	1989	3.504E+04	2.727E+04	0.2630	5.810E+04	5.810E+04	0.25097	0.000E+00
32	1990	5.149E+04	4.860E+04	0.4689	8.105E+04	8.105E+04	0.05768	0.000E+00
33	1991	3.267E+04	3.813E+04	0.3678	4.849E+04	4.849E+04	-0.15430	0.000E+00
34	1992	2.831E+04	4.227E+04	0.4078	4.332E+04	4.332E+04	-0.40075	0.000E+00
35	1993	1.674E+04	3.395E+04	0.3275	2.899E+04	2.899E+04	-0.70707	0.000E+00
36	1994	*	1.374E+04	0.1326	1.132E+04	1.132E+04	0.00000	0.000E+00
37	1995	*	1.557E+04	0.1502	1.350E+04	1.350E+04	0.00000	0.000E+00
38	1996	*	6.137E+03	0.0592	5.789E+03	5.789E+03	0.00000	0.000E+00
39	1997	*	1.191E+03	0.0115	1.300E+03	1.300E+03	0.00000	0.000E+00
40	1998	*	7.586E+02	0.0073	9.710E+02	9.710E+02	0.00000	0.000E+00
41	1999	*	7.199E+02	0.0069	1.068E+03	1.068E+03	0.00000	0.000E+00
42	2000	*	2.273E+03	0.0219	3.825E+03	3.825E+03	0.00000	0.000E+00

* Asterisk indicates missing value(s).

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     0.3187                                         |=============
1960    -0.1990                                 ========|
1961    -0.4635                      ===================|
1962    -0.1103                                     ====|
1963    -0.1304                                    =====|
1964     0.3702                                         |===============
1965    -0.0585                                       ==|
1966     0.5318                                         |=====================
1967     0.5303                                         |=====================
1968    -0.0848                                      ===|
1969     0.0939                                         |====
1970    -0.8023         ================================|
1971    -0.4265                        =================|
1972     0.0574                                         |==
1973     0.1331                                         |=====
1974    -0.1351                                    =====|
1975    -0.1452                                   ======|
1976     0.1345                                         |=====
1977     0.2398                                         |==========
1978     0.0659                                         |===
1979     0.4341                                         |=================
1980     0.1876                                         |========
1981     0.0668                                         |===
1982     0.1467                                         |======
1983     0.2460                                         |==========
1984     0.2423                                         |==========
1985     0.2012                                         |========
1986    -0.2040                                 ========|
1987    -0.3835                          ===============|
1988     0.0960                                         |====
1989     0.2510                                         |==========
1990     0.0577                                         |==
1991    -0.1543                                   ======|
1992    -0.4008                         ================|
1993    -0.7071             ============================|
1994     0.0000                                         |
1995     0.0000                                         |
1996     0.0000                                         |
1997     0.0000                                         |
1998     0.0000                                         |
1999     0.0000                                         |
2000     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	2.273E+00	2.226E+00	-2.09%	1.679E+00	3.329E+00	1.911E+00	2.785E+00	8.738E-01	0.384
K	3.729E+05	3.709E+05	-0.52%	3.088E+05	4.520E+05	3.379E+05	4.092E+05	7.134E+04	0.191
r	2.496E-01	2.523E-01	1.05%	1.717E-01	3.571E-01	2.097E-01	3.031E-01	9.334E-02	0.374
q(1)	7.000E-01	7.000E-01	0.00%	7.000E-01	7.000E-01	7.000E-01	7.000E-01	1.331E-13	0.000
q(2)	9.175E-06	9.647E-06	5.15%	7.625E-06	1.101E-05	8.461E-06	1.011E-05	1.649E-06	0.180
MSY	2.330E+04	2.339E+04	0.40%	1.940E+04	2.750E+04	2.130E+04	2.551E+04	4.211E+03	0.181
Ye(2001)	2.390E+04	2.339E+04	-2.13%	1.896E+04	2.515E+04	2.185E+04	2.464E+04	2.789E+03	0.117
Bmsy	1.864E+05	1.855E+05	-0.52%	1.544E+05	2.260E+05	1.690E+05	2.046E+05	3.567E+04	0.191
Fmsy	1.248E-01	1.261E-01	1.05%	8.585E-02	1.785E-01	1.049E-01	1.515E-01	4.667E-02	0.374
fmsy(1)	1.783E-01	1.802E-01	1.05%	1.226E-01	2.551E-01	1.498E-01	2.165E-01	6.667E-02	0.374
fmsy(2)	1.334E+04	1.307E+04	-2.02%	1.047E+04	1.637E+04	1.184E+04	1.502E+04	3.176E+03	0.238
F(0.1)	1.123E-01	1.135E-01	0.94%	7.726E-02	1.607E-01	9.438E-02	1.364E-01	4.200E-02	0.374
Y(0.1)	2.307E+04	2.316E+04	0.39%	1.921E+04	2.723E+04	2.109E+04	2.526E+04	4.169E+03	0.181
B-ratio	9.971E-01	9.928E-01	-0.44%	6.714E-01	1.375E+00	8.131E-01	1.192E+00	3.791E-01	0.380
F-ratio	1.740E-01	1.739E-01	-0.09%	1.066E-01	3.056E-01	1.336E-01	2.308E-01	9.717E-02	0.558
Y-ratio	1.035E+00	9.999E-01	-3.37%	1.000E+00	1.000E+00	1.000E+00	1.000E+00	0.000E+00	0.000
f0.1(1)	1.605E-01	1.622E-01	0.94%	1.104E-01	2.296E-01	1.348E-01	1.948E-01	6.000E-02	0.374
f0.1(2)	1.201E+04	1.177E+04	-1.82%	9.422E+03	1.474E+04	1.066E+04	1.352E+04	2.858E+03	0.238
q2/q1	1.311E-05	1.378E-05	5.15%	1.089E-05	1.572E-05	1.209E-05	1.444E-05	2.356E-06	0.180

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:	0
Trials replaced for r out-of-bounds:	2
Residual-adjustment factor:	1.0445

Table 16: The 4 plus biomass summary table.

Year	EU survey	SPA/Cohort	XSA	ASPICgeo	XSA/Eusurv
1988	193567			241500	
1989	117015	257874	305578	239600	0.38
1990	78703	221583	259543	204000	0.30
1991	64126	164514	197259	146100	0.33
1992	85620	124233	138954	119000	0.62
1993	46218	97984	95558	94730	0.48
1994	86359	90447	92697	82730	0.93
1995	68804	96118	92543	87990	0.74
1996	94955	89028	86003	91660	1.00
1997	76785	100962	108995	104000	0.70
1998	54039	112131	126560	122500	0.43
1999	77468	100970	106434	143000	0.73
2000	110019	130356	130096	164700	0.85

	geometric mean	arithmetic mean
q 92-00	0.70	0.72

Fig. 10: 3M beaked redfish 4plus biomass

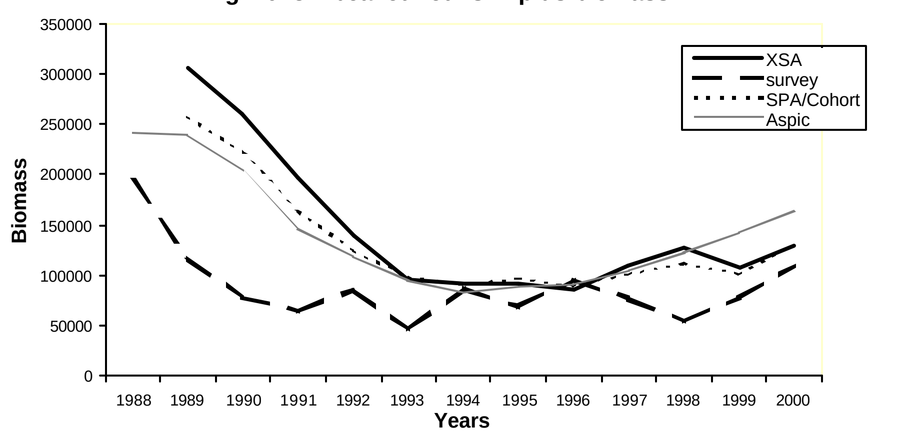


Table 17: An explanation of the red.sen file input data with an exploitation pattern corresponding to $F_{statusquo}$ from XSA

Name	Value	C.V.	Name	Value	C.V.	Name	Value	C.V.	Name	Value	C.V.
Population at age in 2001			Exploitation pattern (H - Human consumption)			Exploitation pattern (D - Discards)			Exploitation pattern (I - Industrials)		
N4	39360	0.5	sH4	0.0048	0.00	sD4	0.00	0.00	sI4	0.00	0.00
N5	20520	0.5	sH5	0.0032	0.00	sD5	0.00	0.00	sI5	0.00	0.00
N6	48201	0.4	sH6	0.0067	0.00	sD6	0.00	0.00	sI6	0.00	0.00
N7	33146	0.4	sH7	0.0095	0.00	sD7	0.00	0.00	sI7	0.00	0.00
N8	41460	0.2	sH8	0.0220	0.00	sD8	0.00	0.00	sI8	0.00	0.00
N9	43236	0.3	sH9	0.0357	0.00	sD9	0.00	0.00	sI9	0.00	0.00
N10	36077	0.2	sH10	0.0243	0.00	sD10	0.00	0.00	sI10	0.00	0.00
N11	158497	0.2	sH11	0.1091	0.00	sD11	0.00	0.00	sI11	0.00	0.00
N12	5362	0.3	sH12	0.0988	0.00	sD12	0.00	0.00	sI12	0.00	0.00
N13	1659	0.3	sH13	0.0691	0.00	sD13	0.00	0.00	sI13	0.00	0.00
N14	997	0.2	sH14	0.2139	0.00	sD14	0.00	0.00	sI14	0.00	0.00
N15	2589	0.2	sH15	0.0985	0.00	sD15	0.00	0.00	sI15	0.00	0.00
N16	588	0.2	sH16	0.0459	0.00	sD16	0.00	0.00	sI16	0.00	0.00
N17	790	0.2	sH17	0.0361	0.00	sD17	0.00	0.00	sI17	0.00	0.00
N18	907	0.2	sH18	0.0377	0.00	sD18	0.00	0.00	sI18	0.00	0.00
N19	15211	0.2	sH19	0.0377	0.00	sD19	0.00	0.00	sI19	0.00	0.00
Stock weight at age			Catch weight at age (H - Human consumption)			Catch weight at age (D - Discards)			Catch weight at age (I - Industrials)		
WS4	0.092	0.00	WH4	0.083	0.00	WD4	0.00	0.00	WI4	0.00	0.00
WS5	0.136	0.00	WH5	0.139	0.00	WD5	0.00	0.00	WI5	0.00	0.00
WS6	0.177	0.00	WH6	0.195	0.00	WD6	0.00	0.00	WI6	0.00	0.00
WS7	0.231	0.00	WH7	0.274	0.00	WD7	0.00	0.00	WI7	0.00	0.00
WS8	0.294	0.00	WH8	0.320	0.00	WD8	0.00	0.00	WI8	0.00	0.00
WS9	0.349	0.00	WH9	0.376	0.00	WD9	0.00	0.00	WI9	0.00	0.00
WS10	0.391	0.00	WH10	0.422	0.00	WD10	0.00	0.00	WI10	0.00	0.00
WS11	0.471	0.00	WH11	0.481	0.00	WD11	0.00	0.00	WI11	0.00	0.00
WS12	0.547	0.00	WH12	0.544	0.00	WD12	0.00	0.00	WI12	0.00	0.00
WS13	0.595	0.00	WH13	0.588	0.00	WD13	0.00	0.00	WI13	0.00	0.00
WS14	0.600	0.00	WH14	0.593	0.00	WD14	0.00	0.00	WI14	0.00	0.00
WS15	0.609	0.00	WH15	0.601	0.00	WD15	0.00	0.00	WI15	0.00	0.00
WS16	0.685	0.00	WH16	0.680	0.00	WD16	0.00	0.00	WI16	0.00	0.00
WS17	0.725	0.00	WH17	0.730	0.00	WD17	0.00	0.00	WI17	0.00	0.00
WS18	0.702	0.00	WH18	0.706	0.00	WD18	0.00	0.00	WI18	0.00	0.00
WS19	0.853	0.00	WH19	0.950	0.00	WD19	0.00	0.00	WI19	0.00	0.00

Name	Value	C.V.	Name	Value	C.V.
Natural mortality at age			Maturity		
M4	0.1	0.00	MT4	0.000	0.00
M5	0.1	0.00	MT5	0.006	0.00
M6	0.1	0.00	MT6	0.015	0.00
M7	0.1	0.00	MT7	0.048	0.00
M8	0.1	0.00	MT8	0.104	0.00
M9	0.1	0.00	MT9	0.150	0.00
M10	0.1	0.00	MT10	0.197	0.00
M11	0.1	0.00	MT11	0.445	0.00
M12	0.1	0.00	MT12	0.417	0.00
M13	0.1	0.00	MT13	0.474	0.00
M14	0.1	0.00	MT14	0.473	0.00
M15	0.1	0.00	MT15	0.518	0.00
M16	0.1	0.00	MT16	0.535	0.00
M17	0.1	0.00	MT17	0.556	0.00
M18	0.1	0.00	MT18	0.557	0.00
M19	0.1	0.00	MT19	0.650	0.00
Natural mortality multiplier in year			Effort multiplier in year (H - Human consumption)		
K2001	1	0.0	HF2001	1.0	0.0
K2002	1	0.0	HF2002	1.0	0.0
K2003	1	0.0	HF2003	1.0	0.0

Table 17b: The 3M beaked redfish input .srr (stock recruitment relationship) file for Mterm projections.

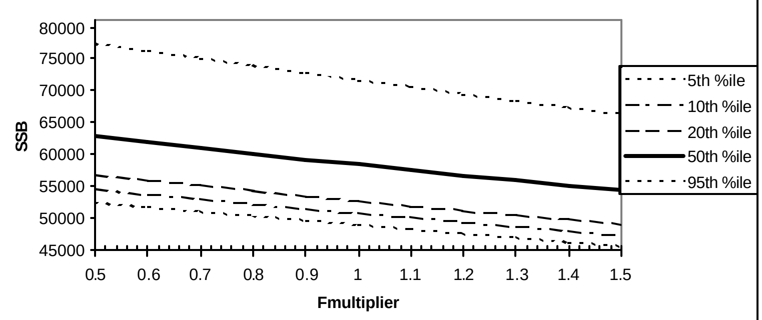
```
5           Nparams
5           Geometric mean model
39.360      1998-2000 age 4 XSA geomean in millions
0.00000E+000
0.00000E+000
0
0.00000E+000
12          Ndata
.5067       1989-2000 XSA Log residuals (ln(age 4,year i)/age 4 geomean)
.4115
-.0764
-.13551
.1606       1993 recruitment given by the geo mean of 1992 and 1995 rec
.1606       1994 recruitment given by the geo mean of 1992 and 1995 rec
.6762
.6452
.4735
.1382
.4084
-.5466
0                 No extra data
```

Table 18a: Redfish 3M short term SSB probability profiles from a range of F multipliers of F status quo and F0.5 status quo.
Observed recruitment randomly resampled.

F status quo
Year projection

2003	Fmultiplier	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5
	5th %ile	52462	51753	51036	50331	49638	48943	48260	47589	46922	46267	45623
	10th %ile	54495	53721	52961	52210	51464	50734	50047	49334	48633	47941	47260
	20th %ile	56758	55931	55110	54289	53475	52678	51918	51184	50468	49749	49053
	50th %ile	62949	61980	61048	60157	59278	58404	57536	56748	55960	55152	54302
	95th %ile	77367	76211	75067	73947	72774	71647	70613	69468	68356	67355	66371

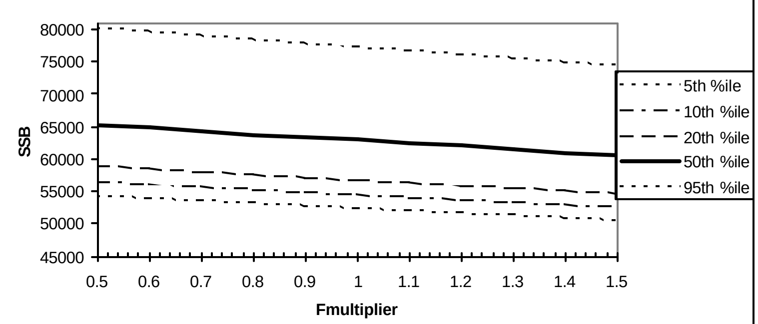
Fig. 11a: SSB 2003



F0.5 status quo
Year projection

2003	Fmultiplier	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5
	5th %ile	54415	54010	53608	53223	52820	52458	52106	51749	51388	51030	50676
	10th %ile	56517	56098	55693	55272	54872	54491	54108	53717	53331	52956	52582
	20th %ile	58921	58480	58040	57608	57180	56754	56339	55926	55517	55105	54691
	50th %ile	65330	64843	64352	63876	63417	62945	62453	61975	61512	61042	60595
	95th %ile	80353	79742	79136	78537	77946	77362	76782	76204	75630	75060	74495

Fig. 11b: SSB 2003



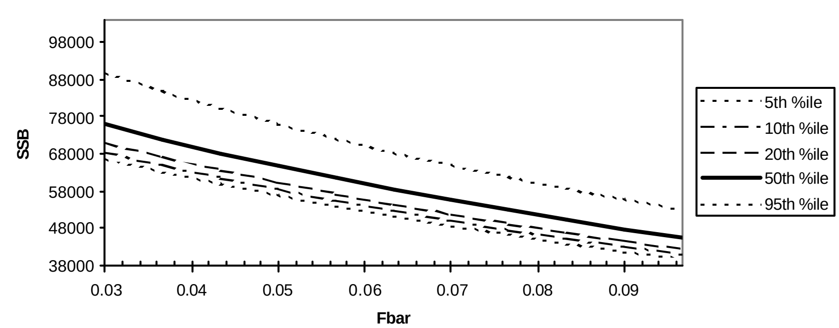
Final assessment data year	2000
1st year for populations in Sen	2001
First SSB profile 3 years ahead	2003

Table 18b: Redfish 3M medium term SSB probability profiles from a range of Fbar's around F status quo and F0.5 status quo. Observed recruitment randomly resampled.

Fstatus quo

Year projection						Fstatus quo					
2010 Fbar	0.033	0.040	0.047	0.053	0.060	**0.067**	0.073	0.080	0.087	0.093	0.100
5th %ile	66611	63120	59944	56945	53948	51172	48667	46279	43981	41896	39946
10th %ile	68424	64826	61521	58445	55496	52743	50091	47616	45312	43158	41175
20th %ile	70787	67119	63666	60333	57300	54407	51699	49200	46792	44570	42526
50th %ile	75919	71976	68257	64773	61528	58415	55568	52863	50313	47940	45710
95th %ile	89571	84734	80158	75934	71984	68326	64895	61701	58676	55797	53069

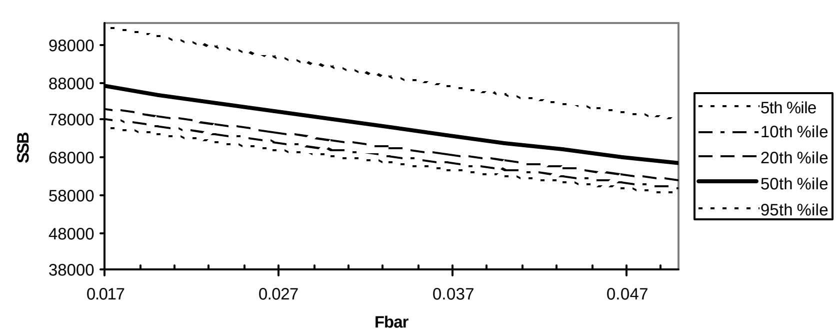
Fig. 12a: SSB 2010



F0.5 status quo

Year projection						F0.5 status quo					
2010 Fbar	0.017	0.020	0.023	0.027	0.030	**0.033**	0.037	0.040	0.043	0.047	0.050
5th %ile	76293	74245	72157	70227	68395	66589	64828	63095	61481	59916	58404
10th %ile	78410	76358	74288	72258	70260	68401	66570	64800	63116	61493	59936
20th %ile	81225	78989	76845	74767	72763	70763	68879	67092	65323	63635	61946
50th %ile	87136	84746	82424	80158	77983	75893	73869	71947	70046	68225	66447
95th %ile	103242	100327	97502	94762	92107	89540	87090	84699	82358	80120	77953

Fig. 12b: SSB 2010



Final assessment data year	2000
1st year for populations in Sen	2001
Last SSB profile 10 years ahead	2010

Table 19: Redfish 3M SSB and yield probability profiles for the next 10 years, with F status quo and F0.5 status quo.
Observed recruitment randomly resampled.

Fstatus quo
SSB

Year	5th %ile	10th %ile	20th %ile	50th %ile	95th %ile
2001	42251	44509	46746	52353	66443
2002	44505	46418	48552	53710	66060
2003	48943	50734	52678	58404	71647
2004	48544	50392	52499	57254	68948
2005	46733	48090	50493	54604	65260
2006	47375	49174	51224	55644	66313
2007	46938	48493	50420	54608	64513
2008	46490	47700	49647	53297	63154
2009	50982	52245	54163	58409	69319
2010	51172	52743	54407	58415	68326

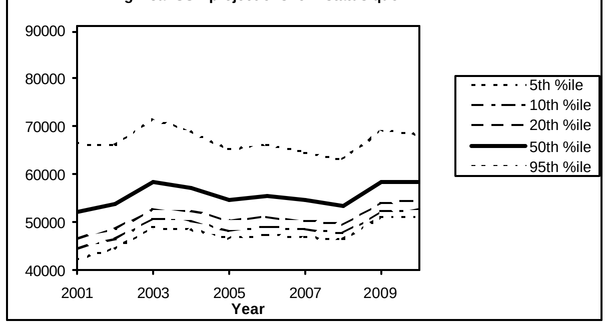


Fig. 13a: SSB projections for Fstatus quo

F 0.5status quo
SSB

Year	5th %ile	10th %ile	20th %ile	50th %ile	95th %ile
2001	42251	44509	46746	52353	66443
2002	46192	48169	50385	55812	68872
2003	52458	54491	56754	62945	77362
2004	53727	55684	58031	63449	76529
2005	54507	56173	58694	63788	76756
2006	57303	59134	61766	67091	80759
2007	58091	60076	62449	67729	80883
2008	58277	60105	62466	67318	79810
2009	65380	67183	69726	75170	89811
2010	66589	68401	70763	75893	89540

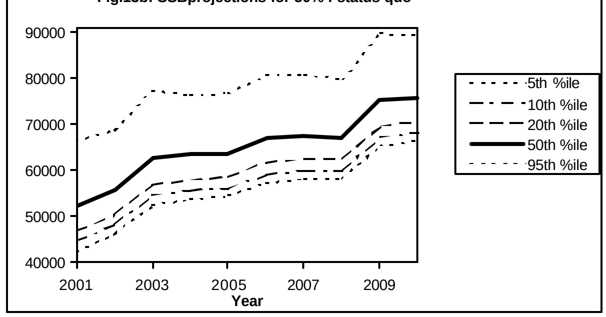


Fig.13b: SSBprojections for 50% Fstatus quo

F status quo
Yield

Year	5th %ile	10th %ile	20th %ile	50th %ile	95th %ile
2001	7845	8307	8835	9972	13122
2002	8165	8454	8921	9959	12584
2003	7485	7790	8129	8926	10912
2004	11900	12525	13227	14768	18950
2005	8408	8738	9109	9869	11756
2006	7140	7420	7756	8582	10484
2007	6480	6659	6963	7564	9031
2008	5830	6016	6348	6989	8517
2009	6329	6600	6897	7648	9483
2010	5997	6199	6480	7107	8371

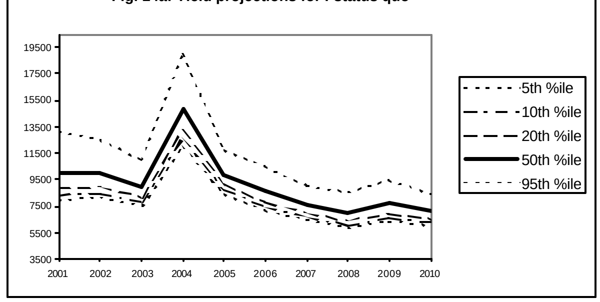


Fig. 14a: Yield projections for Fstatus quo

F 0.5status quo
Yield

Year	5th %ile	10th %ile	20th %ile	50th %ile	95th %ile
2001	4016	4252	4523	5107	6725
2002	4338	4497	4749	5304	6731
2003	4102	4255	4453	4896	5987
2004	6914	7284	7698	8622	11134
2005	5045	5251	5453	5921	7091
2006	4295	4476	4666	5155	6295
2007	3958	4086	4256	4623	5452
2008	3591	3731	3921	4291	5212
2009	3954	4096	4279	4737	5891
2010	3749	3867	4031	4418	5191

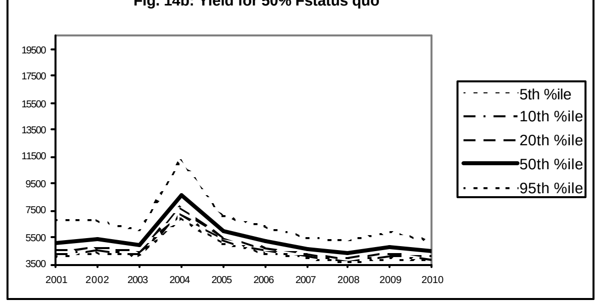


Fig. 14b: Yield for 50% Fstatus quo