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An Assessment of Redfish in NAFO Division 3M Based on Beaked Redfish (*S. mentella and S. fasciatus*) Data

by

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Abstract

The present assessment evaluates the status of the 3M beaked redfish stock, regarded as a management unit composed of two populations from two very similar species (*Sebastes mentella* and *Sebastes fasciatus*). Survey bottom biomass and survey female spawning biomass of Div. 3M beaked redfish were calculated based on the abundance at length from Canadian and EU bottom trawl surveys for the periods 1979-85 and 1988-98 respectively and on the 3M beaked redfish length weight relationship from 1989-1998 EU survey data. During the former period both bottom biomass and female spawning biomass of beaked redfish were stabilised, with female spawning bottom biomass averaging a 42% proportion of the bottom biomass. Bottom female spawning biomass declined throughout the most recent period and represented on average just 9% of the survey bottom biomass over the past five years. A Separable VPA analysis (Pope and Shepherd, 1982) for the most recent period of 1989-98 was conducted. A traditional VPA was finally performed using the separable generated F's matrix, providing estimates of total and female stock biomass for 3M beaked redfish. A logistic surplus production model which does not use the equilibrium assumption (Praguer, 1994 and 1995) was applied using the 1959-98 catch estimates with the STATLANT commercial catch and effort data (1959-1993) as well as the EU bottom biomass (1988-1998). The results, as regards biomass and fishing mortality trends given by the Separable VPA and the ASPIC analysis are identical within the same order of magnitude. Both models pointed out that the 3M beaked redfish stock experienced a continuous decline till 1994 due to a sharp increase of fishing mortality that peak in 1990. Since 1995 fishing mortality declined rapidly, allowing the survival of above average year classes from the turn of the decade. Not being severely affected by the boom of the shrimp fishery on 1993 and 1994, the survival and growth of those year classes contributed not only to alter the former decline but they also forced a discrete but continuous growth of the biomass from 1995 onwards, although the current stock is still below the reference Bmsy.

Introduction

There are three stocks of redfish in NAFO Division 3M: deep-sea redfish (*Sebastes mentella*) with a maximum abundance at depths greater than 300m, and golden (*Sebastes marinus*) and Acadian redfish (*Sebastes fasciatus*) preferring shallower waters of less than 400m. Due to their external resemblance *S. mentella* and *S. fasciatus* are commonly designated as beaked redfish. All stocks have both pelagic and demersal concentrations as well as a long recruitment process to the bottom, extending to lengths up to 30cm-32cm. Beaked redfish also presents wide geographical shifts of its density between the Flemish Cap bank and other 3M neighbouring grounds.

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

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

The major critics raised by NAFO Scientic Council during last year assessment were taken into account, namely in what concerns the reliability of a dome shape exploitation pattern for the redfish trawl fishery. An alternative method of computation, not exclusively dependent of the EU survey abundance at age, allowed the use of a flat top exploitation pattern in the present assessment. A catchability for the EU bottom biomass was also computed independently of the pelagic biomass results obtained by the 1988-1993 Russian acoustic surveys.

Through the 1997 and 98 assessments the available 3M survey series and redfish commercial cpue series have extensively discussed (Ávila de Melo *et al*, 1997 and 1998). Since no new data are available either for the Russian bottom trawl or the Portuguese cpue series, no further comments will be included at present as regards the use of these data. Full information on Portuguese 3M redfish commercial catch is presented on the Portuguese Research Report (Alpoim *et al*, 1999).

Description of the fishery

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

The redfish fishery on Division 3M increased from 20,000 tons in 1985 to 81,000 tons in 1990, falling continuously since then till 1998, when a provisional catch of only 970 tons has been recorded (NAFO, 1999) most as by-catch of the Greenland halibut fishery. The quick drop of the 3M redfish catches from 1990 onwards is related with the abrupt decline of fishing effort deployed in this fishery, caused by the vanishing from the NAFO Regulatory Area of the fleets responsible for the high level of catches on the late eighties-early nineties (former USSR, former DDR and Korean crewed Non Contracting Party vessels). As for the remaining fleets, the Japanese and Portuguese trawlers are still the major partners of the present fishery, with 438 tons and 259 tons recorded in 1998, but for both fleets Greenland halibut has been for several years the priority species in all NAFO divisions.
Recent catches ('000 tons) are as follows:

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
TAC	20	20	20	20	20	50	50	43	30	26	26	26	26	20	10
Catch	20.3	28.9	44.4	23.2	58.1[1]	81.0[1]	48.5[1]	43.3[1]	29.0[1,2]	11.3[1,2]	13.5[1,2]	5.8[1,2]	1.3[2]	1.0[2]	

[1] Includes estimates of non-reported catches from various sources
[2] Provisional

Input data

Length composition of the commercial catch

Most of the commercial sampling data available for the 3M redfish stocks came, since 1989, from the Portuguese fisheries and has been annually included in the Portuguese research reports on the NAFO SCS Document series. Most of these data referred to beaked redfish, and, taking into account that the majority of the length sampling was from depths greater than 400m, they should represent *S. mentella* catches. The 1989-1998 per mille length composition of the 3M beaked redfish Portuguese trawl catch (both sexes combined) was used, together with the 3M beaked redfish length weight relationship from 1989-1998 EU survey data (Saborido-Rey *pers. comm.*, 1999), to get the absolute length frequencies of the 3M redfish total catch for the same period (Table 1-A, 1998 catch from NAFO circular letters). Nevertheless length sampling of the trawl catches was missing for 1993 and 1994. To overcome this gap a "commercial" survey abundance was generated, from the 1993-94 beaked redfish abundance at length (EU survey) multiplied by a length specific conversion factor (given by the 1989-92 catch/survey abundance at length ratio, both expressed as per mille). These 1993 and 94 "commercial" survey abundance's were then converted in per mille length frequencies (Table 1-B) and used, as described above, to get estimates of the absolute length composition of the respective redfish annual catches.

Length composition of the stock and spawning stock survey abundance

In order to update the EU survey abundance and female mature abundance at length for 3M beaked redfish the following parameters were used:

1) Juvenile beaked redfish proportion (Table 2-A) in the total abundance of juvenile redfish at lengths up to 21cm.
2) Female proportion at length by species (Table 2-B), from 1992-1994 *S. mentella* and *S. fasciatus* survey catches (Saborido-Rey, 1994).
3) Female proportion at length for beaked redfish (Table 2-C) found in the total number of beaked redfish at each length, when the *S.mentella* plus the *S. fasciatus* 1994-1998 survey abundance's at length are summed up.
4) Mature female proportion at length by species, given by length maturity ogives obtained for 3M *S.mentella* and *S.fasciatus* by the fit to a sigmoid logistic curve of the observed proportion of mature females on the sampled survey catches (Table 2-B). Those maturity data were based on the histological analysis of a total of 200 *S.mentella* and 141 *S.fasciatus* ovaries, obtained during the 1992 February-March cod tagging EU survey and during 1992 and 1993 June–July regular EU bottom trawl survey (Saborido-Rey, 1994). In order to avoid the appearance of mature females at unrealistic young ages the expected mature female proportions were set at zero for lengths smaller than 21cm.
5) Mature female proportion at length for beaked redfish (Table 2-C) in the total number of beaked redfish at each length, when the *S. mentella* plus the *S. fasciatus* 1994-1998 abundance's at length are summed up.

From 1998 to 1992 beaked redfish survey abundance at length is given by the sum of *S. mentella* and *S.fasciatus* abundance at length with the juvenile beaked redfish abundance at length (juvenile redfish abundance at length times juvenile beaked redfish proportion at length (1)); beaked redfish mature female survey abundance at length is given by the sum of products of abundance times female proportion (2) times mature female proportion (4) at length for *S. mentella* and *S.fasciatus* (Table 3-A).

For 1991 and 1990, when the survey redfish catches were split in golden redfish, beaked redfish (without breakdown by species) and juveniles, beaked redfish survey abundance at length is given by the sum of beaked redfish abundance at length and juvenile beaked redfish abundance at length (juvenile redfish times juvenile beaked redfish proportion at length (1)); beaked redfish mature female survey abundance at length is given by the respective survey abundance times the respective beaked redfish female proportion (3) times the beaked redfish mature female proportion at length (5) (Table 3-A).

For 1989 and 1988, when the survey redfish catches were split just in golden redfish and beaked redfish (without breakdown by species and separation of juveniles), beaked redfish abundance at length is given directly by the EU survey results; beaked redfish mature female survey abundance at length were calculated as described for the 1990-1991 period. The same approach is used to convert the 1979-1985 beaked redfish abundance's at length from the Canadian surveys (Power and Atkinson, 1986) to beaked redfish mature female survey abundance at length (Table 3-A).

As for *S. marinus* the respective abundance's at length is given directly by the EU survey throughout the time series (1988-1998) (Table 3-B); *S. marinus* mature female survey abundance at length is given by the abundance times female proportion times mature female proportion at length for this stock (both vectors, presented on Table 2-B, are based respectivelly on 1989-1994 *S. marinus* survey catches and on the histological analysis of 142 *S. marinus* ovaries obtained during the surveys already mentioned for beaked redfish). The abundance (Table 3-C) and mature female abundance at length for the whole 3M redfish stocks is given by the sum of the beaked and golden redfish results from 1988 to 1998 EU surveys.

Length weight relationships

Length weight relationships for each of the 3M redfish species separately and for *S.mentella* and *S. fasciatus* observations combined were revised in order to include observations from both sexes (Saborido Rey *pers. comm*., 1999) and presented on Table 4.

Survey stock biomass and spawning biomass

The beaked redfish and *S. marinus* length weigth relationships were used to calculate the respective survey biomass and survey female spawning biomass as sums of products of abundance and mature female abundance times mean weight at length (Table 3-A and 3-B). The biomass and female spawning biomass for the whole 3M redfish stocks (Table 3-C) is given by the sum of the beaked and golden redfish results from 1988 to 1998 EU surveys. These survey bottom biomass results are comparable with the correpondent swept area biomass estimates for the EU surveys (Vazquez, 1999).

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

Age composition for the 1989-98 3M beaked redfish EU survey stock and mature female stock (Table 5) were obtained using the *S.mentella* age length keys from the 1990-98 EU surveys, with both sexes combined (due to the fact that the 1989 S.mentella age length key was based on scale readings, the 1990 *S. mentella* age length key was also used with the 1989 beaked redfish length data). The ageing criteria of 3M redfish otoliths has been first revised in 1995 by one of the authors (Saborido-Rey) and all survey age length keys were then standardised accordingly. However an inconsistency was still observed for the more recent years, between the interannual shift of the *S. mentella* survey length distributions and the age assigned every year to each length modal group. The survey *S. mentella* otoliths were again revised, this time only from 1994 to 1997 and for the annual modal length intervals from 14 to 26 cm (Saborido Rey *pers. comm*., 1999). Between 50 and 80 otoliths were revised every year from 1994 to 1997 (the new criteria was already in practice for the ageing of the 1998 *S. mentella* survey otoliths). Results showed that within those modal length intervals there was a wrong interpretation of the age, assigning in most of the cases one year less. The new proportions of age at length were used to build the new age-length keys from the previous ones. The new 1994-97 *S. mentella* age-length keys were subsquentialy used in this assessment together with unrevised ones (1990-1993) in order to transform the survey abundance at length of the 3M beaked redfish into the correspondent age composition. With the new ageing, a clearer consistence exists for the follow up of the strong 1990 cohort (Table 5). It is noticeable that this year class shows a density dependent growth (Saborido-Rey, in preparation). Due to the scarcity of redfish larger than 40cm in the survey a plus group was considered at age 19.

Maturity ogive

A maturity ogive for 3M beaked redfish was calculated as the mean proportion of mature females in the survey stock abundance at age (Table 5). At each age this mean proportion is given by the ratio between the 1989-98 sum of mature females and the correspondent total stock abundance.

Partial recruitment vector

The exploitation pattern, suggesting a dome shape, was first derived from the total mortality at age estimated from the EU *S. mentella* survey abundance at age (Ávila de Melo *et al*, 1997 and 1998). This pattern was considered unrealistic by the Scientific Council in the former assessment. The partial recruitment vector has now been revised assuming a flat top partial recruitment and adjusting it to a normal logistic curve by a log fit of a relative mean Findex at age. This Findex has been derived from the 1995-1998 per mille age composition ratio between the 3M redfish commercial catch and beaked redfish survey abundance (Table 6 and Figures 1 and 2)

Age composition of the catches

Age composition of the catches were obtained using the same *S.mentella* age length keys from the 1990-98 EU surveys used in the stock (Table 7).

Mean weights at age

The beaked redfish length weight relationship was also used to calculate mean weights at age both in the 3M redfish catches (Table 7) as well as in the 3M beaked redfish stock and female spawning stock (Table 8).

Vectors used in yield per recruit analysis

A 3M beaked redfish yield per recruit analysis was conducted incorporating the following sets of vectors (Table8), all of them considered to be representative, in terms of growth and maturity, of beaked redfish as a whole:

1) Mean weights at age in the commercial catch for the most recent years (1995-1998).
2) Mean weights at age in the beaked redfish stock (as well as in the mature female component) from survey abundance (1995-1998).
3) Female beaked redfish maturity ogive at age, from the beaked redfish mature female and stock survey abundance at age (1989-1998).
4) Expected partial recruitment vector given by the logit of the per mille age composition ratio between the 3M redfish commercial catch and beaked redfish survey abundance (1995-98).
5) Natural mortality was set at 0.2 for the youngest age group to allow the juvenile mortality as by-catch on the shrimp fishery, and assumed to be constant at 0.1 for older ages.

Assessment results

Stock and spawning stock bottom biomass from EU bottom trawl surveys (1988-1998) and Canadian bottom trawl surveys (1979-1985)

During the former period of 1979-1985, covered by the Canadian surveys, both bottom biomass and spawning biomass of beaked redfish were stabilised, with spawning bottom biomass averaging a 42% proportion of the bottom biomass. This proportion is close to the one given by the beaked redfish yield per recruit analysis for an unexploited level (50%). The more recent period of 1988-1998, covered by EU surveys, started with a continuous decline of bottom biomass till 1991, followed by a period of biomass fluctuation with no apparent trend from 1992 till 1996, and declining again in 1997 and 1998, when the lowest bottom biomass index was recorded (Table 3-A). It is difficult to justify a decline of bottom biomass from 100,000 tons in 1996 to 57,000 tons in 1998 with catches at 1,300 in 1997 and 970 tons in 1998. This decrease could in turn be related with an increasing proportion of beaked redfish biomass above the bottom, supported by the growth and maturation process of the survivals from the above average 1990-92 cohorts. Bottom spawning biomass declined troughout the EU survey time series and also records a minimum in 1998. For the more recent period of 1994-1998 spawning biomass represented on average just 9% of the bottom biomass (Table 3-A, Fig. 3). Catches well above 20,000 tons between observed 1987 and 1993 have generated unsustainable high levels of fishing mortality that affected primarily beaked redfish larger than 30cm, *i.e* the spawning component of the stock. Despite the survival and growth of the abundant year classes from the early nineties, the slow growth and late maturity of these species should have allowed these cohorts to start to contribute to the recovery of the spawning biomass only very recently. However these recovery is not expected to be reflected so far in the spawning bottom biomass index, taking into account that 3M redfish species spawns in pelagic waters with the larvae eclosion occuring right before or after birth (Saborido-Rey, 1994).

Both bottom biomass and spawning biomass of golden redfish declined from 1989 to 1991, remaining at the lowest level of the EU survey series till 1993. Bottom biomass peaked in 1994 and again in 1997 by a combination of recruitment and growth of three above average year classes (89-91) with an unusual concentration near the bottom of older adults. These concentrations lead to the peaks recorded on 1997 both for stock and spawning survey biomass (Table 3-B, Fig. 4). Despite the fact that the golden redfish stock remained almost unexploited since 1995 due to the collapse of the 3M cod stock (*S. marinus* was one of the main by-catch on this late fishery) its survey biomass and spawning biomass dropped from 68,000 tons to 6,800 tons and from 10,700 tons to 340 tons between

1997 and 1998. These drastic declines can not be associated to fishing mortality and most likely they are the consequence of movements of this stock within the water column, presentig a mobility that seems to be much higher than on beaked redfish. Nevertheless the proportion of the bottom spawning biomass was, even in 1997, at 16%, when, during the former 1988-1990 period represented an average of 25% of the golden redfish bottom biomass. This decline is mainly the consequence of the impact that the uncontrolled 3M cod fishery had on this stock, namely on the 1988-1990 and 1993-94 periods.

As a whole, the combined 3M redfish stocks experienced a decline of their bottom biomass from 1988 to 1991, followed by a period of no apparent trend that is extended till 1998. The survey bottom spawning biomass is not showing yet signs of recovery from the continuous decline suffered from 1988 till 1993, representing on average between 1994 and 1998 half of the mean spawning biomass proportion observed during the former 1988-91 period (Table 3-C, Fig. 5).

Fishing mortality trends, 1988-1998

The ratios between annual STACFIS estimates of 3M redfish catches and 3M beaked redfish survey bottom biomass (given by the EU survey series) were considered to be an index of the mean fishing mortality trend during the past 11 years (Table 9). This approach assumes constant survey catchability over the recruited age groups, no changes in exploitation pattern and a survey biomass representative of the mean annual biomass (EU survey is conducted around the middle of the year). From this F index vector fishing mortality quickly rises to a peak in 1991 and gradually fell since then, reaching a very low level in 1997 and 1998. In order to generate a survey mean fishing mortality trend comparable with the one from a vpa mean fishing mortality (derived from a separable vpa included in this assessment) this survey F index was finally transformed to an F multiplier normalised to the F index on the last year of the time series (Table 9)

Yield-per-recruit analysis

In order to get reference levels of fishing mortality taking into account the growth, maturity and exploitation pattern of the 3M beaked redfish stock an yield per recruit analysis was conducted, incorporating the sets of vectors already described (Table 8).

From the yield, biomass and spawning biomass per recruit curves, different levels of reduction of spawning and total biomass were determined for corresponding levels of fishing mortality (Table 10, Fig. 6). With the assumption of constant recruitment, the results indicated a reduction of 68% of the female spawning biomass from its unexploited level and a 32% proportion of female spawners in the stock biomass when fishing at $F_{0.1}$. If a logistic natural growth of the biomass is accepted, the fishing mortality associated with a long term equilibrium 50% reduction of total biomass (roughly corresponding to the general production F_{msy}) is slightly below $F_{0.1}$. As for the fishing mortality corresponding to the average female spawning biomass proportion of 42% observed during the former period of 1979-85 covered by the Canadian series, its value should be at 0.04 and will lead to a female spawning biomass at a 40% reduction of its unexploited level.

Separabale VPA

The wide inter annual fluctuations of survey abundance at age prevents the use of VPA tuning methods to assess the 3M beaked redfish stock and spawning stock biomass over this last decade. Alternatively a Separable VPA was performed (Pope and Shepherd, 1982) since it doesn't require tuning data, though a previous notion about the trend in F and the exploitation pattern is needed. The model assumes that the exploitation pattern of the fishery remains unchanged, which, in the case of the 3M redfish fishery is difficult to demonstrate despite the fact that, from the mean lengths in the catch based on the Portuguese sampling (Table 1-A), no dramatic exploitation shifts are evident throughout the 1989-98 period. The program used was based in the algorithm implemented by Shepherd and Stevens (1983) and is included in the Lowestoft VPA Suite (Darby and Flatman, 1994). The model algorithms are summarized in Appendix 6 of the respective user guide (Darby and Flatman, 1994). The input files are presented in Table 11.

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

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

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

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

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

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

assuming the aproximation (Gray, 1977)

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

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

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

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

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

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

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

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

and

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

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

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

The age weights were then normalized to the largest reciprocal

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

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

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

Year weights are user defined (from 0.001 to 1) and are directly incorporated in the sum of log catch residuals for each age. 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 disavantage 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 considered and the lack of evidence of important changes in the exploitation pattern no year weights were used.

The Separable VPA runs have assumed a constant natural mortality of 0.1. The first age group considered was age 4 (the first age in the 1989-98 catch at age matrix with catches assigned every year) and age 18 was the last true age (from age 19 onwards both survey and commercial sampling data are scarce and so an age 19 plus group has been considered throughout the assessment). The first age fully exploited, age 11, was taken from the observed exploitation pattern (an age of 13, given by logit exploitation pattern, resulted in sistematic higher final sum of squared residuals and higher number of iteractions). In order to be consistent with a flat top exploitation pattern a selection value of 1 was assigned to the last true age group.

Terminal F was “tuned” by hand under the following constraints:

- should not exceed the Findex for 1998 (0.015), taking into account that being this index given by the catch/survey bottom biomass ratio it is already an overestimate of fishing mortality.
- should not genarate unrealistic values of stock biomass well bellow (20% or less) of the correspondent survey bottom biomass. Most of the catches during the peak of the recent 3M redfish fishery were taken by pelagic trawl and to be consistent with this fact VPA stock biomass should be above or at the same level of the survey bottom biomass throughout the time period considered.

A terminal F of 0.0065 was adopted corresponding, under these constraints, to a minimum of the final sum of squared residuals and of number of iteractions. The matrix of log catch ratio residuals (including the rows and columns totals, with the sum of year residuals incorporating the age weights) as well as the fully exploited fishing mortality for each year (*Fo(y)*) and exploitation pattern (*S(a)*) from the Separable analysis are presented on Table 12. The rows and column totals can be considered near zero despite some high positive and negative residuals observed on the first four age groups, most likely reflecting the long recruitment process of beaked redfish and the consequent poor sampling of those young ages. High negative and positive residuals were observed as well in some ages on the terminal year, reflecting the sensitivity of the Separable analysis to the input terminal F. Patterns in the residuals down the columns (year effects), across the rows (age effects) or the cohort diagonals (year class effects) were also inspected, with no signs of a systematic lack of fit to the model.

After a final run of the Separable analysis with a terminal F of 0.0065 and a terminal S of 1, a traditional VPA was performed using the separable generated F’s (y,a) matrix. The results are presented on Table 13 as regards fishing mortality, stock and spawning stock abundance and biomass at the start of the year (no information has being given as regards spawning time taking into account that beaked redfish is a group of two species with two different spawning seasons).

The fishing mortality trends from the catch/survey biomass ratios (given each year as the product of the correspondent F multiplier and the terminal F adopted) and from the saparable mean F’s for ages 6 to 16 are compared (the two last rows of the relative F at age matrix of Table 13 and Fig’s 7a and 7b). Both fishing mortality vectors present the same general 1990-98 downward pattern despite the opposite directions oberved on 1991/92 and 1992/93 years.

As regards VPA stock biomass and survey bottom biomass they are also compared (the two last rows of the stock biomass at age matrix of Table 13 and Fig. 8). Each series started with a steep decline of the respective biomass but at two distinct levels (the VPA stock biomass at an upper level) till 1991, indicating that at the beginning of the time period an important portion of the beaked redfish stock biomass was still above the bottom, supporting a pelagic fishery at its peak. From 1992 till 1996 VPA stock biomass approaches and "entangles" with the survey bottom biomass reflecting a period of apparent stability at a low level, with most of the stock abundance composed of young age groups and most of the stock biomass concentrated near the bottom. Finally on 1997 and 1998 VPA stock biomass and survey bottom started to diverge with the first one increasing while the second is decreasing, suggesting that the survival and growth of the above average cohorts from the beginning of this decade is being reflected in an increasing pelagic proportion of the beaked redfish stock biomass.

Non-equilibrium stock production model incorporating covariates (ASPIC)

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

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

$$dB_t / dt = rB_t - (r / K)B_t^{\,2}$$

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

$$dB_t / dt = rB_t - (r / K)B_t^{\,2} - C_t$$

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

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

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

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

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

1) Maximum F when estimating effort. From the VPA 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. A first ASPIC run included all series available:

   a) Three survey bottom biomass indices for 3M beaked redfish: Canadian survey series (1978-1985, Power and Atkinson, 1986), EU survey series (1988-1998) and the Russian bottom survey series (1983-1997, Vaskov *et al.*, 1998).
   b) Along with the STACFIS 3M redfish catches (1959-98) two commercial cpue series were used, one just from standardised observed catch and effort data of the Portuguese trawl (1988-1996, Alpoim *et al.*, 1998) and the other from standardised STATLANT catch and effort data for most of the components of the fishery (1959-1993, Gorchinsky and Power,1994).
   c) The VPA stock biomass for 3M beaked redfish (1989-98).

The inclusion of all series resulted in negative or very low correlations between most of them. Despite the reasonable correlations with both EU and Russian surveys the VPA series has also to be discarded due to its negative correlation with the STATLANT commercial cpue, that, due to its longevity is considered to be the backbone of the ASPIC runs. The EU bottom biomass (1988-1998) and the STATLANT commercial cpue (1959-1993) gave a high correlation and so the further ASPIC runs were made with these two series.

4) No series specific statistical weights were given.

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

6) The starting guess for *r* was 0.24. This value was derived from the $F_{0.1}$ given by the yield per recruit analysis, using the model's assumptions as regards $F_{0.1,}$ Fmsy and *r*. Due to the slow growing and long living features of redfish species the lower limit for *r* was set at 0.05, but allowed to vary up to 1.0.

7) The starting guess for EU survey bottom biomass catchability was set at 0.88. This value corresponds to the mean survey bottom biomass/VPA stock biomass ratio for the 1992-96 period, when the two series were overlapping with no apparent trend. This was the only parameter that was kept constant at the starting guess, since when the model is allowed to do this estimate the run does not end normally, generating extremely high biomass estimates, which are kept almost undisturbed over large time intervals namely during the most recent period, as well as an unrealistically low catchability. Taking into account that the 3M redfish fishery has been dominated by its pelagic component at least during the most recent period with the highest level of catch, the EU survey catchability adopted is clearly an overestimate of the mean catchability occuring during the survey time interval, and would generate conservative stock biomass estimates.

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

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

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

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

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

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

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

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

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

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

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

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

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

$$Obj.function = \sum_{t=1959}^{T=1998}\left[Ln(f_t) - Ln(\hat{f}_t)\right]^2 + \sum_{t=1988}^{T=1998}\left[Ln(B_{tsurvey}) - Ln(\hat{B}_{tsurvey})\right]^2$$

This routine is reapeted until the objective function is minimized.

After a first run on the FIT mode (Appendix 1), to have the conventional parameters estimate, effort and survey pattern of unweighted residuals as well as the biomass and fishing mortality trends expressed as ratios to Bmsy and Fmsy, ASPIC runned on BOT mode (Appendix 2). On the bootstrap procedure effort and survey residuals were resampled 1000 times in order to derive bias corrected estimates and probability distribution of the parameters. The program uses bias corrections based on medians and so, being P the fit estimate of a parameter and P_m its median value from the bootstrap, then the bias corrected estimate P_{bc} will be given as

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

The results of the production model converge to a total biomass above the Bmsy level until 1990, though starting to decline in 1987 after more than a decade of aparent stablility (1975-86) where the catches, with the exception of the last year of this period, were within 14,000 and 20,000 tons. From 1989 till 1993 fishing mortality was well above Fmsy inducing a faster stock decline till 1994, when the biomass represented about 44% of the Bmsy. Between 1995 and 1996 fishing mortality droped, being still declining in 1998, when its value was at 5% of the Fmsy. This drop gave room to stock recovery and biomass is gradually increasing from 1995 onwards, most likely being in 1999 at 80% of the Bmsy (bias corrected estimate). As for MSY for 3M beaked redfish stock, the ASPIC bias correct estimate is of 24,000tons with an inter quartile range for 50% confidence limits of 5,000tons. These results, as regards biomass and fishing mortality trends are identical to the ones given by the Separable VPA analysis and within the same order of magnitude.

State of the 3M redfish stocks and prognosis

Both Separable VPA and ASPIC analysis pointed out that the 3M beaked redfish stock experienced a continuous decline till 1994 due to a sharp increase of fishing mortality that peak in 1990. Since 1995 fishing mortality declined as fast as it had went up, allowing the survival of above average year classes from the early nineties. Not being severely affected by the boom of the shrimp fishery on 1993 and 1994, the survival and growth of those year classes contributed not only to alter the former decline but they also forced a discrete but continuous growth of the biomass from 1995 onwards.

However the observed 1989-1995 levels of fishing mortality, well above both $F_{0.1}$ and Fmsy, affected primarily the larger length groups in the *S. mentella* and *S. fasciatus* populations, inducing a decline on the beaked redfish female spawning biomass to a low level from which these stocks are now slowly recovering. From VPA results the female spawning biomass still represented in 1998 about 20% of the stock biomass while back to the late seventies/early eighties, when there is evidence that the stock experienced a period of relative stability, from the Canadian survey series that same proportion, but just for the bottom biomass, was on average of 42%. Despite that no apparent relation is observed between spawning biomass and recruitment (in the NW Atlantic redfish stocks generally produce one or two strong year classes every 5 or 10 years) redfish are slow growing, viviparous species.

For the next coming years the recovery of the 3M beaked redfish will be dependent on the survival and maturation of fish from cohorts that are now reaching maturity. To allow the recovery of the female spawning biomass fishing mortality should be kept at a level below $F_{0.1}$, which on a long-term equilibrium would be sustained at a reduction of 68% of the female spawning biomass from its unexploited level and a 32% proportion of female spawners in the stock biomass. For long living species like redfish this reduction might be too severe to guarantee the “normal” rhythm on the pulse of recruitment. As a precautionary rule of thumb based on the recent history of the 3M beaked redfish stock female spawning biomass should reach a 42% proportion of the stock biomass. In order to achieve this goal a 3M redfish TAC for the year 2000 of 5,000 tons is proposed. Accepting the 1998 level of 3M beaked redfish biomass given by both models (120,000-130,000tons) this TAC is at the level of a catch generated by a fishing mortality of 0.04 which, on a long term equilibrium, would generate a 42% proportion of female spawning biomass in the stock. In practical terms the observance of this proposed TAC for next year would correspond anyway to an important increase from the 1996-1998 level of catches.

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Table 1-A: Length composition (absolute frequencies in '000) of the 3M redfish annual catch, 1989-1998.

length	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
10	4				1	0				
11										
12	4				1	0				
13	16				9	1				
14	36	8			119	12				
15	12	139			402	45				4
16		362			448	135		25		
17		663			170	398		25	1	3
18		1064	347		103	859	117	25		
19	16	1519	1442	69	132	1049	237	83	7	14
20	96	1426	2967	352	147	510	384	450	8	20
21	271	1064	2752	1853	333	525	396	1204	16	48
22	1049	1457	2452	3104	987	609	206	2750	44	95
23	3222	3130	1930	2372	1926	745	78	2044	113	177
24	7828	8412	2991	1466	3430	1434	96	1631	288	218
25	12777	16524	7364	2755	3215	2036	615	922	355	418
26	11755	22600	12710	8640	3403	2042	1059	571	339	416
27	8343	22091	18450	13274	3334	1815	1342	895	216	384
28	5703	17858	15881	13380	4094	2485	1715	912	185	278
29	5778	15390	10671	9592	3591	2635	2220	1039	229	226
30	9338	13709	11576	8104	5351	2834	2244	1007	271	125
31	8796	12082	7374	5786	4691	2573	1783	1058	243	101
32	9165	10602	6652	5115	3692	2236	1875	880	271	97
33	8389	9106	4147	4527	3813	1483	1787	662	293	79
34	8646	8590	3829	4762	3132	948	1508	629	117	52
35	8319	7741	3743	4805	3365	1013	1571	223	83	24
36	6324	6631	2758	3470	2953	634	1539	171	46	15
37	4951	4673	2341	2599	2824	361	1368	240	26	14
38	2922	3416	1350	1730	1563	309	1137	94	30	6
39	1924	2475	1078	1386	1341	155	741	151	12	3
40	1015	1319	697	972	707	102	711	50	4	2
41	531	910	282	582	399	79	525	30	13	1
42	361	509	183	233	345	26	249	40	6	1
43	222	355	103	273	151	15	104	11	1	
44	129	224	43	198	451	27	76	3	7	
45	141	139	31	45	56	17	52	3	1	
46	86	62	18	10	45		11	4	1	
47	45	31	0	0	37		29	1	1	
48	40	23	17	20	508		7			
49	5	23								
50	15	8						33		
51	5	23								
52	5									
53	10	31								
54		15								
55		8								
56										
57										
58		8								
59										
60										
61									12	
no ('000)	128295	196419	126180	101475	61267	30146	25779	17867	3242	2821
catch (tons)	**58100**	**81000**	**48500**	**43300**	**29000**	**11300**	**13500**	**5800**	**1300**	**899**
mean weight (kg)	0.453	0.412	0.384	0.427	0.473	0.375	0.524	0.325	0.401	0.319
mean length (cm)	30.8	29.8	29.1	30.2	31.0	28.6	32.4	27.1	29.5	27.4

Table 1-B: Estimate of the 1993-94 per mille length composition of the 3M redfish catches from the 1989-92 combined survey abundance at length of *S. mentella* and *S. fasciatus*

	permille of the commercial catch at length					permille of the survey abundance at length					conversion	"commercial" survey abundance		"commercial" per mille	
length	1989	1990	1991	1992	sum	1989	1990	1991	1992	sum	factor	1993	1994	93	94
10	0.0				0.0	1.7	2.3	2.2	21.0	27.3	0.0	0.3	0.0	0.0	0.0
11						5.6	1.7	6.1	176.6	189.9		0.0	0.0	0.0	0.0
12	0.0					14.9	2.0	9.3	278.4	304.6	0.0	0.3	0.0	0.0	0.0
13	0.1				0.1	17.5	6.6	3.2	74.1	101.3	0.0	2.7	0.4	0.2	0.0
14	0.3				0.3	41.0	14.3	1.0	16.9	73.2	0.0	34.5	9.6	1.9	0.4
15	0.1	0.7			0.8	84.4	25.8	2.4	38.7	151.2	0.0	116.5	35.5	6.6	1.5
16		1.8			1.8	74.7	45.7	12.9	37.0	170.4	0.0	129.9	106.2	7.3	4.5
17		3.4			3.4	25.0	116.7	46.9	9.0	197.7	0.0	49.3	313.7	2.8	13.2
18		5.4	2.8		8.2	4.5	143.8	92.8	5.5	246.6	0.0	29.8	676.1	1.7	28.5
19	0.1	7.7	11.4	0.7	20.0	2.9	87.1	157.5	8.8	256.3	0.1	38.3	826.0	2.2	34.8
20	0.7	7.3	23.5	3.5	35.0	4.3	17.9	190.3	15.4	228.0	0.2	42.7	401.8	2.4	16.9
21	2.1	5.4	21.8	18.3	47.6	6.6	2.7	97.8	30.8	137.9	0.3	96.4	413.0	5.4	17.4
22	8.2	7.4	19.4	30.6	65.6	15.5	3.7	27.2	48.8	95.2	0.7	286.0	479.8	16.1	20.2
23	25.1	15.9	15.3	23.4	79.7	31.1	8.9	10.2	38.0	88.2	0.9	558.6	587.0	31.4	24.7
24	61.0	42.8	23.7	14.4	142.0	58.8	21.4	11.1	18.6	109.9	1.3	994.6	1129.4	56.0	47.6
25	99.6	84.1	58.4	27.1	269.2	94.7	47.0	22.5	8.3	172.5	1.6	932.1	1602.9	52.5	67.5
26	91.6	115.1	100.7	85.1	392.6	119.1	76.0	30.9	10.7	236.7	1.7	986.6	1607.9	55.5	67.7
27	65.0	112.5	146.2	130.8	454.5	103.5	79.5	32.6	15.3	230.9	2.0	966.7	1429.4	54.4	60.2
28	44.5	90.9	125.9	131.9	393.1	68.8	59.3	29.9	17.4	175.3	2.2	1186.9	1956.4	66.8	82.4
29	45.0	78.4	84.6	94.5	302.5	40.0	35.1	21.7	16.6	113.4	2.7	1041.2	2074.7	58.6	87.4
30	72.8	69.8	91.7	79.9	314.2	25.7	22.1	18.8	11.6	78.2	4.0	1551.7	2231.6	87.3	94.0
31	68.6	61.5	58.4	57.0	245.5	20.7	17.0	14.3	8.4	60.4	4.1	1360.0	2025.8	76.6	85.3
32	71.4	54.0	52.7	50.4	228.5	24.2	16.4	12.9	5.6	59.1	3.9	1070.5	1761.1	60.3	74.2
33	65.4	46.4	32.9	44.6	189.2	18.9	14.6	14.7	5.3	53.5	3.5	1105.5	1167.8	62.2	49.2
34	67.4	43.7	30.3	46.9	188.4	18.7	16.9	15.3	5.4	56.3	3.3	908.2	746.4	51.1	31.4
35	64.8	39.4	29.7	47.4	181.3	19.5	11.9	12.5	4.6	48.5	3.7	975.7	797.5	54.9	33.6
36	49.3	33.8	21.9	34.2	139.1	16.8	11.5	11.6	3.6	43.5	3.2	856.3	499.4	48.2	21.0
37	38.6	23.8	18.6	25.6	106.5	12.6	9.1	9.5	2.9	34.2	3.1	819.0	283.9	46.1	12.0
38	22.8	17.4	10.7	17.0	67.9	8.5	6.9	8.2	2.4	25.9	2.6	453.1	243.2	25.5	10.2
39	15.0	12.6	8.5	13.7	49.8	7.7	4.1	5.2	1.7	18.7	2.7	388.7	122.2	21.9	5.1
40	7.9	6.7	5.5	9.6	29.7	5.4	2.8	3.3	1.1	12.6	2.4	204.9	80.1	11.5	3.4
41	4.1	4.6	2.2	5.7	16.7	2.2	1.4	1.5	0.5	5.6	3.0	115.7	62.5	6.5	2.6
42	2.8	2.6	1.4	2.3	9.1	1.4	0.7	1.1	0.3	3.6	2.6	100.1	20.5	5.6	0.9
43	1.7	1.8	0.8	2.7	7.0	0.6	0.5	0.6	0.1	1.7	4.1	43.9	12.2	2.5	0.5
44	1.0	1.1	0.3	2.0	4.4	0.2	0.1	0.2	0.1	0.6	7.1	130.8	21.2	7.4	0.9
45	1.1	0.7	0.2	0.4	2.5	0.2	0.1	0.3	0.0	0.6	4.4	16.1	13.1	0.9	0.6
46	0.7	0.3	0.1	0.1	1.2	0.1		0.1	0.0	0.2	5.1	13.1		0.7	
47	0.4	0.2			0.5	0.0				0.1	4.3	10.7		0.6	
48	0.3	0.1	0.1	0.2	0.8	0.0				0.0	35.9	147.3		8.3	
49	0.0	0.1			0.2										
50	0.1	0.0			0.2										
51	0.0	0.1			0.2										
52	0.0				0.0										
53	0.1	0.2			0.2										
54		0.1			0.1										
											total	17764.7	23738.2	1000.0	1000.0

Table 2-A: Juvenile beaked redfish proportion in juvenile redfish up to 21cm (EU surveys, 1994-1998, abundance at length in '000)

	1994		1995		1996		1997		1998		total			beaked redfish rati
Length	total	beaked	total	beaked	total	beaked	total	beaked	total	beaked	total	beaked	Length	
4									10	10	10	10	4	1.00
5										1		1	5	1.00
6			28	28							28	28	6	1.00
7			7	7							7	7	7	1.00
8			60	60					38	24	98	84	8	0.86
9			17	17	7	7	51	51	40	40	115	115	9	1.00
10			54	47	25	12	35	28	92	92	206	179	10	0.87
11	21	7	367	316	165	134	56	56	156	156	765	669	11	0.87
12	62	21	2178	1913	1365	1291	265	244	711	678	4581	4147	12	0.91
13	275	143	2032	1259	2344	2130	902	858	1746	1705	7299	6095	13	0.84
14	1083	745	4055	2296	4877	4536	1972	1885	3169	3124	15156	12586	14	0.83
15	2402	1910	8130	5634	10765	10157	6960	6533	7393	7354	35650	31588	15	0.89
16	7353	6682	18278	14557	10047	9069	14255	13555	16785	16690	66718	60553	16	0.91
17	14310	12258	45671	41893	19165	17444	19751	18632	13271	13175	112168	103402	17	0.92
18	34946	31348	81664	77338	41781	38850	21846	20195	9832	9578	190069	177309	18	0.93
19	37140	32988	112224	107224	88289	84714	28193	25915	11466	10855	277312	261696	19	0.94
20	21609	19127	86067	80024	131911	126417	56570	52858	12160	11213	308317	289639	20	0.94
21	14175	11499	37509	32361	124529	118967	88079	83119	16663	15344	280955	261290	21	0.93
													overall mean	**0.91**

Table 2-B: Female and maturity proportion at length for each 3M redfish population (Saborido-Rey,1994)

	S. mentella		S. fasciatus		S. marinus	
Length	female	maturity	female	maturity	female	maturity
1.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
2.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
3.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
4.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
5.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
6.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
7.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
8.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
9.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
10.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
11.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
12.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
13.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
14.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
15.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
16.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
17.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
18.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
19.5	0.44	0.000	0.47	0.000	**0.42**	**0.000**
20.5	0.44	0.000	0.51	0.000	**0.45**	**0.000**
21.5	0.44	0.016	0.51	0.022	**0.45**	**0.002**
22.5	0.44	0.025	0.51	0.046	**0.45**	**0.003**
23.5	0.44	0.040	0.51	0.093	**0.45**	**0.005**
24.5	0.44	0.063	0.51	0.179	**0.45**	**0.008**
25.5	0.39	0.098	0.51	0.316	**0.47**	**0.013**
26.5	0.39	0.149	0.51	0.495	**0.47**	**0.022**
27.5	0.39	0.220	0.51	0.675	**0.47**	**0.036**
28.5	0.39	0.313	0.51	0.814	**0.47**	**0.059**
29.5	0.39	0.424	0.51	0.903	**0.47**	**0.096**
30.5	0.47	0.542	0.49	0.952	**0.62**	**0.152**
31.5	0.47	0.657	0.49	0.977	**0.62**	**0.233**
32.5	0.47	0.755	0.49	0.989	**0.62**	**0.339**
33.5	0.47	0.833	0.49	0.995	**0.62**	**0.464**
34.5	0.47	0.889	0.49	0.997	**0.62**	**0.594**
35.5	0.57	0.928	0.50	0.999	**0.87**	**0.712**
36.5	0.57	0.954	0.50	0.999	**0.87**	**0.807**
37.5	0.57	0.971	0.50	1.000	**0.87**	**0.876**
38.5	0.57	0.982	0.50	1.000	**0.87**	**0.923**
39.5	0.57	0.989	0.50	1.000	**0.87**	**0.953**
40.5	0.85	0.993	0.56	1.000	**1.00**	**0.972**
41.5	0.85	0.996	0.56	1.000	**1.00**	**0.983**
42.5	0.85	0.997	0.56	1.000	**1.00**	**0.990**
43.5	0.85	0.998	0.56	1.000	**1.00**	**0.994**
44.5	0.85	0.999	0.56	1.000	**1.00**	**0.996**
45.5	0.87	0.999	0.88	1.000	**1.00**	**0.998**
46.5	0.87	1.000	0.88	1.000	**1.00**	**0.999**
47.5	0.87	1.000	0.88	1.000	**1.00**	**0.999**
48.5	0.87	1.000	0.88	1.000	**1.00**	**1.000**
49.5	0.87	1.000	0.88	1.000	**1.00**	**1.000**
50.5	0.87	1.000	0.86	1.000	**1.00**	**1.000**
51.5	0.87	1.000	0.86	1.000	**1.00**	**1.000**
52.5	0.87	1.000	0.86	1.000	**1.00**	**1.000**
53.5	0.87	1.000	0.86	1.000	**1.00**	**1.000**
54.5	0.87	1.000	0.86	1.000	**1.00**	**1.000**
55.5	0.87	1.000	0.86	1.000	**1.00**	**1.000**
56.5	0.87	1.000	0.86	1.000	**1.00**	**1.000**
57.5	0.87	1.000	0.86	1.000	**1.00**	**1.000**

Table 2-C: Female and mature female proportion at length for 3M beaked redfish (EU surveys 1994-98, *S. mentella* and *S. fasciatus* data combined, abundance at length in '000)

			1994			1995			1996			1997			1998			TOTAL	proportion		
Length	females	mat. f.	total	females	mat. f.	total	females	mat. f.	total	females	mat. f.	total	females	mat. f.	total	females	mat. f.	total	**females**	**mat. f.**	Length
4													4		10	4		10	**0.43**		4
5													9		19	9		19	**0.43**		5
6				12		28	19		44	0		1	2		5	34		77	**0.43**		6
7				5		12	272		613				4		10	282		635	**0.43**		7
8				82		185	1992		4490	13		29	40		92	2127		4797	**0.43**		8
9				247		557	1433		3232	54		122	84		191	1818		4102	**0.43**		9
10	45		101	348		786	263		594	34		79	60		138	751		1698	**0.43**		10
11	246		556	733		1654	589		1332	108		246	113		261	1790		4049	**0.43**		11
12	698		1576	2291		5177	1999		4530	429		976	607		1386	6024		13645	**0.43**		12
13	1805		4076	1374		3117	1893		4329	792		1806	1355		3094	7218		16422	**0.43**		13
14	11001		24814	1176		2693	2255		5174	945		2193	1562		3604	16939		38479	**0.43**		14
15	31613		71305	2433		5561	4299		9775	2852		6660	3261		7504	44458		100805	**0.43**		15
16	44803		101079	6440		14617	3922		8950	5802		13593	7347		16770	68314		155010	**0.43**		16
17	81373		183618	18491		41793	7026		15996	8033		18636	5767		13186	120690		273229	**0.43**		17
18	87949		198539	34021		76858	17164		38989	8772		20196	4127		9578	152034		344159	**0.43**		18
19	46236		104705	47468		107244	37056		83866	11311		25915	4664		10856	146735		332586	**0.43**		19
20	11947		26973	35368		79985	55664		125877	23393		52858	4973		11213	131345		296906	**0.43**		20
21	5775	107	13026	14555	240	32903	52385	848	118455	36761	598	83119	6796	120	15344	116271	1913	262847	**0.43**	**0.02**	21
22	3232	120	7283	3974	121	8974	34329	938	77610	37683	1015	85202	12619	356	28519	91836	2549	207588	**0.43**	**0.03**	22
23	3061	203	6900	1721	107	3881	16597	796	37509	25491	1153	57631	22305	971	50440	69175	3230	156361	**0.43**	**0.05**	23
24	4005	409	9040	1511	189	3406	8024	674	18131	10419	888	23539	23772	1612	53766	47732	3773	107882	**0.43**	**0.08**	24
25	4314	624	10670	1691	317	4028	3685	703	8755	4246	817	10071	13116	1424	33448	27051	3886	66972	**0.43**	**0.14**	25
26	3952	846	9824	2112	490	5200	2074	698	4816	2888	1142	6476	6170	1069	15675	17197	4245	41991	**0.43**	**0.25**	26
27	2822	752	7128	2051	648	5076	2941	1024	7182	2158	1097	4918	2567	679	6489	12538	4200	30793	**0.43**	**0.34**	27
28	3546	1387	8868	2298	844	5797	2214	1054	5362	2180	1481	4871	1269	478	3190	11506	5244	28088	**0.43**	**0.46**	28
29	3038	1353	7753	2416	1120	6125	2398	1303	5894	1511	1016	3525	623	313	1556	9987	5105	24853	**0.43**	**0.51**	29
30	2630	1470	5579	2909	1644	6148	2095	1317	4251	2358	1893	4248	510	293	1073	10501	6616	21299	**0.48**	**0.63**	30
31	2316	1548	4917	2358	1594	4977	1769	1207	3716	1413	1112	2721	612	416	1289	8468	5876	17620	**0.48**	**0.69**	31
32	2188	1682	4621	1974	1508	4190	1719	1351	3563	1114	931	2183	522	404	1096	7516	5876	15653	**0.48**	**0.78**	32
33	1557	1307	3302	1692	1419	3595	1604	1363	3348	994	879	1960	428	359	911	6275	5327	13116	**0.48**	**0.85**	33
34	1056	945	2232	1451	1294	3089	1118	1000	2364	795	738	1553	366	327	775	4785	4305	10013	**0.48**	**0.90**	34
35	1225	1138	2134	1529	1420	2668	973	907	1669	628	598	976	272	254	467	4627	4317	7914	**0.58**	**0.93**	35
36	893	852	1560	1471	1405	2560	840	807	1397	551	529	921	292	279	510	4046	3871	6948	**0.58**	**0.96**	36
37	521	506	910	1258	1222	2196	636	620	1077	319	310	551	200	195	350	2934	2852	5084	**0.58**	**0.97**	37
38	557	548	928	791	777	1375	459	451	795	217	214	380	143	140	250	2168	2131	3728	**0.58**	**0.98**	38
39	263	260	460	556	550	968	311	308	532	114	113	200	103	102	180	1348	1333	2340	**0.58**	**0.99**	39
40	289	287	340	443	440	520	264	262	310	125	124	146	51	51	60	1172	1164	1376	**0.86**	**0.99**	40
41	179	178	210	383	381	450	221	220	260	119	119	140	68	68	80	971	966	1140	**0.86**	**1.00**	41
42	68	68	80	272	272	320	162	161	190	34	34	40	26	25	30	562	560	660	**0.86**	**1.00**	42
43	26	25	30	136	136	160	60	59	70				60	59	70	281	280	330	**0.86**	**1.00**	43
44	26	26	30	43	43	50	17	17	20	17	17	20	26	26	30	128	128	150	**0.86**	**1.00**	44
45	26	26	30	43	43	50	17	17	20				9	9	10	96	96	110	**0.86**	**1.00**	45
46				26	26	30							9	9	10	35	35	40	**0.86**	**1.00**	46
47				9	9	10										9	9	10	**0.86**	**1.00**	47
48							9	9	10							9	9	10	**0.86**	**1.00**	48

Table 3-A: 3M beaked redfish abundance at length ('000), biomass and spwanning biomass (tons)
from Canadian (1979-1985) and EU (1988-1998) bottom trawl surveys

Canadian series

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

	1979	1980	1981	1982	1983	1984	1985
spawning biomass	**58036**	**111691**	**68198**	**45981**	**79318**	**66825**	**64451**
biomass	**124782**	**290825**	**167002**	**113750**	**181519**	**160789**	**148427**
ssb proportion	46.5%	38.4%	40.8%	40.4%	43.7%	41.6%	43.4%
	41.7%						

Table 3-A: count.

EU series

	1988		1989		1990		1991		1992		1993	
length	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem	stock	mat fem
4												
5												
6			10		73		18					
7	300		30		1198		1482		823		91	
8	2500		420		12767		10042		30089		823	
9	2700		500		13106		6274		26339		549	
10	2700		800		1262		841		26156		3299	
11	8600		2630		814		2094		199189		19388	
12	18600		6980		924		2988		295185		32741	
13	14400		8210		3411		1162		89077		26248	
14	2300		19280		7444		340		20303		90639	
15	500		39640		12321		777		42847		235382	
16	700		35100		21364		4109		40000		124819	
17	900		11750		52509		14854		9392		28748	
18	900		2100		63436		29368		5683		8915	
19	3500		1360		37903		49853		9143		4595	
20	6800		2020		7830		60267		15975		2664	
21	15800	11306	3100	222	1213	47	30958	2214	31925	234	2578	24
22	34600	418	7270	88	1680	20	8620	104	50764	605	4245	73
23	74000	1503	14610	297	3990	81	3230	66	39507	764	6510	184
24	117900	4053	27620	949	9620	331	3520	121	19338	612	7837	342
25	131800	8234	44490	2779	21070	1316	7130	445	8649	436	6023	378
26	101400	10886	55940	6005	34090	3660	9790	1051	11180	749	5966	540
27	45400	6615	48610	7082	35690	5200	10310	1502	15936	1516	4945	579
28	19700	3905	32310	6405	26600	5273	9460	1875	18082	2389	5294	815
29	10200	2268	18800	4180	15760	3504	6860	1525	17260	2962	3930	801
30	14200	4313	12070	3666	9930	3016	5950	1807	12030	3174	3878	1119
31	12300	4114	9720	3251	7620	2549	4540	1519	8662	2782	3336	1125
32	15100	5690	11390	4292	7340	2766	4100	1545	5827	2100	2778	1040
33	15200	6220	8880	3634	6540	2676	4650	1903	5549	2186	3134	1262
34	13600	5898	8800	3816	7580	3287	4850	2103	5608	2362	2716	1133
35	10800	5847	9180	4970	5340	2891	3950	2139	4771	2565	2611	1393
36	9900	5497	7880	4375	5150	2860	3680	2043	3724	2067	2675	1477
37	7600	4287	5940	3351	4090	2307	3020	1704	2966	1672	2625	1461
38	6800	3879	3970	2265	3090	1763	2590	1477	2491	1406	1729	972
39	3700	2124	3610	2072	1860	1068	1640	941	1804	1031	1463	830
40	2600	2219	2540	2168	1250	1067	1040	888	1191	1013	870	742
41	1700	1455	1050	899	650	556	460	394	510	432	389	332
42	700	600	660	566	320	274	350	300	355	302	390	331
43	200	172	260	223	210	180	180	154	150	127	108	92
44	100	86	80	69	60	52	60	52	140	119	185	157
45	100	86	80	69	50	43	80	69	40	35	37	32
46			50	43	10	9	30	26	20	17	26	23
47			20	17	20	17	10	9			25	22
48			10	9							41	36
49												
50												
51												
52												
53												
54												
total	730800	101673	469770	67761	447184	46812	315528	27975	1078680	33659	655246	17312

	1988	1989	1990	1991	1992	1993
spawning biomass	**45976**	**34392**	**23471**	**14949**	**17770**	**10323**
biomass	**207087**	**130803**	**99754**	**65122**	**111576**	**65021**
ssb proportion	22.2%	26.3%	23.5%	23.0%	15.9%	15.9%
	23.6%				**15.9%**	

Table 3-A: count.
EU series

length	1994 stock	1994 mat fem	1995 stock	1995 mat fem	1996 stock	1996 mat fem	1997 stock	1997 mat fem	1998 stock	1998 mat fem
4									10	
5									19	
6			28		44		1		5	
7			12		613				10	
8			185		4490		29		92	
9			557		3232		122		191	
10	101		786		594		79		138	
11	556		1654		1332		246		261	
12	1576		5177		4530		976		1386	
13	4076		3117		4329		1806		3094	
14	24814		2693		5174		2193		3604	
15	71305		5561		9775		6660		7504	
16	101079		14617		8950		13593		16770	
17	183618		41793		15996		18636		13186	
18	198539		76858		38989		20196		9578	
19	104705		107244		83866		25915		10856	
20	26973		79985		125877		52858		11213	
21	13026	107	32903	240	118455	848	83119	598	15344	120
22	7283	120	8974	121	77610	938	85202	1015	28519	356
23	6900	203	3881	107	37509	796	57631	1153	50440	971
24	9040	409	3406	189	18131	674	23539	888	53766	1612
25	10670	624	4028	317	8755	703	10071	817	33448	1424
26	9824	846	5200	490	4816	698	6476	1142	15675	1069
27	7128	752	5076	648	7182	1024	4918	1097	6489	679
28	8868	1387	5797	844	5362	1054	4871	1481	3190	478
29	7753	1353	6125	1120	5894	1303	3525	1016	1556	313
30	5579	1470	6148	1644	4251	1317	4248	1893	1073	293
31	4917	1548	4977	1594	3716	1207	2721	1112	1289	416
32	4621	1682	4190	1508	3563	1351	2183	931	1096	404
33	3302	1307	3595	1419	3348	1363	1960	879	911	359
34	2232	945	3089	1294	2364	1000	1553	738	775	327
35	2134	1138	2668	1420	1669	907	976	598	467	254
36	1560	852	2560	1405	1397	807	921	529	510	279
37	910	506	2196	1222	1077	620	551	310	350	195
38	928	548	1375	777	795	451	380	214	250	140
39	460	260	968	550	532	308	200	113	180	102
40	340	287	520	440	310	262	146	124	60	51
41	210	178	450	381	260	220	140	119	80	68
42	80	68	320	272	190	161	40	34	30	25
43	30	25	160	136	70	59			70	59
44	30	26	50	43	20	17	20	17	30	26
45	30	26	50	43	20	17			10	9
46			30	26					10	9
47			10	9						
48					10	9				
49										
50										
51										
52										
53										
54										
total	825197	16668	449015	18259	615097	18117	438702	16817	293535	10036

	1994	1995	1996	1997	1998
spawning biomass	**8174**	**10233**	**8234**	**6657**	**3642**
biomass	**99599**	**72191**	**100140**	**76999**	**56667**
ssb proportion	8.2%	14.2%	8.2%	8.6%	6.4%
	9.1%				

Table 3-B: 3M golden redfish abundance at length ('000), biomass and spwanning biomass (tons) from EU (1988-1998) bottom trawl surveys

length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
6		6									
7	130	17									
8	992	77									14
9	986	110									
10	1324	328						7	13	7	
11	1929	366					14	51	31		
12	2908	830	7				41	265	74	21	33
13	1432	1241	10	6			132	773	214	44	41
14	590	2470	7	67		17	338	1759	341	87	45
15	329	2820	54	167	13	21	492	2496	608	427	39
16	309	4087	168	382	55	116	671	3721	978	700	95
17	495	1908	321	824	186	311	2052	3778	1721	1119	96
18	618	440	304	1060	174	373	3598	4326	2931	1651	254
19	870	635	471	823	267	461	4152	5000	3575	2278	611
20	896	945	512	1091	503	606	2482	6043	5494	3712	947
21	1630	623	513	1125	443	836	2676	5148	5562	4960	1319
22	1497	1014	935	793	730	762	1700	3686	6076	6887	1645
23	1803	1129	652	667	629	886	1591	2443	6098	8919	2079
24	2555	1203	1009	638	732	877	2999	1424	4807	9517	2468
25	3503	2268	1243	524	583	767	3420	1233	3826	14282	2449
26	5857	2763	992	607	673	683	3120	1292	2476	17344	2586
27	4627	2504	1202	606	637	640	5005	888	1747	15272	2447
28	2652	3383	1798	612	621	569	4684	879	1209	15022	1720
29	1977	3537	2011	472	678	538	3608	906	989	11504	1504
30	2197	3031	3288	678	672	701	4745	568	985	12068	825
31	1581	3329	2844	376	431	486	4297	506	801	8751	604
32	1986	4746	2228	416	471	531	3660	391	517	6469	326
33	1556	4231	2616	309	458	428	3741	498	760	6135	209
34	1292	2951	2127	360	357	342	3665	351	327	4832	114
35	1674	1913	1618	236	326	344	2570	311	271	3660	80
36	885	1738	812	203	208	177	1509	202	243	2727	34
37	1168	1029	844	200	149	129	1705	225	249	3262	48
38	1285	1237	571	196	144	41	1288	153	161	1994	23
39	1429	912	254	77	155	111	757	92	153	1110	21
40	812	429	420	90	92	43	671	142	71	1622	14
41	422	309	112	99	108	53	541	81	10	429	21
42	298	414	230	27	14	60	634	85	41	642	
43	307	460	33	81	21	19	34	55	23	331	14
44	165	212	48	39	35	8	590	35	21	108	
45	89	159	184	42	7	25	843	34	17	56	
46	121	276	27	11	26		530	50	13	132	
47	21	377	7	14	7	17	103	6		18	
48	42	58	85	7	7		152	6		29	
49	6	13	13	19			183			7	
50	19		15	12		17	172			20	
51	37	13	12		7		70	18		29	7
52	23	6			14		77	35		44	
53	12	7	7	6			65	6		7	
54	15	6			15		7			13	
55			7				7		17	6	
56			7						7	7	
57	21						7		7		
total	57372	62560	30618	13962	10648	11995	75398	49968	53464	168261	22732

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
spawning biomas	**5171**	**6860**	**3704**	**914**	**893**	**713**	**9599**	**1090**	**957**	**10730**	**338**
biomass	**21673**	**26625**	**15462**	**4618**	**4366**	**4317**	**34423**	**10036**	**12916**	**67906**	**6806**
ssb proportion	23.9%	25.8%	24.0%	19.8%	20.5%	16.5%	27.9%	10.9%	7.4%	15.8%	5.0%

Table 3-C: 3M redfish abundance at length ('000), biomass and spwanning biomass (tons) from EU (1988-1998) bottom trawl surveys

length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
4											10
5											21
6		16	80	20				28	48	1	5
7	430	47	1310	1620	900	100		13	670		11
8	3492	497	13960	10980	32900	900		197	4910	32	112
9	3686	610	14330	6860	28800	600		608	3533	129	205
10	4024	1128	1380	920	28600	3607	110	862	661	91	142
11	10529	2996	890	2290	217800	21200	621	1830	1475	264	271
12	21508	7810	1017	3260	322760	35800	1762	5747	4907	1065	1485
13	15832	9451	3740	1276	97400	28700	4575	4064	4748	1939	3265
14	2890	21750	8147	427	22200	99124	27425	4493	5595	2309	3694
15	829	42460	13524	957	46842	257389	78317	8068	10405	7099	7557
16	1009	39187	23528	4512	43712	136590	110645	18339	9932	14297	16873
17	1395	13658	57731	15694	10330	31708	201726	45571	17717	19755	13283
18	1518	2540	69654	30440	6113	9989	217996	81184	41920	21847	9832
19	4370	1995	41871	50683	9470	5338	115471	112244	87441	28193	11467
20	7696	2965	9032	61361	16495	3321	30096	86028	131371	56570	12160
21	17430	3723	1783	32085	32385	3423	15745	38051	124017	88079	16663
22	36097	8284	2615	9413	51494	5007	8983	12660	83686	92089	30164
23	75803	15739	4642	3897	40136	7396	8491	6324	43607	66550	52519
24	120455	28823	10629	4158	20070	8714	12039	4830	22938	33056	56234
25	135303	46758	22313	7654	9232	6790	14090	5261	12581	24353	35897
26	107257	58703	35082	10397	11853	6649	12944	6492	7292	23820	18261
27	50027	51114	36892	10916	16573	5585	12133	5964	8929	20190	8936
28	22352	35693	28398	10072	18703	5863	13552	6676	6571	19893	4910
29	12177	22337	17771	7332	17938	4468	11361	7031	6883	15029	3060
30	16397	15101	13218	6628	12702	4579	10324	6716	5236	16316	1898
31	13881	13049	10464	4916	9093	3822	9214	5483	4517	11472	1893
32	17086	16136	9568	4516	6298	3309	8281	4581	4080	8652	1422
33	16756	13111	9156	4959	6007	3562	7043	4093	4108	8095	1120
34	14892	11751	9707	5210	5965	3058	5897	3440	2691	6385	889
35	12474	11093	6958	4186	5097	2955	4704	2979	1940	4636	547
36	10785	9618	5962	3883	3932	2852	3069	2762	1640	3648	544
37	8768	6969	4934	3220	3115	2754	2615	2421	1326	3813	398
38	8085	5207	3661	2786	2635	1770	2216	1528	956	2374	273
39	5129	4522	2114	1717	1959	1574	1217	1060	685	1310	201
40	3412	2969	1670	1130	1283	913	1011	662	381	1768	74
41	2122	1359	762	559	618	442	751	531	270	569	101
42	998	1074	550	377	369	450	714	405	231	682	30
43	507	720	243	261	171	127	64	215	93	331	84
44	265	292	108	99	175	193	620	85	41	128	30
45	189	239	234	122	47	62	873	84	37	56	10
46	121	326	37	41	46	26	530	80	13	132	10
47	21	397	27	24	7	42	103	16		18	
48	42	68	85	7	7	41	152	6	10	29	
49	6	13	13	19			183			7	
50	19		15	12		17	172			20	
51	37	13	12		7		70	18		29	7
52	23	6			14		77	35		44	
53	12	7	7	6			65	6		7	
54	15	6			15		7			13	
55			7				7		17	6	
56			7						7	7	
57	21						7		7		
total	788172	532330	499838	331902	1162268	720809	958068	499771	670123	607197	316568

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
spawning biomass	**49429**	**41221**	**27168**	**15558**	**18513**	**11022**	**17722**	**11262**	**9227**	**17590**	**3936**
biomass	**228760**	**157428**	**117021**	**69787**	**116188**	**67833**	**137521**	**79520**	**109478**	**143020**	**61632**
ssb proportion	21.6%	26.2%	23.2%	22.3%	15.9%	16.2%	12.9%	14.2%	8.4%	12.3%	6.4%
	23.3%				**16.0%**		**11.2%**				

Table 4: 3M redfish length weight relationships (Saborido-Rey, *pers. comm* 1999)

	a	b	n
S. mentella (1991-98)	0.01776	2.93616	10061
S. fasciatus (1991-98)	0.01808	2.96326	7002
***S. marinus* (1989-98)**	**0.02668**	**2.85615**	**8550**
***S. spp* (beaked redfish)**	**0.02471**	**2.84687**	**17063**

Table 5-A: Stock abundance at age ('000) of 3M beaked redfish from EU surveys, 1989-98

Year \ Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989	960	18620	95784	17563	5948	28902	80774	85749	44086	22929	14552	9133	8809	8163	7473	4346	3356	3114	9511
1990	27144	6411	80598	122818	1870	10453	43474	57347	32606	17334	10638	6342	6377	5850	5005	2956	2267	2195	5500
1991	17815	7157	2465	100619	92469	15667	20728	14975	9713	5549	5429	5063	4819	4066	1632	2510	1963	1170	1718
1992	57251	617564	63268	60654	103377	55935	28199	28561	19582	11139	7410	5607	5343	4093	3727	2460	1486	1018	2008
1993	1463	121202	104585	348651	9995	18711	12878	8562	2768	3859	3722	4384	2911	2813	3465	1276	1232	796	1969
1994	0	17754	68662	584791	66174	20432	22160	12324	8555	6079	4974	3667	2795	1614	1832	853	657	799	1072
1995	1569	9582	39701	82466	250467	8669	10321	11125	6320	5622	6115	3583	2704	2383	2648	1753	1025	1054	1907
1996	8972	12376	21047	16664	159818	343928	13691	11072	7871	4127	3146	3169	1669	1915	1582	1174	785	707	1384
1997	232	2796	16412	56245	73664	71044	194558	6088	4846	3814	2143	1939	1080	1328	388	516	613	173	824
1998	464	5360	32144	23911	26523	45921	29061	119233	4734	626	550	2885	396	408	126	267	512	46	368
total	115871	818821	524666	1414383	790305	619662	455845	355036	141079	81078	58679	45773	36903	32633	27878	18111	13895	11073	26263

Table 5-B: Mature female abundance at age ('000) of 3M beaked redfish from EU surveys, 1989-98

Year \ Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989	0	0	0	71	234	1164	7204	12098	8344	5365	4846	3806	4068	3970	3930	2325	1844	1709	6784
1990	0	0	0	16	55	515	4500	8801	6442	4146	3521	2608	2917	2798	2608	1570	1243	1199	3872
1991	0	0	0	316	1821	919	2650	2986	2565	1986	2176	2332	2440	2092	895	1585	1204	700	1308
1992	0	0	0	12	1159	1476	2412	4405	4243	3426	2888	2418	2592	2158	1978	1483	855	691	1462
1993	0	0	0	6	126	779	1282	1602	767	1208	1413	1907	1327	1458	1877	767	747	476	1569
1994	0	0	0	16	218	974	1835	1922	1780	1916	1707	1392	1124	819	926	431	382	492	734
1995	0	0	0	69	345	481	1135	1891	1454	1725	2215	1384	1246	1233	1413	1001	586	616	1466
1996	0	0	0	0	1184	2384	1682	1987	2068	1349	1152	1281	749	910	844	646	440	409	1031
1997	0	0	0	0	110	2181	4740	1794	1858	1564	935	907	536	683	215	289	342	93	570
1998	0	0	0	0	121	778	1305	4235	907	164	188	1129	185	206	69	149	285	25	290
total	0	0	0	507	5373	11652	28744	41721	30427	22850	21041	19163	17185	16327	14754	10247	7928	6411	19087

Table 5-C: Maturity ogive at age for 3M beaked redfish as the average proportion of mature females at age, from EU survey abundance at age 1989-98

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
Maturity Ogive	**0.000**	**0.000**	**0.000**	**0.000**	**0.007**	**0.019**	**0.063**	**0.118**	**0.216**	**0.282**	**0.359**	**0.419**	**0.466**	**0.500**	**0.529**	**0.566**	**0.571**	**0.579**	**0.727**

Table 6: 3M beaked redfish exploitaion pattern derived from a logit of the 1995-98 per milled catch/survey abundance at age ratios .

	Commercial catch permille				Survey abundance per mille						
Age	1995	1996	1997	1998	1995	1996	1997	1998	catch/survey ratios	Observed PR	**Logit PR**
1	0.0	0.0	0.0	0.0	3.5	14.6	0.5	1.6	0.00	0.00	**0.00**
2	0.0	0.0	0.0	0.0	21.3	20.1	6.4	18.3	0.00	0.00	**0.00**
3	0.5	1.1	0.0	1.9	88.4	34.2	37.4	109.5	0.01	0.00	**0.00**
4	9.4	1.7	1.2	3.2	183.7	27.1	128.2	81.5	0.04	0.00	**0.00**
5	43.2	188.0	7.9	22.2	557.8	259.8	167.9	90.4	0.24	0.03	**0.02**
6	23.4	290.5	188.6	59.1	19.3	559.1	161.9	156.4	0.63	0.07	**0.06**
7	90.8	91.4	235.7	170.6	23.0	22.3	443.5	99.0	1.00	0.11	**0.19**
8	137.0	94.4	91.9	425.4	24.8	18.0	13.9	406.2	1.62	0.17	**0.47**
9	89.3	92.1	96.2	171.4	14.1	12.8	11.0	16.1	8.31	0.88	**0.77**
10	82.9	59.8	108.5	19.8	12.5	6.7	8.7	2.1	9.02	0.96	**0.93**
11	105.0	43.8	73.8	17.5	13.6	5.1	4.9	1.9	**9.42**	**1.00**	**0.98**
12	64.5	39.5	65.4	80.4	8.0	5.2	4.4	9.8	9.12	0.97	**0.99**
13	56.1	20.3	33.0	8.7	6.0	2.7	2.5	1.3	9.42	1.00	**1.00**
14	54.0	20.6	40.2	7.5	5.3	3.1	3.0	1.4	9.52	1.01	**1.00**
15	62.1	14.4	9.1	1.6	5.9	2.6	0.9	0.4	8.91	0.95	**1.00**
16	48.5	10.4	9.5	2.7	3.9	1.9	1.2	0.9	8.99	0.95	**1.00**
17	28.1	7.5	11.6	5.3	2.3	1.3	1.4	1.7	7.84	0.83	**1.00**
18	32.1	7.9	3.3	0.5	2.3	1.1	0.4	0.2	10.80	1.15	**1.00**
19+	72.9	16.6	24.1	2.3	4.2	2.2	1.9	1.3			
	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0			

Table 7-A: Catch in number at age ('000) of 3M redfish, 1989-98

Year \ Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989	23	83	335	897	6907	19552	21015	14437	10709	10512	7672	7931	7362	6504	3717	2617	2413	5609
1990		2313	3399	1613	8250	31767	42719	28334	17537	13451	8501	8175	7551	6436	3717	2803	2594	7259
1991			2741	7686	13017	28377	24648	16243	8278	6468	5064	4326	3102	1188	1757	1388	826	1071
1992			259	5715	7662	18546	19813	12753	8103	6122	4863	4679	3605	3223	2132	1298	814	1888
1993	72	177	1207	1644	7551	7881	7616	3531	5070	4818	5415	3406	3146	3862	1282	1152	765	2673
1994	7	150	2367	1626	3141	4709	3700	3373	3056	2356	1669	1218	670	798	351	240	295	421
1995		13	243	1115	604	2341	3532	2302	2138	2707	1663	1447	1391	1601	1251	724	827	1880
1996		20	30	3359	5190	1634	1687	1645	1069	783	706	363	367	257	185	134	141	297
1997		0	4	26	611	764	298	312	352	239	212	107	130	29	31	38	11	78
1998		5	9	63	167	481	1200	483	56	49	227	25	21	4	8	15	1	7

Table 7-B: Weights at age in the catches ('000) of 3M beaked redfish, 1989-98

Year \ Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1989	0.036	0.083	0.161	0.186	0.223	0.262	0.318	0.378	0.426	0.496	0.553	0.597	0.619	0.661	0.677	0.728	0.739	0.937
1990		0.108	0.119	0.174	0.228	0.276	0.322	0.366	0.406	0.480	0.543	0.594	0.614	0.661	0.678	0.729	0.734	0.951
1991			0.128	0.159	0.255	0.303	0.351	0.394	0.470	0.516	0.574	0.626	0.667	0.711	0.792	0.772	0.795	0.989
1992			0.138	0.174	0.240	0.304	0.352	0.398	0.461	0.538	0.579	0.643	0.680	0.698	0.795	0.749	0.875	0.958
1993	0.053	0.059	0.085	0.179	0.224	0.291	0.368	0.419	0.445	0.507	0.572	0.603	0.676	0.708	0.778	0.804	0.816	1.145
1994	0.055	0.092	0.106	0.153	0.236	0.281	0.353	0.397	0.457	0.489	0.526	0.554	0.653	0.644	0.675	0.777	0.800	0.867
1995		0.115	0.141	0.142	0.241	0.301	0.361	0.402	0.452	0.508	0.538	0.616	0.674	0.699	0.775	0.781	0.818	0.990
1996		0.075	0.081	0.180	0.191	0.284	0.342	0.401	0.454	0.487	0.543	0.586	0.599	0.657	0.701	0.758	0.793	1.020
1997		0.085	0.115	0.173	0.241	0.267	0.358	0.403	0.465	0.503	0.548	0.573	0.578	0.623	0.708	0.740	0.689	1.266
1998		0.067	0.111	0.151	0.194	0.287	0.264	0.375	0.417	0.475	0.525	0.575	0.629	0.672	0.748	0.759	0.693	0.879

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

	mean weights 1995-98					
Age	stock	catch	stock mat f	% mat females	PR 95-98	Ref. M
1	0.015	0.000	0.000	0.000	0.000	0.2
2	0.037	0.000	0.000	0.000	0.000	0.2
3	0.071	0.086	0.000	0.000	0.001	0.1
4	0.097	0.112	0.162	0.000	0.004	0.1
5	0.137	0.162	0.176	0.007	0.016	0.1
6	0.189	0.217	0.214	0.019	0.058	0.1
7	0.247	0.285	0.277	0.063	0.190	0.1
8	0.318	0.331	0.328	0.118	0.471	0.1
9	0.391	0.395	0.400	0.216	0.772	0.1
10	0.444	0.447	0.452	0.282	0.928	0.1
11	0.491	0.493	0.494	0.359	0.980	0.1
12	0.541	0.539	0.546	0.419	0.995	0.1
13	0.598	0.588	0.606	0.466	0.999	0.1
14	0.635	0.620	0.643	0.500	1.000	0.1
15	0.672	0.663	0.675	0.529	1.000	0.1
16	0.735	0.733	0.738	0.566	1.000	0.1
17	0.759	0.760	0.762	0.571	1.000	0.1
18	0.789	0.748	0.768	0.579	1.000	0.1
19+	0.944	1.039	0.964	0.727	1.000	0.1

Table 9: Trends in 1988-98 3M beaked redfish fishing mortality, derived from the Catch/survey bottom biomass ratios.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
3M beaked redfish survey biomass	207087	130803	99754	65122	111576	65021	99599	72191	100140	76999	56667
3M redfish catches	23200	58100	81000	48500	43300	29000	11300	13500	5800	1300	899
Findex	0.112	0.444	0.812	0.745	0.388	0.446	0.113	0.187	0.058	0.017	0.016
F index multiplier	**7.06**	**28.00**	**51.18**	**46.94**	**24.46**	**28.11**	**7.15**	**11.79**	**3.65**	**1.06**	**1.00**

Table 10: Fishing mortalities associated with different levels of reduction of spawning and total biomass of 3M beaked redfish. M=0.1 for ages 3 and older. M=0.2 for ages 1 and 2.

	% SSB	% B	Ref. F	Yield	SSB	B	F	Slope
	100%	100%	0.000	0.00	1812.8	3634.8	0.004	2775.2
	90%	93%	0.007	20.62	1631.5	3372.5	0.012	2261.6
	80%	86%	0.016	40.58	1450.2	3107.9	0.022	1790.2
	70%	78%	0.027	59.75	1268.9	2840.2	0.034	1363.0
Fssb	**60%**	**71%**	**0.040**	77.95	1087.7	2568.6	0.049	982.8
	50%	63%	0.058	94.97	906.4	2291.7	0.063	735.6
	45%	59%	0.068	102.93	815.7	2150.7	0.075	584.5
	42%	57%	0.075	106.99	767.6	2074.9	0.082	515.8
	40%	55%	0.081	110.46	725.1	2007.4	0.085	485.2
	34%	50%	0.102	119.45	607.6	1817.4	0.106	329.0
F0.1	**32%**	**48%**	**0.110**	121.97	572.3	1759.1	0.113	290.2
	30%	47%	0.117	123.92	543.8	1711.7	0.130	221.9
	25%	43%	0.143	129.64	453.2	1557.2	0.161	135.0
	20%	38%	0.179	134.51	362.6	1396.0	0.206	67.7
	15%	34%	0.234	138.26	271.9	1224.5	0.285	21.3
	10%	28%	0.336	140.45	181.3	1034.9	0.353	4.9
	9%	27%	0.369	140.61	163.1	993.5	0.383	1.3
Fmax	**8%**	**27%**	**0.396**	140.64	150.6	963.8	0.403	-0.6
	8%	26%	0.410	140.63	145.0	950.3	0.436	-2.8
	7%	25%	0.462	140.49	127.0	905.2	0.496	-5.4
	6%	24%	0.531	140.12	108.8	856.9	0.528	-6.4

Table 11: Input files of Separable VPA for 3M beaked redfish

REDFISH NAFO 3M LANDINGS tons

1	1
1989	1998
4	19
5	
23200	
58100	
81000	
48500	
43300	
29000	
11300	
13500	
5800	
1300	
899	

REDFISH NAFO 3M CATCH NUMBERS thousands

1	2														
1989	1998														
4	19														
1															
335	897	6907	19552	21015	14437	10709	10512	7672	7931	7362	6504	3717	2617	2413	5609
3399	1613	8250	31767	42719	28334	17537	13451	8501	8175	7551	6436	3717	2803	2594	7259
2741	7686	13017	28377	24648	16243	8278	6468	5064	4326	3102	1188	1757	1388	826	1071
259	5715	7662	18546	19813	12753	8103	6122	4863	4679	3605	3223	2132	1298	814	1888
1207	1644	7551	7881	7616	3531	5070	4818	5415	3406	3146	3862	1282	1152	765	2673
2367	1626	3141	4709	3700	3373	3056	2356	1669	1218	670	798	351	240	295	421
243	1115	604	2341	3532	2302	2138	2707	1663	1447	1391	1601	1251	724	827	1880
30	3359	5190	1634	1687	1645	1069	783	706	363	367	257	185	134	141	297
4	26	611	764	298	312	352	239	212	107	130	29	31	38	11	78
9	63	167	481	1200	483	56	49	227	25	21	4	8	15	1	7

REDFISH NAFO 3M CATCH WEIGHT AT AGE kg

1	3														
1989	1998														
4	19														
1															
0.161	0.186	0.223	0.262	0.318	0.378	0.426	0.496	0.553	0.597	0.619	0.661	0.677	0.728	0.739	0.937
0.119	0.174	0.228	0.276	0.322	0.366	0.406	0.480	0.543	0.594	0.614	0.661	0.678	0.729	0.734	0.951
0.128	0.159	0.255	0.303	0.351	0.394	0.470	0.516	0.574	0.626	0.667	0.711	0.792	0.772	0.795	0.989
0.138	0.174	0.240	0.304	0.352	0.398	0.461	0.538	0.579	0.643	0.680	0.698	0.795	0.749	0.875	0.958
0.085	0.179	0.224	0.291	0.368	0.419	0.445	0.507	0.572	0.603	0.676	0.708	0.778	0.804	0.816	1.145
0.106	0.153	0.236	0.281	0.353	0.397	0.457	0.489	0.526	0.554	0.653	0.644	0.675	0.777	0.800	0.867
0.141	0.142	0.241	0.301	0.361	0.402	0.452	0.508	0.538	0.616	0.674	0.699	0.775	0.781	0.818	0.990
0.081	0.180	0.191	0.284	0.342	0.401	0.454	0.487	0.543	0.586	0.599	0.657	0.701	0.758	0.793	1.020
0.115	0.173	0.241	0.267	0.358	0.403	0.465	0.503	0.548	0.573	0.578	0.623	0.708	0.740	0.689	1.266
0.111	0.151	0.194	0.287	0.264	0.375	0.417	0.475	0.525	0.575	0.629	0.672	0.748	0.759	0.693	0.879

REDFISH NAFO 3M STOCK WEIGHT AT AGE kg

1	4														
1989	1998														
4	19														
1															
0.101	0.176	0.220	0.266	0.305	0.341	0.377	0.465	0.544	0.598	0.623	0.666	0.681	0.739	0.742	0.915
0.096	0.174	0.230	0.277	0.314	0.348	0.381	0.464	0.540	0.596	0.617	0.664	0.681	0.738	0.739	0.909
0.112	0.138	0.224	0.288	0.349	0.401	0.481	0.534	0.594	0.645	0.679	0.729	0.802	0.785	0.803	0.996
0.082	0.170	0.207	0.294	0.356	0.397	0.456	0.532	0.576	0.641	0.683	0.704	0.795	0.755	0.875	0.925
0.068	0.160	0.218	0.289	0.364	0.413	0.443	0.511	0.577	0.609	0.682	0.716	0.789	0.811	0.822	1.022
0.091	0.131	0.226	0.275	0.346	0.391	0.459	0.488	0.526	0.547	0.659	0.650	0.692	0.783	0.809	0.860
0.112	0.122	0.224	0.292	0.357	0.402	0.449	0.503	0.533	0.610	0.667	0.693	0.760	0.767	0.804	0.983
0.083	0.147	0.149	0.279	0.337	0.394	0.452	0.489	0.542	0.590	0.610	0.660	0.703	0.756	0.788	0.938
0.097	0.133	0.197	0.181	0.352	0.400	0.456	0.493	0.555	0.591	0.601	0.654	0.712	0.743	0.787	0.847
0.097	0.145	0.187	0.237	0.228	0.368	0.418	0.478	0.534	0.601	0.662	0.679	0.766	0.771	0.777	1.008

REDFISH NAFO 3M NATURAL MORTALITY

1	5														
1989	1998														
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	1998														
4	19														
2															
0.00	0.01	0.02	0.06	0.12	0.22	0.28	0.36	0.42	0.47	0.50	0.53	0.57	0.57	0.58	0.73

Table 12: Analysis of F's and S's of a Separable VPA for 3M beaked redfish for a starting terminal F of 0.065

Separable analysis
from 1989 to 1998 on ages 4 to 18
with Terminal F of .007 on age 11 and Terminal S of 1.000

Initial sum of squared residuals was 187.259 and
final sum of squared residuals is 76.474 after 81 iterations

Matrix of Residuals

Years	1989/9	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	TOT	WT
4/ 5	0.519	0.391	0.967	-0.381	0.451	2.396	-1.99	0.023	-2.403	-0.027	0.22
5/ 6	-0.577	-1.324	1.258	0.741	-0.322	2.215	-1.307	1.191	-1.895	-0.019	0.228
6/ 7	-0.447	-1.038	0.336	0.419	0.267	1.009	-1.254	0.941	-0.247	-0.014	0.401
7/ 8	-0.24	-0.112	0.5	0.775	0.023	0.516	-0.405	0.29	-1.358	-0.011	0.504
8/ 9	-0.095	0.231	0.448	1.245	-0.271	0.388	-0.28	-0.011	-1.664	-0.009	0.413
9/10	-0.1	0.373	0.371	0.324	-1.057	0.267	-0.381	-0.252	0.446	-0.008	0.647
10/11	-0.104	0.172	0.007	-0.049	-0.398	-0.03	-0.101	-0.25	0.746	-0.007	1
11/12	0.443	0.265	0.099	-0.339	0.035	0.341	0.401	-0.262	-0.99	-0.006	0.696
12/13	-0.114	-0.357	-0.404	-0.417	0.161	-0.128	0.312	0.076	0.867	-0.006	0.778
13/14	0.093	0.041	-0.203	-0.278	0.421	-0.277	0.306	-0.627	0.518	-0.006	0.855
14/15	-0.128	0.565	-0.75	-1.087	-0.192	-1.331	0.29	0.565	2.062	-0.006	0.312
15/16	0.359	0.093	-1.227	-0.017	0.891	-0.88	0.779	0.139	-0.144	-0.006	0.464
16/17	0.296	0.027	-0.112	-0.085	0.412	-0.939	1.079	-0.182	-0.502	-0.007	0.565
17/18	-0.224	-0.01	-0.138	-0.435	-0.194	-1.729	0.183	0.433	2.108	-0.006	0.323
TOT	-0.004	-0.008	-0.013	-0.015	-0.016	-0.011	-0.002	0.003	0.006	-0.137	
WTS	1	1	1	1	1	1	1	1	1		

Fishing Mortalities (F)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
F-values	0.3178	0.572	0.4242	0.5169	0.4982	0.2318	0.2635	0.1088	0.021	0.0065

Selection-at-age (S)

	4	5	6	7	8
S-values	0.0149	0.0756	0.261	0.5758	0.8376

	9	10	11	12	13	14	15	16	17	18
S-values	0.9289	0.9416	1	1.2788	1.3037	1.5617	1.3774	1.1964	1.2717	1

Table 13: Separable VPAresults for 3M beaked redfish for a starting terminal F of 0.0065

Traditional vpa Terminal populations from weighted Separable populations

Fishing mortality (F) at age

YEAR / AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	FBAR 96-98
4	0.0042	0.0493	0.0445	0.0073	0.0228	0.0122	0.0015	0.0007	0.0001	0.0001	0.0003
5	0.0092	0.0227	0.1348	0.1107	0.053	0.0349	0.0064	0.0227	0.0007	0.0016	0.0084
6	0.0642	0.0985	0.2291	0.173	0.1873	0.1221	0.0147	0.0337	0.0046	0.0051	0.0145
7	0.1859	0.4095	0.498	0.5181	0.2416	0.1532	0.1131	0.0453	0.0056	0.0041	0.0183
8	0.2763	0.6758	0.568	0.6876	0.3688	0.153	0.1476	0.1003	0.0094	0.0098	0.0398
9	0.2771	0.64	0.5214	0.575	0.2176	0.2466	0.1207	0.0854	0.0218	0.017	0.0414
10	0.252	0.5579	0.3427	0.4739	0.4183	0.2645	0.2181	0.0682	0.0213	0.0044	0.0313
11	0.3136	0.5059	0.3638	0.4063	0.5079	0.3106	0.3513	0.104	0.0176	0.0033	0.0416
12	0.3006	0.3989	0.3207	0.4531	0.6714	0.2928	0.3342	0.1296	0.0334	0.0188	0.0606
13	0.4067	0.5312	0.3228	0.4871	0.5855	0.2727	0.3941	0.1008	0.0235	0.0044	0.0429
14	0.4412	0.7477	0.3487	0.4316	0.627	0.1907	0.5024	0.1458	0.0429	0.0052	0.0646
15	0.5679	0.7645	0.2159	0.65	1.0105	0.2813	0.8028	0.1435	0.0138	0.0015	0.0529
16	0.4673	0.6587	0.4266	0.647	0.5157	0.1944	0.8215	0.1721	0.0208	0.0043	0.0657
17	0.3553	0.6843	0.4866	0.5689	0.7823	0.1509	0.6678	0.1644	0.0436	0.0113	0.0731
18	0.3175	0.628	0.3867	0.5211	0.6904	0.4107	0.9572	0.2297	0.0164	0.0013	0.0824
+gp	0.3175	0.628	0.3867	0.5211	0.6904	0.4107	0.9572	0.2297	0.0164	0.0013	
0 FBAR 6-16	0.323	0.5444	0.378	0.5002	0.4865	0.2256	0.3473	0.1026	0.0195	0.0071	

Relative F at age

YEAR / AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	MEAN 96-98
4	0.0131	0.0905	0.1177	0.0147	0.0469	0.0542	0.0042	0.0073	0.0047	0.0137	0.0086
5	0.0285	0.0418	0.3566	0.2213	0.109	0.1549	0.0185	0.2216	0.0367	0.2282	0.1622
6	0.1987	0.1809	0.606	0.3459	0.385	0.5411	0.0424	0.3288	0.2375	0.7209	0.429
7	0.5755	0.7521	1.3175	1.0357	0.4966	0.6788	0.3257	0.4416	0.2869	0.5724	0.4336
8	0.8554	1.2414	1.5028	1.3746	0.7581	0.6783	0.4249	0.9772	0.481	1.3841	0.9475
9	0.8579	1.1755	1.3794	1.1494	0.4473	1.0931	0.3476	0.8327	1.1172	2.4084	1.4528
10	0.7803	1.0248	0.9067	0.9473	0.8599	1.1724	0.628	0.6643	1.0928	0.6195	0.7922
11	0.9709	0.9292	0.9625	0.8123	1.044	1.3767	1.0114	1.0132	0.9011	0.4696	0.7947
12	0.9307	0.7327	0.8486	0.9057	1.38	1.2978	0.9623	1.2629	1.7088	2.6572	1.8763
13	1.2592	0.9758	0.8539	0.9738	1.2034	1.2086	1.1346	0.9827	1.2023	0.6262	0.9371
14	1.3662	1.3734	0.9226	0.8627	1.2888	0.8451	1.4464	1.4209	2.1988	0.7299	1.4499
15	1.7583	1.4042	0.5713	1.2993	2.077	1.2466	2.3114	1.3983	0.7079	0.211	0.7724
16	1.4469	1.21	1.1286	1.2933	1.0599	0.8615	2.3653	1.6775	1.0657	0.6008	1.1147
17	1.1002	1.2569	1.2875	1.1372	1.608	0.6686	1.9228	1.6026	2.2348	1.5977	1.8117
18	0.9831	1.1535	1.0231	1.0417	1.4192	1.8204	2.7559	2.2383	0.8386	0.1834	1.0868
+gp	0.9831	1.1535	1.0231	1.0417	1.4192	1.8204	2.7559	2.2383	0.8386	0.1834	
0 REFMEAN	0.323	0.5444	0.378	0.5002	0.4865	0.2256	0.3473	0.1026	0.0195	0.0071	
F98*Fmultiplier	**0.1988**	**0.3634**	**0.3333**	**0.1737**	**0.1996**	**0.0508**	**0.0837**	**0.0259**	**0.0076**	**0.0071**	

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

YEAR / AGE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	GMST 89-96	AMST 89-97
4	83681	74289	66166	37224	56233	204530	173730	42190	45359	97909	0	77420	92255
5	102988	75400	63989	57264	33435	49734	182816	156966	38147	41039	88583	77912	90324
6	116682	92335	66691	50600	46386	28691	43456	164359	138835	34492	37074	65663	76150
7	120942	99014	75710	47991	38510	34803	22977	38746	143785	125043	31051	51810	59837
8	91278	90871	59489	41635	25865	27366	27019	18567	33506	129375	112686	40540	47761
9	62548	62656	41830	30502	18940	16185	21249	21094	15197	30034	115923	30173	34375
10	50411	42900	29894	22472	15531	13787	11444	17040	17524	13454	26717	22277	25435
11	40932	35453	22220	19201	12659	9249	9575	8326	14402	15521	12121	16605	19702
12	30978	27068	19343	13974	11572	6893	6134	6098	6789	12805	13998	12699	15257
13	24858	20754	16436	12700	8037	5351	4654	3974	4847	5942	11370	9808	12095
14	21607	14977	11040	10769	7060	4050	3686	2839	3251	4284	5353	7632	9503
15	15701	12576	6416	7048	6329	3412	3028	2018	2221	2818	3856	5740	7066
16	10423	8052	5298	4678	3329	2085	2331	1228	1582	1982	2546	3776	4678
17	9169	5910	3770	3129	2216	1799	1553	927	935	1402	1786	2790	3559
18	9296	5815	2698	2097	1603	917	1400	721	712	810	1254	2148	3068
+gp	21609	16273	3498	4864	5601	1309	3182	1518	5048	5671	5857		
0 TOTAL	813103	684341	494488	366147	293308	410160	518233	486610	472141	522581	470173		

Table 13: Count.

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

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
AGE										
4	0	0	0	0	0	0	0	0	0	0
5	721	528	448	401	234	348	1280	1099	267	287
6	2217	1754	1267	961	881	545	826	3123	2638	655
7	7619	6238	4770	3023	2426	2193	1448	2441	9058	7878
8	10771	10723	7020	4913	3052	3229	3188	2191	3954	15266
9	13510	13534	9035	6588	4091	3496	4590	4556	3283	6487
10	14216	12098	8430	6337	4380	3888	3227	4805	4942	3794
11	14695	12727	7977	6893	4545	3320	3438	2989	5170	5572
12	12980	11341	8105	5855	4849	2888	2570	2555	2845	5365
13	11584	9671	7659	5918	3745	2493	2169	1852	2259	2769
14	10803	7489	5520	5385	3530	2025	1843	1420	1625	2142
15	8306	6653	3394	3729	3348	1805	1602	1068	1175	1491
16	5899	4557	2999	2648	1884	1180	1319	695	895	1122
17	5235	3375	2153	1787	1266	1027	887	530	534	801
18	5383	3367	1562	1214	928	531	810	417	412	469
+gp	15710	11830	2543	3536	4072	952	2313	1104	3670	4123

Stock biomass at age (start of year) Tonnes

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
AGE										
4	8452	7132	7411	3052	3824	18612	19458	3502	4400	9497
5	18126	13120	8830	9735	5350	6515	22304	23074	5074	5951
6	25670	21237	14939	10474	10112	6484	9734	24489	27351	6450
7	32170	27427	21805	14109	11129	9571	6709	10810	26025	29635
8	27840	28533	20762	14822	9415	9469	9646	6257	11794	29498
9	21329	21804	16774	12109	7822	6328	8542	8311	6079	11052
10	19005	16345	14379	10247	6880	6328	5138	7702	7991	5624
11	19033	16450	11865	10215	6469	4513	4816	4071	7100	7419
12	16852	14617	11490	8049	6677	3625	3270	3305	3768	6838
13	14865	12369	10601	8141	4895	2927	2839	2344	2865	3571
14	13461	9241	7496	7355	4815	2669	2459	1732	1954	2836
15	10457	8350	4677	4962	4531	2218	2099	1332	1452	1913
16	7098	5483	4249	3719	2627	1443	1771	863	1126	1518
17	6776	4362	2960	2362	1798	1408	1191	701	695	1081
18	6898	4297	2166	1835	1318	742	1125	568	560	629
+gp	19772	14792	3484	4499	5724	1126	3128	1424	4276	5716
0 TOTALBIO	267804	225559	163887	125686	93386	83979	104228	100486	112509	129229
EU survey	**130803**	**99754**	**65122**	**111576**	**65021**	**99599**	**72191**	**100140**	**76999**	**56667**

Table 13: Count.

Spawning stock biomass at age (spawning time) Tonnes

YEAR	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
AGE										
4	0	0	0	0	0	0	0	0	0	0
5	127	92	62	68	37	46	156	162	36	42
6	488	404	284	199	192	123	185	465	520	123
7	2027	1728	1374	889	701	603	423	681	1640	1867
8	3285	3367	2450	1749	1111	1117	1138	738	1392	3481
9	4607	4710	3623	2616	1690	1367	1845	1795	1313	2387
10	5359	4609	4055	2890	1940	1785	1449	2172	2253	1586
11	6833	5906	4260	3667	2322	1620	1729	1462	2549	2663
12	7061	6124	4814	3372	2798	1519	1370	1385	1579	2865
13	6927	5764	4940	3793	2281	1364	1323	1093	1335	1664
14	6730	4620	3748	3678	2408	1334	1229	866	977	1418
15	5532	4417	2474	2625	2397	1173	1110	705	768	1012
16	4017	3103	2405	2105	1487	817	1003	489	638	859
17	3869	2491	1690	1349	1026	804	680	400	397	617
18	3994	2488	1254	1062	763	430	652	329	324	364
+gp	14375	10754	2533	3271	4161	818	2274	1035	3109	4156
0 TOTSPBIO	75231	60577	39966	33333	25315	14920	16566	13776	18828	25104
SSB ratio	**28.1**	**26.9**	**24.4**	**26.5**	**27.1**	**17.8**	**15.9**	**13.7**	**16.7**	**19.4**

Summary (without SOP correction)

Traditional vpa Terminal populations from weighted Separable populations

	RECRUITS Age 4	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 6-16
1989	83681	267804	75231	58100	0.7723	0.323
1990	74289	225559	60577	81000	1.3371	0.544
1991	66166	163887	39966	48500	1.2135	0.378
1992	37224	125686	33333	43300	1.299	0.5
1993	56233	93386	25315	29000	1.1456	0.487
1994	204530	83979	14920	11300	0.7574	0.226
1995	173730	104228	16566	13500	0.8149	0.347
1996	42190	100486	13776	5800	0.421	0.103
1997	45359	112509	18828	1300	0.069	0.02
1998	97909	129229	25104	899	0.0358	0.007
Arith. Mean	88131	140675	32362	29270	0.7866	0.293
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

Fig.1: Linear regression of Ln(Findex/(1-Findex))

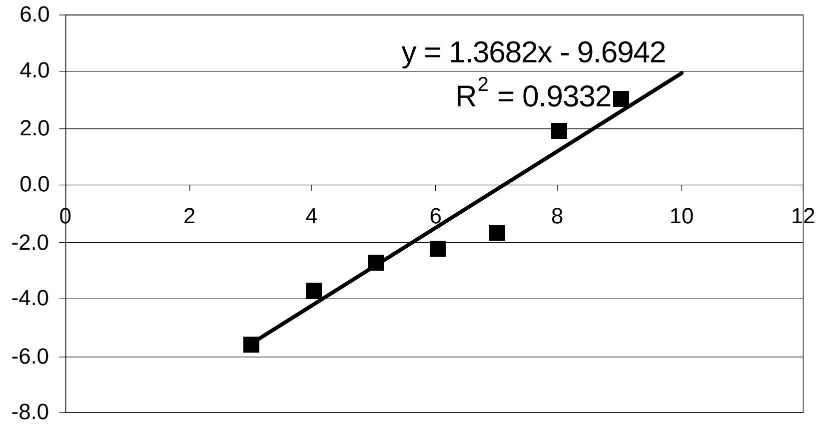


Fig. 2: Partial recruitment curve for 3M deep-sea redfish

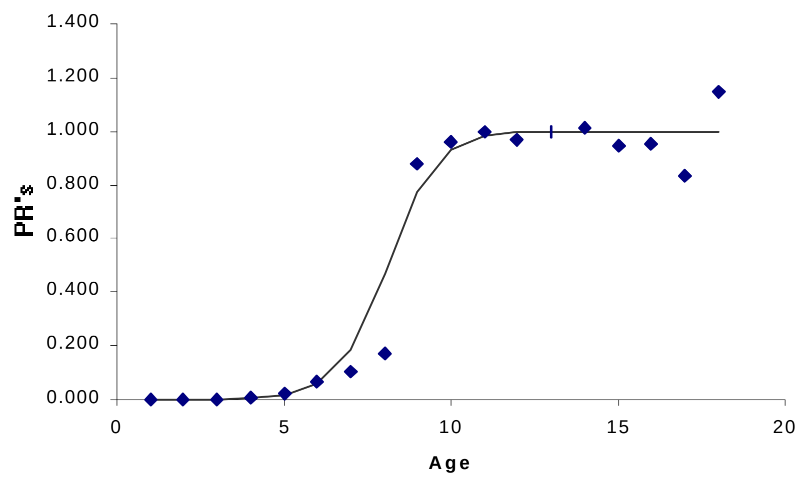


Fig. 3 : 3M Beaked redfish biomass,spawning biomass and abundance (Canada survey, 1979/85; EU survey, 1988/98)

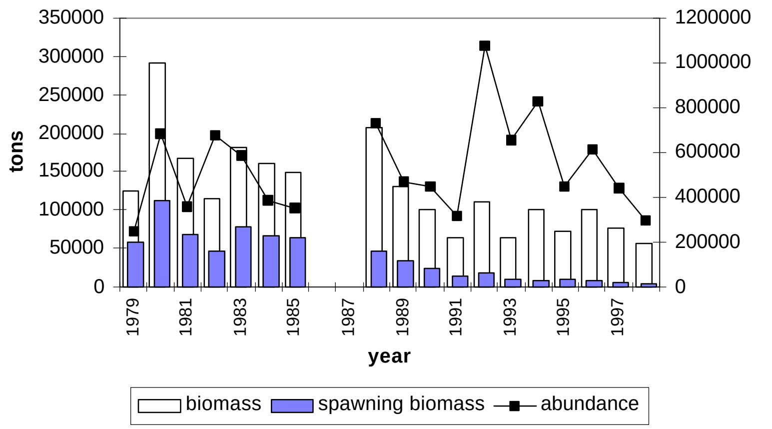


Fig. 4 : 3M golden redfish biomass, spawning biomass and abundance (EU survey, 1988/98)

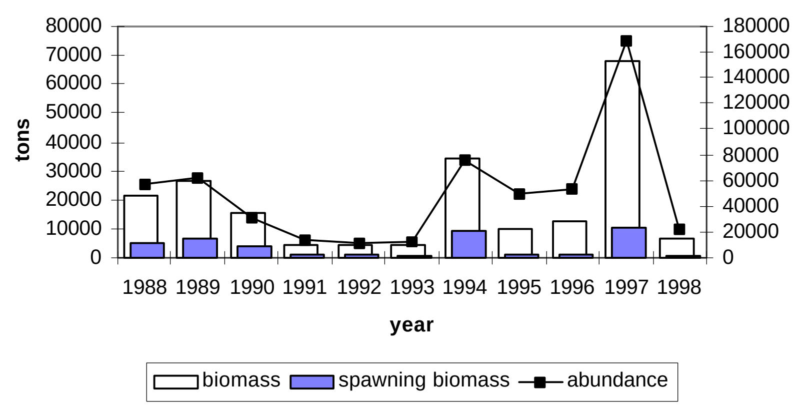
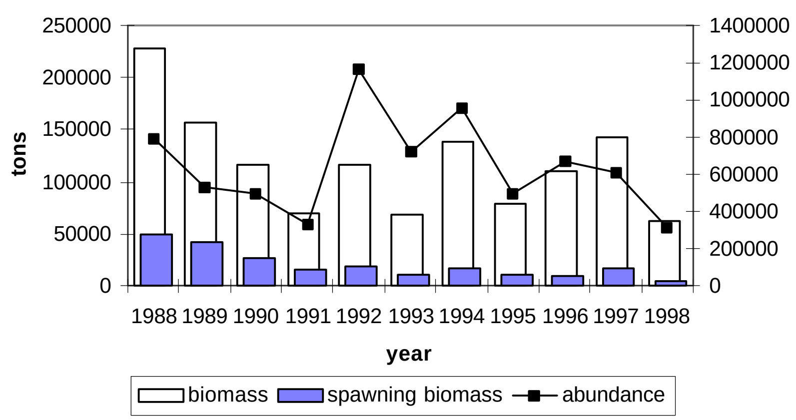


Fig. 5 : 3M redfish biomass, spawning biomass and abundance (EU survey 1988/98)



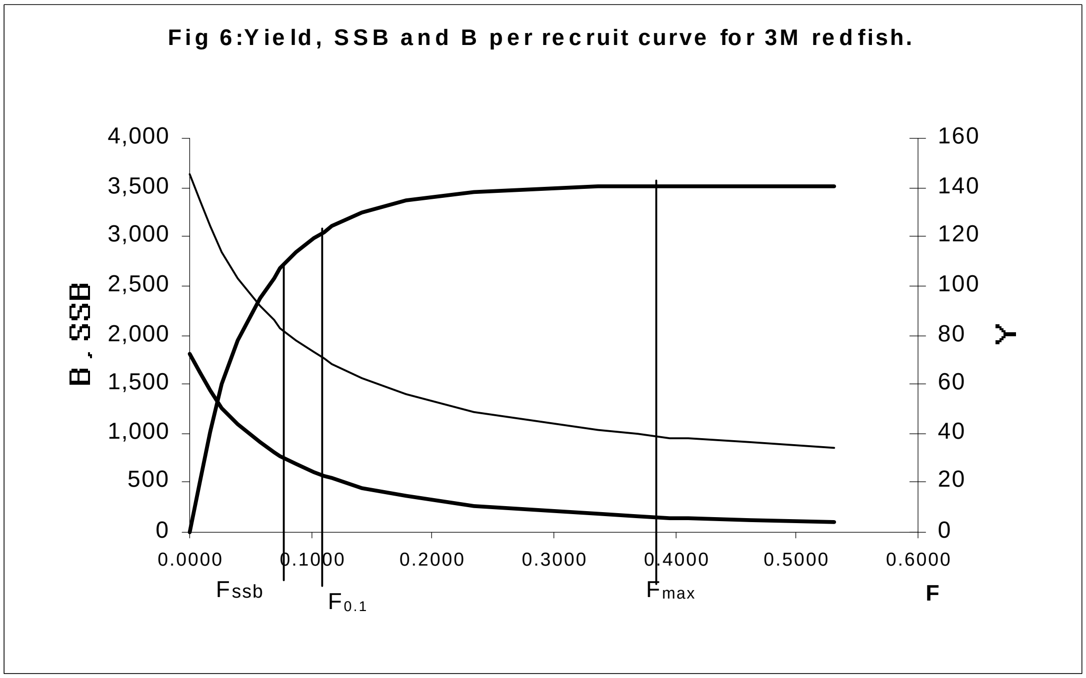


Fig 6:Yield, SSB and B per recruit curve for 3M redfish.
B , SSB
Y
F
Fssb
F0.1
Fmax
0.0000
0.1000
0.2000
0.3000
0.4000
0.5000
0.6000
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
160
140
120
100
80
60
40
20
0

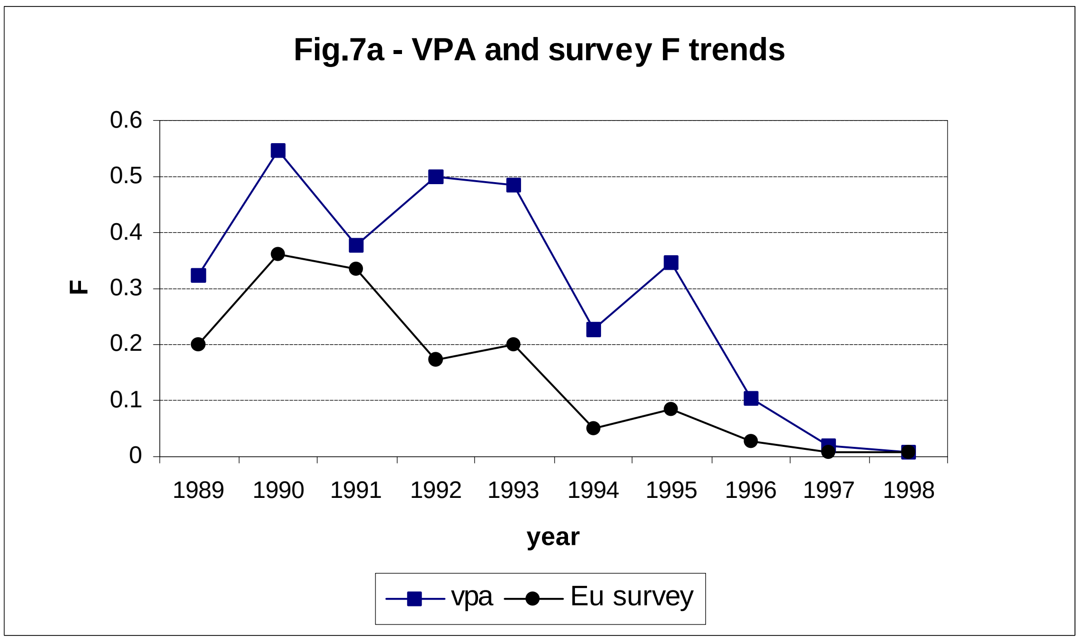


Fig.7a - VPA and survey F trends
F
year
vpa
Eu survey
0.6
0.5
0.4
0.3
0.2
0.1
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998

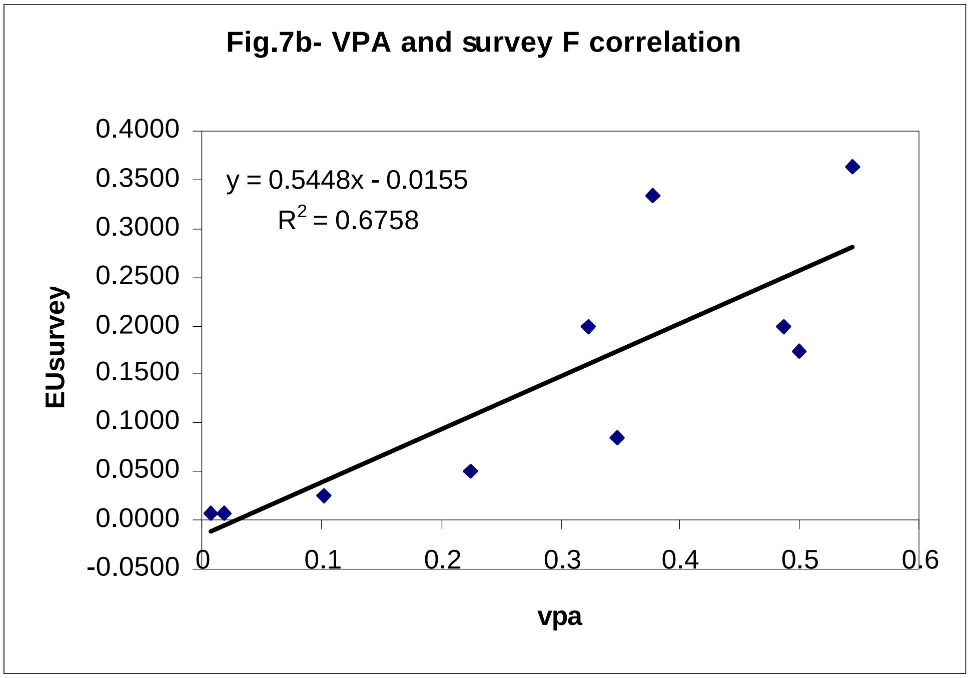


Fig.7b- VPA and survey F correlation
y = 0.5448x - 0.0155
R2 = 0.6758
EUsurvey
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
-0.0500
0
0.1
0.2
0.3
0.4
0.5
0.6
vpa

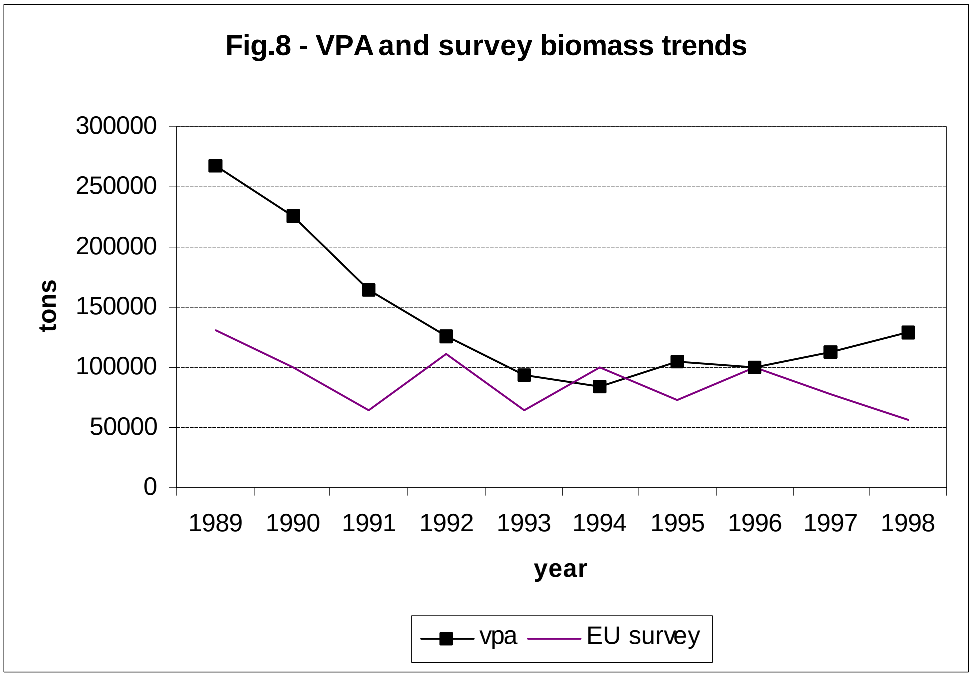


Fig.8 - VPA and survey biomass trends
tons
300000
250000
200000
150000
100000
50000
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
year
vpa
EU survey

APPENDIX 1

3M redfish — Page 1 — 07 Jun 1999 at 17:42

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

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Southwest Fisheries Science Center
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Tiburon, California 94920 USA

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	40	Number of bootstrap trials:	0
Number of data series:	2	Lower bound on MSY:	1.000E+04
Objective function computed:	in EFFORT	Upper bound on MSY:	4.000E+04
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	5.000E-02
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	1.000E+00
Relative conv. criterion (effort):	1.000E-04	Random number seed:	9126738
Maximum F allowed in fitting:	1.500	Monte Carlo search trials:	0

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) — code 0

Normal convergence.

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

	1	2
1 EU survey	1.000 11	
2 Statlant CPUE	0.806 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	1.301E+00	11	1.446E-01	1.000E+00	7.840E-01	0.325
Loss(2) Statlant CPUE	3.503E+00	35	1.061E-01	1.000E+00	1.068E+00	0.294

TOTAL OBJECTIVE FUNCTION: 4.80410773E+00

Number of restarts required for convergence:	2
Est. B-ratio coverage index (0 worst, 2 best):	1.5632
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1959	2.287E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	2.467E+04	2.000E+04	1	1
r	Intrinsic rate of increase	2.859E-01	2.400E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	EU survey	8.800E-01	8.800E-01	0	1
q(2)	Statlant CPUE	1.028E-05	3.791E-05	1	0

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	2.467E+04	Kr/4	
K	Maximum stock biomass	3.452E+05		
Bmsy	Stock biomass at MSY	1.726E+05	K/2	
Fmsy	Fishing mortality at MSY	1.429E-01	r/2	
F(0.1)	Management benchmark	1.286E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	2.443E+04	0.99*MSY	
B-ratio	Ratio of B(1999) to Bmsy	8.219E-01		
F-ratio	Ratio of F(1998) to Fmsy	5.194E-02		
Y-ratio	Proportion of MSY avail in 1999	9.683E-01	2*Br-Br^2	Ye(1999) = 2.389E+04
....	Fishing effort at MSY in units of each fishery:			
fmsy(2)	Statlant CPUE	1.390E+04	r/2q(2)	f(0.1) = 1.251E+04

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1959	0.143	3.948E+05	3.637E+05	5.198E+04	5.198E+04	-5.791E+03	9.998E-01	2.287E+00
2	1960	0.025	3.370E+05	3.342E+05	8.388E+03	8.388E+03	3.045E+03	1.756E-01	1.952E+00
3	1961	0.048	3.317E+05	3.262E+05	1.552E+04	1.552E+04	5.127E+03	3.328E-01	1.921E+00
4	1962	0.022	3.213E+05	3.210E+05	6.958E+03	6.958E+03	6.436E+03	1.516E-01	1.861E+00
5	1963	0.022	3.208E+05	3.205E+05	7.035E+03	7.035E+03	6.559E+03	1.536E-01	1.858E+00
6	1964	0.056	3.203E+05	3.152E+05	1.765E+04	1.765E+04	7.843E+03	3.917E-01	1.856E+00
7	1965	0.112	3.105E+05	2.989E+05	3.343E+04	3.343E+04	1.143E+04	7.824E-01	1.799E+00
8	1966	0.025	2.885E+05	2.915E+05	7.241E+03	7.241E+03	1.297E+04	1.738E-01	1.671E+00
9	1967	0.002	2.942E+05	2.997E+05	7.290E+02	7.290E+02	1.129E+04	1.702E-02	1.705E+00
10	1968	0.016	3.048E+05	3.072E+05	4.963E+03	4.963E+03	9.665E+03	1.130E-01	1.766E+00
11	1969	0.009	3.095E+05	3.125E+05	2.801E+03	2.801E+03	8.480E+03	6.272E-02	1.793E+00
12	1970	0.010	3.152E+05	3.174E+05	3.168E+03	3.168E+03	7.328E+03	6.984E-02	1.826E+00
13	1971	0.025	3.193E+05	3.188E+05	8.033E+03	8.033E+03	6.982E+03	1.763E-01	1.850E+00
14	1972	0.139	3.183E+05	3.018E+05	4.195E+04	4.195E+04	1.079E+04	9.724E-01	1.844E+00
15	1973	0.079	2.871E+05	2.831E+05	2.235E+04	2.235E+04	1.457E+04	5.524E-01	1.663E+00
16	1974	0.128	2.794E+05	2.700E+05	3.467E+04	3.467E+04	1.680E+04	8.984E-01	1.618E+00
17	1975	0.061	2.615E+05	2.625E+05	1.608E+04	1.608E+04	1.799E+04	4.285E-01	1.515E+00
18	1976	0.064	2.634E+05	2.638E+05	1.700E+04	1.700E+04	1.779E+04	4.508E-01	1.526E+00
19	1977	0.077	2.642E+05	2.630E+05	2.027E+04	2.027E+04	1.791E+04	5.392E-01	1.530E+00
20	1978	0.064	2.618E+05	2.625E+05	1.676E+04	1.676E+04	1.799E+04	4.468E-01	1.517E+00
21	1979	0.077	2.631E+05	2.620E+05	2.007E+04	2.007E+04	1.806E+04	5.360E-01	1.524E+00
22	1980	0.061	2.610E+05	2.621E+05	1.596E+04	1.596E+04	1.804E+04	4.259E-01	1.512E+00
23	1981	0.052	2.631E+05	2.650E+05	1.389E+04	1.389E+04	1.760E+04	3.667E-01	1.524E+00
24	1982	0.055	2.668E+05	2.681E+05	1.468E+04	1.468E+04	1.712E+04	3.832E-01	1.546E+00
25	1983	0.073	2.693E+05	2.680E+05	1.953E+04	1.953E+04	1.714E+04	5.097E-01	1.560E+00
26	1984	0.076	2.669E+05	2.655E+05	2.023E+04	2.023E+04	1.753E+04	5.331E-01	1.546E+00
27	1985	0.077	2.642E+05	2.630E+05	2.028E+04	2.028E+04	1.792E+04	5.396E-01	1.530E+00
28	1986	0.113	2.618E+05	2.566E+05	2.887E+04	2.887E+04	1.883E+04	7.873E-01	1.517E+00
29	1987	0.185	2.518E+05	2.395E+05	4.441E+04	4.441E+04	2.094E+04	1.298E+00	1.459E+00
30	1988	0.102	2.283E+05	2.278E+05	2.319E+04	2.319E+04	2.215E+04	7.123E-01	1.323E+00
31	1989	0.278	2.273E+05	2.090E+05	5.810E+04	5.810E+04	2.350E+04	1.945E+00	1.317E+00
32	1990	0.500	1.927E+05	1.620E+05	8.105E+04	8.105E+04	2.436E+04	3.499E+00	1.116E+00
33	1991	0.396	1.360E+05	1.223E+05	4.849E+04	4.849E+04	2.253E+04	2.773E+00	7.877E-01
34	1992	0.443	1.100E+05	9.774E+04	4.332E+04	4.332E+04	1.999E+04	3.101E+00	6.373E-01
35	1993	0.359	8.670E+04	8.085E+04	2.899E+04	2.899E+04	1.769E+04	2.509E+00	5.022E-01
36	1994	0.144	7.539E+04	7.839E+04	1.132E+04	1.132E+04	1.732E+04	1.010E+00	4.368E-01
37	1995	0.161	8.140E+04	8.372E+04	1.350E+04	1.350E+04	1.813E+04	1.128E+00	4.715E-01
38	1996	0.062	8.603E+04	9.274E+04	5.789E+03	5.789E+03	1.938E+04	4.367E-01	4.984E-01
39	1997	0.012	9.962E+04	1.095E+05	1.300E+03	1.300E+03	2.134E+04	8.307E-02	5.771E-01
40	1998	0.007	1.197E+05	1.307E+05	9.700E+02	9.700E+02	2.318E+04	5.194E-02	6.932E-01
41	1999		1.419E+05						8.219E-01

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

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

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1959	0.000E+00	0.000E+00	0.0	*	3.201E+05	0.00000	0.0
2	1960	0.000E+00	0.000E+00	0.0	*	2.941E+05	0.00000	0.0
3	1961	0.000E+00	0.000E+00	0.0	*	2.871E+05	0.00000	0.0
4	1962	0.000E+00	0.000E+00	0.0	*	2.825E+05	0.00000	0.0
5	1963	0.000E+00	0.000E+00	0.0	*	2.821E+05	0.00000	0.0
6	1964	0.000E+00	0.000E+00	0.0	*	2.773E+05	0.00000	0.0
7	1965	0.000E+00	0.000E+00	0.0	*	2.630E+05	0.00000	0.0
8	1966	0.000E+00	0.000E+00	0.0	*	2.565E+05	0.00000	0.0
9	1967	0.000E+00	0.000E+00	0.0	*	2.637E+05	0.00000	0.0
10	1968	0.000E+00	0.000E+00	0.0	*	2.704E+05	0.00000	0.0
11	1969	0.000E+00	0.000E+00	0.0	*	2.750E+05	0.00000	0.0
12	1970	0.000E+00	0.000E+00	0.0	*	2.793E+05	0.00000	0.0
13	1971	0.000E+00	0.000E+00	0.0	*	2.805E+05	0.00000	0.0
14	1972	0.000E+00	0.000E+00	0.0	*	2.656E+05	0.00000	0.0
15	1973	0.000E+00	0.000E+00	0.0	*	2.491E+05	0.00000	0.0
16	1974	0.000E+00	0.000E+00	0.0	*	2.376E+05	0.00000	0.0
17	1975	0.000E+00	0.000E+00	0.0	*	2.310E+05	0.00000	0.0
18	1976	0.000E+00	0.000E+00	0.0	*	2.322E+05	0.00000	0.0
19	1977	0.000E+00	0.000E+00	0.0	*	2.314E+05	0.00000	0.0
20	1978	0.000E+00	0.000E+00	0.0	*	2.310E+05	0.00000	0.0
21	1979	0.000E+00	0.000E+00	0.0	*	2.306E+05	0.00000	0.0
22	1980	0.000E+00	0.000E+00	0.0	*	2.307E+05	0.00000	0.0
23	1981	0.000E+00	0.000E+00	0.0	*	2.332E+05	0.00000	0.0
24	1982	0.000E+00	0.000E+00	0.0	*	2.359E+05	0.00000	0.0
25	1983	0.000E+00	0.000E+00	0.0	*	2.359E+05	0.00000	0.0
26	1984	0.000E+00	0.000E+00	0.0	*	2.336E+05	0.00000	0.0
27	1985	0.000E+00	0.000E+00	0.0	*	2.314E+05	0.00000	0.0
28	1986	0.000E+00	0.000E+00	0.0	*	2.258E+05	0.00000	0.0
29	1987	0.000E+00	0.000E+00	0.0	*	2.107E+05	0.00000	0.0
30	1988	1.000E+00	1.000E+00	0.0	2.071E+05	2.004E+05	0.03263	6.649E+03
31	1989	1.000E+00	1.000E+00	0.0	1.308E+05	1.839E+05	-0.34077	-5.311E+04
32	1990	1.000E+00	1.000E+00	0.0	9.975E+04	1.426E+05	-0.35733	-4.285E+04
33	1991	1.000E+00	1.000E+00	0.0	6.512E+04	1.076E+05	-0.50255	-4.252E+04
34	1992	1.000E+00	1.000E+00	0.0	1.116E+05	8.601E+04	0.26025	2.557E+04
35	1993	1.000E+00	1.000E+00	0.0	6.502E+04	7.115E+04	-0.09004	-6.126E+03
36	1994	1.000E+00	1.000E+00	0.0	9.960E+04	6.898E+04	0.36731	3.062E+04
37	1995	1.000E+00	1.000E+00	0.0	7.219E+04	7.367E+04	-0.02030	-1.480E+03
38	1996	1.000E+00	1.000E+00	0.0	1.001E+05	8.161E+04	0.20457	1.853E+04
39	1997	1.000E+00	1.000E+00	0.0	7.700E+04	9.635E+04	-0.22416	-1.935E+04
40	1998	1.000E+00	1.000E+00	0.0	5.667E+04	1.150E+05	-0.70751	-5.831E+04

* Asterisk indicates missing value(s).

```
3M redfish                                                                                                      Page  4

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     0.0326                                             |=
1989    -0.3408                               ==============|
1990    -0.3573                               ==============|
1991    -0.5025                         ====================|
1992     0.2603                                             |==========
1993    -0.0900                                         ====|
1994     0.3673                                             |===============
1995    -0.0203                                            =|
1996     0.2046                                             |========
1997    -0.2242                                    =========|
1998    -0.7075                 ============================|
                   -------------------------------------------------------------------------------------
```

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	1.390E+04	0.1429	5.198E+04	5.198E+04	0.33002	0.000E+00
2	1960	2.007E+03	2.441E+03	0.0251	8.388E+03	8.388E+03	-0.19577	0.000E+00
3	1961	2.911E+03	4.627E+03	0.0476	1.552E+04	1.552E+04	-0.46345	0.000E+00
4	1962	1.885E+03	2.108E+03	0.0217	6.958E+03	6.958E+03	-0.11190	0.000E+00
5	1963	1.870E+03	2.135E+03	0.0219	7.035E+03	7.035E+03	-0.13251	0.000E+00
6	1964	7.861E+03	5.447E+03	0.0560	1.765E+04	1.765E+04	0.36685	0.000E+00
7	1965	1.020E+04	1.088E+04	0.1118	3.343E+04	3.343E+04	-0.06461	0.000E+00
8	1966	4.089E+03	2.417E+03	0.0248	7.241E+03	7.241E+03	0.52588	0.000E+00
9	1967	4.010E+02	2.366E+02	0.0024	7.290E+02	7.290E+02	0.52753	0.000E+00
10	1968	1.442E+03	1.571E+03	0.0162	4.963E+03	4.963E+03	-0.08565	0.000E+00
11	1969	9.579E+02	8.720E+02	0.0090	2.801E+03	2.801E+03	0.09398	0.000E+00
12	1970	4.355E+02	9.711E+02	0.0100	3.168E+03	3.168E+03	-0.80184	0.000E+00
13	1971	1.600E+03	2.451E+03	0.0252	8.033E+03	8.033E+03	-0.42642	0.000E+00
14	1972	1.427E+04	1.352E+04	0.1390	4.195E+04	4.195E+04	0.05381	0.000E+00
15	1973	8.721E+03	7.681E+03	0.0790	2.235E+04	2.235E+04	0.12699	0.000E+00
16	1974	1.084E+04	1.249E+04	0.1284	3.467E+04	3.467E+04	-0.14200	0.000E+00
17	1975	5.123E+03	5.958E+03	0.0612	1.608E+04	1.608E+04	-0.15097	0.000E+00
18	1976	7.151E+03	6.268E+03	0.0644	1.700E+04	1.700E+04	0.13184	0.000E+00
19	1977	9.524E+03	7.497E+03	0.0771	2.027E+04	2.027E+04	0.23931	0.000E+00
20	1978	6.646E+03	6.212E+03	0.0639	1.676E+04	1.676E+04	0.06754	0.000E+00
21	1979	1.154E+04	7.453E+03	0.0766	2.007E+04	2.007E+04	0.43755	0.000E+00
22	1980	7.181E+03	5.922E+03	0.0609	1.596E+04	1.596E+04	0.19286	0.000E+00
23	1981	5.491E+03	5.098E+03	0.0524	1.389E+04	1.389E+04	0.07414	0.000E+00
24	1982	6.225E+03	5.328E+03	0.0548	1.468E+04	1.468E+04	0.15558	0.000E+00
25	1983	9.150E+03	7.087E+03	0.0729	1.953E+04	1.953E+04	0.25558	0.000E+00
26	1984	9.537E+03	7.412E+03	0.0762	2.023E+04	2.023E+04	0.25213	0.000E+00
27	1985	9.270E+03	7.503E+03	0.0771	2.028E+04	2.028E+04	0.21148	0.000E+00
28	1986	9.017E+03	1.095E+04	0.1125	2.887E+04	2.887E+04	-0.19383	0.000E+00
29	1987	1.240E+04	1.804E+04	0.1855	4.441E+04	4.441E+04	-0.37506	0.000E+00
30	1988	1.100E+04	9.903E+03	0.1018	2.319E+04	2.319E+04	0.10505	0.000E+00
31	1989	3.504E+04	2.704E+04	0.2780	5.810E+04	5.810E+04	0.25914	0.000E+00
32	1990	5.149E+04	4.865E+04	0.5001	8.105E+04	8.105E+04	0.05671	0.000E+00
33	1991	3.267E+04	3.856E+04	0.3964	4.849E+04	4.849E+04	-0.16564	0.000E+00
34	1992	2.831E+04	4.311E+04	0.4432	4.332E+04	4.332E+04	-0.42053	0.000E+00
35	1993	1.674E+04	3.488E+04	0.3586	2.899E+04	2.899E+04	-0.73424	0.000E+00
36	1994	*	1.404E+04	0.1443	1.132E+04	1.132E+04	0.00000	0.000E+00
37	1995	*	1.568E+04	0.1612	1.350E+04	1.350E+04	0.00000	0.000E+00
38	1996	*	6.072E+03	0.0624	5.789E+03	5.789E+03	0.00000	0.000E+00
39	1997	*	1.155E+03	0.0119	1.300E+03	1.300E+03	0.00000	0.000E+00
40	1998	*	7.222E+02	0.0074	9.700E+02	9.700E+02	0.00000	0.000E+00

* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2

```
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1959     0.3300                                             |=============
1960    -0.1958                                     ========|
1961    -0.4635                          ===================|
1962    -0.1119                                         ====|
1963    -0.1325                                        =====|
1964     0.3668                                             |===============
1965    -0.0646                                          ===|
1966     0.5259                                             |=====================
1967     0.5275                                             |=====================
1968    -0.0856                                          ===|
1969     0.0940                                             |====
1970    -0.8018             ================================|
1971    -0.4264                            =================|
1972     0.0538                                             |==
1973     0.1270                                             |=====
1974    -0.1420                                       ======|
1975    -0.1510                                       ======|
1976     0.1318                                             |=====
1977     0.2393                                             |==========
1978     0.0675                                             |===
1979     0.4376                                             |==================
1980     0.1929                                             |========
1981     0.0741                                             |===
1982     0.1556                                             |======
1983     0.2556                                             |==========
1984     0.2521                                             |==========
1985     0.2115                                             |========
1986    -0.1938                                     ========|
1987    -0.3751                               ===============|
1988     0.1051                                             |====
1989     0.2591                                             |==========
1990     0.0567                                             |==
1991    -0.1656                                      =======|
1992    -0.4205                            =================|
1993    -0.7342                =============================|
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
                   -------------------------------------------------------------------------------------
```

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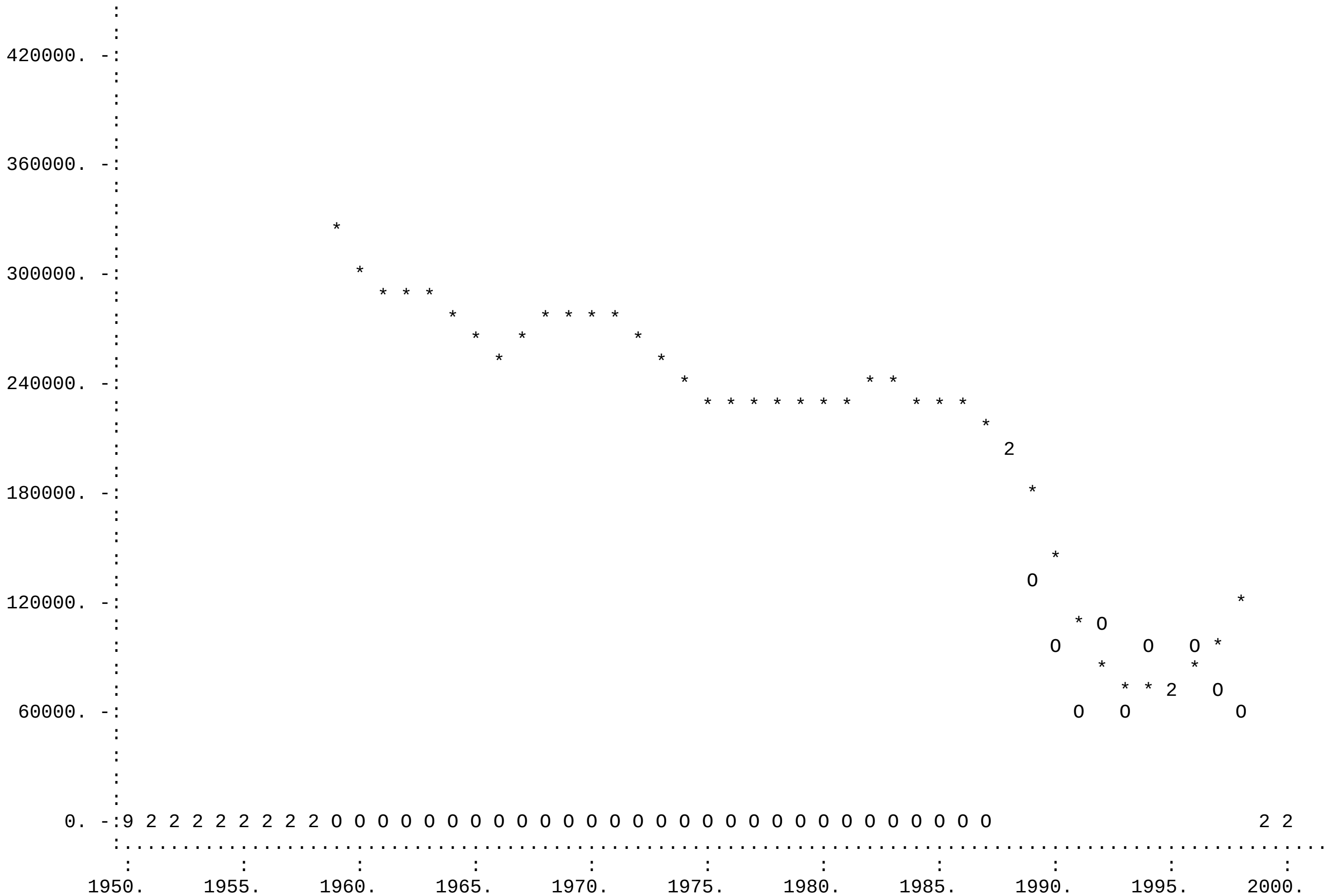
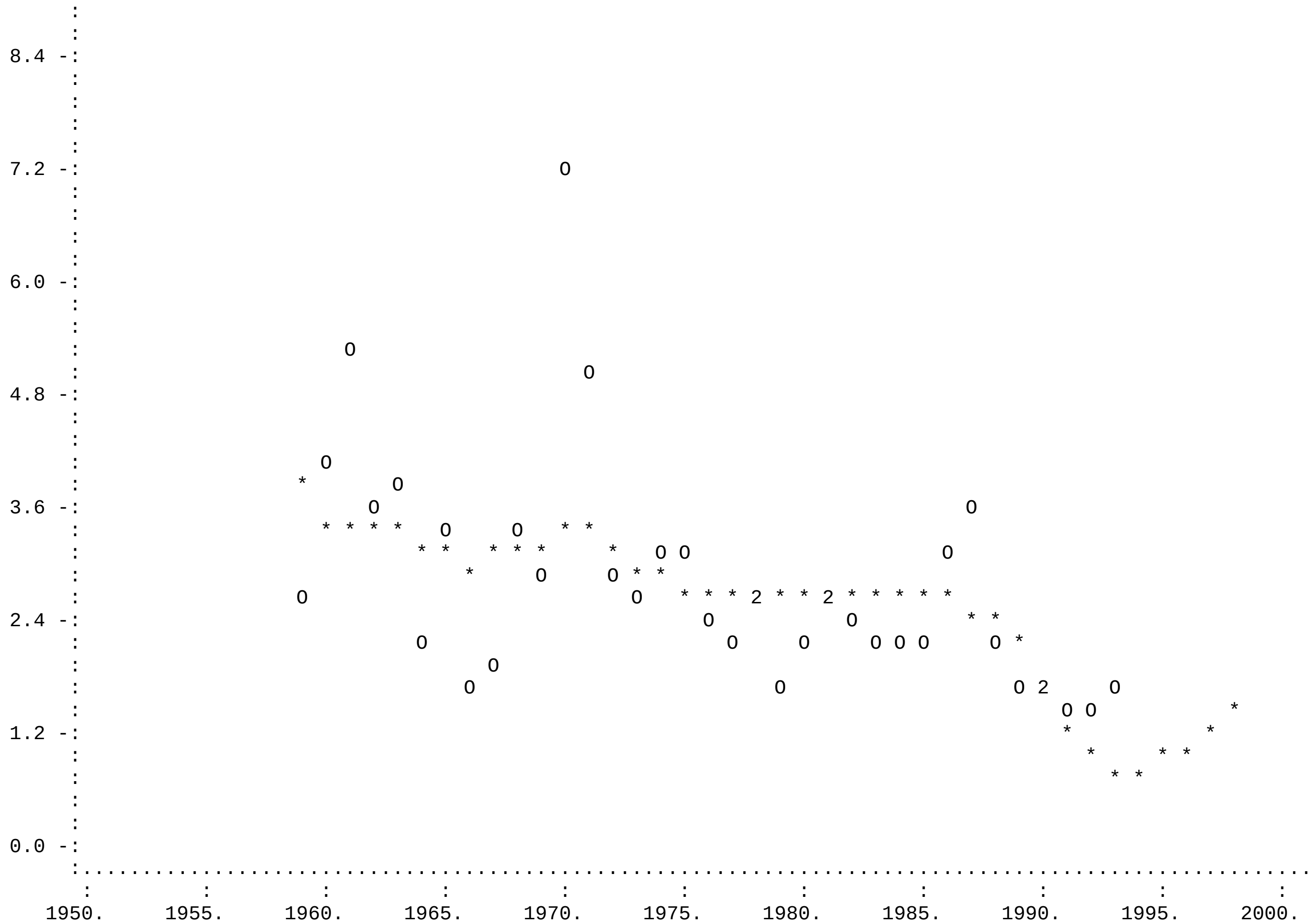
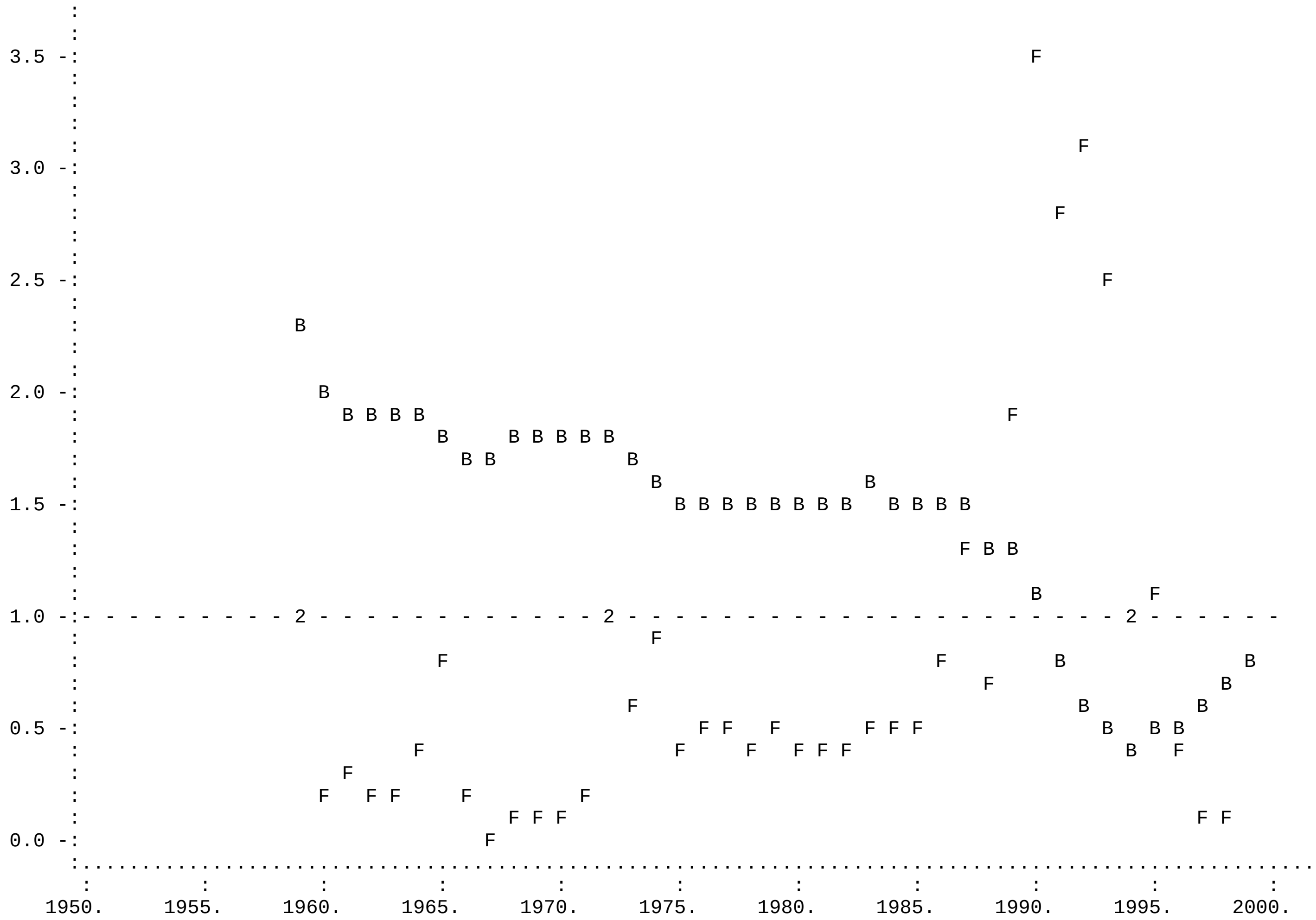
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- EU survey



Observed (O) and Estimated (*) CPUE for Data Series # 2 -- Statlant CPUE



Time Plot of Estimated F-Ratio and B-Ratio



APPENDIX 2

```
3M redfish                                                                                          Page 1
                                                                                      07 Jun 1999 at 16:14

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

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


CONTROL PARAMETERS USED (FROM INPUT FILE)
------------------------------------------------------------------------------------------------------------------------
Number of years analyzed:                       40            Number of bootstrap trials:                         1000
Number of data series:                           2            Lower bound on MSY:                            1.000E+04
Objective function computed:             in EFFORT            Upper bound on MSY:                            4.000E+04
Relative conv. criterion (simplex):       1.000E-08           Lower bound on r:                              5.000E-02
Relative conv. criterion (restart):       3.000E-08           Upper bound on r:                              1.000E+00
Relative conv. criterion (effort):        1.000E-04           Random number seed:                              9126738
Maximum F allowed in fitting:                 1.500           Monte Carlo search trials:                             0


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


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
------------------------------------------------------------------------------------------------------------------------
                                       |
 1  EU survey                          |   1.000
                                       |      11
                                       |
 2  Statlant CPUE                      |   0.806   1.000
                                       |       6      35
                                       --------------------------------------------------
                                               1       2


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

Loss(-1)  SSE in yield                             0.000E+00
Loss( 0)  Penalty for B1R > 2                      0.000E+00    1          N/A    0.000E+00           N/A
Loss( 1)  EU survey                                1.301E+00   11    1.446E-01    1.000E+00     7.840E-01         0.325
Loss( 2)  Statlant CPUE                            3.503E+00   35    1.061E-01    1.000E+00     1.068E+00         0.294
```

TOTAL OBJECTIVE FUNCTION: 4.80410773E+00

Number of restarts required for convergence: 2
Est. B-ratio coverage index (0 worst, 2 best): 1.5632
Est. B-ratio nearness index (0 worst, 1 best): 1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1959	2.287E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	2.467E+04	2.000E+04	1	1
r	Intrinsic rate of increase	2.859E-01	2.400E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	EU survey	8.800E-01	8.800E-01	0	1
q(2)	Statlant CPUE	1.028E-05	3.791E-05	1	0

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	2.467E+04	Kr/4	
K	Maximum stock biomass	3.452E+05		
Bmsy	Stock biomass at MSY	1.726E+05	K/2	
Fmsy	Fishing mortality at MSY	1.429E-01	r/2	
F(0.1)	Management benchmark	1.286E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	2.443E+04	0.99*MSY	
B-ratio	Ratio of B(1999) to Bmsy	8.219E-01		
F-ratio	Ratio of F(1998) to Fmsy	5.194E-02		
Y-ratio	Proportion of MSY avail in 1999	9.683E-01	2*Br-Br^2	Ye(1999) = 2.389E+04
....	Fishing effort at MSY in units of each fishery:			
fmsy(2)	Statlant CPUE	1.390E+04	r/2q(2)	f(0.1) = 1.251E+04

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1959	0.143	3.948E+05	3.637E+05	5.198E+04	5.198E+04	-5.791E+03	9.998E-01	2.287E+00
2	1960	0.025	3.370E+05	3.342E+05	8.388E+03	8.388E+03	3.045E+03	1.756E-01	1.952E+00
3	1961	0.048	3.317E+05	3.262E+05	1.552E+04	1.552E+04	5.127E+03	3.328E-01	1.921E+00
4	1962	0.022	3.213E+05	3.210E+05	6.958E+03	6.958E+03	6.436E+03	1.516E-01	1.861E+00
5	1963	0.022	3.208E+05	3.205E+05	7.035E+03	7.035E+03	6.559E+03	1.536E-01	1.858E+00
6	1964	0.056	3.203E+05	3.152E+05	1.765E+04	1.765E+04	7.843E+03	3.917E-01	1.856E+00
7	1965	0.112	3.105E+05	2.989E+05	3.343E+04	3.343E+04	1.143E+04	7.824E-01	1.799E+00
8	1966	0.025	2.885E+05	2.915E+05	7.241E+03	7.241E+03	1.297E+04	1.738E-01	1.671E+00
9	1967	0.002	2.942E+05	2.997E+05	7.290E+02	7.290E+02	1.129E+04	1.702E-02	1.705E+00
10	1968	0.016	3.048E+05	3.072E+05	4.963E+03	4.963E+03	9.665E+03	1.130E-01	1.766E+00
11	1969	0.009	3.095E+05	3.125E+05	2.801E+03	2.801E+03	8.480E+03	6.272E-02	1.793E+00
12	1970	0.010	3.152E+05	3.174E+05	3.168E+03	3.168E+03	7.328E+03	6.984E-02	1.826E+00
13	1971	0.025	3.193E+05	3.188E+05	8.033E+03	8.033E+03	6.982E+03	1.763E-01	1.850E+00
14	1972	0.139	3.183E+05	3.018E+05	4.195E+04	4.195E+04	1.079E+04	9.724E-01	1.844E+00
15	1973	0.079	2.871E+05	2.831E+05	2.235E+04	2.235E+04	1.457E+04	5.524E-01	1.663E+00
16	1974	0.128	2.794E+05	2.700E+05	3.467E+04	3.467E+04	1.680E+04	8.984E-01	1.618E+00
17	1975	0.061	2.615E+05	2.625E+05	1.608E+04	1.608E+04	1.799E+04	4.285E-01	1.515E+00
18	1976	0.064	2.634E+05	2.638E+05	1.700E+04	1.700E+04	1.779E+04	4.508E-01	1.526E+00
19	1977	0.077	2.642E+05	2.630E+05	2.027E+04	2.027E+04	1.791E+04	5.392E-01	1.530E+00
20	1978	0.064	2.618E+05	2.625E+05	1.676E+04	1.676E+04	1.799E+04	4.468E-01	1.517E+00
21	1979	0.077	2.631E+05	2.620E+05	2.007E+04	2.007E+04	1.806E+04	5.360E-01	1.524E+00
22	1980	0.061	2.610E+05	2.621E+05	1.596E+04	1.596E+04	1.804E+04	4.259E-01	1.512E+00
23	1981	0.052	2.631E+05	2.650E+05	1.389E+04	1.389E+04	1.760E+04	3.667E-01	1.524E+00
24	1982	0.055	2.668E+05	2.681E+05	1.468E+04	1.468E+04	1.712E+04	3.832E-01	1.546E+00
25	1983	0.073	2.693E+05	2.680E+05	1.953E+04	1.953E+04	1.714E+04	5.097E-01	1.560E+00
26	1984	0.076	2.669E+05	2.655E+05	2.023E+04	2.023E+04	1.753E+04	5.331E-01	1.546E+00
27	1985	0.077	2.642E+05	2.630E+05	2.028E+04	2.028E+04	1.792E+04	5.396E-01	1.530E+00
28	1986	0.113	2.618E+05	2.566E+05	2.887E+04	2.887E+04	1.883E+04	7.873E-01	1.517E+00
29	1987	0.185	2.518E+05	2.395E+05	4.441E+04	4.441E+04	2.094E+04	1.298E+00	1.459E+00
30	1988	0.102	2.283E+05	2.278E+05	2.319E+04	2.319E+04	2.215E+04	7.123E-01	1.323E+00
31	1989	0.278	2.273E+05	2.090E+05	5.810E+04	5.810E+04	2.350E+04	1.945E+00	1.317E+00
32	1990	0.500	1.927E+05	1.620E+05	8.105E+04	8.105E+04	2.436E+04	3.499E+00	1.116E+00
33	1991	0.396	1.360E+05	1.223E+05	4.849E+04	4.849E+04	2.253E+04	2.773E+00	7.877E-01
34	1992	0.443	1.100E+05	9.774E+04	4.332E+04	4.332E+04	1.999E+04	3.101E+00	6.373E-01
35	1993	0.359	8.670E+04	8.085E+04	2.899E+04	2.899E+04	1.769E+04	2.509E+00	5.022E-01
36	1994	0.144	7.539E+04	7.839E+04	1.132E+04	1.132E+04	1.732E+04	1.010E+00	4.368E-01
37	1995	0.161	8.140E+04	8.372E+04	1.350E+04	1.350E+04	1.813E+04	1.128E+00	4.715E-01
38	1996	0.062	8.603E+04	9.274E+04	5.789E+03	5.789E+03	1.938E+04	4.367E-01	4.984E-01
39	1997	0.012	9.962E+04	1.095E+05	1.300E+03	1.300E+03	2.134E+04	8.307E-02	5.771E-01
40	1998	0.007	1.197E+05	1.307E+05	9.700E+02	9.700E+02	2.318E+04	5.194E-02	6.932E-01
41	1999		1.419E+05						8.219E-01

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

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

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1959	0.000E+00	0.000E+00	0.0	*	3.201E+05	0.00000	0.0
2	1960	0.000E+00	0.000E+00	0.0	*	2.941E+05	0.00000	0.0
3	1961	0.000E+00	0.000E+00	0.0	*	2.871E+05	0.00000	0.0
4	1962	0.000E+00	0.000E+00	0.0	*	2.825E+05	0.00000	0.0
5	1963	0.000E+00	0.000E+00	0.0	*	2.821E+05	0.00000	0.0
6	1964	0.000E+00	0.000E+00	0.0	*	2.773E+05	0.00000	0.0
7	1965	0.000E+00	0.000E+00	0.0	*	2.630E+05	0.00000	0.0
8	1966	0.000E+00	0.000E+00	0.0	*	2.565E+05	0.00000	0.0
9	1967	0.000E+00	0.000E+00	0.0	*	2.637E+05	0.00000	0.0
10	1968	0.000E+00	0.000E+00	0.0	*	2.704E+05	0.00000	0.0
11	1969	0.000E+00	0.000E+00	0.0	*	2.750E+05	0.00000	0.0
12	1970	0.000E+00	0.000E+00	0.0	*	2.793E+05	0.00000	0.0
13	1971	0.000E+00	0.000E+00	0.0	*	2.805E+05	0.00000	0.0
14	1972	0.000E+00	0.000E+00	0.0	*	2.656E+05	0.00000	0.0
15	1973	0.000E+00	0.000E+00	0.0	*	2.491E+05	0.00000	0.0
16	1974	0.000E+00	0.000E+00	0.0	*	2.376E+05	0.00000	0.0
17	1975	0.000E+00	0.000E+00	0.0	*	2.310E+05	0.00000	0.0
18	1976	0.000E+00	0.000E+00	0.0	*	2.322E+05	0.00000	0.0
19	1977	0.000E+00	0.000E+00	0.0	*	2.314E+05	0.00000	0.0
20	1978	0.000E+00	0.000E+00	0.0	*	2.310E+05	0.00000	0.0
21	1979	0.000E+00	0.000E+00	0.0	*	2.306E+05	0.00000	0.0
22	1980	0.000E+00	0.000E+00	0.0	*	2.307E+05	0.00000	0.0
23	1981	0.000E+00	0.000E+00	0.0	*	2.332E+05	0.00000	0.0
24	1982	0.000E+00	0.000E+00	0.0	*	2.359E+05	0.00000	0.0
25	1983	0.000E+00	0.000E+00	0.0	*	2.359E+05	0.00000	0.0
26	1984	0.000E+00	0.000E+00	0.0	*	2.336E+05	0.00000	0.0
27	1985	0.000E+00	0.000E+00	0.0	*	2.314E+05	0.00000	0.0
28	1986	0.000E+00	0.000E+00	0.0	*	2.258E+05	0.00000	0.0
29	1987	0.000E+00	0.000E+00	0.0	*	2.107E+05	0.00000	0.0
30	1988	1.000E+00	1.000E+00	0.0	2.071E+05	2.004E+05	0.03263	6.649E+03
31	1989	1.000E+00	1.000E+00	0.0	1.308E+05	1.839E+05	-0.34077	-5.311E+04
32	1990	1.000E+00	1.000E+00	0.0	9.975E+04	1.426E+05	-0.35733	-4.285E+04
33	1991	1.000E+00	1.000E+00	0.0	6.512E+04	1.076E+05	-0.50255	-4.252E+04
34	1992	1.000E+00	1.000E+00	0.0	1.116E+05	8.601E+04	0.26025	2.557E+04
35	1993	1.000E+00	1.000E+00	0.0	6.502E+04	7.115E+04	-0.09004	-6.126E+03
36	1994	1.000E+00	1.000E+00	0.0	9.960E+04	6.898E+04	0.36731	3.062E+04
37	1995	1.000E+00	1.000E+00	0.0	7.219E+04	7.367E+04	-0.02030	-1.480E+03
38	1996	1.000E+00	1.000E+00	0.0	1.001E+05	8.161E+04	0.20457	1.853E+04
39	1997	1.000E+00	1.000E+00	0.0	7.700E+04	9.635E+04	-0.22416	-1.935E+04
40	1998	1.000E+00	1.000E+00	0.0	5.667E+04	1.150E+05	-0.70751	-5.831E+04

* Asterisk indicates missing value(s).

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3M redfish                                                                                                      Page  4

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     0.0326                                             |=
1989    -0.3408                               ==============|
1990    -0.3573                               ==============|
1991    -0.5025                         ====================|
1992     0.2603                                             |==========
1993    -0.0900                                         ====|
1994     0.3673                                             |===============
1995    -0.0203                                            =|
1996     0.2046                                             |========
1997    -0.2242                                    =========|
1998    -0.7075                 ============================|
                   ------------------------------------------------------------------------------------
```

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	1.390E+04	0.1429	5.198E+04	5.198E+04	0.33002	0.000E+00
2	1960	2.007E+03	2.441E+03	0.0251	8.388E+03	8.388E+03	-0.19577	0.000E+00
3	1961	2.911E+03	4.627E+03	0.0476	1.552E+04	1.552E+04	-0.46345	0.000E+00
4	1962	1.885E+03	2.108E+03	0.0217	6.958E+03	6.958E+03	-0.11190	0.000E+00
5	1963	1.870E+03	2.135E+03	0.0219	7.035E+03	7.035E+03	-0.13251	0.000E+00
6	1964	7.861E+03	5.447E+03	0.0560	1.765E+04	1.765E+04	0.36685	0.000E+00
7	1965	1.020E+04	1.088E+04	0.1118	3.343E+04	3.343E+04	-0.06461	0.000E+00
8	1966	4.089E+03	2.417E+03	0.0248	7.241E+03	7.241E+03	0.52588	0.000E+00
9	1967	4.010E+02	2.366E+02	0.0024	7.290E+02	7.290E+02	0.52753	0.000E+00
10	1968	1.442E+03	1.571E+03	0.0162	4.963E+03	4.963E+03	-0.08565	0.000E+00
11	1969	9.579E+02	8.720E+02	0.0090	2.801E+03	2.801E+03	0.09398	0.000E+00
12	1970	4.355E+02	9.711E+02	0.0100	3.168E+03	3.168E+03	-0.80184	0.000E+00
13	1971	1.600E+03	2.451E+03	0.0252	8.033E+03	8.033E+03	-0.42642	0.000E+00
14	1972	1.427E+04	1.352E+04	0.1390	4.195E+04	4.195E+04	0.05381	0.000E+00
15	1973	8.721E+03	7.681E+03	0.0790	2.235E+04	2.235E+04	0.12699	0.000E+00
16	1974	1.084E+04	1.249E+04	0.1284	3.467E+04	3.467E+04	-0.14200	0.000E+00
17	1975	5.123E+03	5.958E+03	0.0612	1.608E+04	1.608E+04	-0.15097	0.000E+00
18	1976	7.151E+03	6.268E+03	0.0644	1.700E+04	1.700E+04	0.13184	0.000E+00
19	1977	9.524E+03	7.497E+03	0.0771	2.027E+04	2.027E+04	0.23931	0.000E+00
20	1978	6.646E+03	6.212E+03	0.0639	1.676E+04	1.676E+04	0.06754	0.000E+00
21	1979	1.154E+04	7.453E+03	0.0766	2.007E+04	2.007E+04	0.43755	0.000E+00
22	1980	7.181E+03	5.922E+03	0.0609	1.596E+04	1.596E+04	0.19286	0.000E+00
23	1981	5.491E+03	5.098E+03	0.0524	1.389E+04	1.389E+04	0.07414	0.000E+00
24	1982	6.225E+03	5.328E+03	0.0548	1.468E+04	1.468E+04	0.15558	0.000E+00
25	1983	9.150E+03	7.087E+03	0.0729	1.953E+04	1.953E+04	0.25558	0.000E+00
26	1984	9.537E+03	7.412E+03	0.0762	2.023E+04	2.023E+04	0.25213	0.000E+00
27	1985	9.270E+03	7.503E+03	0.0771	2.028E+04	2.028E+04	0.21148	0.000E+00
28	1986	9.017E+03	1.095E+04	0.1125	2.887E+04	2.887E+04	-0.19383	0.000E+00
29	1987	1.240E+04	1.804E+04	0.1855	4.441E+04	4.441E+04	-0.37506	0.000E+00
30	1988	1.100E+04	9.903E+03	0.1018	2.319E+04	2.319E+04	0.10505	0.000E+00
31	1989	3.504E+04	2.704E+04	0.2780	5.810E+04	5.810E+04	0.25914	0.000E+00
32	1990	5.149E+04	4.865E+04	0.5001	8.105E+04	8.105E+04	0.05671	0.000E+00
33	1991	3.267E+04	3.856E+04	0.3964	4.849E+04	4.849E+04	-0.16564	0.000E+00
34	1992	2.831E+04	4.311E+04	0.4432	4.332E+04	4.332E+04	-0.42053	0.000E+00
35	1993	1.674E+04	3.488E+04	0.3586	2.899E+04	2.899E+04	-0.73424	0.000E+00
36	1994	*	1.404E+04	0.1443	1.132E+04	1.132E+04	0.00000	0.000E+00
37	1995	*	1.568E+04	0.1612	1.350E+04	1.350E+04	0.00000	0.000E+00
38	1996	*	6.072E+03	0.0624	5.789E+03	5.789E+03	0.00000	0.000E+00
39	1997	*	1.155E+03	0.0119	1.300E+03	1.300E+03	0.00000	0.000E+00
40	1998	*	7.222E+02	0.0074	9.700E+02	9.700E+02	0.00000	0.000E+00

* Asterisk indicates missing value(s).

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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1959     0.3300                                             |=============
1960    -0.1958                                     ========|
1961    -0.4635                          ===================|
1962    -0.1119                                         ====|
1963    -0.1325                                        =====|
1964     0.3668                                             |===============
1965    -0.0646                                          ===|
1966     0.5259                                             |=====================
1967     0.5275                                             |=====================
1968    -0.0856                                          ===|
1969     0.0940                                             |====
1970    -0.8018             ================================|
1971    -0.4264                            =================|
1972     0.0538                                             |==
1973     0.1270                                             |=====
1974    -0.1420                                       ======|
1975    -0.1510                                       ======|
1976     0.1318                                             |=====
1977     0.2393                                             |==========
1978     0.0675                                             |===
1979     0.4376                                             |==================
1980     0.1929                                             |========
1981     0.0741                                             |===
1982     0.1556                                             |======
1983     0.2556                                             |==========
1984     0.2521                                             |==========
1985     0.2115                                             |========
1986    -0.1938                                     ========|
1987    -0.3751                              ===============|
1988     0.1051                                             |====
1989     0.2591                                             |==========
1990     0.0567                                             |==
1991    -0.1656                                      =======|
1992    -0.4205                            =================|
1993    -0.7342                =============================|
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     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	2.280E+00	2.287E+00	0.32%	1.621E+00	3.380E+00	1.913E+00	2.758E+00	8.451E-01	0.371
K	3.533E+05	3.452E+05	-2.27%	2.902E+05	4.472E+05	3.180E+05	3.989E+05	8.096E+04	0.229
r	2.739E-01	2.859E-01	4.37%	1.715E-01	3.934E-01	2.156E-01	3.352E-01	1.196E-01	0.437
q(1)	8.800E-01	8.800E-01	0.00%	8.800E-01	8.800E-01	8.800E-01	8.800E-01	8.726E-11	0.000
q(2)	9.710E-06	1.028E-05	5.87%	8.088E-06	1.175E-05	8.929E-06	1.076E-05	1.833E-06	0.189
MSY	2.426E+04	2.467E+04	1.69%	1.918E+04	2.869E+04	2.156E+04	2.672E+04	5.156E+03	0.213
Ye(1999)	2.354E+04	2.389E+04	1.48%	1.523E+04	2.798E+04	1.913E+04	2.677E+04	7.642E+03	0.325
Bmsy	1.766E+05	1.726E+05	-2.27%	1.451E+05	2.236E+05	1.590E+05	1.995E+05	4.048E+04	0.229
Fmsy	1.369E-01	1.429E-01	4.37%	8.576E-02	1.967E-01	1.078E-01	1.676E-01	5.978E-02	0.437
fmsy(1)	1.556E-01	1.624E-01	4.37%	9.745E-02	2.235E-01	1.225E-01	1.905E-01	6.793E-02	0.437
fmsy(2)	1.399E+04	1.390E+04	-0.62%	1.032E+04	1.728E+04	1.214E+04	1.560E+04	3.460E+03	0.247
F(0.1)	1.233E-01	1.286E-01	3.93%	7.718E-02	1.770E-01	9.704E-02	1.508E-01	5.380E-02	0.437
Y(0.1)	2.402E+04	2.443E+04	1.67%	1.899E+04	2.841E+04	2.135E+04	2.645E+04	5.105E+03	0.213
B-ratio	8.092E-01	8.219E-01	1.57%	5.274E-01	1.169E+00	6.530E-01	1.011E+00	3.576E-01	0.442
F-ratio	5.378E-02	5.194E-02	-3.42%	3.122E-02	1.003E-01	3.912E-02	7.340E-02	3.427E-02	0.637
Y-ratio	9.845E-01	9.683E-01	-1.65%	8.447E-01	9.998E-01	9.295E-01	9.977E-01	6.820E-02	0.069
f0.1(1)	1.401E-01	1.462E-01	3.93%	8.771E-02	2.012E-01	1.103E-01	1.714E-01	6.114E-02	0.437
f0.1(2)	1.259E+04	1.251E+04	-0.56%	9.287E+03	1.555E+04	1.093E+04	1.404E+04	3.114E+03	0.247
q2/q1	1.103E-05	1.168E-05	5.87%	9.190E-06	1.335E-05	1.015E-05	1.223E-05	2.083E-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:	1
Residual-adjustment factor:	1.0465