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Northwest Atlantic Fisheries Organization

Serial No. N4666 **NAFO SCR Doc. 02/54**

SCIENTIFIC COUNCIL MEETING – JUNE 2002

The Present Status of Beaked Redfish (*S. mentella and S. fasciatus*) in NAFO Division 3M and Medium Term Projections Under A Low Commercial Catch/ High Shrimp Fishery By-Catch Regime

by

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Abstract

The present assessment evaluates the status of the Division 3M beaked redfish stock, regarded as a management unit composed of two populations from two very similar species (*Sebastes mentella* and *Sebastes fasciatus*). The sum of the absolute length compositions of the 1989-2001 commercial catch with the 1993-2001 by-catch is the Div. 3M redfish catch at length input of this assessment. The VPA based models used a 1989-2001 catch at age matrix starting at age 4 and having a plus group at age 19. An Extended Survivor Analysis (Shepherd, 1999) was performed using 2001 XSA framework. The consistency of the XSA results was checked with a Retrospective Analysis confined to the assessments of the most recent years, 2001-1999. A Separable/Cohort analysis (Pope and Shepherd, 1982) has also been performed afterwards. Compared with XSA the Cohort/SPA model systematically under estimated both stock biomass and spawning stock biomass over the past thirteen years. Despite an apparent lack of residual patterns, the Separable model has a poorer fit to the commercial catch at age matrix than the Extended Survivor model. A logistic surplus production model (ASPIC) which does not use the equilibrium assumption (Praguer, 1994 and 1995) was also applied using the 1959-2001 catch coupled with the STATLANT standardized CPUE series (1959-1993) and the age 4 plus EU bottom biomass (1988-2001). The ASPIC results, as regards biomass and fishing mortality trends are identical to the ones from the VPA based models though with a faster rate of biomass increase over the final years of 1999-2001. Either VPA's and ASPIC analysis pointed out that the Div. 3M beaked redfish stock experienced a steep decline from the second half of the 1980s till 1996. Fishing mortality was kept well above F_{msy} over the first half of the assessment period. From 1995 onwards fishing mortality dropped and since 1997 has been kept well below natural mortality. Despite recent fluctuations biomass and female spawning biomass are generally increasing since 1997 but at a slow rates, being still well bellow the levels of the first years of the time series. However the stock reproductive potential has increased through the nineties compensating the SSB decline and sustaining recruitment at the late-1980s and early-1990s level. By-catch mortality continued to act as a buffer on survival of pre-recruits and its impact increases with year-class strength. With the XSA survivors and recruitment randomly resample from the 1999-2001 geometric mean, short- and medium-term projections were made under three fishing mortality options. Keeping fishing mortality at F*statusquo* will allow a moderate increase of SSB but by the beginning of the next decade female spawning biomass will still be far away from the SSB levels higher than 80,000 tons recorded prior to 1991 and associated with strong recruitments. On the contrary, a reduction to 45%-60% of F*statusquo* will anchored in the short term caches to an interval defined by the present level of catches and the adopted 2000-2002 TAC, but will allow a medium term female spawning biomass closer to that 80,000 tons SSB frontier.

Summary

The redfish fishery on Div. 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. The increase of the redfish catches to 3,800 tons in 2000 reflects the rebirth of a redfish directed fishery in Div. 3M, with EU (Portugal) and Russia consolidating their role as major partners of the actual fishery. The boom in 1993 and further settlement of a shrimp fishery in Flemish Cap lead to high levels of redfish by-catch in 1993-1994. Since 1995 this by-catch in weight fell to apparent low levels but in 2001 redfish by-catch reached 738 tons, the highest level observed since 1994 and justifying 74% of the total catch in numbers.

For several years length sampling data from Russia and from the Japan were available and used to estimate the length composition of the commercial catches for those fleets and time periods. The 1989-2001 length composition of the Portuguese trawl catch was applied to the rest of the commercial catches. The 1993-2001 redfish by-catch in numbers at length for the Div. 3M shrimp fishery was calculated based on data collected on board of Canadian and Norwegian vessels. The sum of the absolute length compositions of the 1989-2001 commercial catch with the 1993-2001 by-catch is the Div. 3M redfish catch at length input of this assessment. The VPA based models used a 1989-2001 catch-at-age matrix starting at age 4 and having a plus group at age 19.

Survey bottom biomass and survey female spawning biomass was calculated based on the abundance at length from Canadian (1979-1985) and EU (1988-2001) bottom trawl surveys, and on the length weight relationships derived from EU survey data.

An Extended Survivor Analysis (Shepherd, 1999) was performed using 2001 XSA framework: no tapered time weighting, no recruiting ages with catchability dependent *t* of year-class strength, constant catchability just at the penultimate age and a minimum standard error of the log catchability for the last true age of 0.5. The XSA converged after a high number of iterations with the diagnostics presenting several high positive and negative log catchability residuals, in general smaller over the most recent years (1999-2001) than through the preceding years. Most of the residuals were positive during the intermediate years of 1994 to 1997, while on the former years till 1991 and again on 1998 and 2001 most ages had negative residuals. Consistency of the XSA results was checked with a Retrospective Analysis. In order to preserve at the maximum extent most of the cohorts occurring from 1989 onwards, namely the 1990 year-class, this retrospective analysis is confined to the assessments of the most recent years, 2001-1999. The retrospective patterns don't present a systematic under-or-over bias through the whole interval in none of the parameters used in the analysis. Both biomass and SSB started with absolute under biases of greater magnitude and ended with smaller over biases, showing an increasing convergence of estimates over the more recent years. From the Extended Survivor Analysis very high fishing mortalities until 1996 forced a rapid and steep decline of either abundance, biomass and female spawning biomass of the Div. 3M beaked redfish stock. From 1997 onwards, low fishing mortalities allowed a discontinuous and slow growth of both biomass and SSB, but abundance is not yet increasing. There was a general increase of the stock reproductive potential between 1992 and 1997 but in 2001 female spawning stock biomass was still far away from a SSB level of 80,000 tons, beyond which above average recruitments were observed.

A Separable/Cohort analysis (Pope and Shepherd, 1982) has been performed afterwards. The purpose was to evaluate if an analytical model free from a noisy survey tuning has a better fitness to the catch data. From the XSA fishing mortality and relative F at age results a first guess of fishing mortality for the first fully exploited age on last year (F_{bar} 6-16, 2001) and a selection value for last true age (relative F at age 18, 2001) were taken to initialize the Separable analysis. Compared with XSA the Cohort/SPA model systematically under estimated both stock biomass and spawning stock biomass over the past thirteen years. Despite an apparent lack of residual patterns the sum of squares of the residuals of the log catch ratios from SPA diagnostics is higher than the sum of squares of the XSA log catchabilitiy residuals. Therefore, and, the Separable model has a poorer fit to the commercial catch-at-age matrix than the Extended Survivor model.

A logistic surplus production model (ASPIC) which does not use the equilibrium assumption (Praguer, 1994 and 1995) was also applied using the 1959-2001 catch coupled with the STATLANT standardized CPUE series (1959-1993) and the age 4 plus EU bottom biomass (1988-2001). ASPIC runned first on the FIT mode, to have the deterministic parameters estimate together with effort and survey pattern of unweighted residuals, as well as biomass and fishing mortality trends (expressed as ratios to B_{msy} and F_{msy}). On a second run on BOT mode effort and survey residuals were resampled 1 000 times in order to derive bias corrected estimates and probability distribution of the parameters. In general there is a small relative bias between the corrected and ordinary estimates (1%-2.5%) indicating for most of the fitted parameters a distribution close to normality. The ASPIC results, as regards biomass and fishing mortality trends are identical to the ones from the VPA based models though with a faster rate of biomass increase over the final years of 1999-2001.

Either VPA's and ASPIC analysis pointed out that the Div. 3M beaked redfish stock experienced a steep decline from the second half of the 1980s till 1996. Fishing mortality was kept well above F_{msy} over the first half of the assessment period, due to increasing commercial catches since the mid eighties that reached a top level within 1989 and 1993. From 1995 onwards fishing mortality dropped and since 1997 has been kept well below natural mortality, allowing the survival and growth of the remainders from all cohorts. Despite recent fluctuations biomass and female spawning biomass are generally increasing since 1997 but at a slow rates, being still well bellow the levels of the first years of the time series. The prospective of a no return consistent increase of both biomass and SSB seems to consolidate under the present low exploitation regime: the stock reproductive potential has increased through the nineties compensating the SSB decline and sustaining a 1998-2001 geomean recruitment at age 4 identical to the former years of 1989-1992. By-catch mortality continued to act as a buffer on survival of pre-recruits and its impact increases with year-class strength. There is little doubt that the major obstacle to a faster rate of stock growth both in biomass and namely in abundance is the survival of abundant cohorts in their early life stage preceding recruitment to commercial fishery. Keeping catch and fishing mortality at a low level can only be effective in supporting a medium term faster stock recovery if measures to drastically reduce by-catch of very small redfish are now implemented.

With the XSA survivors and recruitment randomly resampled from the 1999-2001 geometric mean, short- and medium-term projections were made, under three fishing mortality options that, besides F*statusquo* corresponded to a short-term yield abide to the vicinity of the actual TAC of 5,000 tons (60% of F*statusquo*) or within the average level of recent catches (3,000 tons-4,000 tons). Under a 50th % probability profile keeping fishing mortality at F*statusquo* will allow a moderate increase of SSB but by the beginning of the next decade female spawning biomass will still be far away from the SSB levels higher than 80,000 tons recorded prior to 1991 and associated with strong recruitments. On the contrary, a 45%-60% reduction on F*statusquo* will anchored in the short-term caches to an interval defined by the present level of catches and the adopted 2000-2002 TAC, but will allow with a higher probability (associated with the 25th % probability profile) both the doubling of the actual SSB level by 2005 and a 2011 SSB already representing 80% of the 80,000 tons frontier.

Introduction

There are three stocks of redfish on the Flemish Cap bank (NAFO Div. 3M): deep-sea redfish (*Sebastes mentella*) with a maximum abundance at depths greater than 300 m, golden (*Sebastes marinus*) and Acadian redfish (*Sebastes fasciatus*) preferring shallower waters of less than 400 m. 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 30 cm-32 cm. Beaked redfish also presents wide geographical shifts of its density between the Flemish Cap bank and other Div. 3M neighboring grounds.

The Flemish Cap redfish species are long living and present a slow (and very similar) growth, with fish attaining a size around 20 cm-22 cm at 5 years old and reaching 30 cm 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 is 8 years (mean length of 26.5 cm) for Acadian redfish, 10 years (mean length of 30.1 cm) 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 3M redfish assessment is focused on the beaked redfish stock regarded as a management unit composed of two populations from two very similar species: the Flemish Cap *S. mentella* and *S. fasciatus*. The reasons for this approach are the dominance of this group in the Div. 3M redfish commercial catches, corresponding also to the bulk of the redfish bottom biomass survey indices available for the Flemish Cap bank (on average representing 80% of the redfish survey biomass). Finally, and due to market demand reasons, any recovery of the Div. 3M redfish fishery will be dependent on the recovery of the *S. mentella* plus *S. fasciatus* biomass from recent overexploitation.

An extended survivor analysis (XSA) was used to tune the terminal F's with the EU survey abundance's at age and estimate the survivors by the end of 2001. 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 1999-01 geometric mean, short- and medium-term projections were made under different F and catch assumptions, and the results presented 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 Div. 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 Div. 3M redfish it is assumed that these pelagic catches were also dominated by beaked redfish.

The redfish fishery on Div. 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 Div. 3M redfish catches from 1990 onwards is related with the quick decline of the stock biomass followed by an abrupt decline of fishing effort deployed in this fishery. By 1995 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) had already vanished from NAFO Div. 3M. The remaining Portuguese and Japanese trawlers recorded the major proportion of the catch till 1999, but for these fleets Greenland halibut continued to be the priority species in all NAFO Divisions (NAFO circular letters with monthly provisional catches, 1995-1999). During this period most of the Div. 3M reddish catches were taken as by-catch of the Greenland halibut fishery.

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 1349 tons in 2000 due to a jump in the catches from Portugal: 96 tons to 916 tons. The 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. In 2001 provisional catches were at a somewhat lower level, 3,295 tons, but EU (Portugal) and Russia consolidated their role as major partners of the actual fishery with 92% of the overall catch. About 85% of catch was taken trough the first eight months of 2001, with August recording 41% of the provisional annual catch (NAFO circular letters with monthly provisional catches, 2000-2001).

The boom in 1993 and further settlement of a shrimp fishery in Flemish Cap lead to high levels of redfish by-catch in 1993-1994. Since 1995 this by-catch in weight fell to apparent low levels but in 2001 redfish by-catch reached 738 tons (Kulka, 2002, pers. comm.), the highest level observed since 1994. Translated to numbers this represents an increase from an annual by-catch level of 3.4 millions of redfish, recorded in 1999-2000, to 25.8 millions in 2001 (against a 9.2 millions caught in the commercial fishery last year). In 1998-2000 this by-catch represented on average 42% of the total Div. 3M redfish catch in numbers. In 2001 the redfish by-catch in number from the Flemish Cap shrimp fishery justified 74% of the total catch.

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

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
TAC	20	20	50	50	43	30	26	26	26	26	20	13	5	5
Catch	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]	3.3[2]
By-catch[3]						11.97	5.90	0.37	0.55	0.16	0.19	0.10	0.10	0.75
Total catch	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	4.0

[1] Includes estimates of non-reported catches from various sources
[2] Provisional
[3] Kulka, D. *pers. comm*. 2000, 2001 and 2002

Input data

Length composition of the commercial catch and by-catch

Most of the commercial length sampling data available for the Div. 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 (Alpoim *et al*., 2002). 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, 1998-2001; Vaskov, A., pers. comm. 2000, 2001 and 2002; Vaskov *et al*., 2002) 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 1989-2001 per mille length composition of the Portuguese trawl catch was applied to the rest of the commercial catches. In all cases the Div. aked redfish length weight relationships from 1989-2001 EU surveys (Saborido-Rey, pers. comm., 2000, 2001 and 2002) were used to get each absolute length frequency vector of the Div. 3M redfish commercial catches (Table 1a, 2001 catch from NAFO circular letter Ref.No.GF/02-68).

Redfish by-catch in weight and in numbers at length for the Div. 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 1998-2001 by-catch in numbers-at-length was derived from the 1998 Norwegian and 1999-2001 Canadian length sampling, extrapolated to the estimates of the overall by-catch in weight (Kulka, pers. comm., 2001 and 2002). Length composition of redfish by-catch in the Div. 3M shrimp fishery is presented on Table 1b.

The sum of the absolute length compositions of the 1989-2001 commercial catch with the 1993-2001 by-catch is the Div. 3M redfish catch at length input of this assessment (Table 1c). The generalized fall of the commercial sizes (>18cm) during the first half of the 1990s, the impact of the sorting grades in reducing from 1993 to 1996 the absolute length frequencies of the redfish by-catch and finally the dominance of the very small sizes (10 cm-12 cm) in the total catch whenever a relative abundant year-class appears (as it seems to be the case for the 2000 cohort) is well illustrated in Fig. 1.

Length composition of the stock and spawning stock survey abundance

The EU survey abundance and female mature abundance at length for Div. 3M beaked redfish was updated with the results from 2001 survey (Vazquez, 2002) following the steps described in last assessments (Ávila de Melo *et al*. 1999, 2000 and 2001). From 1992 till 2001 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 1999-2001, 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 21 cm. Both beaked redfish total and mature female at length for the 1992-01 period are the sum of the respective *S. mentella* and *S. fasciatus* sets first calculated by species.

A combined length maturity ogive was calculated on last year assessment from the 1992-2000 female and mature female survey abundance at length of *S. mentella* and *S. fasciatus* (Ávila de Melo *et al*, 2001). This ogive has been used to derive the mature female abundance's at length on the early years of the survey series (1988-1991) from the correspondent beaked redfish female survey abundance at length (Table 2, Fig. 2).

For the 1979-1985 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 maintained unchanged from last revision done in the 2001 assessment (Table 2, Fig. 2).

Length weight relationships

Length weight relationships for each of the Div. 3M beaked redfish species separately (1992-2001) and for *S. mentella* and *S. fasciatus* combined (1989-1991) were calculated with survey length/weight data from both sexes (Saborido Rey, pers. comm., 2002) and used in the assessment on an annual basis (Table 3).

Survey stock biomass and spawning biomass

Survey biomass and female spawning biomass were calculated as sums of products of survey abundance and mature female abundance at length times mean weight at length. *S. mentella* and *S. fasciatus* (1992-2001) and beaked redfish (1988-91) length weight relationships were used with the EU series (1988-2001) while a general length weight relationship representative of the 1989-2000 interval was applied to the Canadian series (1979-85) (Table 2, Fig. 2). Details of this calculation are found on the 1998 assessment (Ávila de Melo *et al*., 1998)

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

The EU survey abundance at age for the 1989-2001 Div. 3M beaked redfish stock and mature female component (Table 5a and b) were obtained using the *S. mentella* age length keys from the 1990-2001 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 Div. 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 standardized 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 40 cm 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 1990-2001 EU surveys (Table 4). The shift of the relative age composition of the catch towards the smallest age groups (1 and 2) from the early (1989-1991) to the most recent years (1999-2001) of the assessment is illustrated in Fig. 3.

Mean weights at age

The annual beaked redfish length weight relationships were used to calculate mean weights at age both in the Div. 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 F_{index} was first derived from the 1989-2001 ratios between the sums of the permile Div. 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 standardized to its highest value recorded at age 13. Assuming a flat top recruitment curve this observed partial recruitment vector, for ages 5 to 18, was adjusted to a general logistic curve (Table 8a, Fig.4). The expected vector has been used in the yield per recruit analysis. However, due to the impact of the shrimp fishery on the mortality of the youngest age groups, the observed PR for ages 1 to 4 was adopted in the long-term projections of Y/R and SSB/R.

Maturity ogive

An observed maturity ogive for Div. 3M beaked redfish was calculated as the mean proportion of mature females in the survey stock abundance at age (Table 5c) and used in the VPA based methods At each age this mean proportion is given by the ratio between the 1989-2001 sum of mature females and the correspondent total stock abundance.

The observed maturity ogive was also fitted to a general logistic curve in order to give an expected maturity ogive for the yield-per-recruit analysis (Table 8b, Fig. 5).

Vectors used in yield per recruit analysis

A Div. 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 (1989-2001):

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 and 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 ages 1-4).
5) Natural mortality, set at 0.2 for ages 1 and 2 to allow a higher juvenile mortality. Assumed to be constant at 0.1 for older ages.

Assessment Results

Bottom biomass, spawning biomass and abundance from EU bottom trawl surveys (1988-2001) and Canadian bottom trawl surveys (1979-1985)

The more recent period of 1988-2001, 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 biomass was recorded (Table 2, Fig. 2). Survey bottom biomass increased in 1999 and 2000 till 110,000 tons, the highest index observed since 1989. However in 2001 biomass fall again to 59,000 tons (Vazquez, 2002). This fall is also reflected in the spawning biomass index, reduced to 7,000 tons after being at 19,500 tons just the year before. It is difficult to associate those drastic declines with fishing mortality, well bellow the assumed natural mortality since 1997. The wide oscillations in bottom biomass survey indices between consecutive time intervals can be induced by changes on the redfish concentration near the bottom, as well as on its distribution in and out of the survey swept area of the Flemish Cap bank, causing “year” (=time interval) effects of alternate sign on survey catchability.

During the former period of 1979-1985, covered by the Canadian surveys, female spawning biomass of beaked redfish (SSB) was stabilized and represented more than 40% of the survey bottom biomass on most of the years. Survey spawning biomass declined through the first years of EU survey series, staying at low level around 8,000 tons between 1994 and 1997. Over the most recent years (1998-2001) this SSB index experienced large interannual variation, from a minimum in 1998 of 3,700 tons to the highest value since 1990, recorded in 2000 with 19,500 tons. In 2001 SSB returned again to a low level of 7,000 tons. From 1988 till 1991 female spawners represented between 22% and 28% of the bottom biomass. Apart a minimum in 1998 of 7% and 18% recorded in 2000, this proportion has been oscillating between 9% and 12% since 1994 (Table 2, Fig. 2).

On the Canadian survey series beaked redfish abundance declined over the 1982-1985 interval. Although not comparable as absolute figures, abundance continues to decline in the EU survey series till 1990. Starting to recruit to the survey gear at age 2 the strongest year-class of the time series, the 1990 year-class, pushed the survey abundance to a maximum in 1992. Abundance declined sharply during the intermediate years, regardless the smaller peaks of 1994 and 1996. The second lowest abundance of the EU survey series is attained in 1998. Stock abundance increased continuously afterwards till 2001, despite the drop on biomass and spawning biomass last year. This most recent increase on stock abundance from 2000 to 2001 has been supported by the pre-recruited age groups (1-4). The 2000 year-class is the most abundant year-class at age 1 of the 1988-2001 interval (Table 5-A).

Yield per recruit analysis

In order to get reference levels of fishing mortality taking into account the growth, maturity and exploitation pattern of the Div. 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, long-term spawning and total biomass were determined for different levels of fishing mortality (Table 8d, Fig. 6). With the assumption of constant recruitment, fishing at an $F_{0.1}$ 0.10 will drive the long-term female spawning biomass to 34% of its unexploited size, representing by then 33% of the stock biomass. Fishing at $F_{0.1}$ will also stabilize long-term stock biomass at 50% of its unexploited size. But the fishing mortality that will allow a long term female spawning biomass at 50% of its unexploited level should be no greater than 0.06. This reduction corresponds to a long term proportion of female spawners in the stock biomass of 39%, a level near the average SSB proportion observed during the 1979-1985 Canadian series (42%). By that time from the survey indices available the stock was showing signs of stability sustaining annual catches around 20,000 tons.

A Precautionary Level of Fishing Mortality Based on Div. 3M *Sebastes mentella* growth

A growth based model (Beverton and Holt, 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 of 0.06 given by the Z "at maturity" assuming a natural mortality of 0.1, has the same magnitude of the F from the yield per recruit analysis associated with a long term 50% reduction on the female spawning 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 on the 2000 assessment using the EU survey abundance at age data as the tuning file (Ávila de Melo *et al*., 2000 and 2001). A Separable Cohort Analysis (SPA) was run next and the respective trends of F and SSB were compared. The purpose of this procedure is to check if the strong 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 and /or inside the swept area) have, or have not, 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 1989-2001 period (Table 5) and the month with a peak of spawning for Div. 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 1993-2001 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 2001 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 thirteen 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 are summarized and adapted to this case study on the two last assessment documents (Ávila de Melo *et al*., 2000 and 2001).

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 couple of years of the assessment, following the higher level of catches in 2000-2001. 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 dependent of year-class strength on all ages till the penultimate true age (17) showed all ages with high regression standard errors, most of them with high *t* values of the slope as well. However the regression statistics of catchability for the younger ages considered (4 and 5) 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 11 degrees of freedom = No. points – 2, significance level of 0.05). This lack of a significant trend on the younger ages regression slopes led us to treat the catchability independent with respect to year-class strength and time through all the age spectrum of the assessment (Darby, pers. com., 2000).

During the 2001 assessment four exploratory runs were performed to select an age for fixing catchability and choose a minimum standard error for the log catchability of the last true age, in order to avoid overweight of the cohort's terminal population estimates by the last true age. Taking into account that catchability declines on older ages, the results of this exercise pointed out that fixing catchability only since age 17 (not shrinking the range of true ages involved on the assessment of a long living stock) and keeping the minimum standard error of the log catchability of age 18 at 0.5 (instead of adopting a lower minimum) improved the fitness of the model to the existing data. The present assessment uses last XSA framework: 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 of the 2002 XSA are presented on Table 11a,c and Fig. 7a.

Extended Survivor Analysis converged after a high number of iterations. The diagnostics present several high positive and negative log catchability residuals, namely until 1996 and on younger ages 4 to 6, still recruiting to survey gear. Most of the residuals were positive during the intermediate years of 1994 to 1997, while on the former years till 1991 and again on 1998 and 2001 most ages had negative residuals. In general the size of log catchability residuals over the most recent years (1999-2001) is smaller than through the preceding years. Low fishing mortalities since 1997, well bellow the assumed level of natural mortality, changes of opposite sign on beaked redfish concentration near the bottom of the survey swept area from one year to the next (amplifying the noise on the log catchabilities at age and introducing strong year effects) together with a declining trend of catchability with age, each of these factors contributed at some extent to the long process of convergence. The poor fit, on the XSA model, of survey data to the catch at age matrix of Div. 3M beaked redfish seems in part related with redfish own biology and behaviour, and is something a redfish assessment has to live with when using VPA based models supported by a survey tuning.

A 2001-1999 retrospective analysis was carried out in order to compare the patterns on the biomass, female spawning stock biomass (SSB), fishing mortality (average F, ages 6-16) and recruitment (age 4) estimates, from different assessments back in time. In order to preserve at the maximum extent most of the cohorts occurring from 1989 onwards, namely the 1990 year-class, in this retrospective analysis the assessments were confined just to the most recent years. This avoids the premature truncation of the (long living) cohorts that are the bulk of the present exploitable stock. The retrospective patterns don't present a systematic under-or-over bias through the whole interval in none of the parameters used in the analysis (Table 11d; Fig. 8a, b, c and d). Fishing mortality shifts from over to under biases between 1993 and 1994, before a 1996-2000 interval where the relative size of the discrepancies between estimates is high. Both biomass and SSB started with absolute under biases of greater magnitude and ended with smaller over biases, showing an increasing convergence of estimates over the more recent years. Biases in assessment results seems to be stock specific and data induced (Sinclair *et al*., 1990; and Anon. 1991), and the uncommon retrospective patterns for Div. 3M beaked redfish, were accuracy apparently increases towards the end of the time series, seems to confirm the specificity of each case. From the possible causes of retrospective patterns – patterns of misreporting, patterns in catchability or mis-specification of natural mortality (Sinclair *et al*., 1990) – the high positive and negative log catchability residuals, most of them observed during the earlier period on younger ages, could be the main cause of bias in this assessment.

The Extended Survivor results are presented on Table 12 and Fig. 9a, b, c and d. Very high fishing mortalities until 1996 forced a rapid and steep decline of either abundance, biomass and female spawning biomass of the Div. 3M beaked redfish stock (Fig. 9a and b). From 1997 onwards, low fishing mortalities allowed a discontinuous and slow growth of both biomass and SSB, but abundance is not yet increasing. There was a general increase of the stock reproductive potential between 1992 and 1997 (Fig. 9c) but in 2001 female spawning stock biomass was still far away from a SSB level of 80,000 tons, beyond which above average recruitments were observed (Fig. 9b and d). All year-classes at age 4 included in the reproductive potential and SR plot had already passed through the shrimp fishery during their early stage.

The Separable VPA

A Separable analysis (SPA), followed by a traditional VPA run (Cohort analysis) has been performed afterwards. The purpose is to evaluate the fitness of the survey abundance at age used in the XSA tuning to the catch at age matrix. In other words if an analytical model free from a noisy survey tuning is telling the same history of the Div. 3M beaked redfish stock, with a better, or worse, fitness to the catch data. The procedure will be to compare the sum of squares of the residuals of the log catch ratios of consecutive ages on consecutive years from SPA with the sum of squares of the EU survey log catchability at age residuals from the XSA. The level of agreement of the F's and SSB's time series from both models will be checked as well.

The Separable VPA (Pope and Shepherd, 1982; Shepherd and Stevens, 1983; Stevens, 1984) 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 apparently difficult to sustain due to the impact that redfish by–catch in numbers caused in the length composition of the redfish removals since 1993 (Table 1c). However on both VPA based models recruitment is at age 4, an age group, which with the exception of the first year of the shrimp fishery, has a length spectrum not significantly affected by the shrimp trawl. In other words these models are basically evaluating the part of the stock available to the trawl fleets targeting round and flatfishes. 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 have been summarised on the two last assessment documents (Ávila de Melo *et al*., 1999-2001). From the XSA fishing mortality and relative F at age results (Table 12, Tables 8 and 9) a first guess of fishing mortality for the first fully exploited age on last year (F_{bar} 6-16, 2001) and a selection value for last true age (relative F at age 18, 2001) were taken to initialise the Separable analysis.

From the diagnostics of the Separable analysis some high positive and negative residuals are observed on the log catch ratios between the younger ages, consequence of the gradual recruitment of beaked redfish (Table 11b and c; Fig. 7a and b). High negative and positive residuals were observed on some older ages as well specially for the 1997/98 and 1999/00 log catch ratios. Those high residuals could be induced by higher mobility of larger fish between those years and, as a consequence, a wider interannual fluctuation of their availability to commercial trawlers. No patterns were detected on the residuals down the columns (year effects), across the rows (age effects) or the cohort diagonals (year-class effects), reflecting a smaller impact of redfish biology and behaviour on the commercial catch than on the survey catch series. Nevertheless the sum of squares of the residuals of the log catch ratios from SPA diagnostics is higher than the sum of squares of the XSA log catchabilitiy residuals. Therefore, and despite an apparent lack of residual patterns, the Separable model has a poorer fit to the commercial catch at age matrix than the Extended Survivor model.

The Separable Analysis was concluded with a traditional VPA (Cohort analysis). The fishing mortality residuals from the Cohort analysis (corresponding to the comparison between VPA and Separable F's) are presented on Table 11b. 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. Despite the general small magnitude of these residuals they are higher on the first half of the time interval till 1995, and lower afterwards. This pattern reflects an improving match between SPA estimated catches and observed catches over time. The Cohort analysis results are summarised and compared with XSA results on Table 13 and Fig. 10.

Comparison of the XSA and Cohort/SPA results

Compared with XSA the Cohort/SPA model systematically under estimated both stock biomass and spawning stock biomass over the past thirteen years. The full weight of the former high catches of adult beaked redfish (greater than 30 cm) on the SPA fit of the correspondent fishing mortalities, lead to higher 1989-93 F's on the Cohort analysis and to SSB's estimates at a much lower level than those from XSA at least until 1999. From XSA an important fishing mortality increase is detected between 1998 and 1999 on the 1990 year-class (the most abundant cohort over the time interval) and on several older cohorts as well, from 1987 back to 1983 (Table 12, Table 8). These higher fishing mortalities are reflected in unexpected declines in 1999 of XSA stock biomass and namely SSB, but these declines are almost absent on the correspondent Cohort/SPA results. This discrepancy suggests the influence of the negative survey catchability effects from 1998 on the higher fishing mortalities estimated by the XSA for the above-mentioned cohorts. Finally recruitment results: a general good match between both model estimates till 1995 is followed by a systematic under estimate of age 4 by the Cohort/SPA from 1996 till 1999. There is a possible link between this change and a shift of the exploitation pattern towards larger lengths occurring between 1995 and 1996 as a consequence of the codend 135 mm mesh size enforcement from 1995 onwards. The difference of the commercial catch age composition from the early- to the late-years of the interval supports this hypothesis (Fig. 3).

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 B_{msy} the long-term yield and biomass associated with F_{msy}, 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 $Y_{0.1} = 0.99\ Y_{msy}$

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

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

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 updated from previous assessments (Ávila de Melo *et al*., 2000 and 2001) and are defined as follows (Table 14a):

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. The EU bottom biomass (1988-2001) is given by the age 4 plus biomass due to its higher correlation with the STATLANT commercial CPUE 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-1970s and the first half of the 1980s. Taking into account the recent history of the Div. 3M redfish fishery the MSY was allowed to vary between 10,000 tons and 50,000 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 0.69. This value corresponds to the geometric mean of the survey bottom biomass/XSA stock biomass ratio for the 1992-2001 interval, after a former period, between 1989 and 1991, when this bottom survey ratio was at a much lower level (Table 15, Fig. 11). 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 has been summarized on previous assessment documents (Ávila de Melo *et al*., 1999-2001).

ASPIC ran first on the FIT mode (Table 14b), to have the deterministic parameters estimate, together with effort and survey pattern of unweighted residuals as well as biomass and fishing mortality trends (expressed as ratios to B_{msy} and F_{msy}). On BOT mode effort and survey residuals were resampled 1000 times in order to derive bias corrected estimates and probability distribution of the parameters. The program uses bias corrections based on medians and so, being P the fit estimate of a parameter and P_m its median value from the bootstrap, then the bias corrected estimate P_{bc} will be given as

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

In general there is a small relative bias between the corrected and ordinary estimates (1%-2.5%) indicating for most of the fitted parameters a distribution close to normality (Table 14b, Page 6: RESULTS OF BOOTSTRAPPED ANALYSIS). The production model estimate a stock biomass 75% above B_{msy} till the early seventies. A first drop of stock biomass occurred between 1973 and 1975: by then stock biomass was already not higher than 48% above B_{msy}. Biomass slowly declined afterwards to 40% above B_{msy} in 1985, while supporting catches between 14,000 tons and 20,000 tons. Decline continues at a faster rate and by 1990 the B_{msy} level was left behind towards an historic minimum of 39% of the B_{msy}, finally reached in 1996. Meanwhile fishing mortality was at or well above F_{msy}, inducing a stock decline that went faster through the first half of the nineties. Low fishing mortalities 1996 onwards gave room to slow stock recovery, with 2001 biomass representing already 67% of the B_{msy} (bias corrected estimate). Fishing mortality recorded a minor increase in 2000 and 2001 but within a level well bellow F_{msy} (20%-30%). As for MSY for Div. 3M beaked redfish stock, the ASPIC bias correct estimate is of 19,000 tons with an inter quartile range for 50% confidence limits of 4,300 tons (Table 14b, Page 6: RESULTS OF BOOTSTRAPPED ANALYSIS).

The ASPIC biomass follows the same pattern of the previous Cohort/SPA and XSA models, though with closer estimates to the Cohort/SPA biomass over the former years till 1993 (the end of the STATLANT CPUE series and of a full scale redfish fishery in Flemish Cap). From 1993 onwards the 4+ ECU survey biomass is the only time series available to adjust to the production model and over those intermediate years the results from ASPIC fits well with the XSA biomass. But just until 1998: the production model is not sensitive to the late survey biomass fluctuations and with low F's and a constant rate of increase ASPIC biomass grow faster than XSA biomass till 2001(Table 15, Fig. 11).

State of the 3M beaked redfish stock

Either VPA's and ASPIC analysis pointed out that the Div. 3M beaked redfish stock experienced a steep decline from the second half of the 1980s till 1996. Fishing mortality was kept well above F_{msy} over the first half of the assessment period, due to increasing commercial catches since the mid-1980s that reached a top level within 1989 and 1993. From 1995 onwards fishing mortality dropped and since 1997 has been kept well below natural mortality, allowing the survival and growth of the remainders from all cohorts. But 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 increasing the growth rate of biomass and female spawning biomass. Despite recent fluctuations biomass is generally increasing since 1997 but slowly, being still well bellow the level estimated for the beginning of the time series (1989). Showing the same irregular and discrete pattern of growth female spawning biomass is also recovering from the 1996 minimum, supported by the survival and biomass growth of the dominant 1991 year-class and by the younger cohorts as well, progressively reaching maturity over recent years. However an SSB target level approaching 80,000 tons (Fig. 9c and 9d), a lower limit of the SSB's that in the former years were concurrent with the most abundant cohorts at age 4 (Fig. 9d), will not be foreseen in the next coming years, even keeping the actual low level of exploitation and assuring a high rate of survival of the promising 2000 year-class.

However the prospective of a no return consistent increase of both biomass and SSB seems to consolidate under the present low exploitation regime: the stock reproductive potential has increased through the nineties (Fig. 9c) compensating the SSB decline and sustaining a 1998-2001 geomean recruitment at age 4 identical to the former years of 1989-1992 (44 million fish). The 1997 year-class, recruiting in 2001, is 20% above the 1989-2001 geomean recruitment (excluding both 1989 and 1990 cohorts).

By-catch mortality continued to act as a buffer on survival of pre-recruits and its impact increases with year-class strength, since, as its is illustrated in the 2001 length composition of redfish by-catch (Table 1c and Fig. 1) the actual sorting grades are ineffective to avoid large amounts of by-catch of redfish of small sizes between 8 cm and 13 cm. In 2001, redfish up to 13 cm from Div. 3M shrimp by-catch represented 67% of the Div. 3M redfish total catch in numbers (Table 1c, Fig. 1), with 2000 and 1999 year-classes forming the bulk of the catch (Table 4, Fig. 3). With the availability of the above average abundance of the 2000 year-class to shrimp trawlers there is little doubt that the major obstacle to a faster rate of stock growth both in biomass and namely in abundance is the survival of abundant cohorts in their early life stage preceding recruitment to commercial fishery. Keeping catch and fishing mortality at a low level can only be effective in supporting a medium term faster stock recovery if measures to drastically reduce by-catch of very small redfish are now implemented.

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 (M_{term}) has been used. This program has first been applied in a NAFO stock in 2000 (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 aggregated in two files:

1. A ".srr" (stock recruitment relationship) file (Table 16a), adopting as Div. 3M redfish SRR model a fluctuation of recruitment around the geometric mean of the 1999-2001 recruitment (but eliminating the 1989 and 1990 "anomalies"). 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 comments.
2. A ". sen" (sensitivity) file (Table 16b) 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 2001, plus the geometric mean of the 1999-2001 XSA recruitment's at age 4). Being the internal and external standard errors two measures of the uncertainty around the survivor's estimates, the correspondent average of these standard errors were adopted as the coefficients of variation associated with the starting population at age in the red.sen file. In order to compare the short- and medium-term SSB projections from a short-term yield a) given by F*statusquo*, b) abide to the vicinity of the actual TAC of 5,000 tons and c) within the average level of recent catches (3,000 tons-4,000 tons), three "exploitation patterns for human consumption" were adopted for the M_{term} runs, corresponding respectively to the average 2001 fishing mortality at age of the XSA (F_{bar} 6-16), and to 60% and 45% of that F*statusquo*.

The results are presented as 5, 10, 25, 50 and 95 probability profiles for:

1. Short-term (2005) female spawning biomass projections for a range of F bar's centred at reference F corresponding to each one of the three chosen options of "exploitation pattern for human consumption" (Table

17a and Fig. 11a,b and c).
2. Medium term (2011) female spawning biomass projections for a range of F's multipliers corresponding to each the three adopted scenarios. (Table 17b and Fig. 12a,b and c).

And also as 2002-2001 female spawning biomass and yield trajectories for 5, 25, 50, 75 and 95 percentiles keeping average fishing mortality at 2001 F*statusquo*, or at 60% or at 45% of that F*statusquo* (Table 18a and Fig. 13a, b and c; Table 18b and Fig. 14a, b and c)

Under a 50^{th} % probability profile, keeping fishing mortality at F*statusquo* will raise the 2003 catches to 8,000 tons but by 2011 the catch level will have declined to 6,000 tons (Fig. 15). As for SSB, and keeping the same probability level, an increase to 47,000 tons is expected in the short-term but by 2011 its level could be still at 57,000 tons, far away from the SSB levels higher than 80,000 tons recorded prior to 1991 and associated with strong recruitments. On the contrary, a 45%-60% reduction on F*statusquo* will anchored in the short-term caches to an interval defined by the present level of catches and the adopted 2000-2002 TAC, allowing with a higher probability (associated with the 25^{th} % probability profile) both the doubling of the actual SSB level by 2005 and a 2011 SSB already representing 80% of the 80,000 tons frontier.

Even associated with a gradient of probability levels, short- and medium-term projections should be taken with caution. The similarity between projections from consecutive years depends not only on the similarity between the near future and the recent past as regards recruitment pattern, but namely as regards a consistent estimate of the population at the first year of two consecutive projections. This consistency depends on how close is the estimate of survivors at age by the end of the last year of the previous assessment (initial population of last year projection) to the new estimate of the same individuals, now calculated by the XSA as the population at age at the beginning of the terminal year of the actual assessment (from which the survivors that initialise this year projection are calculated). These concerns are well illustrated in the comparison of the M_{term} projections for 2001 (50% F_{2000}) and 2002 (60% F_{2001}), both projections resulting in principle in short term catches around the actual TAC of 5,000 tons (Table 19, Fig.16a and b). The difference between the 2001 mature female population at age as the 2001 XSA survivors by the end of 2000, that was used to start the 2001 M_{term} projection, and the same 2001 mature female population at age now calculated by the 2002 XSA, will contribute to apart the trajectories from the two projections: lower magnitude for the 2002 starting population (2001 survivors) when compared with the one predicted by the 2001 M_{term} projection, and a lower SSB trajectory that will tend anyway to approach the previous one with time. Discrepancies are also obvious within the yield trajectories that will get closer over the last common years of the projections. However for 2003, the predicted catch for the 50^{th} probability profiles from 2001 and 2002 projections are around 5,000 tons (Table 19).

On the other hand, the underlying assumption of these projections, that no pulse of recruitment will be foreseen in the next coming years, can fall with the appearance of one or two year-classes strong enough to be still well above average when reaching age 4. That could very well be the case of some recent year-classes. If so a faster biomass growth rate could put the stock at a safe SSB level within a shorter period of time. But this hypothesis is not confirmed yet and further increase of the stock and spawning biomass will continue so far to be dependent on keeping fishing mortality at the recent low levels, well below $F_{0.1}$ and natural mortality. At the present stock size and taking into account the trajectories of the last M_{term} projections this should correspond to a catch for 2003 not higher than 5,000 tons.

Acknowledgements

This assessment is part of an EU research project supported by the European Commission (DG XIV), IPIMAR, CSIC, IEO and AZTI. The authors would like to thank Dave Kulka (DFO/Science Branch, Canada) and Alexander Vaskov (PINRO, Russia) for the early submission of 2001 length data on by-catch and commercial catch from their countries.

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Table 1a: Length composition (absolute frequencies in'000s) of the 3M redfish commercial catch, 1989-01.

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
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	4
16	34	211			440	132		22				1	4
17	69	808			167	391		22	1	2		9	22
18	34	2787	175		101	843	129	22		1		26	62
19	12	6470	726	70	130	1030	291	74	7	9	1	40	45
20	128	6925	1494	352	145	501	1273	400	8	14	2	68	46
21	440	3253	1385	1856	327	515	3222	1073	16	31	1	52	68
22	1316	1344	1323	3110	970	598	6630	2464	44	57	2	120	126
23	4317	2146	1060	2376	1894	732	6431	1825	112	104	1	121	213
24	9628	6157	1904	1469	3372	1408	1901	1472	284	128	10	244	300
25	16884	13302	4193	2760	3160	1999	1282	872	351	246	122	348	490
26	16970	22298	7061	8656	3345	2005	858	569	335	247	116	732	969
27	12796	28705	11632	13299	3277	1782	1028	822	213	229	228	1278	1345
28	8096	29130	14411	13405	4024	2439	1276	842	183	191	317	1604	1570
29	6605	22485	16923	9609	3530	2587	1588	951	227	185	319	1397	1291
30	8465	16982	14634	8119	5261	2783	1621	998	267	178	210	957	1078
31	7949	11308	8359	5797	4611	2526	1356	1058	240	188	218	662	582
32	8432	9266	7907	5124	3629	2196	1405	985	268	172	255	465	368
33	8022	7303	3946	4535	3748	1456	1312	761	290	123	185	357	229
34	7899	7133	4361	4771	3079	931	1084	742	115	81	89	322	160
35	7432	6115	3477	4814	3308	994	1113	310	82	59	150	203	84
36	5607	4900	2938	3476	2903	623	1121	218	46	51	81	160	42
37	4655	3394	2683	2604	2777	354	985	244	26	50	71	151	34
38	2786	2458	1874	1733	1536	303	805	114	29	36	9	128	40
39	1787	1734	1959	1388	1318	152	525	139	12	32	31	54	18
40	1082	856	1148	974	695	100	504	50	4	17	2	35	11
41	577	647	717	583	392	78	372	42	13	12	5	24	5
42	390	384	225	233	339	26	176	50	6	9	1	16	7
43	332	294	317	274	149	15	74	20	1	3	2	22	3
44	155	145	22	199	443	26	54	3	7	2		15	2
45	163	81	16	45	55	16	37	2	1		2	3	1
46	85	36	9	10	45		8	4	1	1		7	1
47	53	18			36		20	1	1			4	
48	32	13	9	20	65		5						1
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	9220
weight (tons)	**58100**	**81000**	**48500**	**43300**	**29000**	**11300**	**13500**	**5789**	**1300**	**971**	**1068**	**3825**	**3295**
mean weight	405	369	415	426	473	382	351	337	406	395	440	396	357
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	28.6

Table 1b: Length composition (absolute frequencies in'000s) of the redfish by-catch in the 3M shrimp fishery, 1993-01.

Length	1993	1994	1995	1996	1997	1998	1999	2000	2001
5								3	8
6				150	1	3	14	5	177
7			4	4408	96	97	111	58	473
8			6	2469	116	222	531	121	1318
9			5	216	65	36	784	55	3739
10			3	426	235	40	816	191	5795
11			14	1081	519	350	377	588	5563
12	2	18	33	861	467	1638	302	997	4429
13	23	331	32	470	149	1540	276	743	1884
14	207	957	59	499	110	304	93	179	662
15	1792	2177	229	749	109	54	87	84	467
16	7171	7115	399	1733	590	104	83	48	459
17	27984	17018	703	1190	168	75	59	16	383
18	45217	20665	915	755	56	28	40	10	250
19	28682	10818	762	386	56	23	37	9	92
20	6435	2274	396	69	71	5	12	10	41
21	947	312	118	96	55	10	6	4	25
22	343	111	25	5	38	12	7	2	23
23	1		6		20	7	5	2	12
24			2		9	17	2	2	9
25			4		3	14	4		4
26			4		1	18		2	1
27			4			9	3		1
28			6			1			2
29			6			1			
30			2						
31									
32						1			
33									
34						1			
no ('000)	118805	61798	3739	15563	2933	4609	3651	3126	25810
weight (tons)	11970	5903	374	550	157	191	96	106	738
mean weight	0.101	0.096	0.100	0.035	0.054	0.041	0.026	0.034	0.029
mean length	18.5	18.1	18.3	11.9	14.0	13.1	11.2	12.5	11.5

Table 1c: Length composition (absolute frequencies in'000s) of the 3M redfish total annual catch, 1989-01.

Length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
5												3	8
6								150	1	3	14	5	177
7							4	4408	96	97	111	58	473
8							6	2469	116	222	531	121	1318
9							5	216	65	36	784	55	3739
10	3				1		3	426	235	40	816	191	5795
11							14	1081	519	350	377	588	5563
12	3				3	18	33	861	467	1638	302	1006	4429
13	12				32	332	32	470	149	1540	276	761	1884
14	29	4			324	969	59	499	110	304	93	180	662
15	9	81			2187	2221	229	749	109	57	87	93	472
16	34	211			7611	7248	399	1755	590	104	83	49	463
17	69	808			28151	17409	703	1212	168	76	59	25	405
18	34	2787	175		45318	21508	1044	777	56	29	40	36	311
19	12	6470	726	70	28812	11848	1052	460	63	32	38	49	137
20	128	6925	1494	352	6580	2775	1669	470	79	20	14	78	88
21	440	3253	1385	1856	1274	827	3340	1168	70	41	7	56	93
22	1316	1344	1323	3110	1313	710	6655	2469	82	69	9	122	149
23	4317	2146	1060	2376	1895	732	6438	1825	132	111	6	123	224
24	9628	6157	1904	1469	3372	1408	1903	1472	294	146	12	246	310
25	16884	13302	4193	2760	3160	1999	1286	872	354	260	126	348	494
26	16970	22298	7061	8656	3345	2005	862	569	336	265	116	734	970
27	12796	28705	11632	13299	3277	1782	1031	822	213	238	231	1278	1346
28	8096	29130	14411	13405	4024	2439	1283	842	183	192	317	1604	1572
29	6605	22485	16923	9609	3530	2587	1594	951	227	186	319	1397	1292
30	8465	16982	14634	8119	5261	2783	1623	998	267	178	210	957	1078
31	7949	11308	8359	5797	4611	2526	1356	1058	240	188	218	662	582
32	8432	9266	7907	5124	3629	2196	1405	985	268	173	255	465	368
33	8022	7303	3946	4535	3748	1456	1312	761	290	123	185	357	229
34	7899	7133	4361	4771	3079	931	1084	742	115	82	89	322	160
35	7432	6115	3477	4814	3308	994	1113	310	82	59	150	203	84
36	5607	4900	2938	3476	2903	623	1121	218	46	51	81	160	42
37	4655	3394	2683	2604	2777	354	985	244	26	50	71	151	34
38	2786	2458	1874	1733	1536	303	805	114	29	36	9	128	40
39	1787	1734	1959	1388	1318	152	525	139	12	32	31	54	18
40	1082	856	1148	974	695	100	504	50	4	17	2	35	11
41	577	647	717	583	392	78	372	42	13	12	5	24	5
42	390	384	225	233	339	26	176	50	6	9	1	16	7
43	332	294	317	274	149	15	74	20	1	3	2	22	3
44	155	145	22	199	443	26	54	3	7	2		15	2
45	163	81	16	45	55	16	37	2	1	0	2	3	1
46	85	36	9	10	45		8	4	1	1		7	1
47	53	18			36		20	1	1			4	
48	32	13	9	20	65		5						1
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	6135	7070	6080	12788	35030
weight (tons)	58100	81000	48500	43300	40970	17203	13874	6339	1457	1162	1164	3931	4033

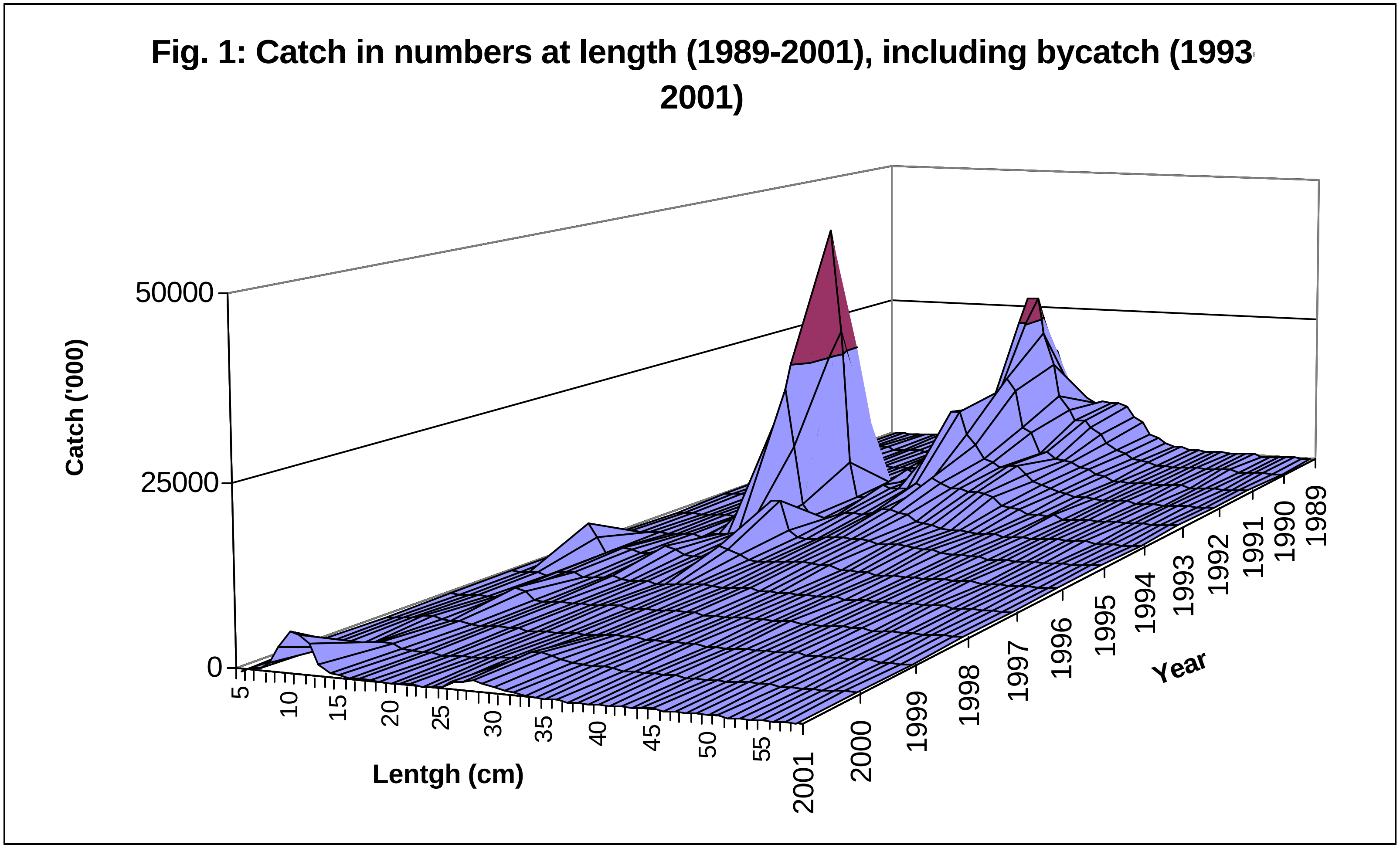


Fig. 1: Catch in numbers at length (1989-2001), including bycatch (1993-2001)
Catch ('000)
50000
25000
0
5
10
15
20
25
30
35
40
45
50
55
Lentgh (cm)
2001
2000
1999
1998
1997
1996
1995
1994
1993
1992
1991
1990
1989
Year

Table 2: 3M beaked redfish abundance at length ('000), biomass and spwanning biomass (tons) from Canadian (1979-1985) and EU (1988-2001) bottom trawl surveys

length	Canadian series						
	1979	1980	1981	1982	1983	1984	1985
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	0	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%**
mean ssb proportion	**42.1%**						

Table 2 (cont.): 3M beaked redfish abundance at length ('000), biomass and spwanning biomass (tons) from Canadian (1979-1985) and EU (1988-2001) bottom trawl surveys

length	EU series													
	1988		1989		1990		1991		1992		1993		1994	
	stock	mat fem	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		86	
11	8700		2620		261		19838		206880		14178		613	
12	18700		6980		298		27836		306721		23675		1385	
13	14400		8210		1090		10973		92559		19060		3390	
14	2300		19280		2406		2295		21097		65615		20783	
15	500		39630		4031		1945		44512		170339		59296	
16	700		35080		6921		5861		41511		90359		84806	
17	1100		11750		17117		16420		9601		20841		154161	
18	900		2090		20705		30448		5884		6714		169625	
19	3400		1330		12602		50563		9263		3714		92551	
20	6700		2030		2830		60548		15981		2433		25753	
21	15900	133	3120	40	768	10	31124	296	31905	234	2476	22	13029	100
22	34700	488	7270	116	1566	27	8610	120	50785	629	4089	61	7280	122
23	74000	1784	14590	396	3612	117	3230	107	39506	795	6189	175	6862	199
24	117900	5057	27620	1236	9246	411	3520	165	19340	619	7391	327	9043	395
25	131800	9552	44480	3057	20248	1379	7187	405	8638	459	5651	467	10666	691
26	101400	10943	55920	5507	32819	3052	9800	804	11190	677	5587	506	9831	1002
27	45500	6449	48630	6555	34269	4365	10320	1284	15927	1199	4613	406	7154	797
28	19700	3681	32350	6467	25550	5383	9450	1741	18072	2294	4935	523	8858	1367
29	10100	2343	18750	4694	15110	4279	6890	1746	13298	2892	3670	719	7762	1364
30	14200	4076	12110	2983	9550	2835	5980	1836	12040	4213	3615	1009	5589	1423
31	12300	4037	9720	2297	7340	1762	4550	1339	8662	3001	3108	852	4907	1465
32	15100	5582	11380	2666	7120	1992	4110	1377	5818	1810	2588	776	4652	1865
33	15200	6031	8890	3808	6340	2683	4650	2177	5570	1986	2912	884	3312	1033
34	13800	6441	8780	4353	7350	4038	4840	2563	5587	2407	2516	868	2253	624
35	10900	5298	9170	4733	5210	3214	3950	2106	4732	2337	2419	759	2134	789
36	9900	5162	7890	4040	5000	2836	3680	2321	3723	1983	2476	1091	1580	754
37	7600	4238	5930	3104	4010	2434	3020	1785	2976	1847	2431	1271	920	563
38	6900	4478	3960	2592	3040	1954	2580	1826	2481	1680	1599	1092	918	648
39	3700	2720	3600	2807	1820	1265	1660	1275	1815	1417	1356	1035	470	297
40	2500	2024	2530	2185	1230	894	1030	814	1190	1053	808	678	340	268
41	1800	1471	1030	856	630	468	450	388	490	339	363	325	200	159
42	800	677	650	539	310	219	350	309	355	344	362	361	80	80
43	300	263	250	230	190	160	170	160	140	140	101	101	30	20
44	100	88	70	60	40	20	50	40	140	110	170	125	20	20
45	100	88	70	30	50	50	50	30	40	30	34	34	30	20
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		
total	731900	93104	469570	65429	279817	45869	535977	27073	1105124	34515	491891	14544	720368	16066

	1988	1989	1990	1991	1992	1993	1994
spawning biomass	**43458**	**32292**	**22890**	**15034**	**18056**	**9046**	**7900**
biomass	**195488**	**123424**	**82238**	**68798**	**104492**	**53804**	**89152**
ssb proportion	**22.2%**	**26.2%**	**27.8%**	**21.9%**	**17.3%**	**16.8%**	**8.9%**

Table 2 (cont.): 3M beaked redfish abundance at length ('000), biomass and spwanning biomass (tons) from Canadian (1979-1985) and EU (1988-2001) bottom trawl surveys

length	EU series													
	1995		1996		1997		1998		1999		2000		2001	
	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						100	
7	12		600				103		79		29		398	
8	176		4406		297		719		1126		392		8267	
9	517		3172		784		1589		7822		1972		91234	
10	731		583		548		553		7377		1930		195814	
11	1553		1320		1988		1216		1557		2181		30392	
12	4914		4452		7666		7951		1763		9871		11840	
13	2946		4287		10480		15985		3343		24448		21512	
14	2636		5137		5014		8054		2512		18261		14990	
15	5562		9770		7795		8852		10116		6123		18149	
16	14624		8962		13934		17535		21811		2431		41307	
17	41775		15988		18639		13259		15808		4776		34614	
18	76859		38991		20173		9575		21401		11863		15177	
19	107204		83847		25914		10865		20686		18079		9319	
20	79964		125875		52838		11213		15397		20578		14227	
21	32884	270	118446	904	83129	627	15332	114	11960	187	18149	253	20582	284
22	8965	130	77619	988	85180	1213	28529	329	14940	327	17309	419	22548	532
23	3872	94	37487	778	57609	1468	50429	1052	26193	907	15587	531	16033	610
24	3388	133	18134	713	23549	1113	53764	1912	57574	3009	25380	1003	14914	996
25	4017	266	8735	775	10041	937	33467	1997	74355	6267	48243	2252	14560	1112
26	5219	490	4814	716	6473	1495	15685	1397	59755	7030	71071	6628	18779	1895
27	5085	620	7163	1030	4920	1548	6459	855	22027	4883	76814	15057	18731	2970
28	5776	742	5361	1298	4841	2506	3191	588	7653	2436	55720	16179	14805	3968
29	6134	1067	5864	1582	3524	1586	1557	338	2997	851	23367	8946	8546	3064
30	6137	1532	4251	1148	4238	2341	1062	279	1036	436	5273	2699	6184	2944
31	4976	1490	3697	1309	2731	1176	1279	422	940	399	2126	1225	1871	844
32	4170	1314	3543	1643	2183	995	1066	301	912	321	1199	785	1054	363
33	3594	1172	3328	1341	1959	880	900	328	697	324	1480	306	497	230
34	3079	892	2374	1458	1543	825	796	266	601	218	816	408	596	208
35	2688	909	1659	787	977	460	467	175	542	207	559	295	312	130
36	2540	889	1397	891	921	453	510	162	359	225	582	336	260	83
37	2206	851	1088	719	541	312	340	165	225	182	548	466	110	57
38	1365	774	785	486	390	196	260	108	137	117	105	91	130	48
39	978	661	512	348	210	129	170	89	70	60	110	94	60	49
40	520	397	290	189	146	105	60	30	44	34	70	39	30	10
41	450	418	260	199	130	110	70	60	20	20	40	30	50	39
42	330	279	180	130	40	30	30	26	30	10			10	10
43	160	130	70	50			60	40	10	10	20		40	40
44	40	20	20	20	20	10	30	20			10	10		
45	40	20	20	20			10	10	20	10				
46	40	40					10	10						
47	10	10												
48			10											
total	448164	15610	614540	19520	461374	20514	323247	11074	413895	28467	487511	58050	668041	20487

	1995	1996	1997	1998	1999	2000	2001
spawning biomass	**8682**	**8821**	**8288**	**3665**	**8314**	**19490**	**7016**
biomass	**69646**	**92656**	**75575**	**56469**	**77926**	**110438**	**58880**
ssb proportion	**12.5%**	**9.5%**	**11.0%**	**6.5%**	**10.7%**	**17.6%**	**11.9%**

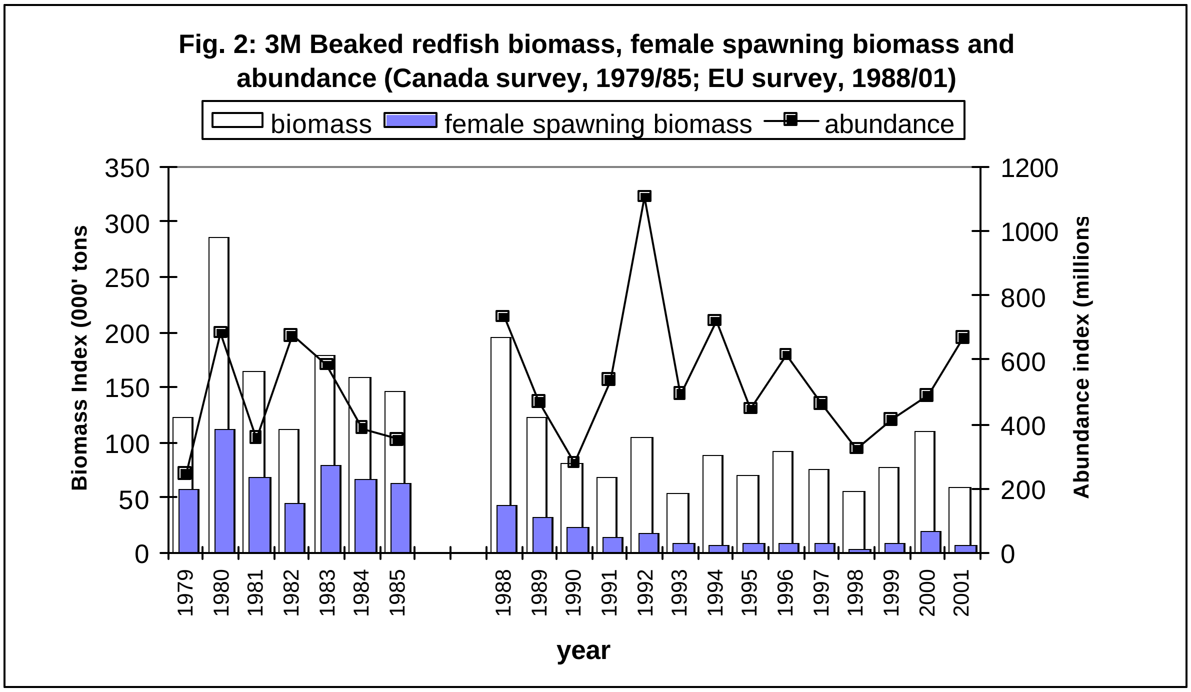


Table 3: Length weight relationships of 3M beaked redfish (Saborido Rey, *pers. comm*. 2002)

	S. mentella		*S. fasciatus*		*Sebastes sp.*	
Year	A	B	A	B	A	B
1989					0.016	2.964
1990					0.023	2.857
1991	0.022	2.861	0.030	2.816	0.031	2.774
1992	0.016	2.968	0.015	3.025	0.025	2.848
1993	0.018	2.938	0.021	2.918	0.023	2.874
1994	0.017	2.951	0.018	2.967	0.023	2.868
1995	0.018	2.937	0.014	3.034	0.024	2.863
1996	0.012	3.046	0.019	2.947	0.018	2.941
1997	0.015	2.983	0.015	3.029	0.025	2.844
1998	0.021	2.891	0.018	2.952	0.026	2.835
1999	0.016	2.958	0.017	2.973	0.020	2.900
2000	0.018	2.937	0.018	2.957	0.023	2.870
2001	0.017	2.953	0.015	3.027	0.025	2.848
1989-00	0.017	2.940	0.018	2.970	0.024	2.849

Table 4-A: Stock abundance at age (' 000) of 3M beaked redfish from EU surveys, 1989-01.

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	0	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	487511
2001	295812	63744	74627	54776	42289	37716	28731	21433	9857	6056	30142	1167	442	269	307	231	92	104	245	668041
total	570469	1008881	593767	1263759	903459	727466	566628	478473	335105	257285	92099	46904	38411	35133	27561	18120	13906	12507	29586	

Table 4-B: Mature female abundance at age (' 000) of 3M beaked redfish from EU surveys, 1989-01.

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
2001					469	1217	2207	3073	2206	2190	7953	468	159	102	111	86	33	38	176	20487
total				183	4753	15572	37899	60956	57811	56022	29151	18300	17417	17152	13982	10644	8210	7600	21565	

Table 4-C: maturity ogive at age for 3M beaked reddish as the average proportion of mature females at age, from the EU survey abundance at age 1989-00.

	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	0.067	0.127	0.173	0.218	0.317	0.390	0.453	0.488	0.507	0.587	0.590	0.608	0.729

Table 5: Catch in numbers at age (' 000) of 3M redfish, 1989-01, 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+
1989		19	156	509	1212	9042	26340	27565	16599	11100	10033	7086	7260	6708	5928	3381	2420	2246	5715
1990			6715	11630	3102	6532	32081	52517	36082	20570	12993	7377	6622	6054	4958	2833	2103	1993	5081
1991				1380	4032	7775	20348	25477	18908	9518	7290	5390	4448	3238	1236	1848	1423	874	3704
1992				259	5725	7676	18580	19850	12776	8118	6134	4873	4687	3611	3229	2136	1301	815	1892
1993		302	3753	106478	10881	8511	7170	7255	3327	5242	5105	4852	3680	3947	3271	1552	1197	1836	1709
1994		746	5093	53387	6637	3094	4624	3633	3311	3000	2314	1639	1196	658	783	344	235	290	413
1995	15	78	910	2931	14563	6056	2046	2607	1671	1584	2014	1224	1039	997	1151	896	519	589	1333
1996	7243	3037	2343	1673	3870	5116	1557	1555	1588	1090	849	811	434	447	313	223	149	147	320
1997	513	1109	447	632	136	636	847	294	308	347	236	209	106	129	29	30	32	11	82
1998	398	3291	725	99	61	116	312	771	464	75	83	389	49	54	13	36	72	5	57
1999	2256	963	220	146	42	16	75	277	638	396	88	122	283	42	84	85	74	113	159
2000	434	2389	256	103	161	233	415	1009	1379	4105	650	181	75	649	64	39	35	42	572
2001	11510	11876	1602	752	333	410	911	1414	941	927	3498	414	127	67	71	65	21	32	67
total	22370	23809	22221	179978	50755	55215	115306	144223	97995	66072	51288	34566	30006	26601	21132	13468	9581	8992	21102

Table 6: Weights at age in the catch (Kg) of 3M redfish, 1989-01.

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
2001	0.017	0.031	0.060	0.093	0.142	0.201	0.254	0.304	0.340	0.388	0.381	0.505	0.574	0.633	0.633	0.580	0.748	0.806	0.926
mean	0.013	0.036	0.070	0.106	0.149	0.214	0.280	0.332	0.379	0.427	0.482	0.542	0.594	0.626	0.645	0.706	0.747	0.760	0.953

Table 7-A: Weights at age of the 3M beaked redfish stock (Kg) from EU surveys, 1989-01.

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
2001	0.018	0.032	0.066	0.092	0.148	0.185	0.242	0.297	0.328	0.379	0.342	0.502	0.578	0.637	0.641	0.599	0.733	0.806	0.927
mean	0.013	0.036	0.067	0.094	0.145	0.200	0.258	0.318	0.363	0.411	0.474	0.544	0.598	0.631	0.650	0.708	0.746	0.760	0.900

Table 7-B: Weights at age of the 3M mature female beaked redfish stock (Kg) from EU surveys, 1989-01.

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
2001					0.171	0.198	0.250	0.306	0.342	0.385	0.373	0.501	0.582	0.638	0.639	0.604	0.737	0.806	0.954
mean				0.072	0.174	0.221	0.280	0.333	0.377	0.424	0.485	0.553	0.608	0.643	0.658	0.722	0.759	0.773	0.923

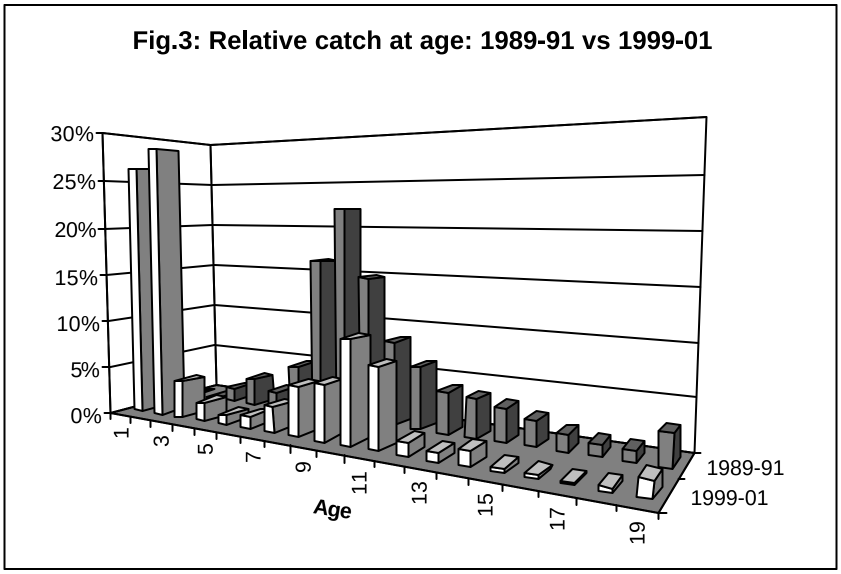


Table 8-A: beaked redfish exploitaion pattern given by the generalized logit of the 1989-01 observed partial recruitment.

Age	F at age index	Observed PR	Logit PR	Squared difference
1	1.249	0.278	0.015	0.069
2	0.660	0.147	0.023	0.015
3	0.481	0.107	0.034	0.005
4	0.731	0.163	0.050	0.013
5	0.344	0.077	0.074	0.000
6	0.519	0.116	0.109	0.000
7	0.989	0.220	0.161	0.003
8	1.214	0.270	0.238	0.001
9	1.492	0.332	0.352	0.000
10	1.884	0.419	0.520	0.010
11	3.688	0.821	0.768	0.003
12	4.491	1.000	0.998	0.000
13	4.493	1.000	1.000	0.000
14	4.491	1.000	1.000	0.000
15	3.923	0.873	1.000	0.016
16	4.356	0.970	1.000	0.001
17	4.099	0.912	1.000	0.008
18	4.287	0.954	1.000	0.002
19+	4.681	1.042	1.000	0.002
		Minimum sum of squares		0.045

Curve parameters	a	b	m
	-105.093	9.000	0.043

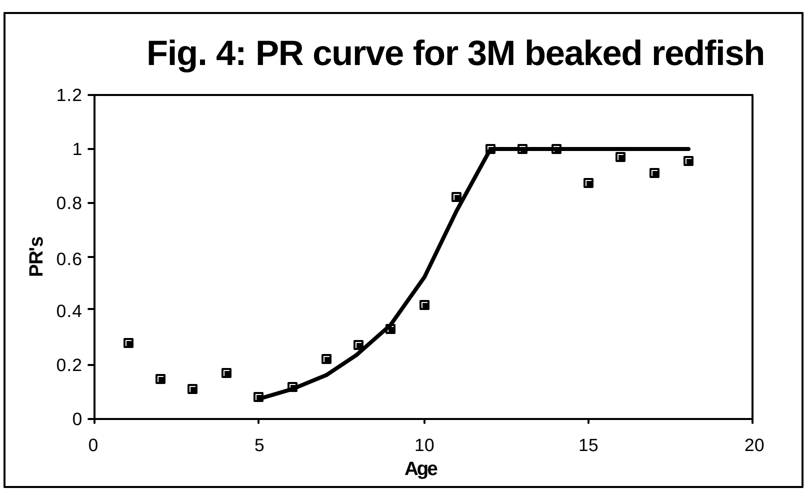


Table 8-B: Female maturity ogive at age for 3M beaked redfish given by a general logit of the 1989-2001 observed maturity at age.

Age	Obs. Mat	Exp. Mat.	Squared difference
1			
2			
3			
4	0.00	0.02	0.000
5	0.01	0.04	0.001
6	0.02	0.06	0.002
7	0.07	0.09	0.001
8	0.13	0.13	0.000
9	0.17	0.18	0.000
10	0.22	0.23	0.000
11	0.32	0.29	0.001
12	0.39	0.35	0.002
13	0.45	0.41	0.002
14	0.49	0.46	0.001
15	0.51	0.52	0.000
16	0.59	0.57	0.000
17	0.59	0.62	0.001
18	0.61	0.67	0.004
19	0.73	0.71	0.000
Minimum sum of squares			0.015

Curve parameters	a	b	m
	5.312	0.162	1509.175

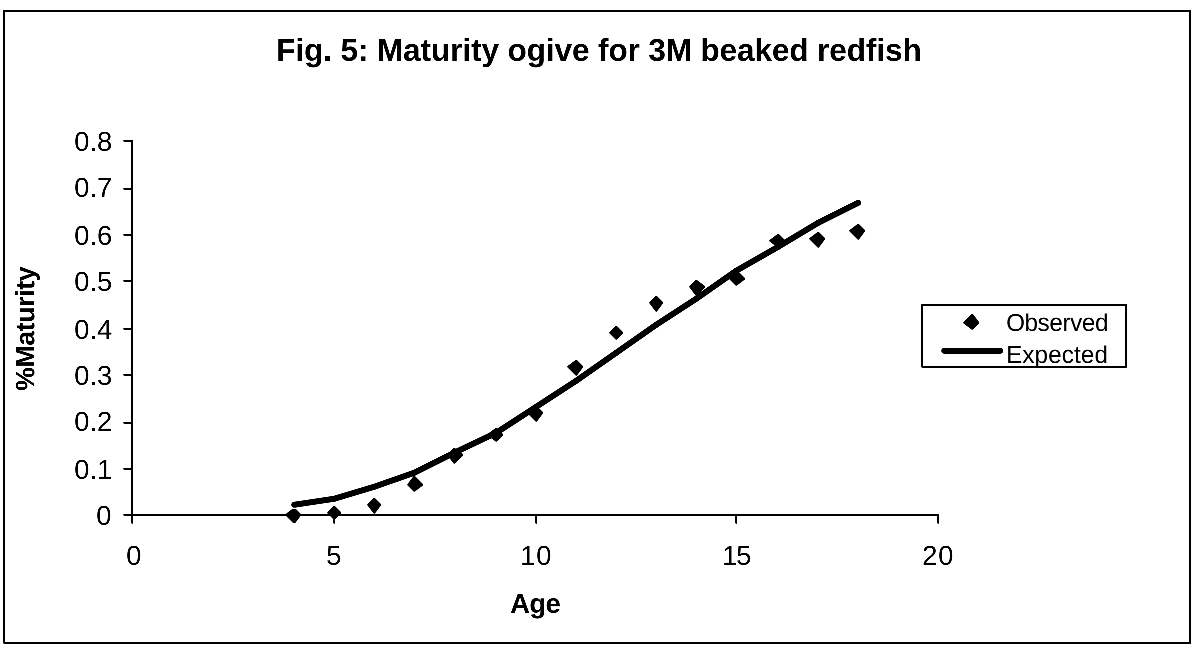


Table 8-C: Yield per recruit parameters for 3M beaked redfish

Age	mean weights 1989-01			% mat females	PR1989-01	Ref. M
	stock	catch	stock mat f			
1	0.013	0.013			0.278	0.20
2	0.036	0.036			0.147	0.20
3	0.067	0.070			0.107	0.10
4	0.094	0.106	0.072	0.021	0.163	0.10
5	0.145	0.149	0.174	0.037	0.074	0.10
6	0.200	0.214	0.221	0.060	0.109	0.10
7	0.258	0.280	0.280	0.092	0.161	0.10
8	0.318	0.332	0.333	0.131	0.238	0.10
9	0.363	0.379	0.377	0.178	0.352	0.10
10	0.411	0.427	0.424	0.231	0.520	0.10
11	0.474	0.482	0.485	0.287	0.768	0.10
12	0.544	0.542	0.553	0.346	0.998	0.10
13	0.598	0.594	0.608	0.406	1.000	0.10
14	0.631	0.626	0.643	0.465	1.000	0.10
15	0.650	0.645	0.658	0.521	1.000	0.10
16	0.708	0.706	0.722	0.575	1.000	0.10
17	0.746	0.747	0.759	0.624	1.000	0.10
18	0.760	0.760	0.773	0.670	1.000	0.10
19+	0.900	0.953	0.923	0.712	1.000	0.10

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

	% SSB	% B	%SSB/B	Ref. F	Yield	SSB	B	F	Slope
	100%	100%	49%	0.00	0	1718	3527	0.01	2391
	86%	90%	47%	0.01	26	1480	3174	0.02	1763
	73%	80%	44%	0.02	51	1248	2824	0.03	1353
	66%	75%	43%	0.03	62	1131	2645	0.04	1103
	59%	70%	41%	0.04	73	1018	2469	0.05	831
Fssb	**50%**	63%	39%	**0.06**	87	861	2220	0.06	636
	46%	60%	38%	0.07	92	797	2117	0.08	496
	40%	55%	36%	0.08	100	691	1942	0.09	342
F0.1	34%	**50%**	33%	**0.10**	107	590	1769	0.10	274
	28%	45%	31%	0.13	112	488	1587	0.15	111
	23%	40%	28%	0.16	116	395	1411	0.18	34
	18%	35%	25%	0.21	117	309	1235	0.24	-17
	13%	30%	22%	0.27	116	231	1059	0.31	-47
	10%	25%	19%	0.35	112	164	882	0.42	-59
	6%	20%	16%	0.49	104	110	707	0.60	-58
	4%	15%	13%	0.70	92	67	531	0.89	-48
	2%	10%	10%	1.07	74	35	356	1.13	-40

Fig 6:Yield, SSB and B per recruit curve for 3M redfish.

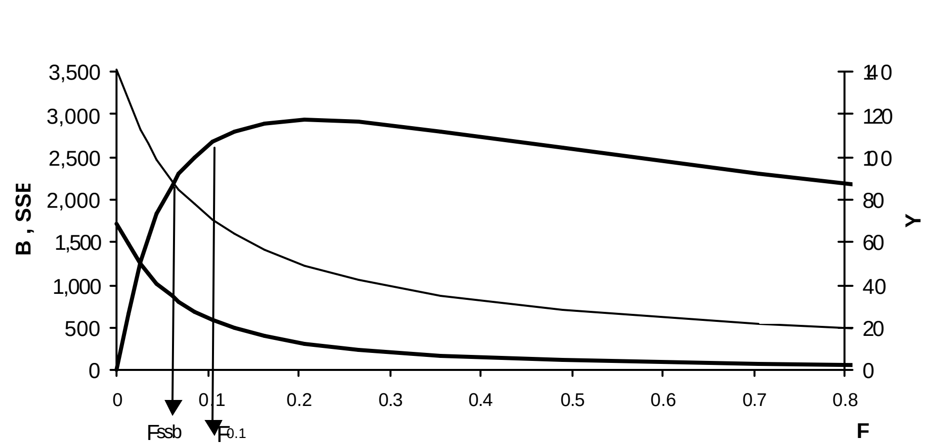


Table 9 : Computation of Z's using female S. mentella length data
(Beverton and Holt, 1957 from Die, D.J. and J.F. Caddy 1997)

1) Mean length in the catch

	1996	1997	1998	1999	2000	2001	mean
$\overline{L}$	27.9	30.9	27.4	30.4	29.9	29.0	29.3

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

	1996	1997	1998	1999	2000	2001	mean
Lc	21.8	20.5	21.0	19.8	20.9	20.8	20.8

3) von Bertalanfy growth parameters

L¥	51.1
K	0.072

4) Length at maturity

Lm	30.14

Z mean 96-01 =	0.186
$Z^*(\overline{L} > L_m) <$	0.161
Assuming M =	0.1
$F^*(\overline{L} > L_m) <$	0.061

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

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

Table 10: Lowestoft VPA input files for 3M beaked redfish (2002 assessment)

REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2002

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	2001
4	19
5	
58100	
81000	
48500	
43300	
40970	
17203	
13874	
5789	
1300	
971	
1068	
3825	
3295	

REDFISH NAFO 3M CATCH NUMBERS thousands

1	2														
1989	2001														
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
752	333	410	911	1414	941	927	3498	414	127	67	71	65	21	32	67

REDFISH NAFO 3M CATCH WEIGHT AT AGE kg

1	3														
1989	2001														
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
0.093	0.142	0.201	0.254	0.304	0.340	0.388	0.381	0.505	0.574	0.633	0.633	0.580	0.748	0.806	0.926

REDFISH NAFO 3M STOCK WEIGHT AT AGE kg

1	4														
1989	2001														
4	19														
1															
0.100	0.161	0.204	0.248	0.287	0.322	0.357	0.445	0.523	0.577	0.602	0.646	0.661	0.719	0.723	0.897
0.101	0.174	0.226	0.272	0.309	0.341	0.374	0.456	0.531	0.587	0.608	0.654	0.670	0.727	0.728	0.894
0.112	0.139	0.222	0.284	0.342	0.391	0.468	0.518	0.573	0.620	0.648	0.694	0.754	0.742	0.770	0.862
0.081	0.169	0.207	0.292	0.354	0.398	0.456	0.531	0.575	0.640	0.681	0.703	0.793	0.754	0.874	0.922
0.068	0.162	0.219	0.292	0.368	0.398	0.436	0.514	0.554	0.623	0.682	0.706	0.830	0.823	0.835	1.061
0.092	0.133	0.229	0.280	0.352	0.398	0.468	0.498	0.537	0.558	0.674	0.664	0.708	0.801	0.827	0.876
0.111	0.122	0.225	0.293	0.359	0.404	0.452	0.507	0.537	0.615	0.673	0.699	0.768	0.774	0.812	0.993
0.078	0.141	0.143	0.273	0.332	0.390	0.450	0.488	0.543	0.593	0.614	0.666	0.710	0.766	0.799	0.956
0.098	0.135	0.200	0.184	0.357	0.405	0.462	0.499	0.562	0.598	0.608	0.662	0.721	0.752	0.708	0.855
0.097	0.145	0.187	0.236	0.227	0.367	0.415	0.475	0.531	0.598	0.657	0.674	0.762	0.765	0.688	0.997
0.090	0.125	0.180	0.226	0.264	0.249	0.328	0.470	0.565	0.514	0.548	0.538	0.551	0.618	0.595	0.730

Table 10: count.

REDFISH NAFO 3M NATURAL MORTALITY

1	5														
1989	2001														
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	2001														
4	19														
2															
0.00	0.01	0.02	0.07	0.13	0.17	0.22	0.32	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	2001
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	2001
4	19
5	
0.159	
0.179	
0.117	
0.134	
0.395	
0.084	
0.226	
0.054	
0.004	
0.002	
0.054	
0.038	
0.038	

REDFISH NAFO 3M F AT AGE IN LAST YEAR

1	10														
1989	2001														
4	19														
2															
0.005	0.003	0.007	0.010	0.022	0.036	0.024	0.109	0.099	0.069	0.214	0.099	0.046	0.036	0.038	0.038

REDFISH NAFO 3M SURVEY TUNNING DATA

101

EU BOTTOM TRAWL SURVEY

1989	2001															
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
10555	54776	42289	37716	28731	21433	9857	6056	30142	1167	442	269	307	231	92	104	245

Table 11a: Extended Survivor Analysis diagnostics for 2002 (Lowestoft VPA Version 3.1)

REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2002
CPUE data from file red3mtun.txt

Catch data for 13 years. 1989 to 2001. Ages 4 to 19.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU BOTTOM TRAWL SURV	1989	2001	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 422 iterations
Regression weights

1	1	1	1	1	1	1	1	1	1

AGE	4	5	6	7	8	9	10	11	12	13
Taper weighted geometric mean of the VPA populations:	60000	47900	44000	37800	29800	20600	14400	10300	6410	5290
Standard error of the weighted Log(VPA populations) :	0.6864	0.6368	0.7706	0.9709	1.1149	1.222	1.2983	1.3432	1.1512	1.2111

AGE	14	15	16	17	18
Taper weighted geometric mean of the VPA populations:	4960	4750	4280	4420	4710
Standard error of the weighted Log(VPA populations) :	1.1706	1.0611	1.0355	0.9533	0.8746

Log catchability residuals.
Fleet : EU BOTTOM TRAWL SURV

Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
4	-1.73	-0.58	1.12	0.87	1.44	0.44	0.32	-1.19	0.17	-0.52	-0.08	-0.28	0
5	-2.41	-3.45	1.07	1.52	-0.53	1.15	0.14	1.33	0.59	-0.3	0.1	0.07	0.74
6	-1.13	-1.73	-0.85	0.87	0.32	0.97	-0.35	0.61	0.67	0.24	0.03	0.31	0.04
7	-0.37	-0.54	-0.75	0.15	-0.47	0.9	0.59	0.33	0.01	-0.26	0.15	0.23	0.03
8	-0.07	-0.2	-0.98	0.23	-0.47	0.04	0.74	1.08	-0.34	-0.43	0.11	0.65	-0.36
9	-0.09	-0.2	-0.91	0.19	-1.14	0.56	-0.03	1.27	0.86	-0.19	0.16	0.4	-0.89
10	-0.28	-0.3	-1.08	0.08	-0.43	0.41	0.96	0.06	1.24	-0.79	0.55	0.6	-1.01
11	-0.18	-0.41	-0.63	-0.08	-0.15	0.67	1.28	1.15	-0.12	-0.24	-0.95	0.35	-0.71
12	-0.45	-0.71	-0.77	-0.2	-0.35	0.34	0.78	1.14	0.98	0.28	-0.19	-0.28	-0.57
13	-0.09	-0.21	-0.39	-0.09	-0.13	0.07	0.67	0.62	0.61	-0.2	-0.16	-0.53	-0.17
14	-0.11	-0.05	-0.28	-0.1	-0.08	-0.32	0.23	0.68	0.65	-0.19	-0.92	0.69	-0.19
15	0.4	0.16	-0.68	0.51	0.32	0.11	0.85	0.44	-0.34	-1.19	0.24	-0.18	-0.64
16	0.17	-0.02	-0.23	0.3	-0.07	-0.28	0.49	0.45	-0.38	-0.4	0.19	-0.53	0.32
17	0.05	0.07	-0.05	0	0.15	-0.1	0.36	0.16	0.21	-0.02	0.01	-0.46	-0.39
18	0	-0.16	-0.58	-0.29	0.5	0.01	0.59	0.17	-1.22	-2.27	0.31	-1.11	-0.53

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	-9.2394	-9.419	-9.4318	-9.2876	-9.2361	-9.4898	-9.7249	-9.984	-9.9268	-10.1533
S.E(Log q)	0.8904	1.4597	0.8122	0.4696	0.567	0.7019	0.7344	0.6867	0.6436	0.3897

Age	14	15	16	17	18
Mean Log q	-10.1793	-10.5612	-10.7234	-10.9933	-10.9933
S.E(Log q)	0.4608	0.5743	0.3451	0.2259	0.881

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	0.84	0.491	9.52	0.46	13	0.77	-9.24
5	2.76	-0.961	7.03	0.03	13	4.04	-9.42
6	1.57	-1.219	8.71	0.29	13	1.25	-9.43
7	1.44	-2.714	8.73	0.77	13	0.55	-9.29
8	1.37	-2.051	8.85	0.74	13	0.69	-9.24
9	1.33	-1.583	9.34	0.68	13	0.88	-9.49
10	1.22	-1.105	9.76	0.7	13	0.89	-9.72
11	1.24	-1.368	10.16	0.74	13	0.82	-9.98
12	1.5	-2.48	10.51	0.69	13	0.81	-9.93
13	1.07	-0.663	10.26	0.9	13	0.43	-10.15
14	1.01	-0.064	10.19	0.86	13	0.48	-10.18
15	0.82	1.42	10.19	0.86	13	0.45	-10.56
16	0.95	0.489	10.61	0.91	13	0.34	-10.72
17	0.89	2.005	10.71	0.97	13	0.18	-10.99
18	0.77	1.178	10.67	0.7	13	0.6	-11.34

Table 11a (count): Extended Survivor Analysis diagnostics for 2002 (Lowestoft VPA Version 3.1)

Terminal year survivor and F summaries :

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 1997

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F	mean se
								0.462
EU BOTTOM TRAWL SURV	50756	0.924	0	0	1	1	0.014	

Age 5 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	mean se
								0.62
EU BOTTOM TRAWL SURV	22434	0.789	0.451	0.57	2	1	0.014	

Age 6 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	mean se
								0.31
EU BOTTOM TRAWL SURV	40616	0.576	0.044	0.08	3	1	0.01	

Age 7 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	mean se
								0.263
EU BOTTOM TRAWL SURV	26855	0.378	0.148	0.39	4	1	0.032	

Age 8 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	mean se
								0.224
EU BOTTOM TRAWL SURV	27890	0.318	0.13	0.41	5	1	0.047	

Age 9 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	mean se
								0.2865
EU BOTTOM TRAWL SURV	28467	0.291	0.282	0.97	6	1	0.031	

Age 10 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	mean se
								0.246
EU BOTTOM TRAWL SURV	24855	0.272	0.22	0.81	7	1	0.035	

Age 11 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	mean se
								0.2105
EU BOTTOM TRAWL SURV	118429	0.255	0.166	0.65	8	1	0.028	

Age 12 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	mean se
								0.203
EU BOTTOM TRAWL SURV	3665	0.25	0.156	0.62	9	1	0.102	

Age 13 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	mean se
								0.23
EU BOTTOM TRAWL SURV	1164	0.236	0.224	0.95	10	1	0.099	

Age 14 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	mean se
								0.2125
EU BOTTOM TRAWL SURV	747	0.235	0.19	0.81	11	1	0.082	

Age 15 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	mean se
								0.1745
EU BOTTOM TRAWL SURV	2004	0.209	0.14	0.67	12	1	0.033	

Age 16 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	mean se
								0.202
EU BOTTOM TRAWL SURV	662	0.215	0.189	0.88	13	1	0.089	

Age 17 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	mean se
								0.185
EU BOTTOM TRAWL SURV	726	0.205	0.165	0.8	13	1	0.027	

Age 18 Catchability constant w.r.t. time and age (fixed at the value for age) 17
Year class = 1983

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F	mean se
								0.196
EU BOTTOM TRAWL SURV	938	0.202	0.19	0.94	13	1	0.032	

Table 11b: Separable VPA diagnostics for 2002 (Lowestoft VPA Version 3.1)

REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2002
Separable analysis
from 1989 to 2001 on ages 4 to 18
with Terminal F of .053 on age 12 and Terminal S of .600 from 2002 XSA
Initial sum of squared residuals was 206.454 and
final sum of squared residuals is 99.516 after 100 iterations

Matrix of Residuals

Years / Ages	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	TOT	WTS
4/ 5	-1.347	0.75	-1.206	-3.532	1.955	1.337	-0.913	0.881	1.651	0.93	0.687	-1.19	0.001	0.144
5/ 6	-0.993	-0.994	-0.197	0.029	0.671	0.367	0.656	0.432	-0.27	1.668	-0.671	-0.695	0.002	0.293
6/ 7	-0.444	-1.079	-0.301	0.59	0.152	0.833	1.13	0.614	0.483	0.967	-2.016	-0.927	0.002	0.242
7/ 8	-0.119	0.025	0.329	1.154	-0.061	0.756	-0.17	0.312	-0.282	0.506	-1.507	-0.94	0.002	0.326
8/ 9	-0.126	0.356	0.55	1.526	-0.451	0.53	-0.377	-0.13	-1.199	0.213	-0.878	-0.012	0.002	0.326
9/10	-0.132	0.6	0.64	0.556	-1.208	0.432	-0.502	-0.272	0.634	0.146	-1.171	0.277	0.002	0.349
10/11	-0.107	0.268	0.198	0.086	-0.537	0.062	-0.334	-0.284	0.635	-0.188	0.179	0.024	0.002	0.744
11/12	0.447	0.204	0.247	-0.076	-0.125	0.4	0.066	-0.278	-1.155	-0.273	0.092	0.452	0.002	0.524
12/13	-0.095	-0.503	-0.328	-0.348	-0.223	-0.094	-0.133	0.038	0.496	0.133	1.003	0.057	0.002	0.571
13/14	0.266	-0.023	-0.007	-0.208	0.39	-0.108	-0.051	-0.507	-0.014	0.234	-0.05	0.08	0.002	1
14/15	-0.016	0.411	-0.623	-0.681	-0.185	-1.274	-0.189	0.555	1.159	-0.808	-0.083	1.736	0.002	0.273
15/16	0.75	0.178	-0.825	0.328	0.86	-0.515	0.633	0.471	-1.075	-1.969	1.38	-0.214	0.002	0.245
16/17	0.449	-0.159	0.038	0.146	0.458	-0.832	0.74	0.013	-1.791	-0.869	1.443	0.364	0.002	0.276
17/18	0.141	0.006	0.221	-0.786	-0.031	-1.374	0.165	0.62	0.876	-0.666	1.058	-0.229	0.002	0.335
TOT	-0.001	-0.001	-0.001	0	0	0.002	0.003	0.003	0.003	0.001	0.001	0	0.023	
WTS	1	1	1	1	1	1	1	1	1	1	1	1		

Fishing Mortalities (F)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
F-values	0.3795	0.6355	0.497	0.6597	0.8934	0.4249	0.4615	0.2521	0.0493	0.0244	0.0256	0.0552	0.0534

Selection-at-age (S)

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S-values	0.147	0.1666	0.2445	0.4404	0.6903	0.7554	0.7985	0.8319	1	0.893	1.0403	0.775	0.7567	0.6972	0.6

Cohort analysis Terminal populations from weighted Separable populations

Fishing mortality residuals

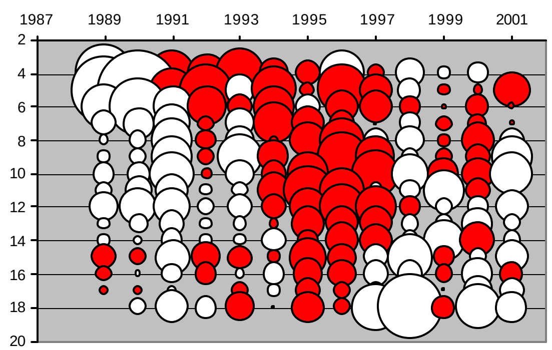
YEAR / AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
4	-0.048	0.1117	-0.0377	-0.0886	1.0126	0.2436	-0.0122	0.0235	0.0203	0.0003	0.001	-0.0042	0
5	-0.048	-0.0519	0.0085	0.0708	0.3515	0.0886	0.0374	0.0452	-0.0026	-0.0011	-0.0025	-0.0034	0.0053
6	-0.0086	-0.0598	0.0451	0.0632	0.1751	0.1243	0.0787	-0.0135	0.0046	-0.0006	-0.0054	-0.0024	0.0036
7	0.0497	0.1423	0.2046	0.361	-0.0926	0.1547	0.0041	-0.0492	-0.0127	-0.0016	-0.0075	0.0008	0.0261
8	0.0524	0.3239	0.275	0.385	-0.112	-0.0745	-0.0256	0.0412	-0.0207	-0.0076	-0.0086	0.0206	0.0639
9	0.0055	0.2846	0.2317	0.1441	-0.3951	0.0812	-0.2158	0.0698	0.0167	0.0054	-0.0109	0.0097	0.024
10	-0.0449	0.1175	0.0108	-0.0221	-0.188	0.0488	-0.065	-0.0932	0.0351	-0.0044	0.0025	0.0185	-0.0026
11	0.0073	-0.0489	0.0022	-0.105	-0.134	0.0577	0.0497	0.0261	-0.0134	0.0004	-0.0015	-0.0028	0.0183
12	-0.0838	-0.2646	-0.1653	-0.1806	-0.2233	-0.0716	-0.1086	0.0244	0.0258	0.0281	0.0088	-0.0086	-0.0219
13	0.0609	-0.1284	-0.0883	-0.1143	-0.0784	-0.0784	-0.0598	-0.0438	0.003	-0.0013	0.0214	-0.0252	-0.01
14	-0.0148	-0.0576	-0.1632	-0.2033	-0.0956	-0.2087	-0.0889	-0.038	0.0162	0.0022	-0.0069	0.0645	-0.0311
15	0.2171	-0.0182	-0.1782	0.1194	0.2795	0.0067	0.3519	-0.0137	-0.0201	-0.0111	0.0293	-0.0086	-0.0256
16	0.1118	-0.0462	-0.0884	0.079	-0.0471	-0.1097	0.3542	0.0593	-0.016	0.0071	0.0389	-0.0156	-0.0006
17	0.0229	-0.0321	0.0133	-0.1597	0.0403	-0.1378	0.1782	0.032	0.0117	0.0419	0.0426	-0.0108	-0.0213
18	0.0004	-0.0202	-0.0323	-0.0755	0.2538	0.0353	0.3684	0.0757	-0.0106	-0.0064	0.0957	0.0068	-0.0032

Table 11c: 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
Catchability independent of age for ages >= 16
Minimum standard error for population estimates derived from EU survey = 0.500

Ages	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
4	-1.73	-0.58	1.12	0.87	1.44	0.44	0.32	-1.19	0.17	-0.52	-0.08	-0.28	0.00	
5	-2.41	-3.45	1.07	1.52	-0.53	1.15	0.14	1.33	0.59	-0.30	0.10	0.07	0.74	
6	-1.13	-1.73	-0.85	0.87	0.32	0.97	-0.35	0.61	0.67	0.24	0.03	0.31	0.04	
7	-0.37	-0.54	-0.75	0.15	-0.47	0.90	0.59	0.33	0.01	-0.26	0.15	0.23	0.03	
8	-0.07	-0.20	-0.98	0.23	-0.47	0.04	0.74	1.08	-0.34	-0.43	0.11	0.65	-0.36	
9	-0.09	-0.20	-0.91	0.19	-1.14	0.56	-0.03	1.27	0.86	-0.19	0.16	0.40	-0.89	
10	-0.28	-0.30	-1.08	0.08	-0.43	0.41	0.96	0.06	1.24	-0.79	0.55	0.60	-1.01	
11	-0.18	-0.41	-0.63	-0.08	-0.15	0.67	1.28	1.15	-0.12	-0.24	-0.95	0.35	-0.71	
12	-0.45	-0.71	-0.77	-0.20	-0.35	0.34	0.78	1.14	0.98	0.28	-0.19	-0.28	-0.57	
13	-0.09	-0.21	-0.39	-0.09	-0.13	0.07	0.67	0.62	0.61	-0.20	-0.16	-0.53	-0.17	
14	-0.11	-0.05	-0.28	-0.10	-0.08	-0.32	0.23	0.68	0.65	-0.19	-0.92	0.69	-0.19	
15	0.40	0.16	-0.68	0.51	0.32	0.11	0.85	0.44	-0.34	-1.19	0.24	-0.18	-0.64	
16	0.17	-0.02	-0.23	0.30	-0.07	-0.28	0.49	0.45	-0.38	-0.40	0.19	-0.53	0.32	
17	0.05	0.07	-0.05	0.00	0.15	-0.10	0.36	0.16	0.21	-0.02	0.01	-0.46	-0.39	**Ssquares**
18	0.00	-0.16	-0.58	-0.29	0.50	0.01	0.59	0.17	-1.22	-2.27	0.31	-1.11	-0.53	**92.10**

Fig. 7a: Eu survey log q residuals from XSA



Ages	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	
4/ 5	-1.35	0.75	-1.21	-3.53	1.96	1.34	-0.91	0.88	1.65	0.93	0.69	-1.19	
5/ 6	-0.99	-0.99	-0.20	0.03	0.67	0.37	0.66	0.43	-0.27	1.67	-0.67	-0.70	
6/ 7	-0.44	-1.08	-0.30	0.59	0.15	0.83	1.13	0.61	0.48	0.97	-2.02	-0.93	
7/ 8	-0.12	0.03	0.33	1.15	-0.06	0.76	-0.17	0.31	-0.28	0.51	-1.51	-0.94	
8/ 9	-0.13	0.36	0.55	1.53	-0.45	0.53	-0.38	-0.13	-1.20	0.21	-0.88	-0.01	
9/10	-0.13	0.60	0.64	0.56	-1.21	0.43	-0.50	-0.27	0.63	0.15	-1.17	0.28	
10/11	-0.11	0.27	0.20	0.09	-0.54	0.06	-0.33	-0.28	0.64	-0.19	0.18	0.02	
11/12	0.45	0.20	0.25	-0.08	-0.13	0.40	0.07	-0.28	-1.16	-0.27	0.09	0.45	
12/13	-0.10	-0.50	-0.33	-0.35	-0.22	-0.09	-0.13	0.04	0.50	0.13	1.00	0.06	
13/14	0.27	-0.02	-0.01	-0.21	0.39	-0.11	-0.05	-0.51	-0.01	0.23	-0.05	0.08	
14/15	-0.02	0.41	-0.62	-0.68	-0.19	-1.27	-0.19	0.56	1.16	-0.81	-0.08	1.74	
15/16	0.75	0.18	-0.83	0.33	0.86	-0.52	0.63	0.47	-1.08	-1.97	1.38	-0.21	
16/17	0.45	-0.16	0.04	0.15	0.46	-0.83	0.74	0.01	-1.79	-0.87	1.44	0.36	**Ssquares**
17/18	0.14	0.01	0.22	-0.79	-0.03	-1.37	0.17	0.62	0.88	-0.67	1.06	-0.23	**99.52**

Fig. 7b: log catch ratio residuals from SPA

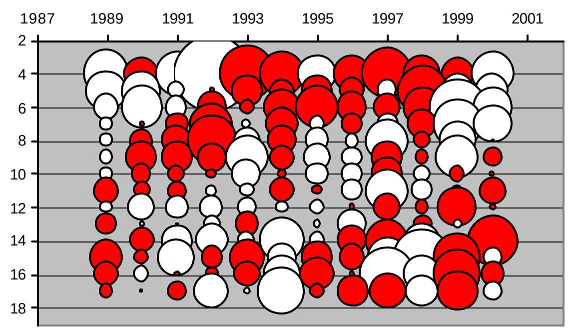
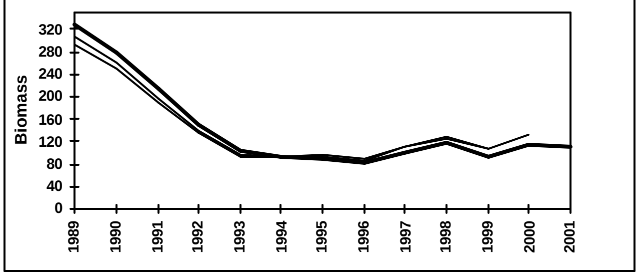


Table 11d: Retrospective XSA, 2001-1994.

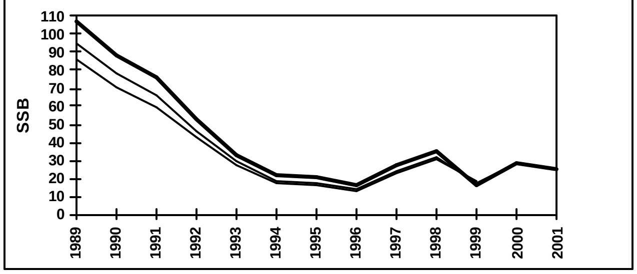
Biomass	2001	2000	1999	99-01 Bias	
1989	328.1	305.6	291.9	-11%	under
1990	278.0	259.5	248.2	-11%	under
1991	213.4	197.3	187.7	-12%	under
1992	149.9	139.0	134.0	-11%	under
1993	102.4	95.6	94.2	-8%	under
1994	93.1	92.7	93.7	1%	over
1995	89.9	92.5	94.5	5%	over
1996	80.2	86.0	88.1	10%	over
1997	101.4	109.0	109.8	8%	over
1998	116.9	126.6	124.5	6%	over
1999	91.4	106.4	107.2	17%	over
2000	115.2	130.1	00-01 Bias	13%	over
2001	110.9				

Fig. 8a: Biomass (thousand tons)



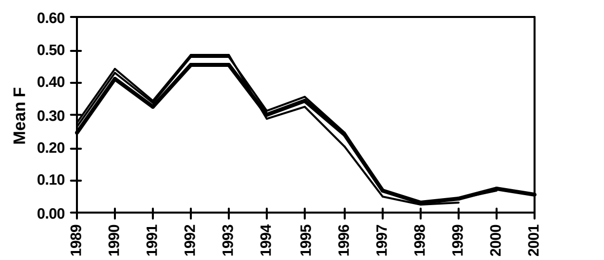
SSB	2001	2000	1999	99-01 Bias	
1989	107.4	94.4	86.1	-20%	under
1990	88.7	77.9	70.9	-20%	under
1991	76.1	66.5	59.9	-21%	under
1992	52.9	46.6	42.5	-20%	under
1993	33.1	29.1	27.1	-18%	under
1994	22.0	18.9	17.7	-20%	under
1995	20.7	17.5	16.3	-21%	under
1996	16.3	14.1	13.5	-17%	under
1997	27.2	24.0	22.8	-16%	under
1998	34.8	32.1	30.4	-13%	under
1999	15.8	17.0	18.2	15%	over
2000	28.5	29.0	00-01 Bias	2%	over
2001	25.6				

Fig. 8b: SSB (thousand tons)



FBAR	2001	2000	1999	99-01 Bias	
1989	0.249	0.265	0.277	11%	over
1990	0.410	0.430	0.443	8%	over
1991	0.325	0.339	0.345	6%	over
1992	0.456	0.477	0.486	7%	over
1993	0.454	0.481	0.484	7%	over
1994	0.303	0.315	0.292	-4%	under
1995	0.343	0.357	0.327	-5%	under
1996	0.241	0.248	0.201	-16%	under
1997	0.067	0.068	0.051	-23%	under
1998	0.034	0.034	0.029	-17%	under
1999	0.045	0.044	0.035	-23%	under
2000	0.073	0.067	00-01 Bias	-8%	under
2001	0.053				

Fig. 8c; Mean F



REC	2001	2000	1999	99-01 Bias	
1989	66	65	65	-1%	under
1990	58	59	58	-0.1%	under
1991	36	36	44	22%	over
1992	27	28	32	19%	over
1993	143	145	146	2%	over
1994	362	410	418	16%	over
1995	63	77	82	29%	over
1996	57	75	66	16%	over
1997	50	63	59	18%	over
1998	42	45	32	-24%	under
1999	56	59	54	-2%	under
2000	28	23	00-01 Bias	-18%	under
2001	57				

Fig. 8d: Recruitment (millions - age 4)

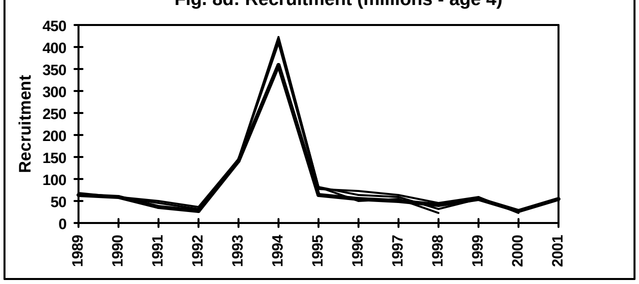


Table 12: Extended Survivor Analysis results for 2002 (Lowestoft version 3.1)

Run title : REDFISH NAFO DIVISION 3M INDEX OF INPUT FILES 2002
Terminal Fs derived using XSA (Without F shrinkage)

(Table 8) Fishing mortality (F) at age

YEAR AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	FBAR 99-01
4	0.0081	0.2345	0.0409	0.0101	1.5264	0.1685	0.0498	0.0312	0.0135	0.0025	0.0028	0.0039	0.014	0.0069
5	0.0155	0.0566	0.1067	0.2125	0.6403	0.2852	0.0569	0.0774	0.0029	0.0015	0.0012	0.0034	0.014	0.0062
6	0.0845	0.0979	0.1759	0.2705	0.4928	0.3311	0.4046	0.023	0.0147	0.0027	0.0004	0.0072	0.0096	0.0057
7	0.2152	0.424	0.4372	0.7092	0.3866	0.482	0.3381	0.1528	0.0043	0.0081	0.0019	0.0121	0.0318	0.0153
8	0.3002	0.7531	0.6227	0.8945	0.5897	0.307	0.4875	0.4124	0.0351	0.0043	0.008	0.0291	0.0471	0.0281
9	0.2697	0.7062	0.5925	0.6516	0.3118	0.5195	0.2017	0.5498	0.1185	0.0643	0.004	0.0451	0.031	0.0267
10	0.2256	0.5516	0.3555	0.4839	0.5388	0.4535	0.4466	0.1756	0.1948	0.0344	0.0646	0.0286	0.0349	0.0427
11	0.2744	0.3967	0.3401	0.3625	0.5667	0.4281	0.5546	0.4057	0.047	0.0585	0.0465	0.1291	0.0277	0.0678
12	0.2499	0.2965	0.2526	0.3556	0.4812	0.3154	0.3746	0.4003	0.1463	0.0918	0.1031	0.1145	0.1021	0.1065
13	0.3031	0.347	0.2613	0.3231	0.4407	0.1843	0.3008	0.1961	0.0738	0.0417	0.0805	0.0766	0.0988	0.0853
14	0.2886	0.3949	0.2538	0.3119	0.4386	0.1159	0.2064	0.1826	0.0738	0.0441	0.0412	0.2388	0.0819	0.1206
15	0.3172	0.3192	0.1157	0.3834	0.4564	0.1286	0.2712	0.0829	0.0145	0.0086	0.0806	0.0734	0.0331	0.0624
16	0.2118	0.2196	0.1683	0.2669	0.2853	0.0696	0.1906	0.069	0.0092	0.0202	0.0642	0.044	0.0893	0.0659
17	0.1335	0.1769	0.1465	0.1538	0.21	0.0568	0.128	0.0394	0.0114	0.0248	0.0474	0.0306	0.0271	0.0351
18	0.1267	0.1393	0.0931	0.1053	0.3003	0.0646	0.1767	0.0437	0.0033	0.002	0.0445	0.031	0.0319	0.0358
+gp	0.1267	0.1393	0.0931	0.1053	0.3003	0.0646	0.1767	0.0437	0.0033	0.002	0.0445	0.031	0.0319	
FBAR 6-16	0.2491	0.4097	0.3251	0.4557	0.4535	0.3032	0.3433	0.2409	0.0665	0.0344	0.045	0.0726	0.0534	

(Table 9) Relative F at age

YEAR AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	MEAN 99-01
4	0.0327	0.5723	0.1259	0.0222	3.3659	0.5557	0.1449	0.1295	0.2029	0.0724	0.0613	0.0536	0.2622	0.1257
5	0.0624	0.1382	0.3284	0.4664	1.4119	0.9405	0.1658	0.3211	0.0429	0.0422	0.026	0.0465	0.2627	0.1117
6	0.3391	0.239	0.5412	0.5936	1.0867	1.0922	1.1784	0.0955	0.2211	0.0783	0.0094	0.0993	0.179	0.0959
7	0.8639	1.035	1.345	1.5561	0.8526	1.5897	0.9848	0.6342	0.0641	0.2344	0.0429	0.1673	0.595	0.2684
8	1.2051	1.8382	1.9156	1.9627	1.3003	1.0125	1.4199	1.7116	0.5269	0.1252	0.1774	0.4015	0.8824	0.4871
9	1.0827	1.7237	1.8228	1.4297	0.6875	1.7136	0.5874	2.2822	1.7806	1.8669	0.088	0.621	0.58	0.4297
10	0.9058	1.3464	1.0937	1.0619	1.188	1.4957	1.3007	0.729	2.9278	1.0004	1.4368	0.394	0.6531	0.828
11	1.1015	0.9682	1.0463	0.7954	1.2496	1.4121	1.6153	1.6838	0.7069	1.7006	1.0334	1.7786	0.5191	1.1104
12	1.0032	0.7236	0.777	0.7803	1.061	1.0403	1.0909	1.6615	2.199	2.6676	2.2906	1.5771	1.912	1.9266
13	1.2166	0.847	0.8039	0.7091	0.9718	0.608	0.8762	0.8138	1.1086	1.211	1.7886	1.0553	1.8508	1.5649
14	1.1585	0.9638	0.7809	0.6844	0.9671	0.3822	0.6011	0.7578	1.1093	1.28	0.9147	3.2886	1.5339	1.9124
15	1.2734	0.7791	0.3559	0.8413	1.0064	0.4242	0.7899	0.344	0.2174	0.2489	1.7914	1.0108	0.621	1.141
16	0.8503	0.536	0.5177	0.5856	0.6291	0.2295	0.5553	0.2866	0.1382	0.5867	1.4269	0.6064	1.6737	1.2357
17	0.5361	0.4319	0.4508	0.3376	0.4632	0.1875	0.3729	0.1634	0.1713	0.7207	1.0546	0.422	0.5086	0.6617
18	0.5086	0.34	0.2864	0.231	0.6622	0.2132	0.5147	0.1813	0.0493	0.0576	0.99	0.4264	0.5984	0.6716
+gp	0.5086	0.34	0.2864	0.231	0.6622	0.2132	0.5147	0.1813	0.0493	0.0576	0.99	0.4264	0.5984	
REFMEAN	0.2491	0.4097	0.3251	0.4557	0.4535	0.3032	0.3433	0.2409	0.0665	0.0344	0.045	0.0726	0.0534	

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

YEAR AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	GMST 89-99	AMST 89-99	GM99-01
4	66029	58497	36188	27007	143017	361951	63486	57253	49543	41806	55691	27895	56883	0	64612	87316	44541
5	82639	59262	41868	31432	24191	28122	276724	54657	50214	44227	37734	50252	25143	50756	50591	66461	
6	117358	73622	50672	34048	22995	11538	19133	236537	45774	45306	39960	34103	45317	22434	44867	63359	
7	143013	97589	60402	38454	23506	12711	7497	11551	209161	40813	40884	36142	30636	40616	38714	62326	
8	111749	104348	57786	35299	17121	14449	7103	4838	8971	188451	36632	36922	32308	26855	29068	53341	
9	73818	74894	44462	28052	13058	8590	9618	3947	2898	7838	169784	32883	32449	27890	18951	39724	
10	57772	51004	33445	22245	13230	8650	4623	7113	2061	2329	6650	153020	28442	28467	10920	19011	
11	43954	41716	26583	21208	12406	6985	4974	2676	5400	1535	2036	5641	134554	24855	8644	15407	
12	33689	30227	25387	17119	13355	6370	4119	2584	1614	4661	1310	1759	4486	118429	7454	12767	
13	29193	23743	20334	17844	10855	7469	4204	2563	1567	1262	3848	1069	1419	3665	6894	11171	
14	28132	19509	15184	14167	11687	6321	5620	2816	1906	1317	1095	3212	896	1164	6025	9796	
15	22927	19074	11894	10659	9384	6821	5094	4137	2123	1602	1140	951	2289	747	5879	8623	
16	18621	15107	12543	9586	6573	5380	5427	3514	3446	1893	1437	952	800	2004	5718	7593	
17	20351	13633	10974	9591	6642	4471	4541	4058	2968	3089	1679	1219	824	662	5792	7454	
18	19844	16113	10335	8576	7441	4871	3822	3615	3530	2655	2727	1449	1070	726	6000	7594	
+gp	50419	41013	43748	19884	6906	6931	8634	7863	26304	30250	3834	19715	2239	2900			
0 TOTAL	919509	739351	501805	345173	342368	501631	434619	409723	417479	419035	406442	407185	399754	352169			

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

YEAR AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	819	585	412	307	228	273	2733	539	498	439	374	498	249
6	2313	1449	991	661	439	223	368	4684	907	899	793	676	898
7	9762	6551	4050	2523	1583	849	507	792	14520	2832	2839	2507	2122
8	14070	12670	7090	4238	2106	1818	881	604	1154	24295	4721	4751	4151
9	12183	11937	7151	4491	2148	1390	1596	637	484	1315	28624	5526	5459
10	12383	10651	7095	4671	2766	1821	974	1531	443	507	1444	33320	6190
11	13650	12829	8212	6540	3764	2143	1510	823	1708	485	644	1772	42620
12	12776	11421	9626	6438	4972	2403	1547	968	617	1790	503	674	1721
13	12720	10309	8889	7762	4678	3285	1832	1126	695	561	1707	474	629
14	13363	9188	7233	6717	5485	3044	2687	1349	921	638	531	1532	433
15	11309	9407	5962	5230	4578	3416	2522	2079	1073	810	573	478	1155
16	10716	8688	7243	5492	3761	3131	3128	2046	2015	1106	837	555	465
17	11785	7867	6348	5545	3823	2605	2631	2368	1735	1805	979	712	481
18	11887	9642	6208	5146	4396	2933	2281	2180	2136	1606	1644	874	646
+gp	36144	29372	31447	14279	4883	4993	6165	5674	19044	21903	2766	14242	1617

Table 12 (count): Extended Survivor Analysis results for 2002 (Lowestoft 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	2001
AGE													
4	6603	5908	4053	2188	9725	33300	7047	4466	4855	4055	5012	2734	5233
5	13305	10312	5820	5312	3919	3740	33760	7707	6779	6413	4717	6784	3721
6	23941	16639	11249	7048	5036	2642	4305	33825	9155	8472	7193	6036	8384
7	35467	26544	17154	11228	6864	3559	2197	3153	38486	9632	9240	8602	7414
8	32072	32243	19763	12496	6300	5086	2550	1606	3203	42778	9671	10634	9596
9	23769	25539	17385	11165	5197	3419	3886	1539	1174	2876	42276	10950	10643
10	20625	19075	15652	10144	5768	4048	2090	3201	952	967	2181	46212	10780
11	19559	19022	13770	11261	6377	3478	2522	1306	2694	729	957	2392	46017
12	17619	16051	14547	9844	7399	3420	2212	1403	907	2475	740	937	2252
13	16844	13937	12607	11420	6763	4168	2586	1520	937	755	1978	719	820
14	16936	11862	9839	9648	7971	4261	3782	1729	1159	865	600	1834	571
15	14811	12474	8254	7493	6625	4529	3561	2755	1405	1080	614	481	1467
16	12309	10121	9457	7602	5456	3809	4168	2495	2484	1443	792	647	479
17	14633	9911	8143	7232	5467	3582	3514	3108	2232	2363	1037	880	604
18	14347	11730	7958	7496	6213	4029	3104	2888	2499	1827	1622	1046	862
+gp	45226	36666	37711	18333	7327	6072	8574	7517	22490	30160	2799	14294	2075
0 TOTALBIO	328066	278035	213362	149909	102407	93141	89856	80219	101411	116889	91429	115183	110919

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

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE													
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	132	102	57	52	37	36	333	76	67	64	47	67	37
6	472	328	220	137	96	51	83	670	181	168	143	120	166
7	2421	1782	1150	737	462	238	148	216	2672	668	642	597	514
8	4038	3915	2425	1500	775	640	316	200	412	5515	1246	1368	1233
9	3923	4070	2796	1787	855	553	645	248	196	483	7127	1840	1790
10	4421	3983	3320	2130	1206	852	440	689	205	210	474	10063	2346
11	6074	5850	4254	3473	1935	1067	766	401	852	230	303	751	14576
12	6682	6064	5515	3702	2754	1290	830	526	347	951	284	359	864
13	7339	6051	5511	4968	2914	1833	1127	668	416	336	877	319	363
14	8044	5587	4687	4574	3741	2052	1809	828	560	419	291	875	276
15	7306	6152	4138	3677	3232	2268	1763	1385	710	546	308	242	740
16	7083	5821	5461	4355	3121	2217	2402	1452	1453	843	461	378	278
17	8473	5719	4710	4181	3146	2087	2036	1814	1305	1380	605	514	353
18	8594	7020	4780	4498	3671	2425	1852	1742	1512	1105	978	631	521
+gp	32421	26259	27107	13165	5180	4374	6122	5425	16282	21838	2020	10326	1499
0 TOTSPBIO	107424	88703	76133	52935	33126	21984	20672	16340	27170	34756	15805	28450	25556

(Table 14) Stock biomass at age with SOP (start of year) Tonnes

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE													
4	6603	5964	4051	2187	9810	34249	7080	4272	4555	3925	4910	2729	5096
5	13304	10409	5816	5312	3953	3847	33918	7373	6360	6207	4621	6772	3623
6	23940	16795	11243	7047	5080	2718	4325	32360	8589	8201	7047	6026	8164
7	35466	26794	17145	11228	6924	3661	2207	3017	36108	9323	9052	8587	7219
8	32071	32547	19752	12495	6356	5231	2562	1537	3005	41407	9474	10615	9344
9	23768	25779	17375	11164	5243	3516	3904	1473	1101	2784	41416	10931	10364
10	20624	19255	15644	10143	5819	4164	2099	3062	893	936	2137	46131	10497
11	19559	19202	13763	11261	6433	3578	2533	1250	2528	706	938	2387	44810
12	17619	16202	14539	9843	7464	3518	2222	1343	851	2396	725	936	2193
13	16844	14068	12600	11419	6822	4286	2598	1454	879	730	1938	718	799
14	16935	11973	9834	9647	8041	4382	3800	1654	1087	838	588	1831	556
15	14810	12592	8250	7493	6683	4658	3577	2636	1318	1045	601	480	1429
16	12308	10217	9452	7601	5504	3918	4187	2387	2331	1396	776	646	466
17	14632	10005	8138	7231	5514	3684	3531	2974	2094	2288	1016	879	588
18	14346	11841	7954	7495	6268	4144	3118	2763	2345	1768	1589	1044	840
+gp	45224	37011	37691	18331	7392	6245	8614	7192	21100	29193	2742	14269	2021
0 TOTALBIO	328053	280654	213247	149896	103305	95797	90275	76746	95145	113142	89569	114981	108008

(Table 15) Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE													
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	132	103	57	52	37	37	335	73	63	62	46	67	36
6	472	331	220	137	97	53	83	641	170	163	140	119	162
7	2421	1799	1150	737	466	245	149	207	2507	647	628	596	500
8	4038	3952	2424	1500	782	658	318	192	386	5338	1221	1366	1200
9	3923	4109	2795	1787	862	569	648	238	184	467	6982	1837	1743
10	4421	4021	3318	2130	1216	876	442	659	192	204	464	10045	2284
11	6074	5905	4252	3472	1952	1097	769	384	799	223	297	750	14193
12	6682	6121	5512	3701	2779	1327	834	503	325	920	278	359	841
13	7339	6108	5508	4968	2940	1885	1132	639	390	325	859	319	354
14	8044	5639	4684	4574	3774	2110	1817	792	525	406	285	873	268
15	7305	6210	4135	3676	3260	2333	1771	1325	666	528	302	242	721
16	7083	5876	5458	4355	3149	2280	2414	1389	1363	816	452	377	271
17	8473	5773	4708	4181	3174	2146	2046	1735	1224	1336	593	513	344
18	8594	7086	4777	4497	3703	2495	1860	1666	1419	1070	958	630	507
+gp	32420	26506	27092	13164	5226	4499	6150	5190	15276	21138	1978	10307	1460

Table 12 (count): Extended Survivor Analysis results for 2002 (Lowestoft 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	FBAR 6-16	ABUNDANCE
1989	66029	328066	107424	58100	0.541	0.249	919509
1990	58497	278035	88703	81000	0.913	0.410	739351
1991	36188	213362	76133	48500	0.637	0.325	501805
1992	27007	149909	52935	43300	0.818	0.456	345173
1993	143017	102407	33126	40970	1.237	0.454	342368
1994	361951	93141	21984	17203	0.783	0.303	501631
1995	63486	89856	20672	13874	0.671	0.343	434619
1996	57253	80219	16340	5789	0.354	0.241	409723
1997	49543	101411	27170	1300	0.048	0.067	417479
1998	41806	116889	34756	971	0.028	0.034	419035
1999	55691	91429	15805	1068	0.068	0.045	406442
2000	27895	115183	28450	3825	0.134	0.073	407185
2001	56883	110919	25556	3295	0.129	0.053	399754
Arith. Mean	80404	143910	42235	24553	0.489	0.235	
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

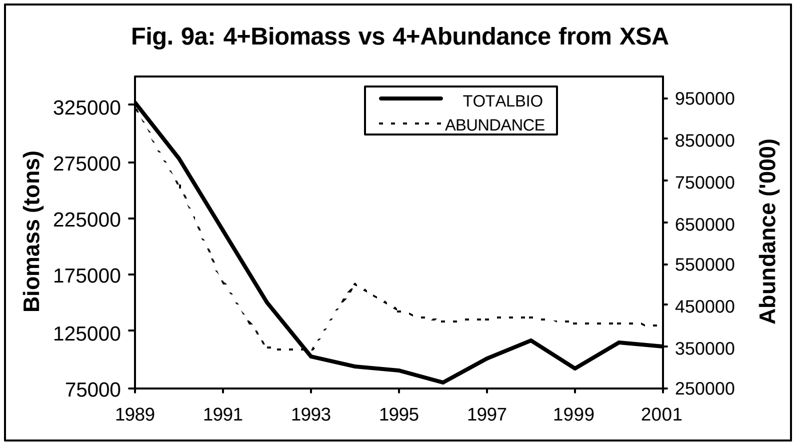


Fig. 9a: 4+Biomass vs 4+Abundance from XSA
TOTALBIO
ABUNDANCE
Biomass (tons)
Abundance ('000)
325000
275000
225000
175000
125000
75000
950000
850000
750000
650000
550000
450000
350000
250000
1989
1991
1993
1995
1997
1999
2001

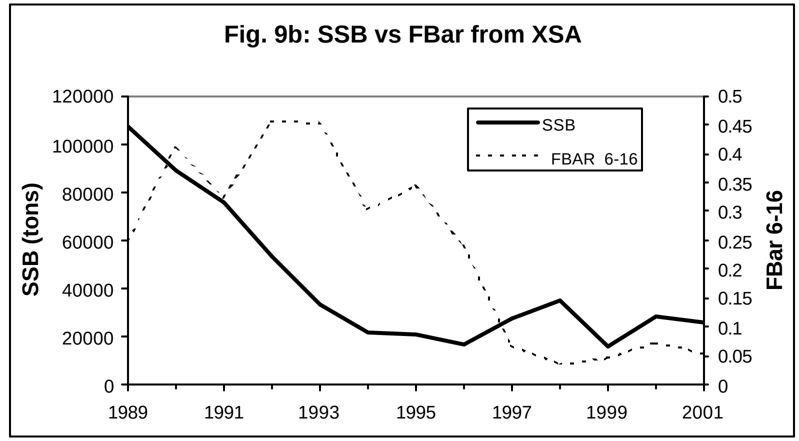


Fig. 9b: SSB vs FBar from XSA
SSB
FBAR 6-16
SSB (tons)
FBar 6-16
120000
100000
80000
60000
40000
20000
0
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1989
1991
1993
1995
1997
1999
2001

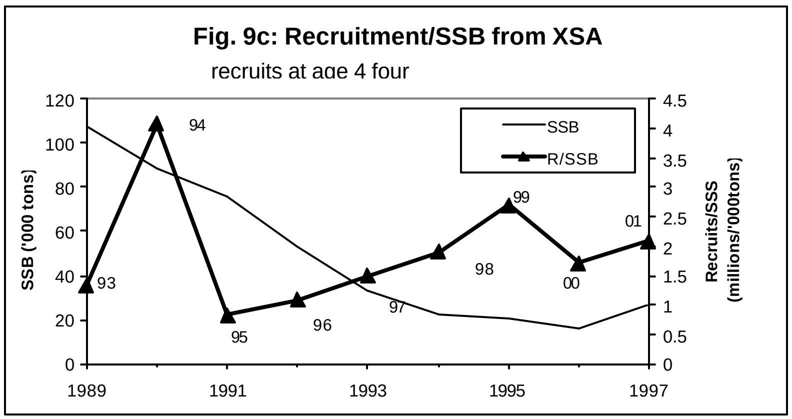


Fig. 9c: Recruitment/SSB from XSA
recruits at age 4 four
SSB
R/SSB
SSB ('000 tons)
Recruits/SSS (millions/'000tons)
93
94
95
96
97
98
99
00
01
1989
1991
1993
1995
1997

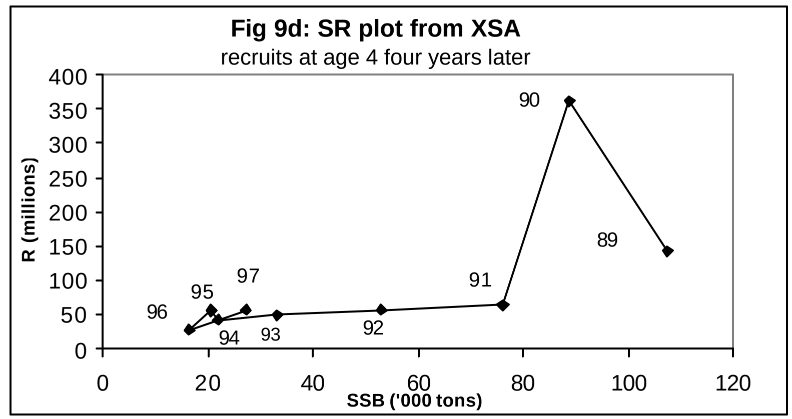


Fig 9d: SR plot from XSA
recruits at age 4 four years later
R (millions)
SSB ('000 tons)
89
90
91
92
93
94
95
96
97
0
20
40
60
80
100
120
400
350
300
250
200
150
100
50

Table 13a: The VPA 4 plus biomass ('000 tons).

Year	XSA	Cohort
1989	328.1	269.4
1990	278.0	224.6
1991	213.4	163.8
1992	149.9	118.0
1993	102.4	85.9
1994	93.1	68.6
1995	89.9	65.6
1996	80.2	55.7
1997	101.4	61.3
1998	116.9	68.7
1999	91.4	62.0
2000	115.2	80.9
2001	110.9	81.9

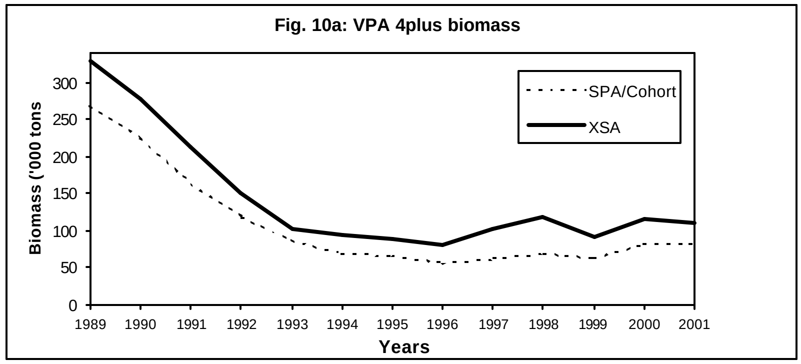


Table 13b: The VPA spawnning stock biomass ('000 tons).

Year	XSA	Cohort
1989	107.4	74.5
1990	88.7	56.8
1991	76.1	45.1
1992	52.9	32.3
1993	33.1	20.7
1994	22.0	11.6
1995	20.7	11.2
1996	16.3	8.5
1997	27.2	11.4
1998	34.8	16.1
1999	15.8	12.6
2000	28.5	23.3
2001	25.6	20.1

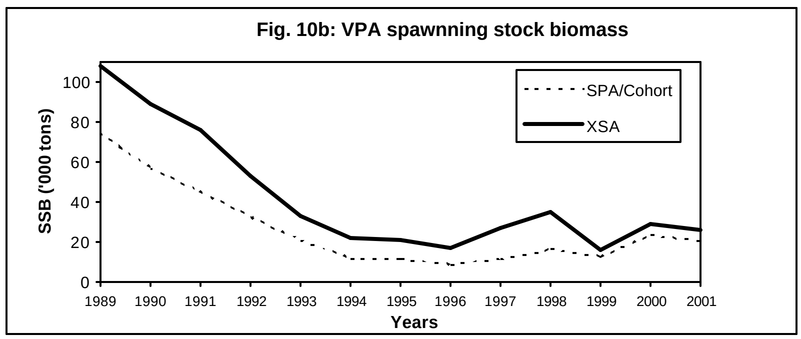


Table 13c: The VPA fishing mortalities (6-16).

Year	XSA	Cohort
1989	0.25	0.32
1990	0.41	0.50
1991	0.33	0.38
1992	0.46	0.54
1993	0.45	0.59
1994	0.30	0.31
1995	0.34	0.37
1996	0.24	0.19
1997	0.07	0.04
1998	0.03	0.02
1999	0.05	0.02
2000	0.07	0.05
2001	0.05	0.04

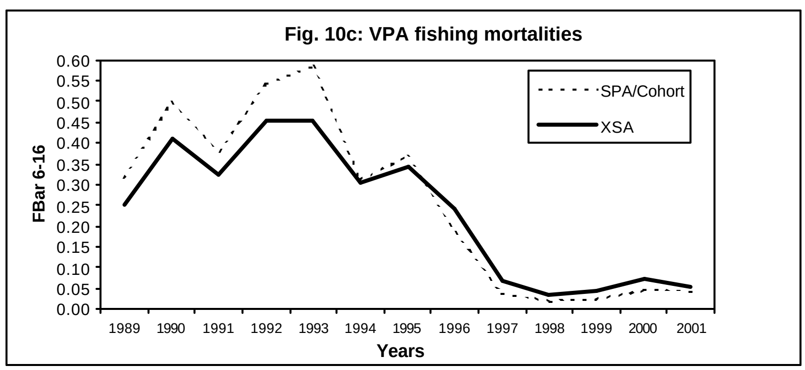


Table 13d: The VPA recruitment at age 4 ('000)

Year	XSA	Cohort
1989	66029	69195
1990	58497	65925
1991	36188	41694
1992	27007	32388
1993	143017	164265
1994	361951	212847
1995	63486	56956
1996	57253	29915
1997	49543	24474
1998	41806	27175
1999	55691	32269
2000	27895	27469
2001	56883	101025

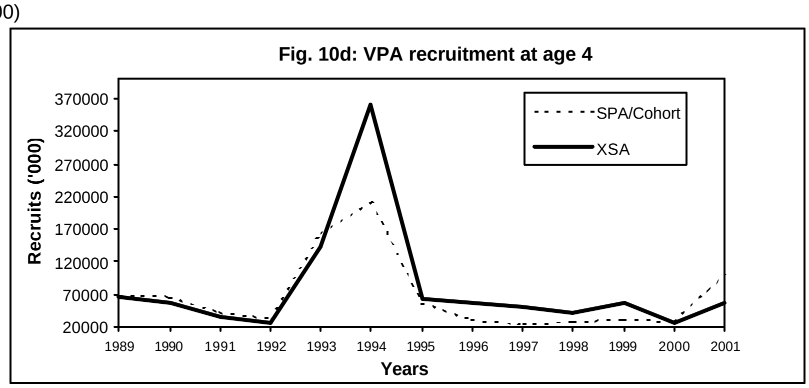


Table 14a:ASPIC input file on bootstrap mode.

```
'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)
0.69d0 0.0d0           ## q (starting guess)
1 1 1 0 1             ## Flags to estimate parameters
0.5d4  5.0d4            ## Min and max allowable MSY
0.05d0  1.0d0          ## Min and max allowable r
9126738                 ## Random number seed
43                      ## 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
 2001       49147.0
'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
 2001  -0.001    3295.0
```

Table 14b: ASPIC-BOT results

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23 Apr 2002 at 16:53

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

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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:	43	Number of bootstrap trials:	1000
Number of data series:	2	Lower bound on MSY:	5.000E+03
Objective function computed:	in EFFORT	Upper bound on MSY:	5.000E+04
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	5.000E-02
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	1.000E+00
Relative conv. criterion (effort):	1.000E-04	Random number seed:	9126738
Maximum F allowed in fitting:	1.500	Monte Carlo search trials:	0

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

	1	2
1 EU survey	1.000 14	
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	1.819E+00	14	1.515E-01	1.000E+00	7.753E-01	0.278
Loss(2) Statlant CPUE	3.557E+00	35	1.078E-01	1.000E+00	1.090E+00	0.295

TOTAL OBJECTIVE FUNCTION: 5.37601418E+00

Number of restarts required for convergence: 2
Est. B-ratio coverage index (0 worst, 2 best): 1.5620
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	1.952E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	1.958E+04	2.000E+04	1	1
r	Intrinsic rate of increase	1.781E-01	2.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	EU survey	6.900E-01	6.900E-01	0	1
q(2)	Statlant CPUE	8.651E-06	4.036E-05	1	0

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	1.958E+04	Kr/4	
K	Maximum stock biomass	4.398E+05		
Bmsy	Stock biomass at MSY	2.199E+05	K/2	
Fmsy	Fishing mortality at MSY	8.903E-02	r/2	
F(0.1)	Management benchmark	8.013E-02	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	1.938E+04	0.99*MSY	
B-ratio	Ratio of B(2002) to Bmsy	7.346E-01		
F-ratio	Ratio of F(2001) to Fmsy	2.399E-01		
Y-ratio	Proportion of MSY avail in 2002	9.296E-01	2*Br-Br^2	Ye(2002) = 1.820E+04
....	Fishing effort at MSY in units of each fishery:			
fmsy(2)	Statlant CPUE	1.029E+04	r/2q(2)	f(0.1) = 9.262E+03

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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	0.128	4.293E+05	4.050E+05	5.198E+04	5.198E+04	5.629E+03	1.441E+00	1.952E+00
2	1960	0.022	3.829E+05	3.831E+05	8.388E+03	8.388E+03	8.789E+03	2.459E-01	1.741E+00
3	1961	0.041	3.833E+05	3.801E+05	1.552E+04	1.552E+04	9.188E+03	4.586E-01	1.743E+00
4	1962	0.018	3.770E+05	3.783E+05	6.958E+03	6.958E+03	9.423E+03	2.066E-01	1.714E+00
5	1963	0.018	3.795E+05	3.806E+05	7.035E+03	7.035E+03	9.129E+03	2.076E-01	1.726E+00
6	1964	0.047	3.816E+05	3.774E+05	1.765E+04	1.765E+04	9.533E+03	5.252E-01	1.735E+00
7	1965	0.092	3.735E+05	3.621E+05	3.343E+04	3.343E+04	1.138E+04	1.037E+00	1.698E+00
8	1966	0.020	3.514E+05	3.540E+05	7.241E+03	7.241E+03	1.230E+04	2.298E-01	1.598E+00
9	1967	0.002	3.565E+05	3.619E+05	7.290E+02	7.290E+02	1.141E+04	2.262E-02	1.621E+00
10	1968	0.013	3.672E+05	3.700E+05	4.963E+03	4.963E+03	1.046E+04	1.507E-01	1.670E+00
11	1969	0.007	3.726E+05	3.762E+05	2.801E+03	2.801E+03	9.690E+03	8.364E-02	1.695E+00
12	1970	0.008	3.795E+05	3.825E+05	3.168E+03	3.168E+03	8.879E+03	9.304E-02	1.726E+00
13	1971	0.021	3.852E+05	3.855E+05	8.033E+03	8.033E+03	8.479E+03	2.341E-01	1.752E+00
14	1972	0.114	3.857E+05	3.694E+05	4.195E+04	4.195E+04	1.050E+04	1.276E+00	1.754E+00
15	1973	0.064	3.543E+05	3.493E+05	2.235E+04	2.235E+04	1.279E+04	7.187E-01	1.611E+00
16	1974	0.104	3.447E+05	3.342E+05	3.467E+04	3.467E+04	1.428E+04	1.165E+00	1.567E+00
17	1975	0.050	3.243E+05	3.239E+05	1.608E+04	1.608E+04	1.520E+04	5.575E-01	1.475E+00
18	1976	0.053	3.234E+05	3.226E+05	1.700E+04	1.700E+04	1.531E+04	5.919E-01	1.471E+00
19	1977	0.063	3.217E+05	3.193E+05	2.027E+04	2.027E+04	1.557E+04	7.129E-01	1.463E+00
20	1978	0.053	3.170E+05	3.166E+05	1.676E+04	1.676E+04	1.580E+04	5.948E-01	1.442E+00
21	1979	0.064	3.161E+05	3.140E+05	2.007E+04	2.007E+04	1.599E+04	7.181E-01	1.437E+00
22	1980	0.051	3.120E+05	3.121E+05	1.596E+04	1.596E+04	1.614E+04	5.743E-01	1.419E+00
23	1981	0.044	3.122E+05	3.133E+05	1.389E+04	1.389E+04	1.605E+04	4.980E-01	1.420E+00
24	1982	0.047	3.143E+05	3.150E+05	1.468E+04	1.468E+04	1.592E+04	5.237E-01	1.429E+00
25	1983	0.062	3.156E+05	3.138E+05	1.953E+04	1.953E+04	1.601E+04	6.990E-01	1.435E+00
26	1984	0.065	3.121E+05	3.100E+05	2.023E+04	2.023E+04	1.629E+04	7.328E-01	1.419E+00
27	1985	0.066	3.081E+05	3.062E+05	2.028E+04	2.028E+04	1.656E+04	7.440E-01	1.401E+00
28	1986	0.097	3.044E+05	2.983E+05	2.887E+04	2.887E+04	1.708E+04	1.087E+00	1.384E+00
29	1987	0.159	2.926E+05	2.790E+05	4.441E+04	4.441E+04	1.814E+04	1.788E+00	1.331E+00
30	1988	0.088	2.663E+05	2.641E+05	2.319E+04	2.319E+04	1.879E+04	9.863E-01	1.211E+00
31	1989	0.240	2.619E+05	2.417E+05	5.810E+04	5.810E+04	1.933E+04	2.700E+00	1.191E+00
32	1990	0.426	2.232E+05	1.901E+05	8.105E+04	8.105E+04	1.909E+04	4.788E+00	1.015E+00
33	1991	0.335	1.612E+05	1.449E+05	4.849E+04	4.849E+04	1.727E+04	3.759E+00	7.331E-01
34	1992	0.376	1.300E+05	1.152E+05	4.332E+04	4.332E+04	1.511E+04	4.224E+00	5.911E-01
35	1993	0.310	1.018E+05	9.356E+04	2.899E+04	2.899E+04	1.311E+04	3.481E+00	4.628E-01
36	1994	0.131	8.589E+04	8.642E+04	1.132E+04	1.132E+04	1.236E+04	1.471E+00	3.906E-01
37	1995	0.156	8.694E+04	8.637E+04	1.350E+04	1.350E+04	1.236E+04	1.755E+00	3.954E-01
38	1996	0.065	8.580E+04	8.921E+04	5.789E+03	5.789E+03	1.266E+04	7.288E-01	3.902E-01
39	1997	0.013	9.267E+04	9.875E+04	1.300E+03	1.300E+03	1.363E+04	1.479E-01	4.214E-01
40	1998	0.009	1.050E+05	1.119E+05	9.710E+02	9.710E+02	1.484E+04	9.751E-02	4.775E-01
41	1999	0.008	1.189E+05	1.263E+05	1.068E+03	1.068E+03	1.602E+04	9.500E-02	5.406E-01
42	2000	0.027	1.338E+05	1.404E+05	3.825E+03	3.825E+03	1.701E+04	3.060E-01	6.086E-01
43	2001	0.021	1.470E+05	1.542E+05	3.295E+03	3.295E+03	1.783E+04	2.399E-01	6.686E-01
44	2002		1.615E+05						7.346E-01

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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	*	2.795E+05	0.00000	0.0
2	1960	0.000E+00	0.000E+00	0.0	*	2.644E+05	0.00000	0.0
3	1961	0.000E+00	0.000E+00	0.0	*	2.623E+05	0.00000	0.0
4	1962	0.000E+00	0.000E+00	0.0	*	2.610E+05	0.00000	0.0
5	1963	0.000E+00	0.000E+00	0.0	*	2.626E+05	0.00000	0.0
6	1964	0.000E+00	0.000E+00	0.0	*	2.604E+05	0.00000	0.0
7	1965	0.000E+00	0.000E+00	0.0	*	2.498E+05	0.00000	0.0
8	1966	0.000E+00	0.000E+00	0.0	*	2.443E+05	0.00000	0.0
9	1967	0.000E+00	0.000E+00	0.0	*	2.497E+05	0.00000	0.0
10	1968	0.000E+00	0.000E+00	0.0	*	2.553E+05	0.00000	0.0
11	1969	0.000E+00	0.000E+00	0.0	*	2.596E+05	0.00000	0.0
12	1970	0.000E+00	0.000E+00	0.0	*	2.639E+05	0.00000	0.0
13	1971	0.000E+00	0.000E+00	0.0	*	2.660E+05	0.00000	0.0
14	1972	0.000E+00	0.000E+00	0.0	*	2.549E+05	0.00000	0.0
15	1973	0.000E+00	0.000E+00	0.0	*	2.410E+05	0.00000	0.0
16	1974	0.000E+00	0.000E+00	0.0	*	2.306E+05	0.00000	0.0
17	1975	0.000E+00	0.000E+00	0.0	*	2.235E+05	0.00000	0.0
18	1976	0.000E+00	0.000E+00	0.0	*	2.226E+05	0.00000	0.0
19	1977	0.000E+00	0.000E+00	0.0	*	2.203E+05	0.00000	0.0
20	1978	0.000E+00	0.000E+00	0.0	*	2.184E+05	0.00000	0.0
21	1979	0.000E+00	0.000E+00	0.0	*	2.167E+05	0.00000	0.0
22	1980	0.000E+00	0.000E+00	0.0	*	2.153E+05	0.00000	0.0
23	1981	0.000E+00	0.000E+00	0.0	*	2.162E+05	0.00000	0.0
24	1982	0.000E+00	0.000E+00	0.0	*	2.173E+05	0.00000	0.0
25	1983	0.000E+00	0.000E+00	0.0	*	2.165E+05	0.00000	0.0
26	1984	0.000E+00	0.000E+00	0.0	*	2.139E+05	0.00000	0.0
27	1985	0.000E+00	0.000E+00	0.0	*	2.113E+05	0.00000	0.0
28	1986	0.000E+00	0.000E+00	0.0	*	2.059E+05	0.00000	0.0
29	1987	0.000E+00	0.000E+00	0.0	*	1.925E+05	0.00000	0.0
30	1988	1.000E+00	1.000E+00	0.0	1.936E+05	1.822E+05	0.06041	1.135E+04
31	1989	1.000E+00	1.000E+00	0.0	1.170E+05	1.668E+05	-0.35438	-4.977E+04
32	1990	1.000E+00	1.000E+00	0.0	7.870E+04	1.312E+05	-0.51085	-5.247E+04
33	1991	1.000E+00	1.000E+00	0.0	6.413E+04	9.997E+04	-0.44400	-3.584E+04
34	1992	1.000E+00	1.000E+00	0.0	8.562E+04	7.948E+04	0.07436	6.135E+03
35	1993	1.000E+00	1.000E+00	0.0	4.622E+04	6.456E+04	-0.33416	-1.834E+04
36	1994	1.000E+00	1.000E+00	0.0	8.636E+04	5.963E+04	0.37040	2.673E+04
37	1995	1.000E+00	1.000E+00	0.0	6.880E+04	5.959E+04	0.14373	9.211E+03
38	1996	1.000E+00	1.000E+00	0.0	9.496E+04	6.156E+04	0.43342	3.340E+04
39	1997	1.000E+00	1.000E+00	0.0	7.678E+04	6.814E+04	0.11946	8.646E+03
40	1998	1.000E+00	1.000E+00	0.0	5.404E+04	7.718E+04	-0.35639	-2.314E+04
41	1999	1.000E+00	1.000E+00	0.0	7.747E+04	8.713E+04	-0.11750	-9.659E+03
42	2000	1.000E+00	1.000E+00	0.0	1.100E+05	9.686E+04	0.12734	1.315E+04
43	2001	1.000E+00	1.000E+00	0.0	4.915E+04	1.064E+05	-0.77266	-5.728E+04

* Asterisk indicates missing value(s).

3M redfish
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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     0.0604                                             |==
1989    -0.3544                               ==============|
1990    -0.5108                         ====================|
1991    -0.4440                           ==================|
1992     0.0744                                             |===
1993    -0.3342                                =============|
1994     0.3704                                             |===============
1995     0.1437                                             |======
1996     0.4334                                             |=================
1997     0.1195                                             |=====
1998    -0.3564                               ==============|
1999    -0.1175                                        =====|
2000     0.1273                                             |=====
2001    -0.7727              ===============================|
                   ------------------------------------------------------------------------------------
```

3M redfish
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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	1.483E+04	0.1283	5.198E+04	5.198E+04	0.26513	0.000E+00
2	1960	2.007E+03	2.531E+03	0.0219	8.388E+03	8.388E+03	-0.23171	0.000E+00
3	1961	2.911E+03	4.719E+03	0.0408	1.552E+04	1.552E+04	-0.48319	0.000E+00
4	1962	1.885E+03	2.126E+03	0.0184	6.958E+03	6.958E+03	-0.12032	0.000E+00
5	1963	1.870E+03	2.137E+03	0.0185	7.035E+03	7.035E+03	-0.13338	0.000E+00
6	1964	7.861E+03	5.405E+03	0.0468	1.765E+04	1.765E+04	0.37454	0.000E+00
7	1965	1.020E+04	1.067E+04	0.0923	3.343E+04	3.343E+04	-0.04548	0.000E+00
8	1966	4.089E+03	2.364E+03	0.0205	7.241E+03	7.241E+03	0.54769	0.000E+00
9	1967	4.010E+02	2.328E+02	0.0020	7.290E+02	7.290E+02	0.54362	0.000E+00
10	1968	1.442E+03	1.551E+03	0.0134	4.963E+03	4.963E+03	-0.07242	0.000E+00
11	1969	9.579E+02	8.607E+02	0.0074	2.801E+03	2.801E+03	0.10704	0.000E+00
12	1970	4.355E+02	9.575E+02	0.0083	3.168E+03	3.168E+03	-0.78774	0.000E+00
13	1971	1.600E+03	2.409E+03	0.0208	8.033E+03	8.033E+03	-0.40900	0.000E+00
14	1972	1.427E+04	1.313E+04	0.1136	4.195E+04	4.195E+04	0.08330	0.000E+00
15	1973	8.721E+03	7.396E+03	0.0640	2.235E+04	2.235E+04	0.16480	0.000E+00
16	1974	1.084E+04	1.199E+04	0.1038	3.467E+04	3.467E+04	-0.10127	0.000E+00
17	1975	5.123E+03	5.738E+03	0.0496	1.608E+04	1.608E+04	-0.11335	0.000E+00
18	1976	7.151E+03	6.091E+03	0.0527	1.700E+04	1.700E+04	0.16041	0.000E+00
19	1977	9.524E+03	7.336E+03	0.0635	2.027E+04	2.027E+04	0.26101	0.000E+00
20	1978	6.646E+03	6.121E+03	0.0530	1.676E+04	1.676E+04	0.08239	0.000E+00
21	1979	1.154E+04	7.390E+03	0.0639	2.007E+04	2.007E+04	0.44601	0.000E+00
22	1980	7.181E+03	5.910E+03	0.0511	1.596E+04	1.596E+04	0.19484	0.000E+00
23	1981	5.491E+03	5.125E+03	0.0443	1.389E+04	1.389E+04	0.06883	0.000E+00
24	1982	6.225E+03	5.389E+03	0.0466	1.468E+04	1.468E+04	0.14418	0.000E+00
25	1983	9.150E+03	7.194E+03	0.0622	1.953E+04	1.953E+04	0.24062	0.000E+00
26	1984	9.537E+03	7.541E+03	0.0652	2.023E+04	2.023E+04	0.23476	0.000E+00
27	1985	9.270E+03	7.656E+03	0.0662	2.028E+04	2.028E+04	0.19124	0.000E+00
28	1986	9.017E+03	1.119E+04	0.0968	2.887E+04	2.887E+04	-0.21559	0.000E+00
29	1987	1.240E+04	1.840E+04	0.1592	4.441E+04	4.441E+04	-0.39471	0.000E+00
30	1988	1.100E+04	1.015E+04	0.0878	2.319E+04	2.319E+04	0.08048	0.000E+00
31	1989	3.504E+04	2.779E+04	0.2404	5.810E+04	5.810E+04	0.23208	0.000E+00
32	1990	5.149E+04	4.928E+04	0.4263	8.105E+04	8.105E+04	0.04392	0.000E+00
33	1991	3.267E+04	3.869E+04	0.3347	4.849E+04	4.849E+04	-0.16888	0.000E+00
34	1992	2.831E+04	4.347E+04	0.3760	4.332E+04	4.332E+04	-0.42870	0.000E+00
35	1993	1.674E+04	3.582E+04	0.3099	2.899E+04	2.899E+04	-0.76074	0.000E+00
36	1994	*	1.513E+04	0.1309	1.132E+04	1.132E+04	0.00000	0.000E+00
37	1995	*	1.806E+04	0.1563	1.350E+04	1.350E+04	0.00000	0.000E+00
38	1996	*	7.500E+03	0.0649	5.789E+03	5.789E+03	0.00000	0.000E+00
39	1997	*	1.522E+03	0.0132	1.300E+03	1.300E+03	0.00000	0.000E+00
40	1998	*	1.003E+03	0.0087	9.710E+02	9.710E+02	0.00000	0.000E+00
41	1999	*	9.777E+02	0.0085	1.068E+03	1.068E+03	0.00000	0.000E+00
42	2000	*	3.149E+03	0.0272	3.825E+03	3.825E+03	0.00000	0.000E+00
43	2001	*	2.469E+03	0.0214	3.295E+03	3.295E+03	0.00000	0.000E+00

* Asterisk indicates missing value(s).

3M redfish
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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2

```
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    --------------------------------------------------------------------------------------------
1959     0.2651                                             |===========
1960    -0.2317                                    =========|
1961    -0.4832                          ===================|
1962    -0.1203                                         =====|
1963    -0.1334                                         =====|
1964     0.3745                                             |===============
1965    -0.0455                                            ==|
1966     0.5477                                             |======================
1967     0.5436                                             |======================
1968    -0.0724                                           ===|
1969     0.1070                                             |====
1970    -0.7877              ================================|
1971    -0.4090                             ================|
1972     0.0833                                             |===
1973     0.1648                                             |=======
1974    -0.1013                                          ====|
1975    -0.1133                                         =====|
1976     0.1604                                             |======
1977     0.2610                                             |==========
1978     0.0824                                             |===
1979     0.4460                                             |==================
1980     0.1948                                             |========
1981     0.0688                                             |===
1982     0.1442                                             |======
1983     0.2406                                             |==========
1984     0.2348                                             |=========
1985     0.1912                                             |========
1986    -0.2156                                    =========|
1987    -0.3947                             ================|
1988     0.0805                                             |===
1989     0.2321                                             |=========
1990     0.0439                                             |==
1991    -0.1689                                       =======|
1992    -0.4287                            =================|
1993    -0.7607                ==============================|
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     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	2.019E+00	1.952E+00	-3.32%	1.468E+00	2.940E+00	1.713E+00	2.379E+00	6.666E-01	0.330
K	4.460E+05	4.398E+05	-1.40%	3.635E+05	5.924E+05	4.014E+05	5.114E+05	1.101E+05	0.247
r	1.737E-01	1.781E-01	2.49%	1.073E-01	2.573E-01	1.365E-01	2.155E-01	7.901E-02	0.455
q(1)	6.900E-01	6.900E-01	0.00%	6.900E-01	6.900E-01	6.900E-01	6.900E-01	4.483E-10	0.000
q(2)	8.198E-06	8.651E-06	5.52%	6.885E-06	9.807E-06	7.448E-06	8.995E-06	1.547E-06	0.189
MSY	1.938E+04	1.958E+04	1.01%	1.551E+04	2.335E+04	1.727E+04	2.159E+04	4.316E+03	0.223
Ye(2002)	1.800E+04	1.820E+04	1.09%	1.089E+04	2.321E+04	1.417E+04	2.158E+04	7.409E+03	0.412
Bmsy	2.230E+05	2.199E+05	-1.40%	1.818E+05	2.962E+05	2.007E+05	2.557E+05	5.504E+04	0.247
Fmsy	8.686E-02	8.903E-02	2.49%	5.364E-02	1.287E-01	6.825E-02	1.078E-01	3.951E-02	0.455
fmsy(1)	1.259E-01	1.290E-01	2.49%	7.774E-02	1.865E-01	9.891E-02	1.562E-01	5.725E-02	0.455
fmsy(2)	1.052E+04	1.029E+04	-2.15%	7.563E+03	1.338E+04	9.052E+03	1.218E+04	3.132E+03	0.298
F(0.1)	7.818E-02	8.013E-02	2.24%	4.828E-02	1.158E-01	6.142E-02	9.698E-02	3.555E-02	0.455
Y(0.1)	1.919E+04	1.938E+04	1.00%	1.536E+04	2.311E+04	1.710E+04	2.137E+04	4.273E+03	0.223
B-ratio	7.346E-01	7.346E-01	0.00%	4.591E-01	1.099E+00	5.821E-01	9.177E-01	3.356E-01	0.457
F-ratio	2.443E-01	2.399E-01	-1.80%	1.358E-01	4.797E-01	1.755E-01	3.463E-01	1.708E-01	0.699
Y-ratio	9.401E-01	9.296E-01	-1.12%	7.377E-01	9.978E-01	8.501E-01	9.880E-01	1.379E-01	0.147
f0.1(1)	1.133E-01	1.161E-01	2.24%	6.997E-02	1.678E-01	8.902E-02	1.406E-01	5.153E-02	0.455
f0.1(2)	9.465E+03	9.262E+03	-1.93%	6.807E+03	1.204E+04	8.147E+03	1.097E+04	2.819E+03	0.298
q2/q1	1.188E-05	1.254E-05	5.52%	9.978E-06	1.421E-05	1.079E-05	1.304E-05	2.242E-06	0.189

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:	1
Trials replaced for r out-of-bounds:	2
Residual-adjustment factor:	1.0435

Table 15: The 4 plus biomass (' 000 tons)summary table.

Year	XSA	SPA	ASPIC
1989	328	269	262
1990	278	225	223
1991	213	164	161
1992	150	118	130
1993	102	86	102
1994	93	69	86
1995	90	66	87
1996	80	56	86
1997	101	61	93
1998	117	69	105
1999	91	62	119
2000	115	81	134
2001	111	82	147

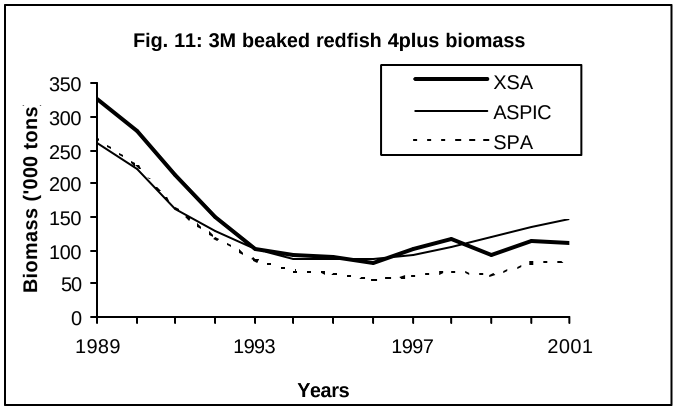


Table 16a: An explanation of the red.sen file input data with an exploitation pattern corresponding to F*statusquo*

Name	Value	C.V.	Name	Value	C.V.	Name	Value	C.V.	Name	Value	C.V.
Population at age in 2002			Exploitation pattern (H - Human consumption)			Exploitation pattern (D - Discards)			Exploitation pattern (I - Industrials)		
N4	44541	0.46	sH4	0.0140	0.00	sD4	0.00	0.00	sI4	0.00	0.00
N5	50756	0.62	sH5	0.0140	0.00	sD5	0.00	0.00	sI5	0.00	0.00
N6	22434	0.31	sH6	0.0096	0.00	sD6	0.00	0.00	sI6	0.00	0.00
N7	40616	0.26	sH7	0.0318	0.00	sD7	0.00	0.00	sI7	0.00	0.00
N8	26855	0.22	sH8	0.0471	0.00	sD8	0.00	0.00	sI8	0.00	0.00
N9	27890	0.29	sH9	0.0310	0.00	sD9	0.00	0.00	sI9	0.00	0.00
N10	28467	0.25	sH10	0.0349	0.00	sD10	0.00	0.00	sI10	0.00	0.00
N11	24855	0.21	sH11	0.0277	0.00	sD11	0.00	0.00	sI11	0.00	0.00
N12	118429	0.20	sH12	0.1021	0.00	sD12	0.00	0.00	sI12	0.00	0.00
N13	3665	0.23	sH13	0.0988	0.00	sD13	0.00	0.00	sI13	0.00	0.00
N14	1164	0.21	sH14	0.0819	0.00	sD14	0.00	0.00	sI14	0.00	0.00
N15	747	0.17	sH15	0.0331	0.00	sD15	0.00	0.00	sI15	0.00	0.00
N16	2004	0.20	sH16	0.0893	0.00	sD16	0.00	0.00	sI16	0.00	0.00
N17	662	0.19	sH17	0.0271	0.00	sD17	0.00	0.00	sI17	0.00	0.00
N18	726	0.20	sH18	0.0319	0.00	sD18	0.00	0.00	sI18	0.00	0.00
N19	2900	0.20	sH19	0.0319	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	0.093	0.00	WH4	0.087	0.00	WD4	0.00	0.00	WI4	0.00	0.00
WS5	0.136	0.00	WH5	0.133	0.00	WD5	0.00	0.00	WI5	0.00	0.00
WS6	0.181	0.00	WH6	0.187	0.00	WD6	0.00	0.00	WI6	0.00	0.00
WS7	0.235	0.00	WH7	0.267	0.00	WD7	0.00	0.00	WI7	0.00	0.00
WS8	0.283	0.00	WH8	0.313	0.00	WD8	0.00	0.00	WI8	0.00	0.00
WS9	0.303	0.00	WH9	0.342	0.00	WD9	0.00	0.00	WI9	0.00	0.00
WS10	0.336	0.00	WH10	0.379	0.00	WD10	0.00	0.00	WI10	0.00	0.00
WS11	0.412	0.00	WH11	0.438	0.00	WD11	0.00	0.00	WI11	0.00	0.00
WS12	0.533	0.00	WH12	0.535	0.00	WD12	0.00	0.00	WI12	0.00	0.00
WS13	0.588	0.00	WH13	0.586	0.00	WD13	0.00	0.00	WI13	0.00	0.00
WS14	0.585	0.00	WH14	0.583	0.00	WD14	0.00	0.00	WI14	0.00	0.00
WS15	0.562	0.00	WH15	0.560	0.00	WD15	0.00	0.00	WI15	0.00	0.00
WS16	0.610	0.00	WH16	0.598	0.00	WD16	0.00	0.00	WI16	0.00	0.00
WS17	0.691	0.00	WH17	0.703	0.00	WD17	0.00	0.00	WI17	0.00	0.00
WS18	0.708	0.00	WH18	0.716	0.00	WD18	0.00	0.00	WI18	0.00	0.00
WS19	0.794	0.00	WH19	0.810	0.00	WD19	0.00	0.00	WI19	0.00	0.00

Table 16a (count): An explanation of the red.sen file input data with an exploitation pattern corresponding to F*statusquo*

Natural mortality at age / Maturity

M4	0.1	0.00	MT4	0.000	0.00
M5	0.1	0.00	MT5	0.005	0.00
M6	0.1	0.00	MT6	0.021	0.00
M7	0.1	0.00	MT7	0.067	0.00
M8	0.1	0.00	MT8	0.127	0.00
M9	0.1	0.00	MT9	0.173	0.00
M10	0.1	0.00	MT10	0.218	0.00
M11	0.1	0.00	MT11	0.317	0.00
M12	0.1	0.00	MT12	0.390	0.00
M13	0.1	0.00	MT13	0.453	0.00
M14	0.1	0.00	MT14	0.488	0.00
M15	0.1	0.00	MT15	0.507	0.00
M16	0.1	0.00	MT16	0.587	0.00
M17	0.1	0.00	MT17	0.590	0.00
M18	0.1	0.00	MT18	0.608	0.00
M19	0.1	0.00	MT19	0.729	0.00

Natural mortality multiplier in year / Effort multiplier in year (H - Human consumption)

K2002	1	0.0	HF2002	1.0	0.0
K2003	1	0.0	HF2003	1.0	0.0
K2004	1	0.0	HF2004	1.0	0.0

Table 16b: The 3M beaked redfish input.srr (stock recruitment relationship) file for Mterm projections.

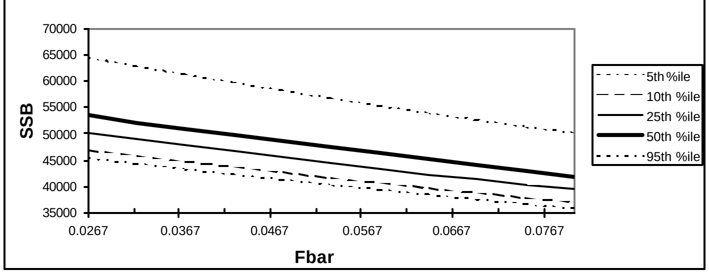
```
5                 Nparams
5                 Geometric mean model
44.541            1999-2001 age 4 XSA geomean in millions
0.00000E+000
0.00000E+000
0
0.00000E+000
13    Ndata
.3937       Residuals
.2726
-.2077
-.5003
-.0730
-.0730
.3544
.2511
.1064
-.0634
.2234
-.4680
.2446
0        No extra data
```

Table 17a: Redfish 3M short term SSB probability profiles from Fstatusquo, 0.6Fstatusquo and 0.45Fstatusquo. Observed recruitment randomly resampled.

F status quo
Year projection

2005 Fmultiplier	0.0267	0.0320	0.0374	0.0427	0.0481	**0.0534**	0.0587	0.0641	0.0694	0.0747	0.0801
5^{th} %ile	45390	44313	43258	42268	41267	40272	39368	38427	37511	36645	35787
10^{th} %ile	46930	45805	44737	43668	42628	41615	40627	39668	38737	37825	36951
25^{th} %ile	50137	48935	47752	46605	45490	44388	43339	42318	41285	40313	39369
50^{th} %ile	53582	52259	50970	49749	48512	**47331**	46199	45087	43994	42955	41926
95^{th} %ile	64474	62840	61251	59687	58204	56744	55319	53933	52604	51324	50112

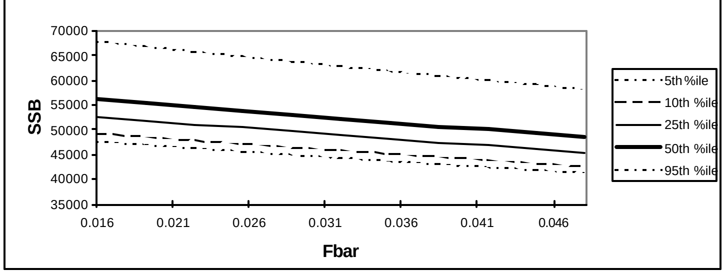
Fig. 12a: SSB 2005 vs Fstatusquo



0.6Fstatusquo
Year projection

2005	0.0160	0.0192	0.0224	0.0256	0.0288	**0.0320**	0.0353	0.0385	0.0417	0.0449	0.0481
5^{th} %ile	47653	46961	46279	45610	44951	44312	43665	43058	42465	41871	41265
10^{th} %ile	49293	48569	47859	47159	46471	45804	45164	44520	43878	43247	42626
25^{th} %ile	52636	51870	51126	50381	49646	48933	48222	47516	46820	46166	45488
50^{th} %ile	56298	55466	54647	53843	53053	**52257**	51482	50720	49996	49244	48509
95^{th} %ile	67884	66840	65814	64805	63813	62838	61879	60936	59997	59098	58201

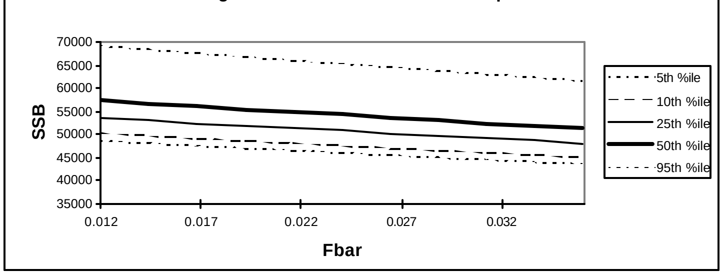
Fig. 12b: SSB 2005 vs 0.6Fstatusquo



0.45 Fstatus quo
Year projection

2005	0.0120	0.0144	0.0168	0.0192	0.0216	**0.0240**	0.0264	0.0288	0.0312	0.0337	0.0361
5^{th} %ile	48546	48007	47478	46960	46447	45941	45442	44950	44468	43983	43506
10^{th} %ile	50213	49663	49110	48568	48034	47506	46985	46469	45964	45481	45003
25^{th} %ile	53618	53028	52440	51869	51313	50751	50195	49644	49111	48574	48044
50^{th} %ile	57342	56716	56088	55465	54846	**54240**	53645	53052	52453	51862	51287
95^{th} %ile	69213	68411	67620	66839	66067	65306	64554	63811	63078	62354	61639

Fig. 12c: SSB 2005 vs 0.45 Fstatusquo



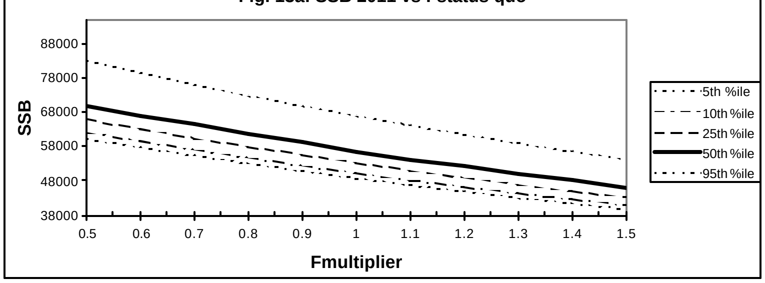
Final assessment data year	2001
1st year for populations in Sen	2002
First SSB profile 3 years ahead	2005

Table 17b: Redfish 3M medium term SSB probability profiles from a range of multipliers of F status quo and 0.6Fstatus quo. Observed recruitment randomly resampled.

Fstatus quo
Year projection

2011 Fbar	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5
5^{th} %ile	60215	57715	55330	53057	50882	48752	46783	44874	43061	41355	39727
10^{th} %ile	62178	59491	57035	54672	52378	50237	48170	46199	44369	42604	40919
25^{th} %ile	65878	63095	60437	57954	55562	53253	51079	48935	46956	45054	43256
50^{th} %ile	70087	67146	64333	61639	59113	**56697**	54399	52168	50037	48013	46059
95^{th} %ile	83024	79452	76046	72831	69810	66925	64174	61485	58953	56537	54268

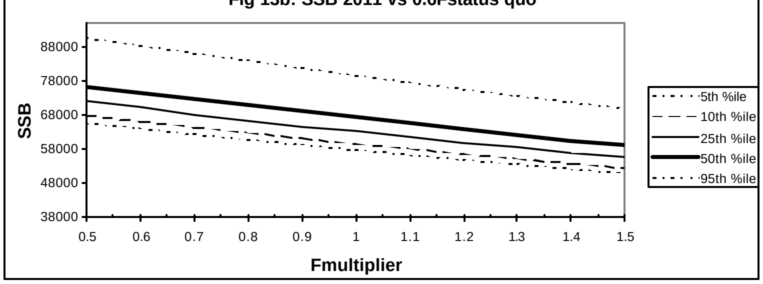
Fig. 13a: SSB 2011 vs Fstatus quo



F0.6 status quo
Year projection

2011 Fbar	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5
5^{th} %ile	65581	63917	62301	60728	59199	57713	56269	54864	53501	52175	50879
10^{th} %ile	67749	66045	64330	62706	61073	59490	57987	56562	55141	53752	52375
25^{th} %ile	71872	70030	68211	66452	64743	63093	61493	59929	58451	56977	55560
50^{th} %ile	76383	74417	72520	70694	68903	**67143**	65433	63781	62159	60617	59110
95^{th} %ile	90460	88131	85908	83761	81560	79449	77416	75367	73449	71661	69806

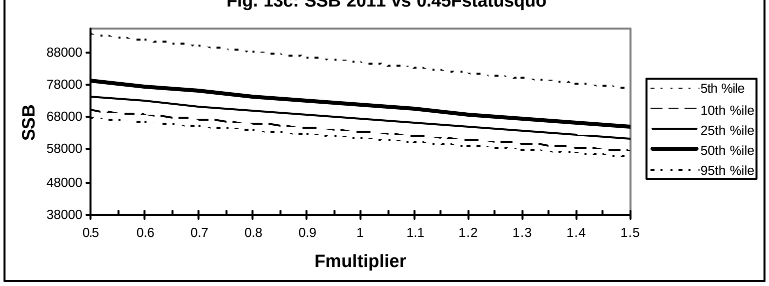
Fig 13b: SSB 2011 vs 0.6Fstatus quo



F0.45 status quo
Year projection

2011	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5
5^{th} %ile	67742	66431	65156	63912	62695	61502	60335	59192	58073	56978	55905
10^{th} %ile	69991	68617	67313	66039	64748	63504	62301	61064	59878	58710	57618
25^{th} %ile	74228	72794	71402	70023	68653	67318	66012	64734	63490	62296	61079
50^{th} %ile	78895	77374	75881	74411	72982	**71597**	70228	68895	67570	66271	65005
95^{th} %ile	93464	91645	89865	88123	86448	84820	83196	81548	79954	78419	76885

Fig. 13c: SSB 2011 vs 0.45Fstatusquo

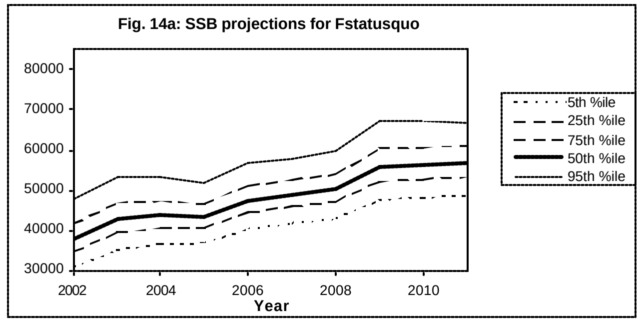


Final assessment data year	2001
1st year for populations in Sen	2002
Last SSB profile 10 years ahead	2010

Table 18a: Redfish 3M SSB probability profiles for the next 10 years, with F status quo, 0.6Fstatus quo and 0.45Fstatus quo.
Observed recruitment randomly resampled.

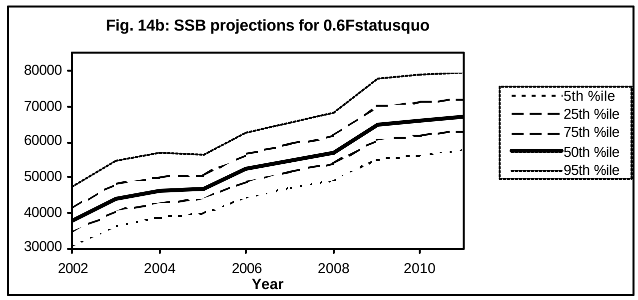
Fstatus quo

Year	5th %ile	25th %ile	75th %ile	50th %ile	95th %ile
2002	30579	34614	41423	37795	47608
2003	35054	39378	46810	42765	53246
2004	36556	40505	47274	43650	53388
2005	36805	40574	46589	43261	51649
2006	40272	44388	51113	47331	56744
2007	41752	45879	52614	48722	57911
2008	42843	47150	53860	50038	59781
2009	47613	52149	60454	55831	67300
2010	48073	52716	60725	56220	67483
2011	48752	53253	60792	56697	66925



F 0.6status quo

Year	5th %ile	25th %ile	75th %ile	50th %ile	95th %ile
2002	30579	34614	41423	37795	47608
2003	36092	40575	48241	44088	54972
2004	38695	42863	50155	46312	56691
2005	39804	43927	50527	46893	56276
2006	44312	48933	56441	52257	62838
2007	47000	51775	59344	54993	65507
2008	49041	53910	61623	57203	68522
2009	55173	60632	70063	64733	77962
2010	56292	61771	71237	65980	79154
2011	57713	63093	71961	67143	79449



F 0.45status quo

Year	5th %ile	25th %ile	75th %ile	50th %ile	95th %ile
2002	30579	34614	41423	37795	47608
2003	36488	41030	48808	44609	55640
2004	39518	43762	51326	47348	57996
2005	41037	45280	52134	48361	58128
2006	45941	50751	58578	54240	65306
2007	49141	54208	62208	57550	68807
2008	51607	56748	64896	60195	72166
2009	58275	64171	74154	68507	82638
2010	59844	65676	75620	70112	84126
2011	61502	67318	76786	71597	84820

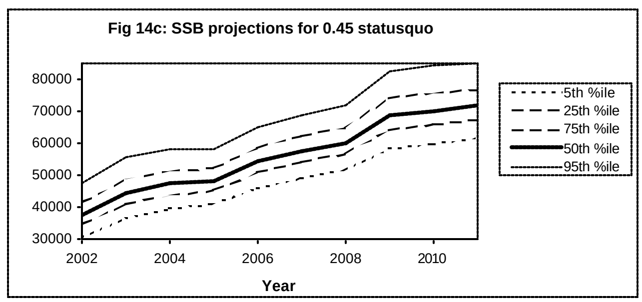


Table 18b: Redfish 3M Yield probability profiles for the next 10 years, with F status quo, 0.6Fstatus quo and 0.45Fstatus quo. Observed recruitment randomly resampled.

F status quo

Year	5th %ile	25th %ile	75th %ile	50th %ile	95th %ile
2002	6423	7340	9004	8155	10404
2003	6659	7523	8959	8175	10291
2004	6176	6883	8020	7413	8958
2005	4834	5360	6126	5722	6815
2006	6085	6700	7740	7164	8558
2007	4904	5377	6069	5707	6696
2008	4820	5245	5883	5571	6430
2009	4774	5335	6391	5799	7638
2010	4739	5325	6352	5765	7367
2011	4976	5508	6405	5935	7253

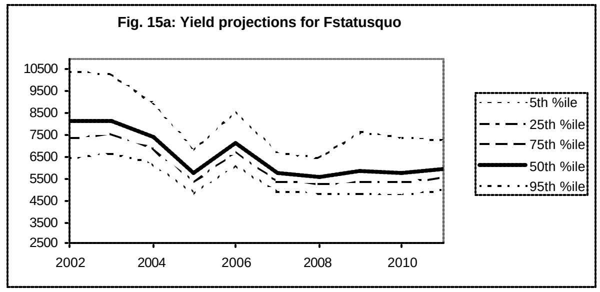


Fig. 15a: Yield projections for Fstatusquo

F 0.6status quo

Year	5th %ile	25th %ile	75th %ile	50th %ile	95th %ile
2002	3918	4478	5495	4978	6354
2003	4175	4725	5643	5142	6479
2004	3966	4414	5160	4764	5783
2005	3131	3467	3968	3703	4402
2006	4049	4458	5151	4771	5731
2007	3276	3584	4043	3805	4454
2008	3243	3535	3968	3754	4325
2009	3248	3619	4329	3942	5143
2010	3241	3642	4345	3943	5059
2011	3420	3793	4423	4094	5009

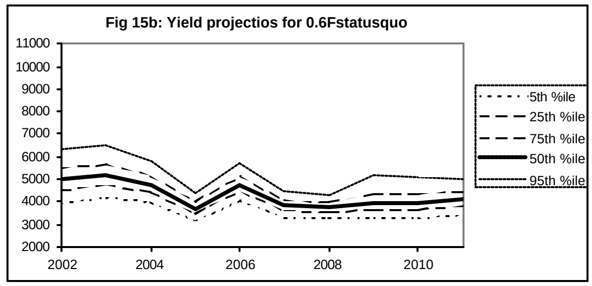


Fig 15b: Yield projectios for 0.6Fstatusquo

F 0.45status quo

Year	5th %ile	25th %ile	75th %ile	50th %ile	95th %ile
2002	2954	3376	4143	3754	4792
2003	3188	3605	4311	3925	4953
2004	3055	3400	3977	3671	4464
2005	2417	2675	3059	2857	3393
2006	3159	3478	4024	3723	4472
2007	2559	2797	3150	2967	3475
2008	2545	2776	3117	2946	3397
2009	2559	2850	3408	3102	4041
2010	2558	2875	3432	3112	3999
2011	2702	3003	3506	3246	3974

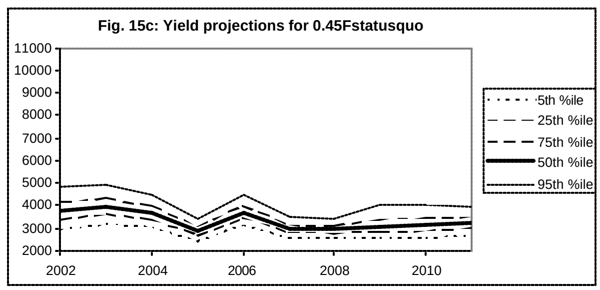


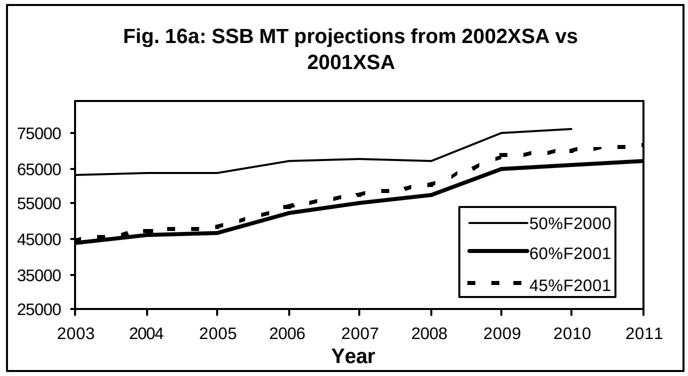
Fig. 15c: Yield projections for 0.45Fstatusquo

Table 19: SSB and yield Mtprojections from 2001 and 2002. For 2002 projections 2002 and 2003 catches are kept around the actual TAC(5000tons) or the most recent level of catches.

50%F2000 collumn: SSB in 2000 and survivors (SSB in 2001) from 2001XSA results.
60%F2001 and 45%F2001 collumns: SSB in 2000 and 2001, and survivors (SSB in 2002) from 2002XSA results.

SSB 50th %ile profiles

Year	60%F2001	45%F2001	50%F2000
2000	28450	28450	28922
2001	25556	25556	52353
2002	37795	37795	55812
2003	44088	44609	62945
2004	46312	47348	63449
2005	46893	48361	63788
2006	52257	54240	67091
2007	54993	57550	67729
2008	57203	60195	67318
2009	64733	68507	75170
2010	65980	70112	75893
2011	67143	71597	



Yield 50th %ile profiles

Year	60%F2001	45%F2001	50%F2000
2003	5142	3925	4896
2004	4764	3671	8622
2005	3703	2857	5921
2006	4771	3723	5155
2007	3805	2967	4623
2008	3754	2946	4291
2009	3942	3102	4737
2010	3943	3112	4418
2011	4094	3246