NOT TO BE CITED WITHOUT PRIOR REFERENCE TO THE AUTHOR(S)

Northwest Atlantic Fisheries Organization

Serial No. N3044

NAFO SCR Doc. 98/53

SCIENTIFIC COUNCIL MEETING - JUNE 1998

An Assessment of Redfish in NAFO Div. 3M Including an Approach to Precautionary Manegement Based on Spawning Biomass and Growth.

by

A. Ávila de Melo [1] , F. Saborido-Rey [2] and R. Alpoim [1]

[1] Instituto de Investigação das Pescas e do Mar, Av. Brasília 1400 Lisboa, Portugal.
[2] Instituto de Investigaciones Marinas, Eduardo Cabello 6, Vigo, Spain.

Introduction

There are three stocks of redfish in NAFO Division 3M: deep-sea redfish (*Sebates mentella*), golden redfish (*Sebastes marinus*) and Acadian redfish (*Sebastes fasciatus*). Due to their external resemblance *S. mentella* and *S.fasciatus* are commonly designated as beaked redfish. Deep-sea redfish has its maximum abundance at depths greater than 300m while either golden and Acadian redfish prefer shallower waters of less than 400m. Each of the three species of redfish has both a pelagic and demersal behaviour presenting wide inter annual shifts in their concentrations between the Flemish Cap bank and other 3M fishing grounds in the vicinity of this bank.

From a recent study on growth and maturation of redfish populations on Flemish Cap (Saborido-Rey, 1994) all 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. All species are viviparous with the larvae eclosion occuring right before or after birth. Mean age of 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.

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 until very recently and from survey results, *S. mentella* and *S. fasciatus* together represented most of the whole 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 1997, when a catch of only 1,300 tons has been recorded, most as by-catch of the Greenland halibut fishery. The quick drop of the 3M redfish catches from 1990 to 1996 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 from the late eighties-early nineties (former USSR, former DDR and Korean crewed Non Contracting Party vessels). As for the remaining fleets, such as the Portuguese trawlers, 3M redfish has been a second choice target as regards cod or American plaice and, more recently, Greenland halibut.

Recent catches ('000 tons) are as follows:

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
TAC	20	20	20	20	20	50	50	43	30	26	26	26	26	20
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 Includes estimates of non-reported catches from various sources
2 Provisional

The breakdown of the 3M redfish nominal catches by country is presented in Table 1 and Fig. 1.

Commercial fisheries data

Sampling data

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 Portuguese research reports in the NAFO SCS Document series. A summary for the 1993-1996 period was presented in last assessment (Ávila de Melo *et al.*, 1997). Most of these data referred to beaked redfish. No action was taken to separate *S. fasciatus* and *S. mentella* in those samples, but taking into account that most of them were from depths greater than 400m, they should represent *S. mentella* catches. As in previous years (with the exception of 1995, when otoliths from commercial catches were read) information on age composition for the 1997 3M redfish catches from Portuguese bottom trawl were obtained using the *S.mentella* age length keys from the July 1997 EU survey. The ageing criteria of 3M redfish otoliths has been revised recently (Saborido-Rey, 1995) and all age information since 1988 has been standardised accordingly, regardless coming from the commercial fishery or from the annual EU survey. Mean weights at age were derived from the Power and Atkinson length-weight relationship (1990). This length weight relationship differs from the one derived from the EU survey, but since most of the Portuguese 3M reddish catches have been taken from deeper bottoms in Division 3M outside the surveyed area and at the vicinity of divisions 3L or 3N (Sackville spur and Beotuk knoll) this second relationship seems more appropriate for those commercial catches. Mean lengths and weights at age are a mean of the mean lengths and weights at age by sex, weighted by the abundance in the sampled catches of males and females at each age and year.

The relatively small sample of 1997 3M beaked redfish came from the by-catch of the Portuguese Greenland halibut fishery on the first three quarters of the year. The length composition peak at 25cm-26cm and all 27cm-36cm length groups increase their proportion in the 1997 catch compared to the previous year, followed by an increase of the mean length and weight in the catch (Table 2a). The 1991, 1990 and 1989 year classes continue to dominate in 1997 the commercial beaked redfish catches. Ages 9 to 14 are again well represented, but older ages were kept at a low level in the 1997 catch (Table 2b).

Redfish by-catch in the 3M shrimp fishery

The loss of commercial yield of deep-sea redfish due to the 1993-1995 by-catches by the 3M shrimp fishery was calculated to be at 23,000 tons for a exploitation level around F0.1 (Ávila de Melo *et al.*, 1997). For this overall figure the 1993 by-catch contributed with 63% of the yield loss while the 1995 by-catch is only responsible for 3%. In terms of year classes the 1989 year class was the one with a major contribution to this overall yield loss (49%) followed by the 1990 year class (30%).

From the available information for the Icelandic 3M shrimp fishery (Skúladóttir, 1998), in terms of weight the redfish by-catch was kept at a low stable level around 1.5% on 1996 and 1997. If a catch of 3M shrimp for 1997 of 25,000 tons, predicted on the 1997 assessment of the 3M shrimp (NAFO, 1998), is confirmed and if the Icelandic by-catch data is representative of the whole 3M shrimp fishery, a redfish by-catch of 340 tons is estimated for 1997 corresponding to 6.6 millions of fish. Also from the Icelandic data on length composition of redfish by-catch from January 1996 to March 1998, the 1995 year class had dominated the redfish by-catch during these last couple of years and since January-February 1997 the 1996 year class is also showing up in the redfish by-catch as relatively abundant.

CPUE data

No directed redfish hauls on Division 3M have been observed during the three trips monitored in 1997, and so no new cpue data are available for 1997. However the additive model used to standardise the observed catch and effort data (Ávila de Melo and Alpoim, 1995) has been reformulated in order to include a vessel factor (Alpoim *et al.*, 1998). Each observation continues to correspond to a month and a trawler with 10 hours or more of directed effort on redfish, but is no longer aggregated and averaged by month prior to standardisation.

The revised Portuguese cpue series is presented and compared with the EU survey biomass series for the three species combined (Table 3, Fig. 2). The revised cpue series maintains a good agreement with the survey biomass series namely over the 1990-1996 period, despite the differences on the time scale and "swept area" from which these indices were derived.

Research survey data

There are two survey series providing biomass indices as well as length and age structure of the Flemish Cap redfish stocks. The Russian survey has been conducted annually in April-May as a bottom trawl survey down to the 400 phts (728 m) depth contour since 1983 till 1996, with an interruption in 1994. This survey has been complemented with an acoustic estimate of the overall pelagic component for the three redfish stocks between 1988 and 1993. The bottom biomass estimates are available for golden and beaked redfish separately since 1987.

The EU survey has been conducted annually in June-July since 1988 as a bottom trawl survey, also down to the 400 phts depth contour. During the 1988 and 1989 surveys only golden redfish has been separated from the rest of the redfish catches. Next, since 1990, juvenile redfish (less than 21 cm) has also been separated as an independent category, and 1991 forward all the 3 species and juveniles were separated in each haul catch prior to sampling procedures. However, with the continuation of these surveys, the skill to identify redfish smaller than 21 cm increased. The small redfish that has been identified is directly allocated in its species, contributing to the decreasing the proportion of small redfish classified as juvenile over the most recent years.

Each survey series presents a different picture of the recent evolution of the trawlable biomass and abundance of the 3M redfish stocks, primarily as regards the beaked redfish stock. The Russian bottom trawl series has an associated interannual variability higher than EU survey series, sometimes with biomass changes between consecutive years too dramatic to be explained by shifts in redfish distribution or by fishing mortality. Differences are also recorded on several years on the strata (and depths) with a higher proportion of redfish biomass estimated by each of the surveys, which is difficult to explain taking into account the relatively short time lag between them. The differences observed in survey design (EU survey with the number of sets proportional to the area of each stratum and higher number of valid tows each year) and the constancy on the vessel and gear used throughout most of the EU survey series should have accounted for those discrepancies in the bottom biomass indices from the two surveys.

A bottom trawl survey was also conducted by Canada on Flemish Cap during autumn 1996, the first one since 1985 (Brodie *et al.*, 1997). Considering only the strata till 400 phts depth contour there was reasonably good agreement between the biomass estimates from the Canadian survey and the EU survey for both golden and beaked redfish. There was also a good match between the strata where most of the redfish biomass was found on both 1996 surveys. The former Canadian bottom trawl survey series on Flemish Cap has been conducted from 1979 till 1985 in January-February months and the respective abundance estimates for 3M beaked redfish (Power and Atkinson, 1986) were also found to be within the same range of magnitude than the ones found on the following EU series.

Biomass indices from each survey series, since 1983 till 1997, are presented in Table 4a and Fig. 3 and 4.

a. Bottom biomass from EU surveys, 1988-1997

From the EU survey the bottom biomass of the 3M redfish stocks gradually declined from 1988 till 1991, most probably as a consequence of the unusual high level of the 3M redfish catches. Since then either biomass and abundance estimates suggests an overall stability of these stocks, followed by a biomass growth (the bottom biomass index for 1997 of 139,000 tons is the second highest in the EU series). The recruitment to all redfish stocks (but primarily to *S. mentella*, see Vazquez *et al.*, 1998) of three consecutive strong year classes from the beginning of the nineties, along with the drop of the 3M redfish fishery from 1993 onwards and the collapse of 3M cod in 1994 (leading to a continuous decline of fishing mortality on each of the three stocks) contributed to the present status of the 3M redfish. The fluctuation of the redfish bottom biomass during the middle years of the EU survey series should reflect both vertical and geographical movements within NAFO Division 3M of the bulk of these populations which, as a consequence of recent heavy exploitation, were progressively dominated by juvenile 20cm-30cm redfish.

The bottom biomass of golden redfish (*S. marinus*) fell from 23,000 tons in 1989 to 4,100 tons in 1991, induced by to the high level of by-catch suffered on the 1989-1990 3M cod fishery, and remained at this low level till 1993. In 1994 a first peak occurred in the golden redfish biomass: an unusual availability near the bottom of most of the age groups in the population pushed the biomass to 33,000 tons. During 1995 and 1996 the bottom biomass of golden redfish stabilised at an intermediate level around 10,000 tons. In 1997 the growth of the survivals of the 1990 and 1991 cohorts, the recruitment to the bottom of the 1992 cohort and again the concentration near the bottom of 8 years and older age groups (Vazquez *et al.*, 1998) lead to a maximum bottom biomass of golden redfish of 65,000 tons.

The deep-sea redfish (*S. mentella*) bottom biomass increased steadily from 1993 (25,000 tons) to 1996 (78,000 tons) due to the gradual recruitment to the bottom of the abundant year classes between 1990 and 1992. In 1997 the 1992 year class was still the most abundant on the bottom, but the preceding cohorts of 1991 and 1990 and, on a smaller scale, the rest of the older age groups diminished their demersal abundance, leading to a bottom biomass of deep sea redfish of 56,000 tons (Vazquez *et al.*, 1998). This decline can not be justified by the present fishing mortality (directed fishing effort to 3M redfish dropped since 1993, reaching an almost residual level in 1997) or, as regards the cohorts from the early nineties, by the by-catch on the former years of the recent 3M shrimp fishery (Ávila de Melo *et al.*, 1997).

Finally, and as regards Acadian redfish (*S. fasciatus*) its bottom biomass is increasing continuously since 1993, reaching a maximum of 18,000 tons in 1997. This increase is related not only with the individual growth of fish from the 1991 and 1992 year classes (Vazquez *et al.*, 1998) but also with the recruitment to the bottom of what seems to bee other abundant cohorts (1993 and 1994).

b. Pelagic biomass from Russian survey, 1988-1993

The Russian bottom trawl survey series has been complemented with an acoustic estimate of the pelagic component of the redfish stocks between 1987 and 1993. At present this is the only series providing an acoustic estimate of 3M pelagic redfish biomass. These acoustic results have been revised recently, as regards abundance and biomass of redfish 15cm and smaller and larger than 15cm existing in the column of water from surface to 4m bottom layer (Vaskov *et al.*, 1998).
From the Russian acoustic surveys pelagic redfish biomass declined gradually from 579,400 tons in 1987 to 228,700 tons in 1990. A major drop to just 62,300 tons is recorded in 1991 being in 1993 still at 76,500 tons. Even taking into account the unusually high level of catches observed between 1989 and 1991 (from 50,000 tons to 80,000 tons) is difficult to explain the drop between the range of acoustic biomass estimates from the former 1987-1990 period to the late 1991-1993 period. From this acoustic survey series redfish 15cm and smaller dominated the pelagic redfish abundance in 1987-1988 and in 1991-1992.

c. Total 3M redfish biomass from EU bottom trawl and Russian acoustic surveys, 1988-1997

According to the bottom trawl catchability of the EU survey, total 3M redfish biomass for each of the overlapping years of the 2 survey series (1988-1993) is given by the sum of the EU bottom biomass with the Russian acoustic biomass. In order to get a proportion of redfish biomass near the bottom that could be used in the conversion of the EU redfish bottom biomass to a total biomass estimate for the more recent period of overall fluctuation (1992-1995), and for 1991, 1996 and 1997 as well, a mean proportion of bottom redfish biomass was estimated by averaging the annual ratios between the EU bottom biomass and the total biomass (EU bottom and Russian acoustic combined). As for the former years of the EU survey series (1988-1990) and due to the similarity of the bottom proportion found on these years, total redfish biomass was accepted simply as the sum of the respective EU bottom and Russia acoustic indices (Table 4b and 4c).

d. Spawning bottom biomass from EU bottom trawl surveys (1988-1997) and Canadian bottom trawl surveys (1979-1985)

Female spawning biomass of 3M beaked (*S. mentella* plus *S. fasciatus*) and golden (*S.marinus*) redfish have been calculated based on abundance at length given by Canadian and EU bottom surveys for the periods of 1979-1985 and 1988-1997 respectively. Calculations were made from 1997 backwards. The following parameters from EU survey series have been used as factors to transform, by a sequence of products, abundance into biomass and female spawning biomass at length and finally to total bottom biomass and female spawning biomass, both given as a sum of products:

1) Length weight relationships by species and for beaked redfish from individual length/weight data collected throughout the whole series (Vazquez, *pers. comm.*).
2) Juvenile beaked redfish proportion at length (Table 5a) given by the total number of beaked redfish found in the total number of redfish at each length up to 21cm, when the *S.marinus*, *S.mentella* plus the *S. fasciatus* 1994-1997 abundance's at length are summed up.
3) Female proportion at length by species (Table 5b), from 1989-1994 *S. marinus* survey catches and from 1992-1994 *S. mentella* and *S. fasciatus* survey catches (Saborido-Rey, 1994).
4) Female proportion at length for beaked redfish (Table 5c) given by the total number of beaked redfish females found in the total number of beaked redfish at each length, when the *S.mentella* plus the *S. fasciatus* 1994-1997 abundance's at length are summed up.
5) Mature female proportion at length by species, given by length maturity ogives obtained for each 3M redfish species by the fit to a sigmoid logistic curve of the observed proportion of mature females on the sampled survey catches (Table 5b). Those maturity data were based on the histological analysis of a total of 483 ovaries (*S.marinus*, 142; *S. mentella*, 200; *S.fasciatus*, 141) 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).
6) Mature female proportion at length for beaked redfish (Table 5c) given by the total number of mature beaked redfish females found in the total number of beaked redfish at each length, when the *S. mentella* plus the *S.fasciatus* 1994-1997 abundance's at length are summed up.

From 1997 to 1992 beaked redfish abundance at length is given by the sum of *S. mentella* and *S.fasciatus* abundance at length with juvenile beaked redfish abundance at length (juvenile redfish abundance at length times juvenile beaked redfish proportion at length (2)) from the EU surveys; beaked redfish biomass at length is given by the product between beaked redfish abundance at length and beaked redfish mean weight at length; beaked redfish spawning biomass at length is given by the sum of the mature female abundance's at length of *S. mentella* and *S.fasciatus* (abundance times female proportion (4) times mature female proportion (5) at length for each species) multiplied by the beaked redfish mean weight at length. Biomass and spawning biomass were finally given by the sums of the respective values at length.

From 1991 to 1990 beaked redfish 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 (2)) from the EU surveys; beaked redfish biomass at length is given by the product between beaked redfish abundance at length and beaked redfish mean weight at length; beaked redfish spawning biomass at length is given by the beaked redfish mature female abundance at length (abundance times beaked redfish mature female proportion at length (6)) multiplied by the beaked redfish mean weight at length.

From 1989 to 1988 beaked redfish abundance at length is given directly by the EU survey results. Biomass and spawning biomass are 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 biomass and spawning biomass (Table 6a and Fig. 5).
As for *S. marinus* the biomass and spawning biomass have been calculated the same way throughout the EU survey series, from the respective abundance's at length, length weight relationship, female and mature female proportions at length (Table 6b and Fig. 6). The abundance, biomass and spawning biomass for the whole 3M redfish stocks from 1988 to 1997 based on the EU surveys is presented as the sum of the beaked and golden redfish results (Table 6c and Fig 7).

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 biomass averaging a 42% proportion of the bottom biomass. The more recent period of 1988-1997, covered by EU surveys, started with a continuous decline of bottom biomass till 1991, followed by a period of stability since then. Bottom spawning biomass however gradually declined since 1988 and for the more recent period of 1994-1997 spawning biomass represented on average just 10% of the bottom biomass (Table 6a, Fig. 5). Catches higher than 40,000 tons observed on most of the years between 1987 and 1992 have generated unsustainable high levels of fishing mortality that affected primarily beaked redfish larger than 30cm. Despite the survival and growth of the abundant year classes from the early nineties, that recruited to the bottom between 1992 and 1994, the slow growth and late maturity of these species didn't allowed yet these cohorts to start to contribute to the recovery of the spawning biomass.

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 consecutive strong year classes together with mobility within the water column, that seems to be higher than on beaked redfish. To a lesser extent this peaks were also followed by the spawning biomass, which had a maximum in 1997 (Table 6b, Fig. 6). However the proportion of the bottom spawning biomass was in 1997 at 16% when during the former 1988-1990 period represented an average of 25% of the golden redfish bottom biomass.

As a whole, the combined 3M redfish stocks experienced a decline of their bottom biomass from 1988 to 1991, followed by an intermediate period of no apparent trend and a gradual growth observed during the last couple of years. However the bottom spawning biomass didn't recovered from the decline suffered during the late eighties early nineties, remaining at a low level since 1992 (Table 6c, Fig. 7). The average proportion of spawning to bottom biomass declined from 23% to 12% from the former (1988-1991) to the late period (1994-1997) of the EU survey series.

Fishing mortality trends, 1988-1997

The ratios between annual STACFIS estimates of 3M redfish catches and 3M redfish total biomass (given by the EU bottom trawl and Russian acoustic surveys as described above) were considered to be an estimate of the magnitude of the mean fishing mortality and its trend during the past 10 years (Table 4c, Fig.9). This approach assumes constant survey catchability over the recruited age groups and a survey biomass representative of the mean annual biomass (both surveys were conducted around the middle of the year). Fishing mortality quickly rises to a peak in 1991 and gradually fell since then, reaching a level near zero in 1997. From the yield per recruit analysis included in the present assessment fishing mortality was above F0.1 from 1989 to 1993 and even higher than Fmax on 1990 and 1991. From the non-equilibrium stock production model results presented bellow fishing mortality was higher than Fmsy from 1989 to 1992.

A growth based model was also applied (Beverton and Holt, 1957 from Die and Caddy, 1997) in order to get an estimate of the mean total mortality (Z) for the most recent years (1995-1997) and a precautionary limit of Z, corresponding to a fishery where the mean length in the catch is above the mean length at maturity (Table 7). The fishing mortality derived from the mean Z, assuming natural mortality of 0.1, was similar to an implied F from the catch/total biomass ratio for the same period. As for the F given by the Z "at maturity", its value was near the F associated with a 50% reduction on the female spawning stock biomass from its unexploited level.

Non-equilibrium stock production model incorporating covariates (ASPIC)

A logistic surplus production model which does not use the equilibrium assumption - ASPIC (Praguer, 1994) was applied with the 1959-1997 catch estimates, and the following survey and cpue data:

1) Three bottom trawl biomass indices: Canadian survey series (1978-1985), EU survey series (1988-1997) and the Russian survey series (1983-1997).
2) Two commercial cpue series were used, one just from standardised observed catch and effort data of the Portuguese trawl (1988-1996) and the other from standardised catch and effort STATLANT data for most of the components of the fishery (1959-1993).

First all the biomass index series were incorporated in the ASPIC model. The model runned in IRF mode (so that the statistical weight for each series is provided by the program) with the following specifications (Praguer, 1995):

1) no additional penalty term to the objective function (to prevent major differences between the first year's biomass, B1, and the carrying capacity, K),
2) a maximum F allowed of 3.0 (eight times larger than the largest estimated F for the 1988-1997 period),
3) no starting guesses for the q's, either as the catchability coefficients of the cpue series or as the constants relating the survey indices to ASPIC estimates of biomass, and
4) a starting guess for r (intrinsic rate of increase) of 0.3, taking into account the slow growing/long living characteristic of the redfish species.

The inclusion of the Canadian, Russian and EU survey indices as well as the STATLANT and Portuguese cpue series resulted in negative or very low correlations. The STATLANT commercial cpue (1959-1993) and the EU bottom biomass (1988-1997) alone gave reasonable correlations. Another run as been conducted with the STATLANT commercial cpue (1959-1993) and EU bottom biomass (1988-1997), but this time just with the beaked redfish biomass taken as a sum of products from Table 6a (historically the major proportion on the 3M redfish catches), increasing the correlation between the two series. On the two selected runs (Apendix 1 and 2) the catchability of the EU survey was fixed at the ratio of the mean bottom biomass (EU survey)/ total biomass (EU survey plus Russian acoustic) for the overlapping years of these two series, and an additional penalty of 100 was set, to force close estimates of B1 and K (similar results were obtained however with and without this input).

The results of both selected runs of the production model converge to a total biomass above the Bmsy level for most of time period, declining from the mid eighties till the early nineties and recovering in the last years of the series. The model predicted that total biomas should be in 1998 at, or above, the B_{msy} level and that MSY should between 28,000 tons at 30,000 tons. The F0.1 is within the range but higher than the $F_{0.1}$ given by the yield per recruit analysis. The 1998 yields at Fmsy predicted by the yield per recruit analysis (from the 1997 biomass) and by both runs of the production models are the same (27,000 tons).

Yield per recruit analysis

In order to get reference levels of fishing mortality taking into account the growth, maturity and bottom exploitation pattern of the 3M redfish stocks an yield per recruit analysis was conducted, incorporating the following sets of vectors (Table 9):

1) Mean weights at age in the Portuguese commercial catch for the most recent years (1995-1997), taking notice of the very low level of the present catches and the small proportion that the Portuguese catches represented during the period with the highest level of catches.
2) Mean weights at age in the stock (as well as in the female component) from EU survey data (1995-1997).
3) Female ratio at age from EU survey data (1992-1997).
4) Maturity ogive at age, from the histological analysis of gonads collected during the 1991-1994 EU surveys.
5) Partial recruitment vector derived from the average total mortality at age estimated from the EU survey abundance at age for 1992-1997 period (Table 8), the way described on the previous assessment (Ávila de Melo *et al.*, 1997).

All biological information is referred to deep-sea redfish taking into account not only its predominance in the bottom commercial catches but also its growth and maturity being positioned between those of the two other redfish species. Natural mortality was assumed to be constant at 0.1

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. 8). With the assumption of constant recruitment, the results indicated a reduction of 70% of the female spawning biomass from its unexploited level when fishing at $F_{0.1}$ and, if a logistic natural growth of the biomass is accepted, the fishing mortality associated with a 50% reduction of total biomass.(corresponding to F_{msy}) is below $F_{0.1}$.

State of the 3M redfish stocks and prognosis

Over the past ten years the whole 3M redfish stocks experienced a continuous decline from 1988 to 1991 due to a sharp increase of fishing mortality that peak in 1991. Since then fishing mortality declined as fast as it had went up, allowing the survival of three consecutive strong year classes from the early nineties that showed up in each of the Flemish Cap redfish populations. 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 also to a discrete but continuous growth of the biomass since 1995.

However the observed levels of fishing mortality, higher than $F_{0.1}$ or even Fmsy, that have determined the decline of the 3M redfish stocks affected primarily the larger length groups in each population, inducing a decline on the spawning stock biomass to a low level from which these stocks have not yet recovered. 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 redfish spawning biomass will be dependent on the survival and maturation of fish from the abundant 1990 to 1992 cohorts. To allow for this recovery 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 70% of the female unexploited spawning biomass. For long living species like redfish this reduction might be too severe to guarantee the "normal" rhythm on the pulse of recruitment and, as a general precautionary rule, spawning biomass of fish species with such biology should be kept at or above 50% reduction from its unexploited level. In order to achieve this goal a reduction of the 1999 3M redfish TAC to 10,500 tons is proposed. This TAC corresponds to a fishing mortality which, on a long term equilibrium, would be sustained at a reduction about 40% of the female unexploited spawning biomass, applied to the 1992-1997 average 3M redfish biomass (Table 11). In pratical terms the observance of this proposed 1999 TAC would correspond anyway to an important increase from the 1996-1997 level of catches (Table 11).

The proposed reduction will be ineffective if the uncontrolled activity of reflaged fleets on Flemish Cap is allowed to continue.

Acknowledgements

This assessment is part of an EU research project (Study 96-30) supported by the European Commission (DG XIV), IPIMAR, CSIC, IEO and AZTI.

References

Alpoim R., M. L. Godinho, E. Santos and A.M. Ávila de Melo, 1998. Portuguese research report for 1996. *NAFO SCS Doc.* 98/13 Ser. No N3025, 37p.

Ávila de Melo, A. M. and R. Alpoim, 1995. Portuguese Cod Fisheries in NAFO Divisions 3N and 3O, 1989-93. *NAFO Sci. Coun. Studies* 23: 65-84.

Ávila de Melo, A.M., R. Alpoim, F. Saborido-Rey and L. Motos, 1997. Status of the redfish stocks in NAFO Div. 3M (Flemish Cap) in 1996. *NAFO SCR Doc.* 97/44 Ser. No N2878, 25p.

Brodie, W. B., Morgan, M. J. and E. F. Murphy, 1997. Results for selected species from a Canadian reseach vessel survey on Flemish Cap, NAFO Div. 3M, in 1996. *NAFO SCR. Doc.* 97/42 Ser. No 2876, 15p.

Die, D. J. and J. F. Caddy, 1997. Sustainable indicators from biomass:are there appropriate reference points for use in tropical fisheries? *Fish. Res.* , 32: 69-79.

NAFO, 1998. Scientific Council Reports, 1997. Northwest Atlantic Fisheries Organization, Dartmouth, Canada, 274p.

Power, D. and B. Atkinson, 1986. An estimate of redfish year-class strength from surveys to Flemish Cap. *NAFO SCR. Doc.* 86/27 Ser. No N1141, 14p.

Praguer, M. H., 1994. A suite of extensions to no-equilibrium surplus-production model. *Fish. Bull. U.S.*, 90(4): 374-389.

Praguer, M. H., 1995. User's manual for ASPIC: a stock production model incorporating covariates, program version 3.6x. Miami Lab. Doc. MIA-92/93-55.

Saborido-Rey, F., 1994. El género *Sebastes* Cuvier, 1829 (Pisce, Scorpaenidae) en el Atlántico Norte: identificación de espécies y poblaciones mediante métodos morfométricos; crescimiento y reprducción de las poblaciones en Flemish Cap. Universidad Autónoma de Madrid, Facultad de Biología, Departamento de Zoología, Madrid. Phd Thesis, xi, 276p.

Saborido-Rey, F., 1995. Age and growth of redfish in Flemish Cap (Div. 3M). *NAFO SCR. Doc.* 95/31 Ser. No N2540, 16p.

Skúladóttir, U., 1998. The by-catch in the shrimp fishery of Iceland at Flemish Cap in 1997 and 1998. *NAFO SCR. Doc.* 98/29 Ser. No N3106, 5p.

Vaskov, A.A, V. S. Mamylov and S. V. Ratushny, 1998. Review of 1983-1996 Russian trawl acoustic surveys to assess redfish stock on the Flemish Cap Bank. *NAFO SCR. Doc.* 98/15 Ser. No N2994, 15p.

Vazquez, A., A. Ávila de Melo and F. Saborido-Rey, 1998. Results from bottom trawl survey of Flemish Cap in July 1997. *NAFO SCR. Doc.* 98/30 Ser. No N3017, 38p.

Table 1: 3M Redfish nominal catches, 1985-1997.

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
CAN							2		10			2	
CUB	1831	1764	1757	1759	1765	4195	1772	2303	945				
DDR		88				4025							
GRL								1		26			
JPN	313	400	131	393	885	2082	1432	1424	967	488	553	678	212
SUN/RUS	15703	15045	19875	13747	13937	34581	24661	2937	2035	2980	3560	52	
LVA								7441	5099	94	304		
LTU									2128				
EST										47			
E GER	848	145			2	91	5847	3443					
E ESP	281	643	825	146	211	1916	472	204	100	610			128
E GBR							5						
E PRT	1306	10783	21823	7101	13012	11665	3787	3198	4781	5630	1282	332	83
KOR-S		5		43	17885	8332	2936	8350	2962				
FAROE IS.								16					
NORWAY										8	3		
Total	20282	28873	44411	23189	47697	66887	40914	29317	19027	9883	5702	1064	423
STCAFIS Estimates of total catches from various sources													
Total	20282	28873	44411	23189	58102	81046	48489	43317	28993	11315	13495	5789	1323

TABLE 2a: BEAKED REDFISH (*S. mentella* and *S. fasciatus*), DIV. 3M, 1995-97: length composition of the portuguese trawl catches.

LENGTH GROUP	1995	1996	1997	LENGTH GROUP
16	0.01	1.4		16
17		1.4	0.2	17
18	4.5	1.4		18
19	9.2	4.7	2.1	19
20	14.9	25.2	2.5	20
21	15.4	67.4	4.9	21
22	8.0	153.9	13.7	22
23	3.0	114.4	34.9	23
24	3.7	91.3	88.7	24
25	23.8	51.6	109.7	25
26	41.1	31.9	104.7	26
27	52.1	50.1	66.6	27
28	66.5	51.0	57.0	28
29	86.1	58.2	70.8	29
30	87.0	56.4	83.5	30
31	69.2	59.2	75.1	31
32	72.7	49.2	83.7	32
33	69.3	37.1	90.4	33
34	58.5	35.2	36.0	34
35	60.9	12.5	25.6	35
36	59.7	9.6	14.3	36
37	53.1	13.4	8.0	37
38	44.1	5.3	9.1	38
39	28.8	8.4	3.7	39
40	27.6	2.8	1.2	40
41	20.4	1.7	4.0	41
42	9.7	2.2	1.7	42
43	4.0	0.6	0.5	43
44	2.9	0.2	2.1	44
45	2.0	0.1	0.5	45
46	0.4	0.2	0.5	46
47	1.1	0.1	0.5	47
48	0.3			48
49				49
50		1.9		50
51				51
52				52
53				53
54				54
55				55
56				56
57				57
58				58
59				59
60				60
61			3.8	61
TOTAL	1000	1000	1000	
No. SAMPLES	46	23	12	
No.F.MEASURED	4713	1309	672	
SAMPLING WEIGHT(Kg)	2346	597	297	
MEAN LENGTH(cm)	32.4	27.1	29.5	
MEAN WEIGHT (g)	526	320	398	
DEPTH RANGE (m)	260/981	130/1120	251/1260	

TABLE 2b: BEAKED REDFISH (*S.mentella* and *S. fasciatus*), DIV. 3M, 1995-97: age composition (‰), mean length (cm) and mean weight (Kg) at age of the portuguese trawl catches.

AGE	1995 AGE COMP.	1996 AGE COMP.	1997 AGE COMP.	1995 MEAN LENGTH	1996 MEAN LENGTH	1997 MEAN LENGTH	1995 MEAN WEIGHT	1996 MEAN WEIGHT	1997 MEAN WEIGHT	AGE
3		1.4	0.05		16.8	17.5		0.069	0.078	3
4	24.3	12.0	1.3	19.9	19.8	19.6	0.116	0.115	0.110	4
5	28.8	270.2	21.1	21.7	22.3	22.1	0.149	0.162	0.157	5
6	11.5	197.9	224.4	25.0	24.0	24.9	0.228	0.201	0.225	6
7	68.6	90.2	160.4	26.6	26.7	26.6	0.273	0.275	0.275	7
8	95.2	94.7	121.6	28.2	28.5	28.6	0.327	0.335	0.336	8
9	84.5	93.5	92.7	29.4	30.1	30.3	0.368	0.393	0.400	9
10	98.8	59.4	104.9	30.7	31.5	31.7	0.421	0.451	0.458	10
11	83.3	42.0	66.5	31.9	32.2	32.5	0.468	0.479	0.495	11
12	98.8	38.5	62.7	32.5	33.5	33.5	0.497	0.548	0.549	12
13	68.9	22.6	27.6	33.7	34.5	33.4	0.558	0.602	0.542	13
14	44.8	24.0	65.6	34.9	34.6	34.4	0.617	0.608	0.602	14
15	66.1	14.0	7.2	36.1	35.9	35.5	0.681	0.681	0.648	15
16	70.5	8.2	9.2	37.0	36.9	36.4	0.729	0.734	0.706	16
17	40.8	6.5	5.8	38.1	38.0	37.1	0.802	0.800	0.732	17
18	37.7	8.4	5.7	39.2	38.2	37.7	0.884	0.821	0.789	18
19+	77.2	16.4	23.4	40.8	41.6	44.2	1.002	1.074	1.371	19+
	1000	1000	1000							

TABLE 3: REDFISH TRAWL CATCH RATES, 1988-96: observed mean annual cpue's corrected for the month of each observation by an additive model.

	3M CPUE	3M ST.ERROR	3M C.V.	
1988	0.577	0.094	28.3	1988
1989	0.705	0.067	39.0	1989
1990	0.623	0.052	45.0	1990
1991	0.477	0.053	43.2	1991
1992	0.689	0.103	44.7	1992
1993	0.318	0.210	114.0	1993
1994	0.875	0.191	43.6	1994
1995	0.459	0.083	44.1	1995
1996	0.663	0.210	44.7	1996

TABLE 4-A: Trawlable biomass by species from the EU survey and combined trawlable biomass from EU, Russian and Canadian surveys (1983-1997). Total redfish biomass (trawl plus acoustic estimate) from the Russian survey, 1988-1993.

	UE							Canada			Russia			
YEAR	*S.marinus*	*Sebastes spp.*	Beaked redfish	*S.mentella*	*S.fasciatus*	juveniles	total	*S.marinus*	*Sebastes spp.*	total	*S.marinus*	*Sebastes spp.*	bottom(1)	total(2)
1983												154.900		
1984												132.300		
1985												51.900		
1986												309.500		
1987											4.300	106.400	110.700	690.100
1988	15.289	142.933					158.222				14.400	47.000	61.400	452.600
1989	22.958	113.675					136.633				6.800	83.300	90.100	372.700
1990	14.699		72,893			16.601	104.193				3.000	17.700	20.700	249.400
1991	4.093		55.751	50.071	5.680	4.001	63.846				0.100	45.400	45.500	107.800
1992	4.130		77.118	71.810	5.308	23.229	104.477				0.300	18.200	18.500	58.600
1993	4.173		29.481	25.056	4.425	28.935	62.589				2.800	69.800	72.600	149.100
1994	33.240		43.539	35.710	7.829	49.233	126.011							
1995	9.042		64.364	59.332	5.032	0.235	73.641				0.900	20.700	21.600	
1996	11.293		88.922	77.897	11.025	0.329	100.544	10.8	112.687	123.487	5.900	10.000	15.900	
1997	64.847		73.564	56.093	17.471	0.830	139.241							

TABLE 4-B: Trawlable biomass from EU (1988-1997) survey and acoustic biomass from Russian (1987-1993) survey : Total redfish biomass (EU trawl plus Russian acoustic), 1988-1993.

YEAR	EU bottom	Russia Acoustic	Total	bottom proportion
1987		579.400		
1988	158.222	391.200	549.422	0.288
1989	136.633	282.600	419.233	0.326
1990	104.193	228.700	332.893	0.313
1991	63.846	62.300	126.146	0.506
1992	104.477	40.100	144.577	0.723
1993	62.589	76.500	139.089	0.450
1994	126.011			
1995	73.641			
1996	100.544			
1997	139.241			

0.434 mean

Table 4c: 3M redfish fishing mortality trend, 1988-1997

Year	Catch	Biomass	F	Year
1988	23189	549422	0.04221	1988
1989	58102	419233	0.13859	1989
1990	81046	332893	0.24346	1990
1991	48489	147018	0.32982	1991
1992	43317	211110	0.20519	1992
1993	28993	211110	0.13734	1993
1994	11315	211110	0.05360	1994
1995	13495	211110	0.06392	1995
1996	5789	231522	0.02500	1996
1997	1323	320630	0.00413	1997

Table 5: biological parameters used in the computation of the abundance, biomass and spawnning biomass at length of 3M beaked and golden redfish

5a) juvenile beaked redfish proportion in juvenile redfish up to 21cm (EU surveys, 1994-1997)

	1994		1995		1996		1997		total		beaked redfish ratio
Length	total	beaked	total	beaked	total	beaked	total	beaked	total	beaked	
6	0	0	28	28	0	0	0	0	28	28	1.00
7	0	0	7	7	0	0	0	0	7	7	1.00
8	0	0	60	60	0	0	0	0	60	60	1.00
9	0	0	17	17	7	7	51	51	75	75	1.00
10	0	0	54	47	25	12	35	28	114	87	0.76
11	21	7	367	316	165	134	56	56	609	513	0.84
12	62	21	2178	1913	1365	1291	265	244	3870	3469	0.90
13	275	143	2032	1259	2344	2130	902	858	5553	4390	0.79
14	1083	745	4055	2296	4877	4536	1972	1885	11987	9462	0.79
15	2402	1910	8130	5634	10765	10157	6960	6533	28257	24234	0.86
16	7353	6682	18278	14557	10047	9069	14255	13555	49933	43863	0.88
17	14310	12258	45671	41893	19165	17444	19751	18632	98897	90227	0.91
18	34946	31348	81664	77338	41781	38850	21846	20195	180237	167731	0.93
19	37140	32988	112224	107224	88289	84714	28193	25915	265846	250841	0.94
20	21609	19127	86067	80024	131911	126417	56570	52858	296157	278426	0.94
21	14175	11499	37509	32361	124529	118967	88079	83119	264292	245946	0.93
overall ratio		0.88		0.92		0.95		0.94		0.92	

5b) 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
6	0.444	0.000	0.474	0.000	0.421	0.000
7	0.444	0.000	0.474	0.000	0.421	0.000
8	0.444	0.000	0.474	0.000	0.421	0.000
9	0.444	0.000	0.474	0.000	0.421	0.000
10	0.444	0.000	0.474	0.000	0.421	0.000
11	0.444	0.000	0.474	0.000	0.421	0.000
12	0.444	0.000	0.474	0.000	0.421	0.000
13	0.444	0.000	0.474	0.000	0.421	0.000
14	0.444	0.001	0.474	0.000	0.421	0.000
15	0.444	0.001	0.474	0.000	0.421	0.000
16	0.444	0.001	0.474	0.001	0.421	0.000
17	0.444	0.002	0.474	0.001	0.421	0.000
18	0.444	0.004	0.474	0.002	0.421	0.000
19	0.444	0.006	0.474	0.005	0.421	0.001
20	0.442	0.010	0.514	0.011	0.445	0.001
21	0.442	0.016	0.514	0.022	0.445	0.002
22	0.442	0.025	0.514	0.046	0.445	0.003
23	0.442	0.040	0.514	0.093	0.445	0.005
24	0.442	0.063	0.514	0.179	0.445	0.008
25	0.389	0.098	0.507	0.316	0.474	0.013
26	0.389	0.149	0.507	0.495	0.474	0.022
27	0.389	0.220	0.507	0.675	0.474	0.036
28	0.389	0.313	0.507	0.814	0.474	0.059
29	0.389	0.424	0.507	0.903	0.474	0.096
30	0.467	0.542	0.488	0.952	0.623	0.152
31	0.467	0.657	0.488	0.977	0.623	0.233
32	0.467	0.755	0.488	0.989	0.623	0.339
33	0.467	0.833	0.488	0.995	0.623	0.464
34	0.467	0.889	0.488	0.997	0.623	0.594
35	0.572	0.928	0.503	0.999	0.869	0.712
36	0.572	0.954	0.503	0.999	0.869	0.807
37	0.572	0.971	0.503	1.000	0.869	0.876
38	0.572	0.982	0.503	1.000	0.869	0.923
39	0.572	0.989	0.503	1.000	0.869	0.953
40	0.851	0.993	0.562	1.000	1.000	0.972
41	0.851	0.996	0.562	1.000	1.000	0.983
42	0.851	0.997	0.562	1.000	1.000	0.990
43	0.851	0.998	0.562	1.000	1.000	0.994
44	0.851	0.999	0.562	1.000	1.000	0.996
45	0.870	0.999	0.875	1.000	1.000	0.998
46	0.870	1.000	0.875	1.000	1.000	0.999
47	0.870	1.000	0.875	1.000	1.000	0.999
48	0.870	1.000	0.875	1.000	1.000	1.000
49	0.870	1.000	0.875	1.000	1.000	1.000
50	0.870	1.000	0.864	1.000	1.000	1.000
51	0.870	1.000	0.864	1.000	1.000	1.000
52	0.870	1.000	0.864	1.000	1.000	1.000
53	0.870	1.000	0.864	1.000	1.000	1.000
54	0.870	1.000	0.864	1.000	1.000	1.000
55	0.870	1.000	0.864	1.000	1.000	1.000
56	0.870	1.000	0.864	1.000	1.000	1.000
57	0.870	1.000	0.864	1.000	1.000	1.000

sex ratio data: S.marinus, 1989-1994; S. mentella and S. fasciatus, 1992-1994
histological maturity data: 1992-1994 for all species

5c) female and mature female proportion in beaked redfish (EU surveys 1994-1997, S. mentella and S. fasciatus combined)

Length	1994 females	1994 mature f.	1994 total	1995 females	1995 mature f.	1995 total	1996 females	1996 mature f.	1996 total	1997 females	1997 mature f.	1997 total	TOTAL females	TOTAL mature f.	TOTAL total	proportion females	proportion mature f.
6				12		28							12		28	0.421	0.000
7				3		7							3		7	0.421	0.000
8				27		60							27		60	0.444	0.000
9				7		17	3		7	22		51	32		75	0.433	0.000
10	4		10	20		47	5		12	12		28	42		97	0.430	0.000
11	3		7	139		316	58		134	24		56	224		513	0.436	0.000
12	9		21	844		1913	562		1291	105		244	1519		3469	0.438	0.000
13	60		143	549		1259	918		2130	372		858	1900		4390	0.433	0.000
14	321		745	999		2296	1967	1	4536	809		1885	4095	1	9462	0.433	0.000
15	828	1	1910	2461	2	5634	4455	3	10157	2795	1	6533	10539	7	24234	0.435	0.000
16	2920	3	6682	6415	9	14557	3971	5	9069	5785	5	13555	19090	22	43863	0.435	0.000
17	5364	11	12258	18533	42	41893	7635	16	17444	8032	14	18632	39564	83	90227	0.438	0.001
18	13742	48	31348	34223	127	77338	17105	61	38850	8772	28	20195	73843	265	167731	0.440	0.002
19	14450	85	32988	47459	287	107224	37413	225	84714	11311	65	25915	110634	662	250841	0.441	0.003
20	8476	86	19127	35386	348	80024	55904	551	126417	23393	233	52858	123159	1218	278426	0.442	0.004
21	5097	93	11499	14314	234	32361	52612	854	118967	36761	598	83119	108783	1779	245946	0.442	0.007
22	3089	113	6962	3908	118	8826	34020	924	76916	37683	1015	85202	78700	2169	177906	0.442	0.012
23	2880	186	6493	1690	104	3812	15765	718	35641	25491	1153	57631	45826	2161	103577	0.442	0.021
24	3874	386	8745	1498	187	3376	8203	706	18532	10419	888	23539	23994	2166	54192	0.443	0.040
25	4125	565	10272	1679	313	4004	3360	600	8069	4246	817	10071	13410	2296	32416	0.414	0.071
26	3891	816	9695	2116	491	5208	1827	576	4294	2888	1142	6476	10721	3025	25673	0.418	0.118
27	2885	795	7262	2036	639	5045	2957	1036	7217	2158	1097	4918	10036	3566	24442	0.411	0.146
28	3479	1332	8726	2294	841	5789	2235	1071	5406	2180	1481	4871	10187	4725	24792	0.411	0.191
29	3050	1364	7779	2416	1120	6125	2188	1113	5451	1511	1016	3525	9166	4614	22880	0.401	0.202
30	2613	1454	5553	2904	1639	6140	1813	1050	3799	2358	1893	4248	9688	6035	19740	0.491	0.306
31	2356	1587	4981	2358	1594	4977	1845	1281	3838	1413	1112	2721	7972	5574	16517	0.483	0.337
32	2148	1642	4557	1974	1508	4190	1719	1351	3563	1114	931	2183	6955	5433	14493	0.480	0.375
33	1557	1307	3302	1692	1419	3595	1528	1287	3226	994	879	1960	5771	4893	12083	0.478	0.405
34	1056	945	2232	1451	1294	3089	1118	1000	2364	795	738	1553	4419	3978	9238	0.478	0.431
35	1225	1138	2134	1529	1420	2668	1079	1012	1791	628	598	976	4461	4169	7569	0.589	0.551
36	893	852	1560	1488	1405	2560	747	701	1275	551	529	921	3679	3487	6316	0.582	0.552
37	521	506	910	1258	1222	2196	636	620	1077	319	310	551	2734	2657	4734	0.577	0.561
38	557	548	928	791	777	1375	459	451	795	217	214	380	2025	1991	3478	0.582	0.572
39	263	260	460	556	550	968	311	308	532	114	113	200	1245	1231	2160	0.576	0.570
40	289	287	340	443	440	520	264	262	310	125	124	146	1121	1114	1316	0.852	0.846
41	179	178	210	383	381	450	221	220	260	119	119	140	902	899	1060	0.851	0.848
42	68	68	80	272	272	320	162	161	190	34	34	40	536	535	630	0.851	0.849
43	26	25	30	136	136	160	60	59	70				221	221	260	0.851	0.850
44	26	26	30	43	43	50	17	17	20	17	17	20	102	102	120	0.851	0.851
45	26	26	30	43	43	50	17	17	20				87	87	100	0.870	0.869
46				26	26	30							26	26	30	0.870	0.869
47				9	9	10							9	9	10	0.870	0.869
48							9	9	10				9	9	10	0.870	0.869

Table 6a: 3M beaked redfish abundance, biomass and spwanning biomass at length from Canadian (1979-1985) and EU (1988-1997) bottom trawl surveys
Growth parameters from EU surveys, 1988-1997

	Beaked redfish abundance at length ('0000)																		
length	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
5					11														
6	11	1	3	72	85						1	8	2				3	5	
7	132	3	120	4222	264	3	1			30	3	131	162	90	10		1	67	
8	110	16	66	6344	184	402	1			250	42	1396	1098	3290	90		20	491	
9	14	13	5	918	942	200	2			270	50	1433	686	2880	60		61	353	5
10	27	18	3	6397	3716	157	17			270	80	105	70	2183	275	9	66	50	3
11	106	7	10	15844	4191	247	57			860	263	75	193	18347	1786	51	155	124	6
12	53	8	15	11555	1690	233	49			1860	698	91	293	28932	3209	154	511	447	24
13	17	29	14	2536	2308	404	91			1440	821	295	101	7700	2269	354	287	403	86
14	39	23	11	107	4514	703	190			230	1928	643	31	1752	7827	2174	267	527	189
15	69	19	7	35	6982	891	291			50	3964	1156	77	4019	22071	6735	575	1038	653
16	128	19	18	32	2340	813	583			70	3510	2052	410	3845	11993	9813	1456	911	1356
17	191	38	18	36	609	1344	1043			90	1175	5238	1485	937	2886	18369	4189	1744	1863
18	163	124	36	33	134	1516	1699			90	210	6455	2937	574	900	20407	7734	3885	2020
19	178	194	20	51	117	1399	2532			350	136	3909	4986	919	492	10602	10722	8471	2592
20	249	310	32	58	106	631	2748			680	202	804	6027	1602	278	2618	8002	12642	5286
21	412	518	81	71	139	389	2004			1580	310	122	3096	3199	279	1198	3238	11897	8312
22	819	1563	174	101	165	307	818			3460	727	168	862	5069	415	696	883	7692	8520
23	1361	4069	318	128	245	307	187			7400	1461	399	323	3948	618	649	381	3564	5763
24	1455	8727	890	210	272	358	82			11790	2762	962	352	1933	770	875	338	1853	2354
25	817	10067	2222	418	339	407	98			13180	4449	2107	713	867	597	1027	400	807	1007
26	328	7895	4508	652	423	607	156			10140	5594	3409	979	1114	595	970	521	429	648
27	88	3007	5311	1389	966	874	277			4540	4861	3569	1031	1595	491	726	505	722	492
28	200	746	3100	2240	1936	1547	750			1970	3231	2660	946	1807	529	873	579	541	487
29	479	704	1437	1953	2619	2899	1689			1020	1880	1576	886	1726	390	778	613	545	353
30	992	1148	928	1258	2480	3069	2175			1420	1207	993	595	1202	386	555	614	380	425
31	1364	1908	1099	911	2350	3572	2513			1230	972	762	454	869	334	498	498	384	272
32	1913	2624	1506	956	2126	2928	1989			1510	1139	734	410	580	277	456	419	356	218
33	1999	3380	1886	1083	2361	2226	1916			1520	888	654	465	555	313	330	360	323	196
34	2288	4221	2251	1271	2598	2177	2155			1360	880	758	485	561	272	223	309	236	155
35	2105	4208	2150	1472	2407	1855	2083			1080	918	534	395	477	261	213	267	179	98
36	1939	3635	2174	1425	2277	1772	2001			990	788	515	368	372	268	156	256	128	92
37	1625	3236	1563	1273	2079	1518	1785			760	594	409	302	297	263	91	220	108	55
38	1164	2315	1416	919	1629	1036	1289			680	397	309	259	249	173	93	138	80	38
39	799	1605	886	686	1319	740	809			370	361	186	164	180	146	46	97	53	20
40	474	907	531	330	683	467	549			260	254	125	104	119	87	34	52	31	15
41	274	492	354	221	320	267	277			170	105	65	46	51	39	21	45	26	14
42	124	257	207	198	218	177	188			70	66	32	35	36	39	8	32	19	4
43	97	95	130	72	98	86	74			20	26	21	18	15	11	3	16	7	
44	38	59	66	46	61	37	38			10	8	6	6	14	19	3	5	2	2
45	17	18	33	21	32	18	18			10	8	5	8	4	4	3	5	2	
46	3	31	10	9	23	9	14				5	1	3	2	3		3		
47	4	7	9	0	13	4	3				2	2	1		3		1		
48			3	2	4	2	2				1				4			1	
49			2	1	3	1													
50	1	4		1			1												
51					1														
52	1																		
53																			
54					1														
total ('000000)	247	683	356	676	584	386	352			731	470	449	317	1039	617	818	448	615	436

Table 6a: count.

3M Beaked redfish growth parameters for length weight relationship

a= 0.02484

b= 2.83310

	Beaked redfish biomass at length (tons)																		
length	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
6	1			4	4														
7	10		9	316	20					2		10	12	7	1	0	0	5	
8	12	2	7	677	20	43				27	4	149	117	351	10	0	2	52	
9	2	2	1	134	138	29				39	7	210	100	421	9	0	9	52	1
10	5	3	1	1242	722	30	3			52	16	20	14	424	53	2	13	10	1
11	27	2	2	3962	1053	62	14			216	66	19	48	4611	449	13	39	31	1
12	17	3	5	3678	538	74	16			592	222	29	93	9209	1021	49	163	142	8
13	7	11	5	1004	914	160	36			570	325	117	40	3048	898	140	113	160	34
14	19	11	6	52	2188	341	92			111	934	311	15	849	3793	1054	130	256	91
15	40	11	4	21	4088	521	170			29	2321	676	45	2353	12921	3943	336	607	382
16	89	13	13	22	1635	568	407			49	2453	1434	287	2687	8381	6858	1018	636	947
17	158	31	15	30	503	1110	861			74	970	4325	1226	774	2383	15166	3459	1440	1538
18	157	120	35	31	129	1465	1642			87	203	6238	2838	555	869	19722	7474	3755	1952
19	200	217	22	57	132	1569	2841			393	153	4385	5593	1031	552	11894	12029	9504	2907
20	322	401	41	75	137	815	3552			879	261	1039	7791	2070	359	3384	10344	16341	6833
21	609	766	120	105	206	576	2965			2337	459	181	4580	4732	413	1770	4787	17600	12297
22	1378	2630	292	170	278	516	1377			5822	1223	283	1451	8530	699	1172	1485	12943	14337
23	2590	7746	605	245	466	585	357			14085	2781	759	615	7515	1176	1236	726	6784	10969
24	3117	18693	1906	449	583	767	176			25253	5916	2061	754	4139	1649	1873	723	3969	5042
25	1961	24151	5331	1003	814	977	235			31618	10673	5055	1710	2081	1433	2464	961	1936	2416
26	877	21120	12060	1744	1131	1623	417			27126	14965	9120	2619	2981	1591	2594	1393	1149	1732
27	262	8935	15780	4126	2870	2597	822			13489	14443	10604	3063	4738	1459	2158	1499	2144	1461
28	658	2453	10192	7366	6365	5085	2466			6476	10622	8745	3110	5941	1740	2869	1903	1777	1601
29	1737	2550	5211	7078	9494	10508	6121			3697	6815	5713	2487	6257	1415	2820	2220	1976	1278
30	3950	4574	3698	5012	9880	12225	8665			5657	4809	3956	2370	4788	1538	2212	2446	1514	1692
31	5952	8329	4797	3977	10257	15593	10971			5369	4243	3326	1962	3792	1460	2174	2173	1675	1188
32	9125	12515	7192	4561	10137	13965	9488			7202	5432	3501	1955	2768	1321	2173	1998	1699	1041
33	10390	17565	9802	5628	12270	11569	9958			7900	4615	3399	2417	2884	1625	1716	1868	1677	1019
34	12926	23840	12717	7179	14673	12298	12176			7682	4971	4282	2740	3168	1534	1261	1745	1335	877
35	12896	25776	13167	9013	14743	11364	12758			6615	5623	3271	2419	2922	1599	1307	1634	1097	598
36	12848	24088	14405	9443	15085	11745	13261			6560	5222	3413	2439	2468	1773	1034	1696	845	610
37	11623	23147	11183	9104	14872	10857	12771			5437	4249	2926	2160	2122	1878	651	1571	770	394
38	8975	17844	10912	7080	12559	7989	9933			5241	3060	2382	1996	1920	1333	715	1060	613	293
39	6624	13307	7342	5684	10931	6137	6706			3067	2992	1542	1359	1495	1213	381	802	441	166
40	4215	8069	4720	2938	6072	4152	4880			2313	2260	1112	925	1060	774	302	463	276	130
41	2613	4690	3379	2105	3053	2542	2639			1621	1001	620	439	486	371	200	429	248	133
42	1264	2625	2109	2019	2227	1808	1717			714	673	326	357	362	398	82	326	194	41
43	1053	1031	1418	790	1048	940	805			218	283	229	196	163	118	33	174	76	0
44	446	680	767	532	704	426	441			116	93	70	70	163	215	35	58	23	23
45	209	219	410	265	390	224	221			124	99	62	99	49	46	37	62	25	
46	42	412	134	117	298	119	182				66	13	39	26	34		39		
47	57	102	130		187	61	39				28	28	14		35		14		
48	7		39	27	58	35	27				15				61		0	15	
49			34	17	54	9													
50	20	60		9			10												
51					10														
52	12																		
53																			
54					23														
total	119503	278745	160016	109110	173959	154079	142219			198862	125565	95939	62586	105940	60600	95494	69387	95792	74035

Table 6a: count.

length	Beaked redfish spawning biomass at length (tons)																		
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
14															1				
15					1						1				5	2			
16					1						1	1			5	4	1		
17						1	1				1	4	1		2	16	4	1	1
18						2	3				0	10	4		1	33	12	6	3
19	1	1				4	7			1	0	12	15	2	1	32	32	25	7
20	1	2			1	4	16			4	1	5	34	9	2	15	45	71	30
21	4	6	1	1	1	4	21			17	3	1	33	34	4	14	35	126	88
22	17	32	4	2	3	6	17			71	15	3	18	102	12	19	20	155	171
23	54	162	13	5	10	12	7			294	58	16	13	145	32	35	20	137	219
24	125	747	76	18	23	31	7			1010	237	82	30	131	71	83	40	151	190
25	139	1710	378	71	58	69	17			2239	756	358	121	105	89	135	75	144	196
26	103	2488	1421	205	133	191	49			3196	1763	1074	309	198	143	218	131	154	305
27	38	1303	2302	602	419	379	120			1968	2107	1547	447	452	169	236	190	308	326
28	125	468	1943	1404	1213	969	470			1234	2025	1667	593	784	268	438	276	352	487
29	350	514	1051	1427	1914	2119	1234			746	1374	1152	501	1074	286	495	408	404	368
30	1208	1398	1131	1533	3021	3738	2649			1730	1470	1210	725	1262	442	579	653	418	754
31	2009	2811	1619	1342	3461	5262	3702			1812	1432	1122	669	1221	493	693	696	559	485
32	3421	4692	2696	1710	3800	5235	3557			2700	2036	1312	733	995	494	783	719	645	444
33	4207	7113	3969	2279	4968	4684	4032			3199	1869	1376	979	1136	653	679	738	669	457
34	5566	10265	5476	3091	6318	5296	5243			3308	2140	1844	1180	1334	640	534	731	565	417
35	7103	14196	7252	4964	8120	6259	7027			3644	3097	1802	1333	1571	853	697	870	620	368
36	7093	13298	7953	5213	8326	6484	7321			3622	2883	1884	1346	1370	979	565	931	465	351
37	6524	12993	6277	5110	8348	6094	7168			3052	2385	1642	1213	1196	1045	362	874	443	222
38	5136	10212	6245	4052	7188	4572	5685			3000	1751	1363	1143	1084	749	423	599	348	165
39	3776	7585	4185	3240	6231	3498	3823			1748	1705	879	775	855	688	216	456	255	94
40	3566	6828	3994	2486	5138	3513	4129			1957	1912	941	783	901	660	256	391	233	111
41	2215	3975	2865	1785	2588	2155	2237			1374	849	525	372	412	317	170	364	210	113
42	1073	2229	1791	1714	1891	1535	1458			606	572	277	303	308	338	69	277	165	35
43	895	876	1205	671	891	799	684			185	241	194	167	139	100	28	148	65	0
44	379	579	653	452	599	363	375			99	79	59	59	138	183	30	49	20	20
45	182	191	356	230	339	194	192			108	86	54	88	43	40	32	54	22	
46	37	358	116	102	259	103	158				57	11	34	23	30		34		
47	49	88	113	0	162	53	34				24	24	12		30		12		
48	6		34	24	50	30	24				13				53		0	13	
49			30	15	47	8													
50	17	53		8			9												
51					8														
52	10																		
53																			
54					20														
total	55431	107174	65145	43758	75557	63668	61477			42921	32944	22453	14029	17025	9878	7890	9883	7749	6425

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
spawning biomass	55431	107174	65145	43758	75557	63668	61477			42921	32944	22453	14029	17025	9878	7890	9883	7749	6425
biomass	119503	278745	160016	109110	173959	154079	142219			198862	125565	95939	62586	105940	60600	95494	69387	95792	74035
spawning biomass proportion	46.4%	38.4%	40.7%	40.1%	43.4%	41.3%	43.2%			21.6%	26.2%	23.4%	22.4%	16.1%	16.3%	8.3%	14.2%	8.1%	8.7%
				41.5%							23.3%			16.2%			9.5%		

Table 6b: 3M golden redfish abundance, biomass and spwanning biomass at length from EU bottom trawl surveys, 1988-1997.
Growth parameters from EU surveys, 1988-1997

	Golden redfish abundance at length ('000)									
length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
6		6								
7	130	17								
8	992	77								
9	986	110								
10	1324	328						7	13	7
11	1929	366					14	51	31	0
12	2908	830	7				41	265	74	21
13	1432	1241	10	6			132	773	214	44
14	590	2470	7	67		17	338	1759	341	87
15	329	2820	54	167	13	21	492	2496	608	427
16	309	4087	168	382	55	116	671	3721	978	700
17	495	1908	321	824	186	311	2052	3778	1721	1119
18	618	440	304	1060	174	373	3598	4326	2931	1651
19	870	635	471	823	267	461	4152	5000	3575	2278
20	896	945	512	1091	503	606	2482	6043	5494	3712
21	1630	623	513	1125	443	836	2676	5148	5562	4960
22	1497	1014	935	793	730	762	1700	3686	6076	6887
23	1803	1129	652	667	629	886	1591	2443	6098	8919
24	2555	1203	1009	638	732	877	2999	1424	4807	9517
25	3503	2268	1243	524	583	767	3420	1233	3826	14282
26	5857	2763	992	607	673	683	3120	1292	2476	17344
27	4627	2504	1202	606	637	640	5005	888	1747	15272
28	2652	3383	1798	612	621	569	4684	879	1209	15022
29	1977	3537	2011	472	678	538	3608	906	989	11504
30	2197	3031	3288	678	672	701	4745	568	985	12068
31	1581	3329	2844	376	431	486	4297	506	801	8751
32	1986	4746	2228	416	471	531	3660	391	517	6469
33	1556	4231	2616	309	458	428	3741	498	760	6135
34	1292	2951	2127	360	357	342	3665	351	327	4832
35	1674	1913	1618	236	326	344	2570	311	271	3660
36	885	1738	812	203	208	177	1509	202	243	2727
37	1168	1029	844	200	149	129	1705	225	249	3262
38	1285	1237	571	196	144	41	1288	153	161	1994
39	1429	912	254	77	155	111	757	92	153	1110
40	812	429	420	90	92	43	671	142	71	1622
41	422	309	112	99	108	53	541	81	10	429
42	298	414	230	27	14	60	634	85	41	642
43	307	460	33	81	21	19	34	55	23	331
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	0	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	0		7
50	19	0	15	12		17	172	0		20
51	37	13	12		7		70	18		29
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 ('000000)	57	63	31	14	11	12	75	50	53	168

Table 6b: count.

3M Golden redfish growth parameters for length weight relationship

a= 0.020138

b= 2.9285

	Golden redfish biomass at length (tons)									
length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
7	1									
8	11	1								
9	14	2								
10	26	6								
11	50	9						1	1	
12	95	27					1	9	2	1
13	59	51					5	32	9	2
14	30	125		3		1	17	89	17	4
15	20	174	3	10	1	1	30	154	37	26
16	23	303	12	28	4	9	50	275	72	52
17	44	168	28	72	16	27	180	332	151	98
18	64	46	31	110	18	39	372	448	303	171
19	105	77	57	99	32	56	501	604	432	275
20	125	132	72	153	70	85	347	845	768	519
21	262	100	82	181	71	134	430	827	894	797
22	275	186	172	146	134	140	312	677	1116	1264
23	376	235	136	139	131	185	332	509	1272	1860
24	602	283	238	150	172	207	707	336	1133	2242
25	928	601	329	139	154	203	906	327	1013	3783
26	1736	819	294	180	200	202	925	383	734	5142
27	1529	827	397	200	210	211	1654	293	577	5047
28	970	1241	660	225	228	209	1718	322	444	5511
29	805	1436	816	192	275	218	1464	368	401	4669
30	995	1356	1471	303	301	314	2123	254	441	5400
31	783	1637	1399	185	212	239	2113	249	394	4304
32	1070	2558	1201	224	254	286	1973	211	279	3487
33	916	2492	1541	182	270	252	2203	293	448	3613
34	829	1894	1365	231	229	220	2353	225	210	3102
35	1168	1335	1129	165	228	240	1794	217	189	2555
36	670	1316	615	154	157	134	1143	153	184	2065
37	957	843	692	164	122	106	1397	184	204	2673
38	1137	1095	505	173	127	36	1140	135	143	1765
39	1364	870	242	73	148	106	722	88	146	1059
40	834	440	431	92	94	44	689	146	73	1665
41	465	341	124	109	119	58	597	89	11	473
42	352	490	272	32	17	71	750	101	48	759
43	389	582	42	103	27	24	43	70	29	419
44	223	287	65	53	47	11	798	47	28	146
45	128	230	266	61	10	36	1217	49	25	81
46	186	425	42	17	40		816	77	20	203
47	34	617	11	23	11	28	169	10		29
48	73	101	148	12	12		265	10		50
49	11	24	24	35			338			13
50	37	0	29	24		33	337			39
51	77	27	25		15		145	37		60
52	50	13			31		169	77		97
53	28	16	16	14			151	14		16
54	37	15			37		17			32
55			18				18		44	15
56			19						19	19
57	60	0					20		20	0
total	21028	25855	15022	4456	4226	4165	33453	9568	12332	65606

Table 6b: count.

length	Golden redfish spawnning biomass at length (tons)									
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
21								1	1	1
22								1	2	2
23	1	1					1	1	3	4
24	2	1	1	1	1	1	3	1	4	9
25	6	4	2	1	1	1	6	2	7	25
26	19	9	3	2	2	2	10	4	8	56
27	28	15	7	4	4	4	30	5	10	92
28	29	37	20	7	7	6	52	10	13	165
29	39	70	40	9	13	11	71	18	20	227
30	74	101	109	23	22	23	158	19	33	401
31	89	186	159	21	24	27	240	28	45	489
32	177	423	199	37	42	47	326	35	46	577
33	208	565	349	41	61	57	499	66	101	819
34	240	549	396	67	66	64	682	65	61	899
35	419	479	405	59	82	86	643	78	68	916
36	272	534	250	62	64	54	464	62	75	839
37	422	372	305	72	54	47	616	81	90	1179
38	528	508	235	81	59	17	529	63	66	820
39	654	417	116	35	71	51	346	42	70	508
40	455	241	236	50	52	24	376	80	40	910
41	257	188	68	60	66	32	330	49	6	261
42	196	272	151	18	9	39	417	56	27	422
43	217	325	23	57	15	13	24	39	16	234
44	125	161	36	30	27	6	447	27	16	82
45	112	200	232	53	9	32	1063	43	21	71
46	163	371	36	15	35	0	713	67	17	178
47	30	540	10	20	10	24	148	9		26
48	64	88	129	11	11		231	9		44
49	10	21	21	31			298			11
50	32	0	25	20		29	291			34
51	66	23	22		13		126	32		52
52	44	11			27		146	66		83
53	24	14	14	12			130	12		14
54	32	13			32		15			28
55			16				16		38	13
56			16						16	16
57	52						17		17	0
total	5088	6741	3633	899	877	699	9464	1073	939	10506

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
spawning biomass	5088	6741	3633	899	877	699	9464	1073	939	10506
biomass	21028	25855	15022	4456	4226	4165	33453	9568	12332	65606
spawning biomass proportion	24.2%	26.1%	24.2%	20.2%	20.8%	16.8%	28.3%	11.2%	7.6%	16.0%

Table 6c: 3M redfish (golden plus beaked redfish) abundance, biomass and spwanning biomass at length from EU bottom trawl surveys, 1988-1997.

	Redfish abundance at length ('0000)									
length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
6		2	8	2	0			3	5	
7	43	5	131	162	90	10		1	67	
8	349	50	1396	1098	3290	90		20	491	
9	369	61	1433	686	2880	60		61	353	5
10	402	113	105	70	2183	275	9	67	51	4
11	1053	300	75	193	18347	1786	53	160	127	6
12	2151	781	91	293	28932	3209	159	538	454	27
13	1583	945	296	101	7700	2269	367	364	424	90
14	289	2175	643	38	1752	7828	2208	443	562	197
15	83	4246	1161	94	4021	22073	6784	824	1098	696
16	101	3919	2069	448	3851	12004	9880	1828	1008	1426
17	140	1366	5270	1568	956	2917	18574	4567	1917	1975
18	152	254	6485	3043	592	937	20767	8166	4178	2185
19	437	200	3956	5068	945	538	11017	11222	8829	2819
20	770	297	855	6136	1652	339	2866	8607	13191	5657
21	1743	372	174	3208	3243	363	1464	3751	12453	8808
22	3610	828	262	941	5142	491	866	1251	8299	9209
23	7580	1574	464	390	4011	707	808	626	4174	6655
24	12046	2882	1063	416	2006	858	1174	480	2334	3306
25	13530	4676	2231	765	926	674	1369	524	1190	2435
26	10726	5870	3508	1040	1182	663	1282	650	677	2382
27	5003	5111	3689	1092	1659	555	1227	593	896	2019
28	2235	3569	2840	1007	1869	586	1341	667	662	1989
29	1218	2234	1777	733	1794	444	1139	703	644	1503
30	1640	1510	1322	663	1269	456	1030	671	478	1632
31	1388	1305	1046	492	912	383	928	548	464	1147
32	1709	1614	957	452	627	330	822	458	408	865
33	1676	1311	916	496	601	355	704	409	399	810
34	1489	1175	971	521	597	306	590	344	269	639
35	1247	1109	696	419	510	296	470	298	206	464
36	1079	962	596	388	393	285	307	276	152	365
37	877	697	493	322	312	275	262	242	133	381
38	809	521	366	279	264	177	222	153	96	237
39	513	452	211	172	196	157	122	106	69	131
40	341	297	167	113	128	91	101	66	38	177
41	212	136	76	56	62	44	75	53	27	57
42	100	107	55	38	37	45	71	41	23	68
43	51	72	24	26	17	13	6	22	9	33
44	27	29	11	10	18	19	62	9	4	13
45	19	24	23	12	5	6	87	8	4	6
46	12	33	4	4	5	3	53	8	1	13
47	2	40	3	2	1	4	10	2		2
48	4	7	9	1	1	4	15	1	1	3
49	1	1	1	2			18			1
50	2		2	1		2	17			2
51	4	1	1		1		7	2		3
52	2	1			1		8	4		4
53	1	1	1	1			7	1		1
54	2	1			2		1			1
55			1				1		2	1
56			1						1	1
57	2						1		1	
total ('000000)	788	532	479	331	1050	629	893	498	669	604

Table 6c: count.

	3M redfish biomass at length (tons)									
length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
7	3		10	12	7	1			5	
8	37	5	149	117	351	10		2	52	
9	54	9	210	100	421	9		9	52	1
10	79	22	20	14	424	53	2	13	10	1
11	266	76	19	48	4611	449	13	40	32	1
12	687	249	29	93	9209	1021	51	171	145	8
13	629	376	117	40	3048	898	146	145	168	36
14	141	1060	312	18	849	3794	1071	219	273	96
15	50	2495	680	55	2354	12923	3973	490	645	409
16	72	2756	1447	315	2692	8390	6908	1293	709	999
17	118	1138	4353	1299	790	2410	15347	3791	1592	1637
18	151	248	6270	2948	573	908	20095	7922	4058	2123
19	498	229	4442	5693	1063	607	12396	12633	9936	3182
20	1004	393	1110	7943	2141	444	3731	11189	17109	7352
21	2599	559	263	4761	4803	548	2200	5615	18494	13094
22	6097	1410	454	1596	8664	838	1484	2162	14059	15602
23	14461	3016	895	754	7646	1361	1568	1235	8055	12829
24	25855	6199	2298	904	4312	1856	2580	1059	5102	7284
25	32546	11274	5384	1849	2235	1636	3370	1287	2949	6199
26	28863	15784	9414	2799	3181	1794	3519	1776	1883	6875
27	15018	15270	11001	3264	4949	1671	3812	1792	2722	6508
28	7447	11863	9405	3335	6168	1949	4587	2226	2221	7113
29	4503	8251	6529	2678	6532	1634	4284	2588	2377	5947
30	6652	6165	5427	2674	5089	1852	4336	2700	1954	7093
31	6153	5880	4725	2167	4004	1699	4288	2421	2069	5492
32	8272	7990	4702	2180	3022	1607	4146	2209	1978	4528
33	8816	7107	4940	2599	3154	1877	3919	2162	2124	4632
34	8512	6865	5647	2971	3397	1754	3614	1970	1545	3979
35	7783	6958	4400	2584	3150	1839	3101	1851	1286	3153
36	7230	6538	4027	2592	2625	1907	2176	1849	1029	2675
37	6394	5093	3618	2324	2244	1984	2048	1755	975	3067
38	6379	4155	2887	2170	2047	1369	1855	1195	755	2058
39	4430	3862	1784	1433	1643	1319	1104	890	587	1225
40	3147	2700	1543	1018	1154	818	991	608	349	1795
41	2086	1342	743	548	605	429	797	518	259	607
42	1066	1163	598	389	379	469	831	427	242	800
43	606	865	271	299	190	142	76	244	105	419
44	339	380	135	122	210	226	833	105	52	169
45	252	329	328	160	60	82	1254	111	49	81
46	186	490	55	56	66	34	816	116	20	203
47	34	645	39	37	11	63	169	24		29
48	73	116	148	12	12	61	265	10	15	50
49	11	24	24	35	0	0	338			13
50	37		29	24	0	33	337			39
51	77	27	25		15		145	37		60
52	50	13			31		169	77		97
53	28	16	16	14			151	14		16
54	37	15			37		17			32
55			18				18		44	15
56			19				0		19	19
57	60						20		20	0
total	219890	151421	110961	67042	110166	64766	128947	78955	108124	139642

Table 6c: count.

	3M spawnning redfish biomass at length (tons)									
length	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
14						1				
15		1				5	2			
16		1	1			5	4	1		
17		1	4	1		2	16	4	1	1
18			10	5		1	33	12	6	3
19	1		12	15	2	1	32	32	25	7
20	4	1	5	34	9	2	15	45	72	30
21	17	3	1	33	35	4	15	35	127	89
22	71	15	4	18	102	12	19	21	157	173
23	295	59	16	13	145	33	36	21	140	224
24	1012	238	83	31	132	72	85	41	156	199
25	2245	760	360	122	106	90	141	77	151	221
26	3215	1772	1078	311	200	146	228	136	162	362
27	1996	2122	1554	451	455	172	266	195	318	418
28	1264	2062	1687	600	791	274	489	286	366	652
29	785	1444	1192	511	1087	297	566	424	423	596
30	1804	1571	1319	747	1284	465	737	672	451	1155
31	1901	1618	1281	690	1245	520	933	724	604	974
32	2877	2460	1511	770	1037	541	1110	754	691	1021
33	3406	2433	1725	1020	1197	710	1178	804	770	1276
34	3548	2690	2240	1247	1401	703	1216	796	626	1316
35	4062	3576	2206	1392	1653	939	1340	948	688	1282
36	3894	3417	2134	1409	1434	1033	1029	993	539	1189
37	3474	2757	1947	1285	1250	1092	978	956	533	1400
38	3528	2260	1598	1223	1143	766	952	662	414	984
39	2402	2123	995	810	925	739	562	498	325	602
40	2413	2153	1177	833	953	684	632	471	273	1020
41	1631	1037	594	432	478	349	499	413	216	375
42	802	844	428	321	317	377	487	333	192	457
43	402	566	218	224	154	113	52	187	81	234
44	224	240	96	89	165	189	477	76	36	102
45	220	287	286	139	52	71	1095	97	43	71
46	163	428	48	49	58	30	713	102	17	178
47	30	564	34	32	10	55	148	21		26
48	64	101	129	11	11	53	231	9	13	44
49	10	21	21	31			296			11
50	32	0	25	20		29	291			34
51	66	23	22	0	13		126	32		52
52	44	11			27		146	66		83
53	24	14	14	12			130	12		14
54	32	13			32		15			28
55			16				16		38	13
56			16						16	16
57	52						17		17	0
total	48009	39686	26086	14928	17902	10577	17354	10956	8688	16932

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
spawning biomass	48009	39686	26086	14928	17902	10577	17354	10956	8688	16932
biomass	219890	151421	110961	67042	110166	64766	128947	78955	108124	139642
spawning biomass proportion	21.8%	26.2%	23.5%	22.3%	16.3%	16.3%	13.5%	13.9%	8.0%	12.1%

Table 7: Computation of Z's using female *S. mentella* length data
(Beverton and Holt, 1957 from Die, D.J. and J.F. Caddy 1997)

1) Mean length in the catch

	95	96	97	mean
$\overline{L}$	32.7	27.9	30.9	30.5

2) Mean length of age of first capture (age 4)

	95	96	97	mean
Lc	19.4	19.6	20.2	19.7

3) von Bertalanfy growth parameters

$L\infty$	51.07
K	0.072

4) Length at maturity

Lm	30.14

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

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

Z mean 95-97 =	0.138	
$Z^{*}(\overline{L} > L_m) <$	0.145	
Assuming M=0.1		
F mean 95-97 =	0.038	0.031 from catch versus survey biomass
$F^{*}(\overline{L} > L_m) <$	0.045	0.057 F_{SSB50} from SSB/R curve

Table 8: Estimates of total mortalities and a partial recruitment vector for 3M redfish (*S.mentella*).

Age	redfish abundance at age (' 0000s) 1992	1993	1994	1995	1996	1997	mean Z's	Z's for PR	PR
1			10	6			-0.87	0.00	0.00
2			49	259	280	58	-0.23	0.00	0.00
3	132		1074	3040	1620	480	-0.12	0.00	0.00
4	2673	173	5249	19700	11726	3190	0.23	0.23	0.24
5	*9884*	*550*	*2273*	*11900*	*30498*	*17631*	*0.99*	*0.99*	*1.00*
6	3829	1420	1285	490	4765	10163	0.73	0.73	0.74
7	3048	1013	1915	870	850	794	0.65	0.65	0.66
8	2181	637	1178	980	826	331	0.61	0.61	0.62
9	1361	228	778	570	641	217	0.49	0.49	0.50
10	862	317	605	550	374	251	0.44	0.44	0.45
11	631	335	519	610	281	133	0.44	0.44	0.44
12	465	410	330	280	284	133	0.47	0.45	0.46
13	446	259	253	220	168	72	0.42	0.45	0.46
14	321	266	161	250	188	121	0.47	0.45	0.46
15	174	297	172	260	147	34	0.63	0.61	0.61
16	172	69	85	160	106	48	0.50	0.61	0.61
17	107	95	59	102	69	44	0.51	0.61	0.61
18	69	44	84	87	67	11	0.64	0.61	0.61
19	72	34	38	46	32	14	0.50	0.61	0.61
20	19	26	22	38	41	16	0.65	0.61	0.61
21	13	31	13	25	18	6	0.87	0.61	0.61
22			13	11	5	2	0.55	0.61	0.61
23	5	10	7	5	13				0.61
24					5				*0.61*
25	16	3	2	31	17				0.61

TABLE 9: Yield per recruit parameters for 3M redfish

Age	Weights at age			%mat	%females	PR	Ref. M	Age
	stock 95-97	stockf 95-97	catch 95-97	91-94	91-97	91-97		
1	0.007	0.007	0.007	0%	45%	0.00	0.10	1
2	0.029	0.032	0.029	0%	45%	0.00	0.10	2
3	0.060	0.052	0.074	0%	45%	0.00	0.10	3
4	0.092	0.086	0.113	0%	47%	0.24	0.10	4
5	0.128	0.131	0.156	0%	47%	1.00	0.10	5
6	0.173	0.188	0.218	7%	47%	0.74	0.10	6
7	0.251	0.260	0.274	13%	47%	0.66	0.10	7
8	0.323	0.324	0.332	22%	47%	0.62	0.10	8
9	0.373	0.385	0.387	36%	47%	0.50	0.10	9
10	0.430	0.434	0.443	53%	47%	0.45	0.10	10
11	0.482	0.460	0.481	69%	47%	0.44	0.10	11
12	0.515	0.505	0.531	82%	47%	0.46	0.10	12
13	0.618	0.576	0.567	90%	47%	0.46	0.10	13
14	0.627	0.597	0.609	95%	47%	0.46	0.10	14
15	0.669	0.688	0.670	97%	47%	0.61	0.10	15
16	0.719	0.729	0.723	99%	57%	0.61	0.10	16
17	0.749	0.788	0.778	99%	57%	0.61	0.10	17
18	0.775	0.848	0.831	100%	57%	0.61	0.10	18
19	0.853	0.869	0.869	100%	72%	0.61	0.10	19
20	0.897	0.953	0.950	100%	72%	0.61	0.10	20
21	0.983	1.008	1.067	100%	72%	0.61	0.10	21
22	0.807	0.860	1.017	100%	83%	0.61	0.10	22
23	0.963	1.001	1.055	100%	83%	0.61	0.10	23
24	1.071	1.063	1.154	100%	83%	0.61	0.10	24
25+	1.584	1.584	1.584	100%	86%	0.61	0.10	25+

Table 10: Fishing mortalities associated with different levels of reduction of spawning and total biomass of 3M redfish (*S.mentella*, from 1000 recruits)

	% SSB	% B	Ref. F	Yield	SSB	B	F	Slope
	100%	100%	0.0000	0	2,584	4,536	0.013	2003
	90%	92%	0.0080	19	2,325	4,189	0.032	1378
	80%	85%	0.0173	37	2,067	3,837	0.037	1237
	70%	77%	0.0282	55	1,809	3,480	0.043	1097
	60%	69%	0.0413	71	1,550	3,116	0.049	955
FLmat	**58%**	**67%**	**0.0448**	75	1,489	3,029	0.051	922
FSSB50	**50%**	**60%**	**0.0575**	87	1,292	2,743	0.057	813
	40%	52%	0.0784	101	1,033	2,356	0.152	167
FB50	**38%**	**50%**	**0.0840**	104	976	2,268	0.067	684
	30%	43%	0.1073	113	775	1,952	0.166	107
F0.1	**28%**	**41%**	**0.1153**	115	718	1,859	0.116	257
	20%	33%	0.1518	122	517	1,518	0.188	49
Fmax	**11%**	**24%**	**0.2270**	125	283	1,074	0.228	0
	10%	23%	0.2393	125	258	1,023	0.232	-4
	9%	22%	0.2500	125	239	982	0.263	-21
	7%	18%	0.3000	124	170	824	0.313	-37
	6%	17%	0.3250	123	145	762	0.338	-41

Table 11: 3M redfish yield for different reference fishing mortalities

	bottom biomass	bottom proportion	total biomass	FLmat	FSSB50	FB50	F0.1	Fmax
mean 1992-1997	101.1	0.434	232.8	0.045	0.057	0.084	0.115	0.227
1997	139.2	0.434	320.6	0.045	0.057	0.084	0.115	0.227

	total biomass	Yield at FLmat	Yield at FSSB50	Yield at FB50	Yield at F0.1	Yield at Fmax
mean 1992-1997	**232800**	**10428**	**13383**	**19554**	**26847**	**52838**
	240000	10752	13799	20162	27681	54480
	250000	11200	14374	21002	28835	56750
	260000	11648	14949	21842	29988	59020
	270000	12096	15524	22682	31141	61290
	280000	12544	16099	23522	32295	63560
	290000	12992	16674	24362	33448	65830
	300000	13440	17249	25202	34601	68100
	310000	13888	17824	26042	35755	70370
1997	**320630**	**14364**	**18435**	**26935**	**36981**	**72783**
1998 yield at Fmsy from ASPIC 1 (bottom redfish biomass by swept area method)				**26790**		
1998 yield at Fmsy from ASPIC 2 (bottom beaked redfish biomass by sum of products)				**27300**		

Fig. 1: 3M redfish nominal catches, 1985-1997.

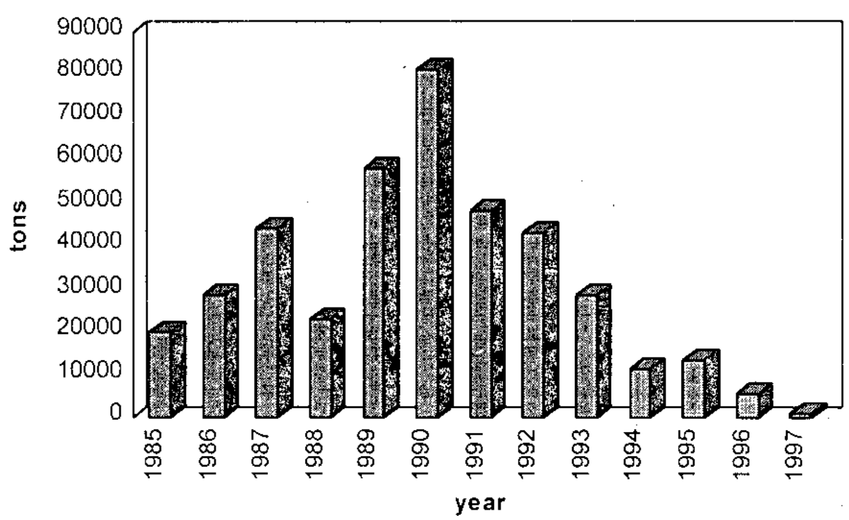


Fig. 2: Comparison between observed 3M redfish commercial catch rates (additive model) and 3M redfish trawlable biomass from the EU surveys.

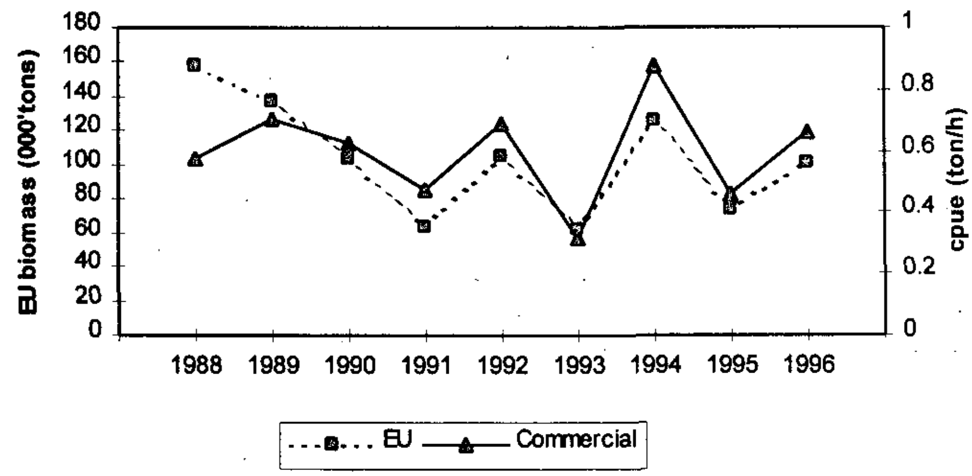


Fig. 3: Redfish combined biomass in Div. 3M.

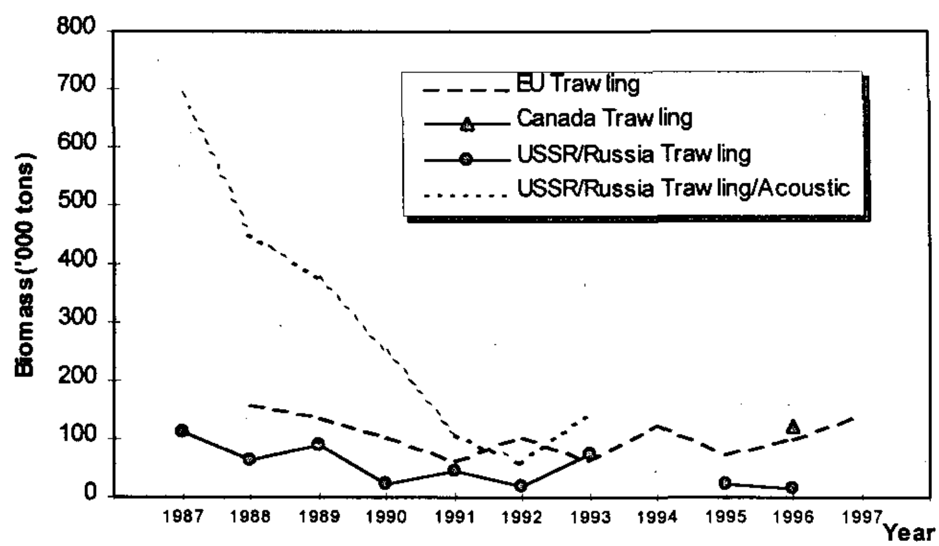


Fig. 4: Trawlable biomass by species from EU survey, 1991-1997.

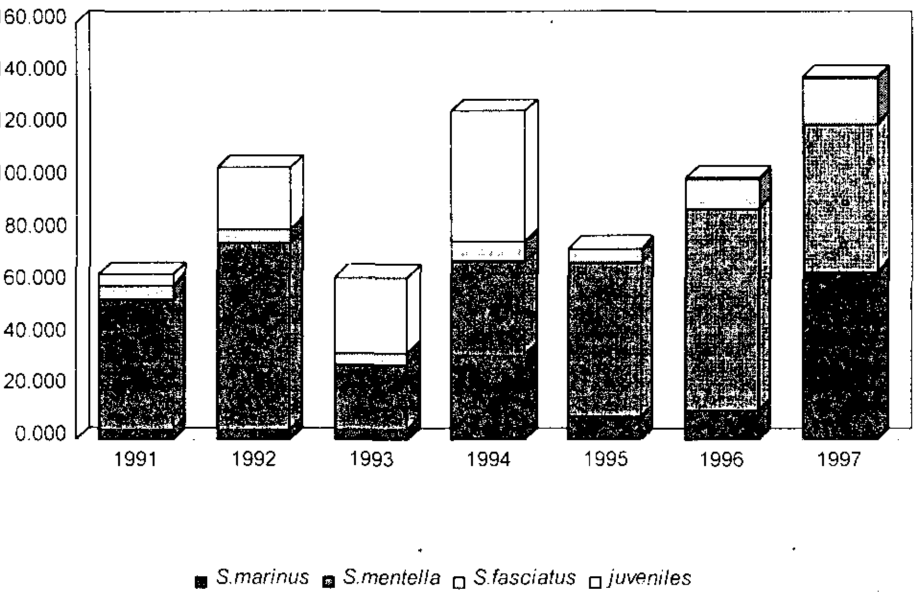


Fig. 5 : 3M Beaked redfish biomass,spawning biomass and abundance
(Canada survey, 1979/85; EU survey, 1988/97)

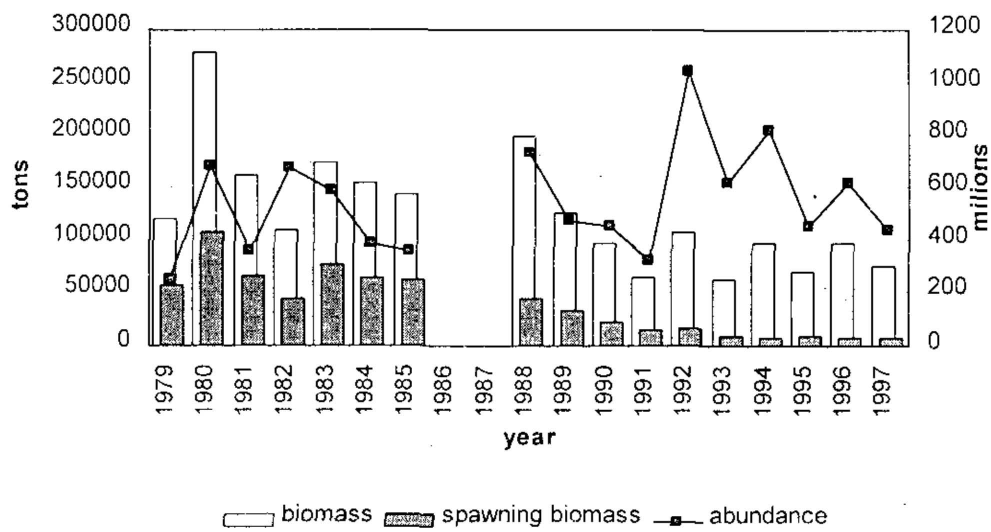


Fig. 6 : 3M golden redfish biomass, spawning biomass and abundance (EU survey, 1988/97)

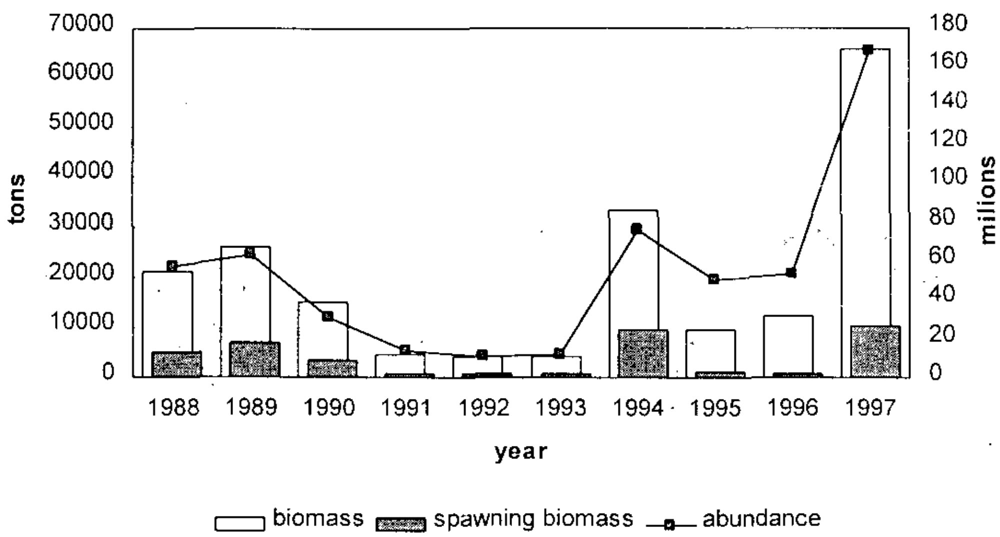
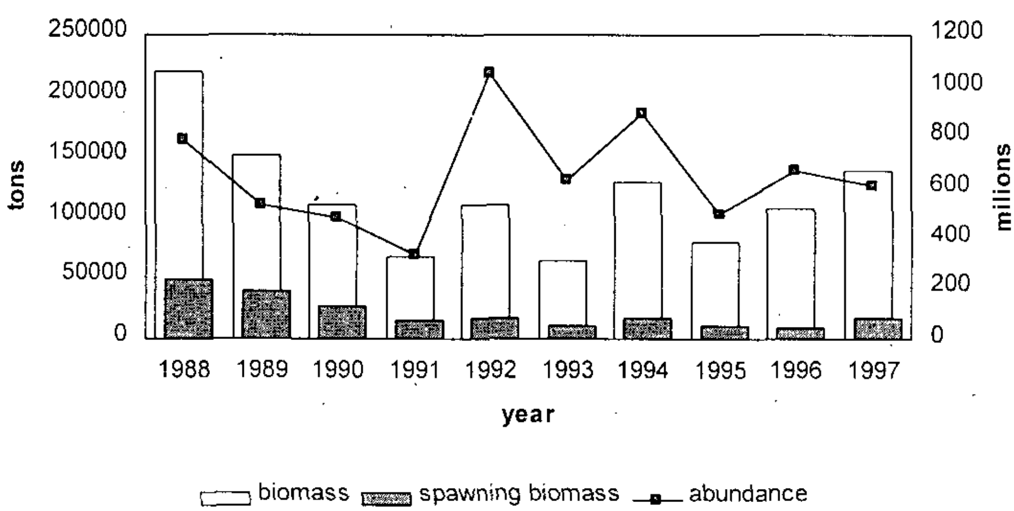


Fig. 7 : 3M redfish biomass, spawning biomass and abundance (EU survey 1988/97)



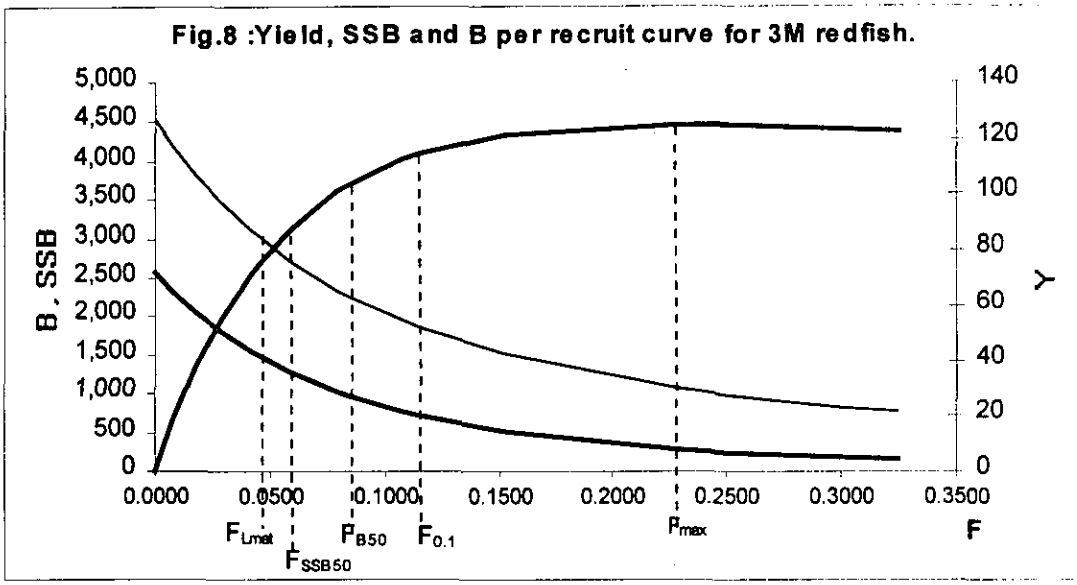


Fig.8 :Yield, SSB and B per recruit curve for 3M redfish.
B , SSB
Y
F
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
140
120
100
80
60
40
20
0
0.0000
0.0500
0.1000
0.1500
0.2000
0.2500
0.3000
0.3500
F Lmat
F SSB50
F B50
F 0.1
F max

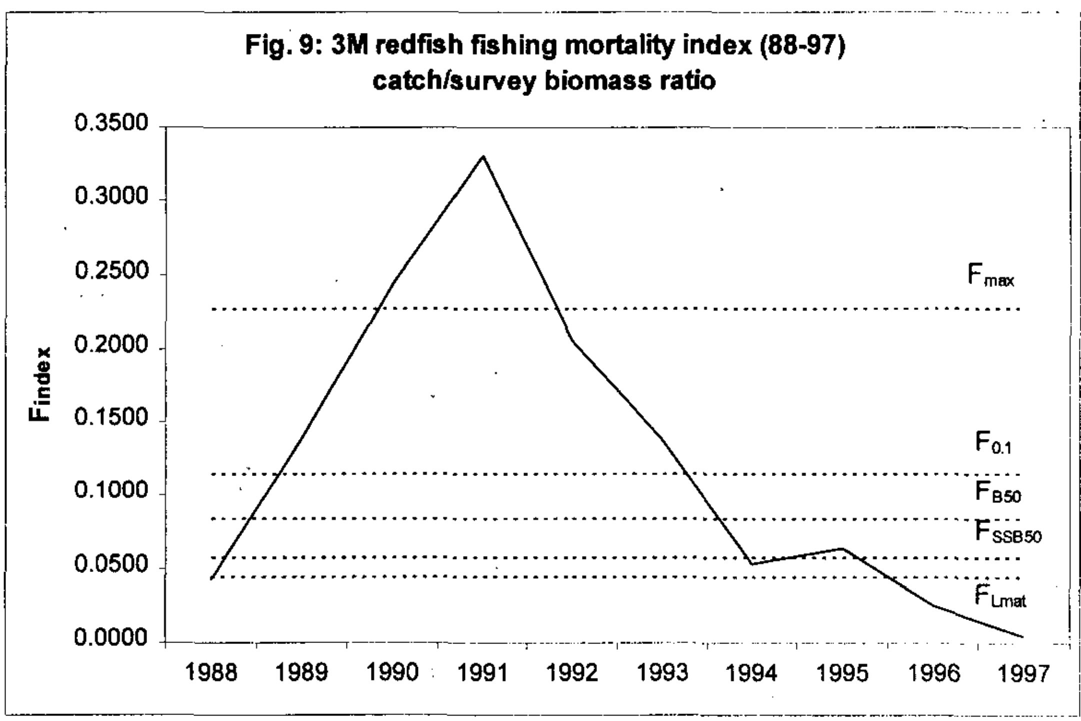


Fig. 9: 3M redfish fishing mortality index (88-97)
catch/survey biomass ratio
Findex
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
F max
F 0.1
F B50
F SSB50
F Lmat
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

APPENDIX 1

```
3M redfish                                                                        Page 1
                                                                     06 Jun 1998 at 20:46

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

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

CONTROL PARAMETERS USED (FROM INPUT FILE)
------------------------------------------------------------------------------------------
Number of years analyzed:                    39     Number of bootstrap trials:          0
Number of data series:                        2     Lower bound on MSY:          2.000E+03
Objective function computed:          in EFFORT     Upper bound on MSY:          5.000E+05
Relative conv. criterion (simplex):   1.000E-08     Lower bound on r:            2.000E-02
Relative conv. criterion (restart):   3.000E-08     Upper bound on r:            5.000E+00
Relative conv. criterion (effort):    1.000E-04     Random number seed:            9126738
Maximum F allowed in fitting:             3.000     Monte Carlo search trials:       10000

ITERATIVE REWEIGHTING PHASE
------------------------------------------------------------------------------------------
Iter   Angle      Loss    Revised weights...

User     --         --    1.00E+00 1.00E+00
Start    --         --    1.00E+00 1.00E+00
  1    9.19  3.582E+00    1.28E+00 9.21E-01
  2    0.09  3.488E+00    1.28E+00 9.20E-01

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
                                     |      10
                                     |
 2  Statlant CPUE                    |   0.646   1.000
                                     |       6      35
                                     ------------------------------------
                                             1       2
```

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	2.872E-03	1	N/A	1.000E+02	N/A	
Loss(1)	EU survey	6.783E-01	10	8.479E-02	1.277E+00	1.280E+00	0.488
Loss(2)	Statlant CPUE	2.807E+00	35	8.507E-02	9.210E-01	9.201E-01	0.234

TOTAL OBJECTIVE FUNCTION: 3.48839242E+00

NOTE: B1-ratio constraint term contributing to loss. Sensitivity analysis advised.

Number of restarts required for convergence:	2
Est. B-ratio coverage index (0 worst, 2 best):	1.0842
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	2.011E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	3.060E+04	1.000E+05	1	1
r	Intrinsic rate of increase	3.000E-01	3.000E-01	0	1
....	Catchability coefficients by fishery:				
q(1)	EU survey	4.340E-01	4.340E-01	0	1
q(2)	Statlant CPUE	8.024E-06	3.704E-05	1	0

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	3.060E+04	Kr/4	
K	Maximum stock biomass	4.080E+05		
Bmsy	Stock biomass at MSY	2.040E+05	K/2	
Fmsy	Fishing mortality at MSY	1.500E-01	r/2	
F(0.1)	Management benchmark	1.350E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	3.029E+04	0.99*MSY	
B-ratio	Ratio of B(1998) to Bmsy	1.353E+00		
F-ratio	Ratio of F(1997) to Fmsy	1.390E-02		
Y-ratio	Proportion of MSY avail in 1998	8.756E-01	2*Br-Br^2	Ye(1998) = 2.679E+04
....	Fishing effort at MSY in units of each fishery:			
fmsy(2)	Statlant CPUE	1.869E+04	r/2q(2)	f(0.1) = 1.682E+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	0.135	4.102E+05	3.858E+05	5.198E+04	5.198E+04	6.180E+03	8.983E-01	2.011E+00
2	1960	0.023	3.644E+05	3.659E+05	8.388E+03	8.388E+03	1.132E+04	1.528E-01	1.786E+00
3	1961	0.042	3.673E+05	3.652E+05	1.552E+04	1.552E+04	1.149E+04	2.832E-01	1.801E+00
4	1962	0.019	3.633E+05	3.656E+05	6.958E+03	6.958E+03	1.139E+04	1.269E-01	1.781E+00
5	1963	0.019	3.677E+05	3.695E+05	7.035E+03	7.035E+03	1.045E+04	1.269E-01	1.803E+00
6	1964	0.048	3.711E+05	3.676E+05	1.765E+04	1.765E+04	1.091E+04	3.200E-01	1.819E+00
7	1965	0.094	3.644E+05	3.542E+05	3.343E+04	3.343E+04	1.399E+04	6.292E-01	1.786E+00
8	1966	0.021	3.450E+05	3.491E+05	7.241E+03	7.241E+03	1.512E+04	1.383E-01	1.691E+00
9	1967	0.002	3.529E+05	3.592E+05	7.290E+02	7.290E+02	1.289E+04	1.353E-02	1.730E+00
10	1968	0.013	3.650E+05	3.681E+05	4.963E+03	4.963E+03	1.081E+04	8.989E-02	1.789E+00
11	1969	0.007	3.709E+05	3.742E+05	2.801E+03	2.801E+03	9.286E+03	4.990E-02	1.818E+00
12	1970	0.008	3.773E+05	3.798E+05	3.168E+03	3.168E+03	7.873E+03	5.561E-02	1.850E+00
13	1971	0.021	3.820E+05	3.817E+05	8.033E+03	8.033E+03	7.379E+03	1.403E-01	1.873E+00
14	1972	0.115	3.814E+05	3.652E+05	4.195E+04	4.195E+04	1.143E+04	7.656E-01	1.870E+00
15	1973	0.064	3.509E+05	3.473E+05	2.235E+04	2.235E+04	1.550E+04	4.291E-01	1.720E+00
16	1974	0.103	3.440E+05	3.352E+05	3.467E+04	3.467E+04	1.792E+04	6.895E-01	1.686E+00
17	1975	0.049	3.273E+05	3.289E+05	1.608E+04	1.608E+04	1.914E+04	3.259E-01	1.604E+00
18	1976	0.051	3.303E+05	3.312E+05	1.700E+04	1.700E+04	1.870E+04	3.421E-01	1.619E+00
19	1977	0.061	3.320E+05	3.312E+05	2.027E+04	2.027E+04	1.870E+04	4.079E-01	1.628E+00
20	1978	0.051	3.305E+05	3.314E+05	1.676E+04	1.676E+04	1.866E+04	3.371E-01	1.620E+00
21	1979	0.061	3.324E+05	3.316E+05	2.007E+04	2.007E+04	1.863E+04	4.036E-01	1.629E+00
22	1980	0.048	3.309E+05	3.322E+05	1.596E+04	1.596E+04	1.851E+04	3.202E-01	1.622E+00
23	1981	0.041	3.335E+05	3.355E+05	1.389E+04	1.389E+04	1.788E+04	2.760E-01	1.635E+00
24	1982	0.043	3.374E+05	3.388E+05	1.468E+04	1.468E+04	1.724E+04	2.890E-01	1.654E+00
25	1983	0.058	3.400E+05	3.388E+05	1.953E+04	1.953E+04	1.724E+04	3.842E-01	1.667E+00
26	1984	0.060	3.377E+05	3.364E+05	2.023E+04	2.023E+04	1.771E+04	4.009E-01	1.655E+00
27	1985	0.061	3.352E+05	3.341E+05	2.028E+04	2.028E+04	1.816E+04	4.047E-01	1.643E+00
28	1986	0.088	3.331E+05	3.281E+05	2.887E+04	2.887E+04	1.928E+04	5.868E-01	1.633E+00
29	1987	0.142	3.235E+05	3.117E+05	4.441E+04	4.441E+04	2.204E+04	9.498E-01	1.586E+00
30	1988	0.077	3.011E+05	3.013E+05	2.319E+04	2.319E+04	2.363E+04	5.130E-01	1.476E+00
31	1989	0.204	3.015E+05	2.845E+05	5.810E+04	5.810E+04	2.577E+04	1.361E+00	1.478E+00
32	1990	0.335	2.692E+05	2.417E+05	8.105E+04	8.105E+04	2.939E+04	2.235E+00	1.320E+00
33	1991	0.233	2.176E+05	2.082E+05	4.849E+04	4.849E+04	3.057E+04	1.552E+00	1.066E+00
34	1992	0.224	1.996E+05	1.930E+05	4.332E+04	4.332E+04	3.050E+04	1.496E+00	9.786E-01
35	1993	0.155	1.868E+05	1.875E+05	2.899E+04	2.899E+04	3.040E+04	1.031E+00	9.158E-01
36	1994	0.057	1.882E+05	1.979E+05	1.132E+04	1.132E+04	3.055E+04	3.811E-01	9.227E-01
37	1995	0.062	2.075E+05	2.161E+05	1.350E+04	1.350E+04	3.047E+04	4.164E-01	1.017E+00
38	1996	0.024	2.244E+05	2.366E+05	5.789E+03	5.789E+03	2.978E+04	1.631E-01	1.100E+00
39	1997	0.002	2.484E+05	2.624E+05	5.470E+02	5.470E+02	2.805E+04	1.390E-02	1.218E+00
40	1998		2.759E+05						1.353E+00

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

Data type I1: Year-average biomass index Series weight: 1.277

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	*	1.674E+05	0.00000	0.0
2	1960	0.000E+00	0.000E+00	0.0	*	1.588E+05	0.00000	0.0
3	1961	0.000E+00	0.000E+00	0.0	*	1.585E+05	0.00000	0.0
4	1962	0.000E+00	0.000E+00	0.0	*	1.587E+05	0.00000	0.0
5	1963	0.000E+00	0.000E+00	0.0	*	1.604E+05	0.00000	0.0
6	1964	0.000E+00	0.000E+00	0.0	*	1.595E+05	0.00000	0.0
7	1965	0.000E+00	0.000E+00	0.0	*	1.537E+05	0.00000	0.0
8	1966	0.000E+00	0.000E+00	0.0	*	1.515E+05	0.00000	0.0
9	1967	0.000E+00	0.000E+00	0.0	*	1.559E+05	0.00000	0.0
10	1968	0.000E+00	0.000E+00	0.0	*	1.597E+05	0.00000	0.0
11	1969	0.000E+00	0.000E+00	0.0	*	1.624E+05	0.00000	0.0
12	1970	0.000E+00	0.000E+00	0.0	*	1.648E+05	0.00000	0.0
13	1971	0.000E+00	0.000E+00	0.0	*	1.657E+05	0.00000	0.0
14	1972	0.000E+00	0.000E+00	0.0	*	1.585E+05	0.00000	0.0
15	1973	0.000E+00	0.000E+00	0.0	*	1.507E+05	0.00000	0.0
16	1974	0.000E+00	0.000E+00	0.0	*	1.455E+05	0.00000	0.0
17	1975	0.000E+00	0.000E+00	0.0	*	1.427E+05	0.00000	0.0
18	1976	0.000E+00	0.000E+00	0.0	*	1.437E+05	0.00000	0.0
19	1977	0.000E+00	0.000E+00	0.0	*	1.437E+05	0.00000	0.0
20	1978	0.000E+00	0.000E+00	0.0	*	1.438E+05	0.00000	0.0
21	1979	0.000E+00	0.000E+00	0.0	*	1.439E+05	0.00000	0.0
22	1980	0.000E+00	0.000E+00	0.0	*	1.442E+05	0.00000	0.0
23	1981	0.000E+00	0.000E+00	0.0	*	1.456E+05	0.00000	0.0
24	1982	0.000E+00	0.000E+00	0.0	*	1.470E+05	0.00000	0.0
25	1983	0.000E+00	0.000E+00	0.0	*	1.470E+05	0.00000	0.0
26	1984	0.000E+00	0.000E+00	0.0	*	1.460E+05	0.00000	0.0
27	1985	0.000E+00	0.000E+00	0.0	*	1.450E+05	0.00000	0.0
28	1986	0.000E+00	0.000E+00	0.0	*	1.424E+05	0.00000	0.0
29	1987	0.000E+00	0.000E+00	0.0	*	1.353E+05	0.00000	0.0
30	1988	1.000E+00	1.000E+00	0.0	1.582E+05	1.308E+05	0.19051	2.745E+04
31	1989	1.000E+00	1.000E+00	0.0	1.366E+05	1.235E+05	0.10125	1.316E+04
32	1990	1.000E+00	1.000E+00	0.0	1.042E+05	1.049E+05	-0.00675	-7.058E+02
33	1991	1.000E+00	1.000E+00	0.0	6.385E+04	9.037E+04	-0.34749	-2.653E+04
34	1992	1.000E+00	1.000E+00	0.0	1.045E+05	8.376E+04	0.22098	2.071E+04
35	1993	1.000E+00	1.000E+00	0.0	6.259E+04	8.139E+04	-0.26266	-1.880E+04
36	1994	1.000E+00	1.000E+00	0.0	1.260E+05	8.590E+04	0.38322	4.011E+04
37	1995	1.000E+00	1.000E+00	0.0	7.364E+04	9.377E+04	-0.24165	-2.013E+04
38	1996	1.000E+00	1.000E+00	0.0	1.005E+05	1.027E+05	-0.02098	-2.132E+03
39	1997	1.000E+00	1.000E+00	0.0	1.392E+05	1.139E+05	0.20111	2.537E+04

* Asterisk indicates missing value(s).

3M redfish

```
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    0.1905                                               |========
1989    0.1012                                               |====
1990   -0.0068                                               |
1991   -0.3475                                 ==============|
1992    0.2210                                               |=========
1993   -0.2627                                    ===========|
1994    0.3832                                               |===============
1995   -0.2417                                     ==========|
1996   -0.0210                                              =|
1997    0.2011                                               |========
                 ------------------------------------------------------------------------------------
```

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

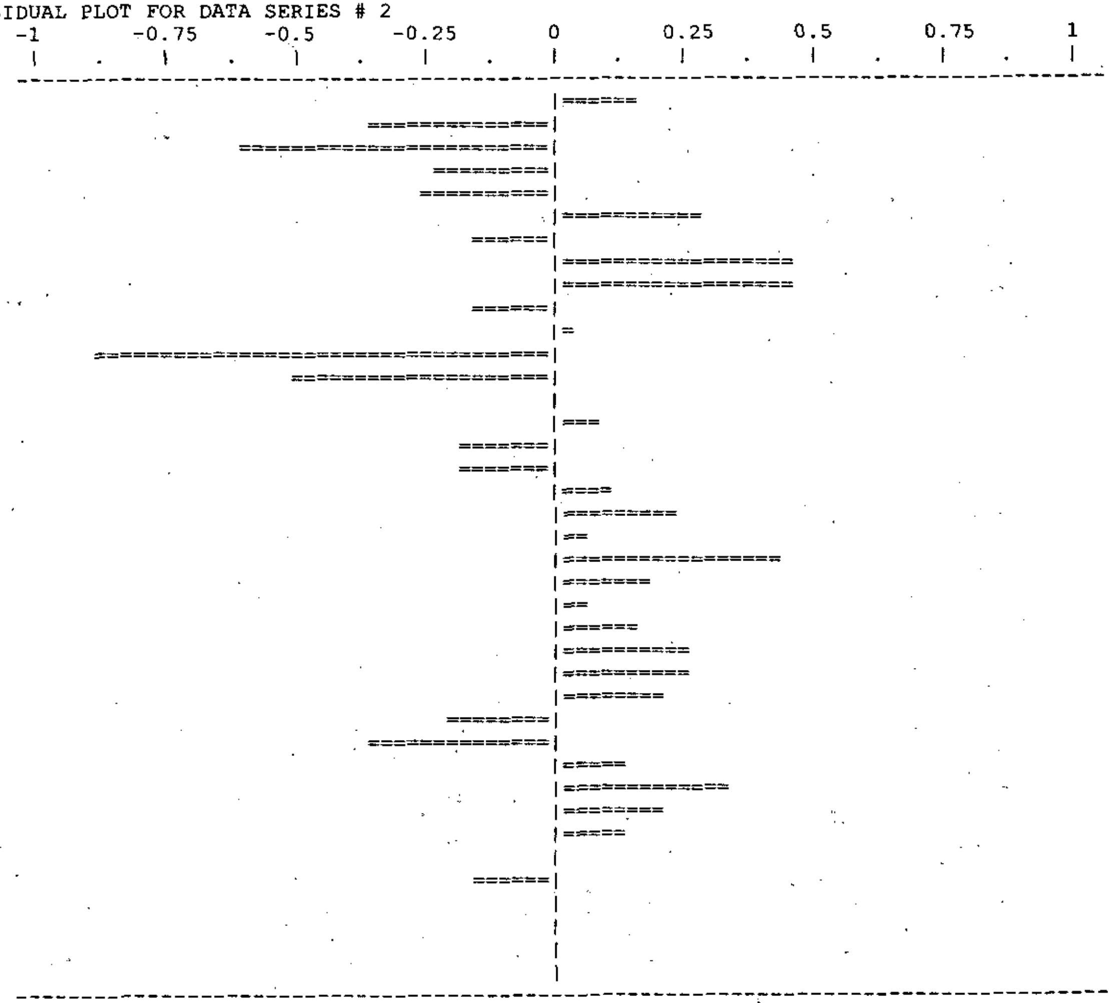
Data type CC: CPUE-catch series Series weight: 0.921

Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1959	1.934E+04	1.679E+04	0.1347	5.198E+04	5.198E+04	0.14110	0.000E+00
2	1960	2.007E+03	2.857E+03	0.0229	8.388E+03	8.388E+03	-0.35297	0.000E+00
3	1961	2.911E+03	5.295E+03	0.0425	1.552E+04	1.552E+04	-0.59836	0.000E+00
4	1962	1.885E+03	2.372E+03	0.0190	6.958E+03	6.958E+03	-0.22965	0.000E+00
5	1963	1.870E+03	2.373E+03	0.0190	7.035E+03	7.035E+03	-0.23807	0.000E+00
6	1964	7.861E+03	5.982E+03	0.0480	1.765E+04	1.765E+04	0.27303	0.000E+00
7	1965	1.020E+04	1.176E+04	0.0944	3.343E+04	3.343E+04	-0.14272	0.000E+00
8	1966	4.089E+03	2.585E+03	0.0207	7.241E+03	7.241E+03	0.45842	0.000E+00
9	1967	4.010E+02	2.530E+02	0.0020	7.290E+02	7.290E+02	0.46074	0.000E+00
10	1968	1.442E+03	1.680E+03	0.0135	4.963E+03	4.963E+03	-0.15283	0.000E+00
11	1969	9.579E+02	9.328E+02	0.0075	2.801E+03	2.801E+03	0.02663	0.000E+00
12	1970	4.355E+02	1.040E+03	0.0083	3.168E+03	3.168E+03	-0.86997	0.000E+00
13	1971	1.600E+03	2.623E+03	0.0210	8.033E+03	8.033E+03	-0.49409	0.000E+00
14	1972	1.427E+04	1.431E+04	0.1148	4.195E+04	4.195E+04	-0.00317	0.000E+00
15	1973	8.721E+03	8.021E+03	0.0644	2.235E+04	2.235E+04	0.08367	0.000E+00
16	1974	1.084E+04	1.289E+04	0.1034	3.467E+04	3.467E+04	-0.17333	0.000E+00
17	1975	5.123E+03	6.092E+03	0.0489	1.608E+04	1.608E+04	-0.17327	0.000E+00
18	1976	7.151E+03	6.396E+03	0.0513	1.700E+04	1.700E+04	0.11161	0.000E+00
19	1977	9.524E+03	7.626E+03	0.0612	2.027E+04	2.027E+04	0.22227	0.000E+00
20	1978	6.646E+03	6.303E+03	0.0506	1.676E+04	1.676E+04	0.05310	0.000E+00
21	1979	1.154E+04	7.544E+03	0.0605	2.007E+04	2.007E+04	0.42532	0.000E+00
22	1980	7.181E+03	5.986E+03	0.0480	1.596E+04	1.596E+04	0.18212	0.000E+00
23	1981	5.491E+03	5.159E+03	0.0414	1.389E+04	1.389E+04	0.06218	0.000E+00
24	1982	6.225E+03	5.402E+03	0.0433	1.468E+04	1.468E+04	0.14179	0.000E+00
25	1983	9.150E+03	7.183E+03	0.0576	1.953E+04	1.953E+04	0.24213	0.000E+00
26	1984	9.537E+03	7.494E+03	0.0601	2.023E+04	2.023E+04	0.24110	0.000E+00
27	1985	9.270E+03	7.566E+03	0.0607	2.028E+04	2.028E+04	0.20310	0.000E+00
28	1986	9.017E+03	1.097E+04	0.0880	2.887E+04	2.887E+04	-0.19591	0.000E+00
29	1987	1.240E+04	1.776E+04	0.1425	4.441E+04	4.441E+04	-0.35911	0.000E+00
30	1988	1.100E+04	9.591E+03	0.0770	2.319E+04	2.319E+04	0.13715	0.000E+00
31	1989	3.504E+04	2.545E+04	0.2042	5.810E+04	5.810E+04	0.31984	0.000E+00
32	1990	5.149E+04	4.179E+04	0.3353	8.105E+04	8.105E+04	0.20878	0.000E+00
33	1991	3.267E+04	2.902E+04	0.2329	4.849E+04	4.849E+04	0.11862	0.000E+00
34	1992	2.831E+04	2.797E+04	0.2244	4.332E+04	4.332E+04	0.01212	0.000E+00
35	1993	1.674E+04	1.927E+04	0.1546	2.899E+04	2.899E+04	-0.14062	0.000E+00
36	1994	*	7.125E+03	0.0572	1.132E+04	1.132E+04	0.00000	0.000E+00
37	1995	*	7.784E+03	0.0625	1.350E+04	1.350E+04	0.00000	0.000E+00
38	1996	*	3.050E+03	0.0245	5.789E+03	5.789E+03	0.00000	0.000E+00
39	1997	*	2.598E+02	0.0021	5.470E+02	5.470E+02	0.00000	0.000E+00

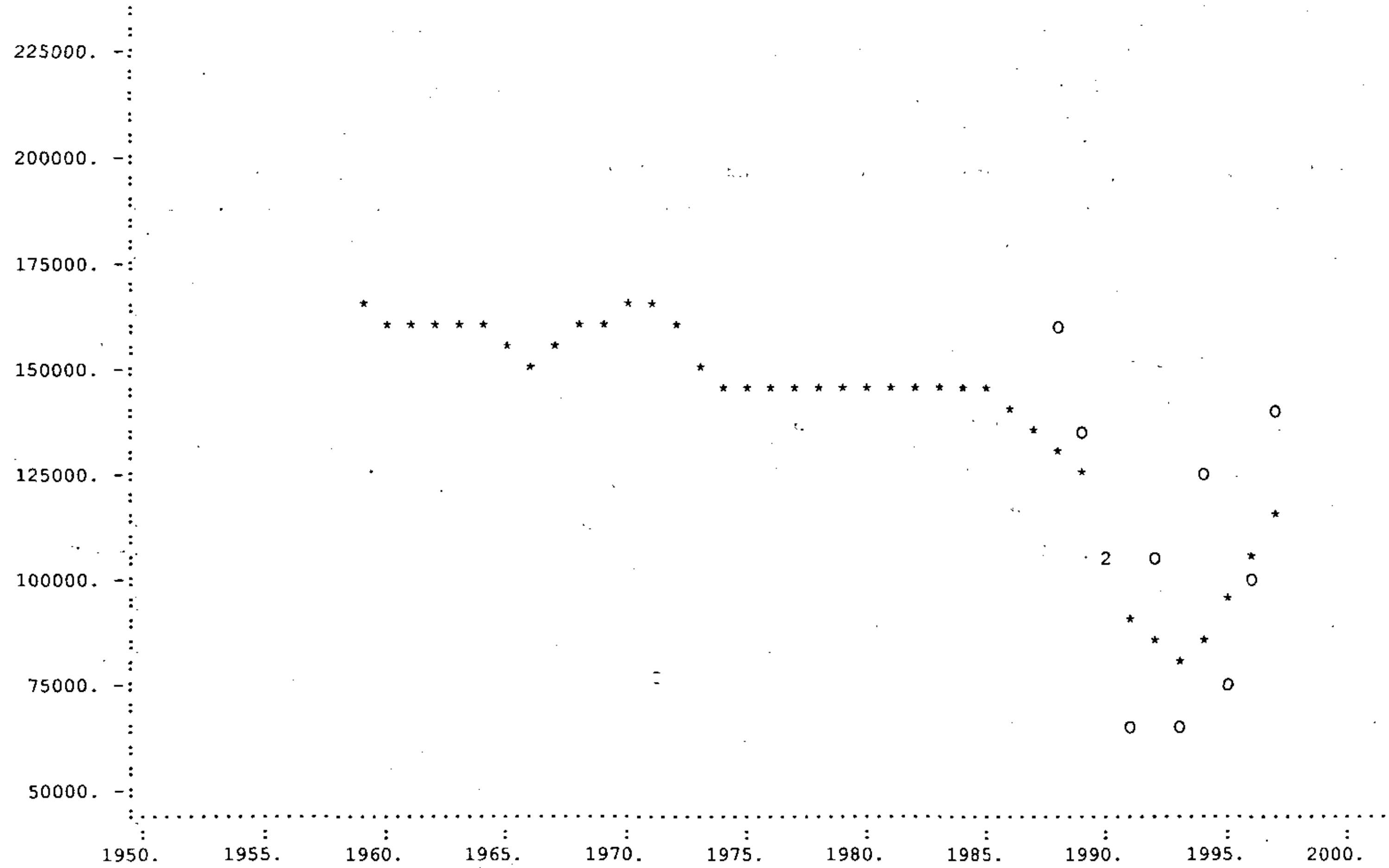
* Asterisk indicates missing value(s).

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2

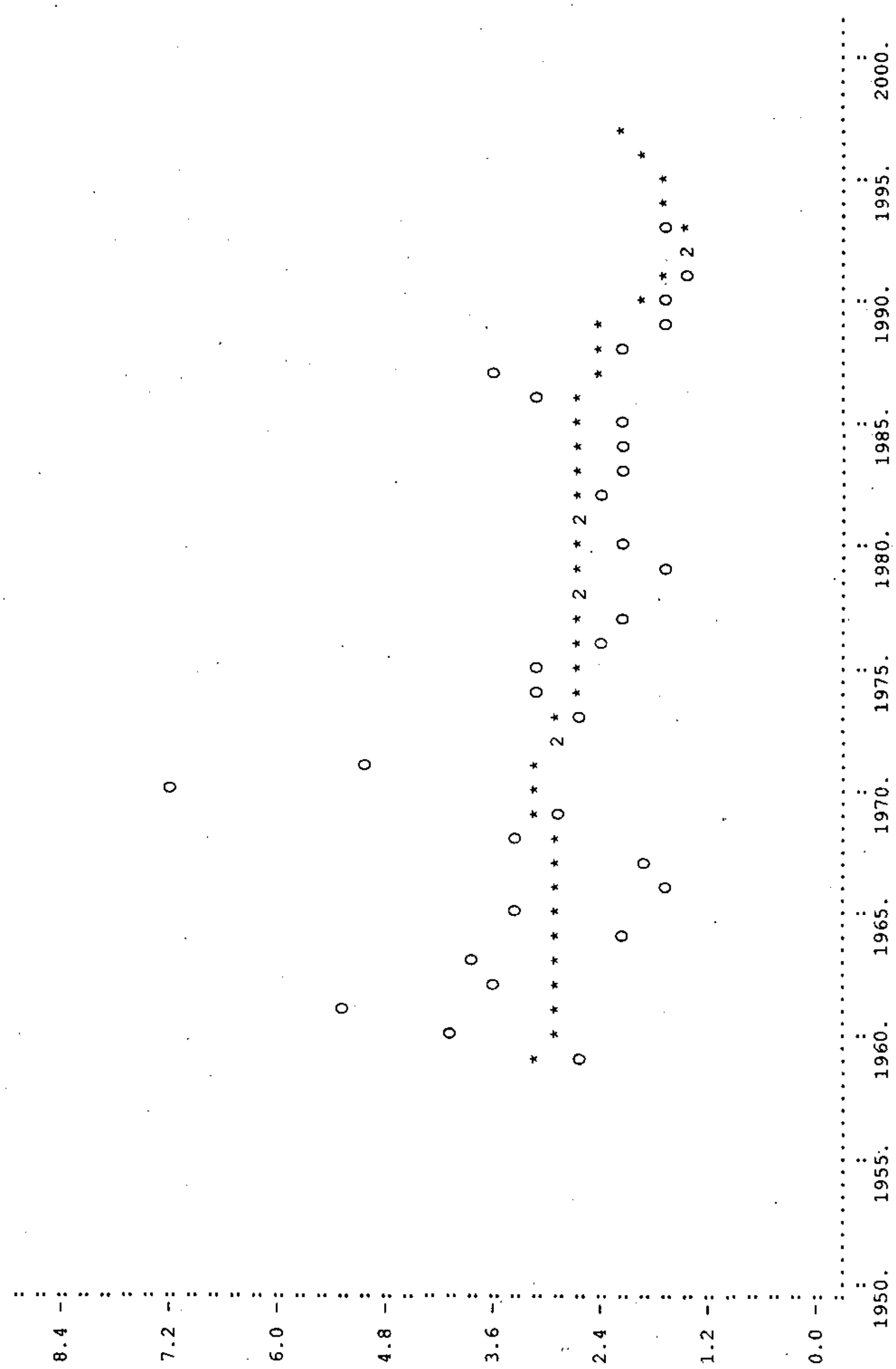
Year	Residual
1959	0.1411
1960	-0.3530
1961	-0.5984
1962	-0.2297
1963	-0.2381
1964	0.2730
1965	-0.1427
1966	0.4584
1967	0.4607
1968	-0.1528
1969	0.0266
1970	-0.8700
1971	-0.4941
1972	-0.0032
1973	0.0837
1974	-0.1733
1975	-0.1733
1976	0.1116
1977	0.2223
1978	0.0531
1979	0.4253
1980	0.1821
1981	0.0622
1982	0.1418
1983	0.2421
1984	0.2411
1985	0.2031
1986	-0.1959
1987	-0.3591
1988	0.1371
1989	0.3198
1990	0.2088
1991	0.1186
1992	0.0121
1993	-0.1406
1994	0.0000
1995	0.0000
1996	0.0000
1997	0.0000



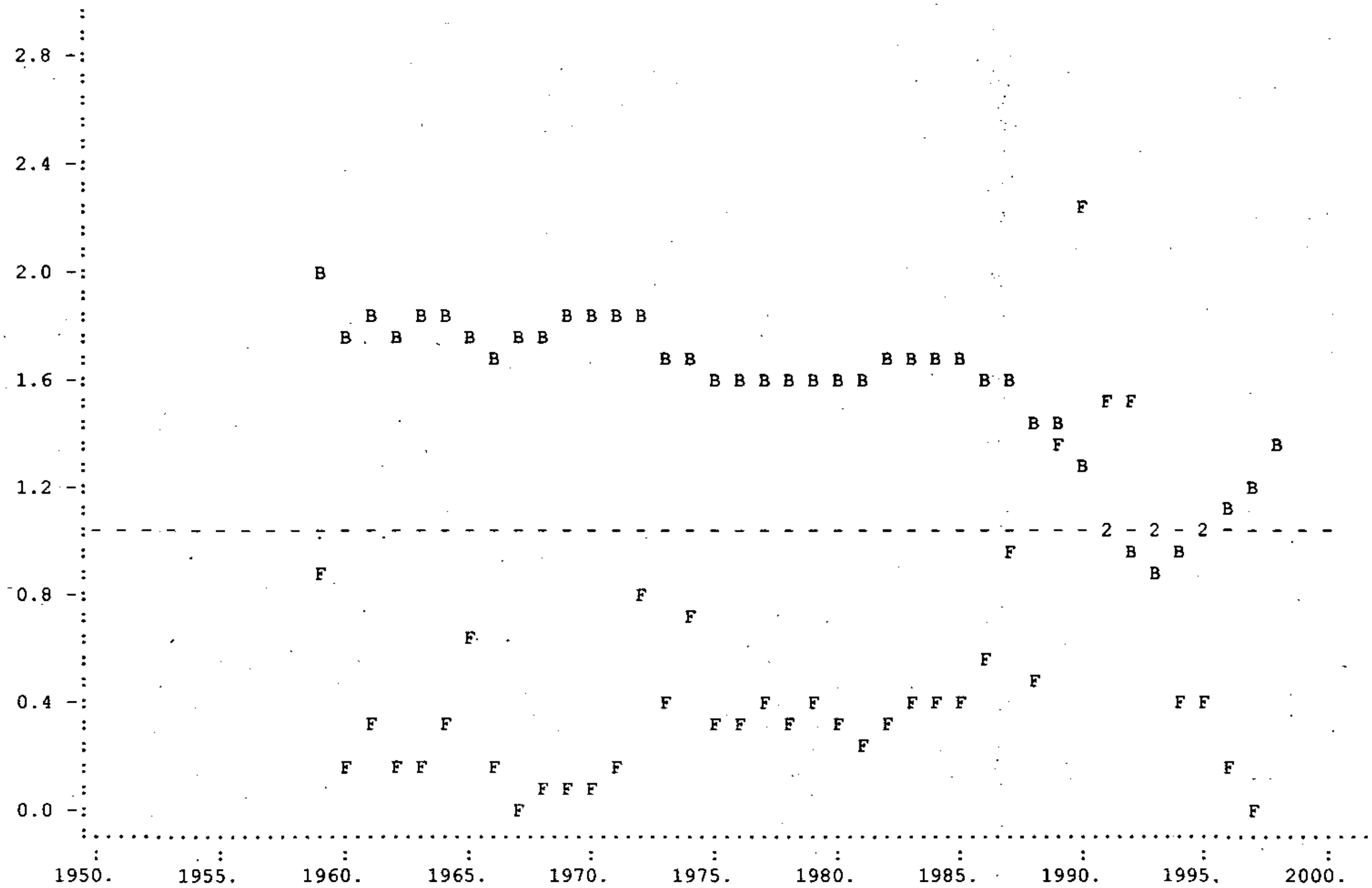
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- EU survey



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
                                                          06 Jun 1998 at 21:46

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

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

CONTROL PARAMETERS USED (FROM INPUT FILE)
------------------------------------------------------------------------------------------
Number of years analyzed:                  39    Number of bootstrap trials:            0
Number of data series:                      2    Lower bound on MSY:            2.000E+03
Objective function computed:        in EFFORT    Upper bound on MSY:            5.000E+05
Relative conv. criterion (simplex):  1.000E-08   Lower bound on r:              2.000E-02
Relative conv. criterion (restart):  3.000E-08   Upper bound on r:              5.000E+00
Relative conv. criterion (effort):   1.000E-04   Random number seed:              9126738
Maximum F allowed in fitting:            3.000   Monte Carlo search trials:         10000

ITERATIVE REWEIGHTING PHASE
------------------------------------------------------------------------------------------
Iter  Angle     Loss     Revised weights...

User    --        --     1.00E+00 1.00E+00
Start   --        --     1.00E+00 1.00E+00
  1   6.03  3.636E+00    1.17E+00 9.50E-01
  2   0.26  3.588E+00    1.18E+00 9.48E-01

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-beaked redfish           |   1.000
                                       |      10
                                       |
 2  Statlant CPUE                      |   0.802   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                 2.056E-03    1              N/A    1.000E+02          N/A
Loss( 1)  EU survey-beaked redfish            6.944E-01   10        8.680E-02    1.175E+00    1.183E+00        0.528
Loss( 2)  Statlant CPUE                       2.891E+00   35        8.761E-02    9.501E-01    9.478E-01        0.258

TOTAL OBJECTIVE FUNCTION:                3.58766936E+00

NOTE: B1-ratio constraint term contributing to loss. Sensitivity analysis advised.

Number of restarts required for convergence:          2
Est. B-ratio coverage index (0 worst, 2 best):   1.2699
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   2.009E+00        1.000E+00           1            1
MSY       Maximum sustainable yield           2.793E+04        1.000E+05           1            1
r         Intrinsic rate of increase          3.000E-01        3.000E-01           0            1
........  Catchability coefficients by fishery:
q( 1)     EU survey-beaked redfish            5.145E-01        4.340E-01           1            1
q( 2)     Statlant CPUE                       9.126E-06        3.704E-05           1            0

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
-------------------------------------------------------------------------------------------------------------
Parameter                                      Estimate          Formula

MSY       Maximum sustainable yield           2.793E+04             Kr/4
K         Maximum stock biomass               3.724E+05
Bmsy      Stock biomass at MSY                1.862E+05              K/2
Fmsy      Fishing mortality at MSY            1.500E-01              r/2

F(0.1)    Management benchmark                1.350E-01        0.9*Fmsy
Y(0.1)    Equilibrium yield at F(0.1)         2.765E+04        0.99*MSY

B-ratio   Ratio of B(1998) to Bmsy            1.150E+00
F-ratio   Ratio of F(1997) to Fmsy            1.819E-02
Y-ratio   Proportion of MSY avail in 1998     9.776E-01       2*Br-Br^2    Ye(1998) = 2.730E+04

........  Fishing effort at MSY in units of each fishery:
fmsy( 2)  Statlant CPUE                       1.644E+04        r/2q( 2)      f(0.1) = 1.479E+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	0.149	3.741E+05	3.497E+05	5.198E+04	5.198E+04	6.263E+03	9.910E-01	2.009E+00
2	1960	0.025	3.284E+05	3.299E+05	8.388E+03	8.388E+03	1.130E+04	1.695E-01	1.764E+00
3	1961	0.047	3.313E+05	3.292E+05	1.552E+04	1.552E+04	1.146E+04	3.143E-01	1.779E+00
4	1962	0.021	3.272E+05	3.295E+05	6.958E+03	6.958E+03	1.138E+04	1.408E-01	1.757E+00
5	1963	0.021	3.316E+05	3.334E+05	7.035E+03	7.035E+03	1.046E+04	1.407E-01	1.781E+00
6	1964	0.053	3.351E+05	3.315E+05	1.765E+04	1.765E+04	1.091E+04	3.549E-01	1.800E+00
7	1965	0.105	3.283E+05	3.180E+05	3.343E+04	3.343E+04	1.390E+04	7.007E-01	1.763E+00
8	1966	0.023	3.088E+05	3.128E+05	7.241E+03	7.241E+03	1.501E+04	1.543E-01	1.658E+00
9	1967	0.002	3.166E+05	3.229E+05	7.290E+02	7.290E+02	1.287E+04	1.505E-02	1.700E+00
10	1968	0.015	3.287E+05	3.318E+05	4.963E+03	4.963E+03	1.085E+04	9.973E-02	1.765E+00
11	1969	0.008	3.346E+05	3.380E+05	2.801E+03	2.801E+03	9.357E+03	5.524E-02	1.797E+00
12	1970	0.009	3.412E+05	3.437E+05	3.168E+03	3.168E+03	7.954E+03	6.146E-02	1.832E+00
13	1971	0.023	3.459E+05	3.456E+05	8.033E+03	8.033E+03	7.449E+03	1.549E-01	1.858E+00
14	1972	0.127	3.454E+05	3.292E+05	4.195E+04	4.195E+04	1.140E+04	8.495E-01	1.855E+00
15	1973	0.072	3.148E+05	3.111E+05	2.235E+04	2.235E+04	1.535E+04	4.789E-01	1.691E+00
16	1974	0.116	3.078E+05	2.989E+05	3.467E+04	3.467E+04	1.768E+04	7.733E-01	1.653E+00
17	1975	0.055	2.908E+05	2.923E+05	1.608E+04	1.608E+04	1.887E+04	3.667E-01	1.562E+00
18	1976	0.058	2.936E+05	2.944E+05	1.700E+04	1.700E+04	1.850E+04	3.849E-01	1.577E+00
19	1977	0.069	2.951E+05	2.942E+05	2.027E+04	2.027E+04	1.853E+04	4.593E-01	1.585E+00
20	1978	0.057	2.934E+05	2.943E+05	1.676E+04	1.676E+04	1.852E+04	3.797E-01	1.576E+00
21	1979	0.068	2.951E+05	2.943E+05	2.007E+04	2.007E+04	1.851E+04	4.547E-01	1.585E+00
22	1980	0.054	2.936E+05	2.948E+05	1.596E+04	1.596E+04	1.842E+04	3.608E-01	1.577E+00
23	1981	0.047	2.960E+05	2.981E+05	1.389E+04	1.389E+04	1.784E+04	3.107E-01	1.590E+00
24	1982	0.049	3.000E+05	3.013E+05	1.468E+04	1.468E+04	1.725E+04	3.249E-01	1.611E+00
25	1983	0.065	3.025E+05	3.014E+05	1.953E+04	1.953E+04	1.724E+04	4.320E-01	1.625E+00
26	1984	0.068	3.003E+05	2.989E+05	2.023E+04	2.023E+04	1.769E+04	4.511E-01	1.613E+00
27	1985	0.068	2.977E+05	2.966E+05	2.028E+04	2.028E+04	1.811E+04	4.559E-01	1.599E+00
28	1986	0.099	2.955E+05	2.905E+05	2.887E+04	2.887E+04	1.916E+04	6.627E-01	1.587E+00
29	1987	0.162	2.858E+05	2.739E+05	4.441E+04	4.441E+04	2.170E+04	1.081E+00	1.535E+00
30	1988	0.088	2.631E+05	2.631E+05	2.319E+04	2.319E+04	2.316E+04	5.876E-01	1.413E+00
31	1989	0.237	2.631E+05	2.456E+05	5.810E+04	5.810E+04	2.501E+04	1.577E+00	1.413E+00
32	1990	0.403	2.300E+05	2.014E+05	8.105E+04	8.105E+04	2.755E+04	2.683E+00	1.235E+00
33	1991	0.293	1.765E+05	1.656E+05	4.849E+04	4.849E+04	2.756E+04	1.952E+00	9.480E-01
34	1992	0.295	1.556E+05	1.469E+05	4.332E+04	4.332E+04	2.667E+04	1.965E+00	8.356E-01
35	1993	0.211	1.389E+05	1.374E+05	2.899E+04	2.899E+04	2.601E+04	1.407E+00	7.462E-01
36	1994	0.079	1.359E+05	1.435E+05	1.132E+04	1.132E+04	2.645E+04	5.256E-01	7.301E-01
37	1995	0.085	1.511E+05	1.580E+05	1.350E+04	1.350E+04	2.728E+04	5.693E-01	8.114E-01
38	1996	0.033	1.649E+05	1.759E+05	5.789E+03	5.789E+03	2.781E+04	2.194E-01	8.854E-01
39	1997	0.003	1.869E+05	2.005E+05	5.470E+02	5.470E+02	2.771E+04	1.819E-02	1.004E+00
40	1998		2.141E+05						1.150E+00

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

Data type I1: Year-average biomass index   Series weight: 1.175

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	*	1.799E+05	0.00000	0.0
2	1960	0.000E+00	0.000E+00	0.0	*	1.697E+05	0.00000	0.0
3	1961	0.000E+00	0.000E+00	0.0	*	1.694E+05	0.00000	0.0
4	1962	0.000E+00	0.000E+00	0.0	*	1.695E+05	0.00000	0.0
5	1963	0.000E+00	0.000E+00	0.0	*	1.716E+05	0.00000	0.0
6	1964	0.000E+00	0.000E+00	0.0	*	1.706E+05	0.00000	0.0
7	1965	0.000E+00	0.000E+00	0.0	*	1.636E+05	0.00000	0.0
8	1966	0.000E+00	0.000E+00	0.0	*	1.610E+05	0.00000	0.0
9	1967	0.000E+00	0.000E+00	0.0	*	1.661E+05	0.00000	0.0
10	1968	0.000E+00	0.000E+00	0.0	*	1.707E+05	0.00000	0.0
11	1969	0.000E+00	0.000E+00	0.0	*	1.739E+05	0.00000	0.0
12	1970	0.000E+00	0.000E+00	0.0	*	1.768E+05	0.00000	0.0
13	1971	0.000E+00	0.000E+00	0.0	*	1.778E+05	0.00000	0.0
14	1972	0.000E+00	0.000E+00	0.0	*	1.694E+05	0.00000	0.0
15	1973	0.000E+00	0.000E+00	0.0	*	1.601E+05	0.00000	0.0
16	1974	0.000E+00	0.000E+00	0.0	*	1.538E+05	0.00000	0.0
17	1975	0.000E+00	0.000E+00	0.0	*	1.504E+05	0.00000	0.0
18	1976	0.000E+00	0.000E+00	0.0	*	1.515E+05	0.00000	0.0
19	1977	0.000E+00	0.000E+00	0.0	*	1.514E+05	0.00000	0.0
20	1978	0.000E+00	0.000E+00	0.0	*	1.514E+05	0.00000	0.0
21	1979	0.000E+00	0.000E+00	0.0	*	1.514E+05	0.00000	0.0
22	1980	0.000E+00	0.000E+00	0.0	*	1.517E+05	0.00000	0.0
23	1981	0.000E+00	0.000E+00	0.0	*	1.534E+05	0.00000	0.0
24	1982	0.000E+00	0.000E+00	0.0	*	1.550E+05	0.00000	0.0
25	1983	0.000E+00	0.000E+00	0.0	*	1.550E+05	0.00000	0.0
26	1984	0.000E+00	0.000E+00	0.0	*	1.538E+05	0.00000	0.0
27	1985	0.000E+00	0.000E+00	0.0	*	1.526E+05	0.00000	0.0
28	1986	0.000E+00	0.000E+00	0.0	*	1.495E+05	0.00000	0.0
29	1987	0.000E+00	0.000E+00	0.0	*	1.409E+05	0.00000	0.0
30	1988	1.000E+00	1.000E+00	0.0	1.989E+05	1.354E+05	0.38459	6.349E+04
31	1989	1.000E+00	1.000E+00	0.0	1.256E+05	1.264E+05	-0.00647	-8.155E+02
32	1990	1.000E+00	1.000E+00	0.0	9.594E+04	1.036E+05	-0.07681	-7.660E+03
33	1991	1.000E+00	1.000E+00	0.0	6.259E+04	8.520E+04	-0.30843	-2.261E+04
34	1992	1.000E+00	1.000E+00	0.0	1.059E+05	7.560E+04	0.33745	3.034E+04
35	1993	1.000E+00	1.000E+00	0.0	6.060E+04	7.070E+04	-0.15410	-1.010E+04
36	1994	1.000E+00	1.000E+00	0.0	9.549E+04	7.385E+04	0.25709	2.165E+04
37	1995	1.000E+00	1.000E+00	0.0	6.939E+04	8.130E+04	-0.15845	-1.191E+04
38	1996	1.000E+00	1.000E+00	0.0	9.579E+04	9.050E+04	0.05680	5.289E+03
39	1997	1.000E+00	1.000E+00	0.0	7.404E+04	1.032E+05	-0.33186	-2.914E+04

* Asterisk indicates missing value(s).

3M redfish

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    0.3846                                            |===============
1989   -0.0065                                            |
1990   -0.0768                                         ===|
1991   -0.3084                                ============|
1992    0.3375                                            |=============
1993   -0.1541                                      ======|
1994    0.2571                                            |==========
1995   -0.1585                                      ======|
1996    0.0568                                            |==
1997   -0.3319                               =============|
                  -------------------------------------------------------------------------------------
```

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

Data type CC: CPUE-catch series   Series weight: 0.950

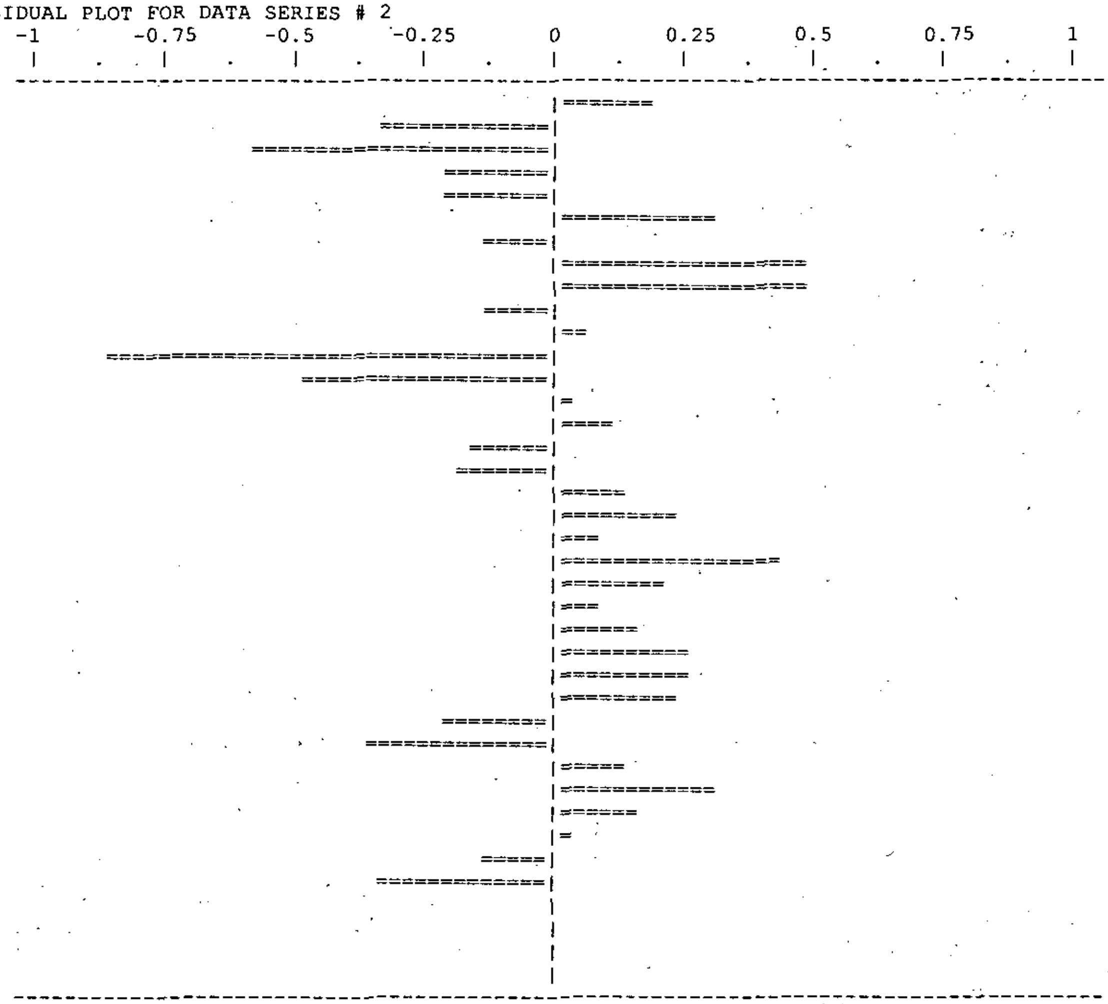
Obs	Year	Observed effort	Estimated effort	Estim F	Observed yield	Model yield	Resid in log effort	Resid in yield
1	1959	1.934E+04	1.629E+04	0.1487	5.198E+04	5.198E+04	0.17152	0.000E+00
2	1960	2.007E+03	2.786E+03	0.0254	8.388E+03	8.388E+03	-0.32796	0.000E+00
3	1961	2.911E+03	5.166E+03	0.0471	1.552E+04	1.552E+04	-0.57364	0.000E+00
4	1962	1.885E+03	2.314E+03	0.0211	6.958E+03	6.958E+03	-0.20488	0.000E+00
5	1963	1.870E+03	2.312E+03	0.0211	7.035E+03	7.035E+03	-0.21215	0.000E+00
6	1964	7.861E+03	5.833E+03	0.0532	1.765E+04	1.765E+04	0.29841	0.000E+00
7	1965	1.020E+04	1.152E+04	0.1051	3.343E+04	3.343E+04	-0.12166	0.000E+00
8	1966	4.089E+03	2.536E+03	0.0231	7.241E+03	7.241E+03	0.47749	0.000E+00
9	1967	4.010E+02	2.474E+02	0.0023	7.290E+02	7.290E+02	0.48286	0.000E+00
10	1968	1.442E+03	1.639E+03	0.0150	4.963E+03	4.963E+03	-0.12793	0.000E+00
11	1969	9.579E+02	9.080E+02	0.0083	2.801E+03	2.801E+03	0.05351	0.000E+00
12	1970	4.355E+02	1.010E+03	0.0092	3.168E+03	3.168E+03	-0.84130	0.000E+00
13	1971	1.600E+03	2.547E+03	0.0232	8.033E+03	8.033E+03	-0.46467	0.000E+00
14	1972	1.427E+04	1.396E+04	0.1274	4.195E+04	4.195E+04	0.02154	0.000E+00
15	1973	8.721E+03	7.872E+03	0.0718	2.235E+04	2.235E+04	0.10246	0.000E+00
16	1974	1.084E+04	1.271E+04	0.1160	3.467E+04	3.467E+04	-0.15940	0.000E+00
17	1975	5.123E+03	6.027E+03	0.0550	1.608E+04	1.608E+04	-0.16257	0.000E+00
18	1976	7.151E+03	6.327E+03	0.0577	1.700E+04	1.700E+04	0.12241	0.000E+00
19	1977	9.524E+03	7.549E+03	0.0689	2.027E+04	2.027E+04	0.23245	0.000E+00
20	1978	6.646E+03	6.241E+03	0.0570	1.676E+04	1.676E+04	0.06285	0.000E+00
21	1979	1.154E+04	7.474E+03	0.0682	2.007E+04	2.007E+04	0.43470	0.000E+00
22	1980	7.181E+03	5.930E+03	0.0541	1.596E+04	1.596E+04	0.19139	0.000E+00
23	1981	5.491E+03	5.107E+03	0.0466	1.389E+04	1.389E+04	0.07250	0.000E+00
24	1982	6.225E+03	5.340E+03	0.0487	1.468E+04	1.468E+04	0.15327	0.000E+00
25	1983	9.150E+03	7.100E+03	0.0648	1.953E+04	1.953E+04	0.25367	0.000E+00
26	1984	9.537E+03	7.415E+03	0.0677	2.023E+04	2.023E+04	0.25173	0.000E+00
27	1985	9.270E+03	7.493E+03	0.0684	2.028E+04	2.028E+04	0.21274	0.000E+00
28	1986	9.017E+03	1.089E+04	0.0994	2.887E+04	2.887E+04	-0.18887	0.000E+00
29	1987	1.240E+04	1.777E+04	0.1621	4.441E+04	4.441E+04	-0.35976	0.000E+00
30	1988	1.100E+04	9.657E+03	0.0881	2.319E+04	2.319E+04	0.13021	0.000E+00
31	1989	3.504E+04	2.592E+04	0.2365	5.810E+04	5.810E+04	0.30161	0.000E+00
32	1990	5.149E+04	4.410E+04	0.4025	8.105E+04	8.105E+04	0.15483	0.000E+00
33	1991	3.267E+04	3.209E+04	0.2928	4.849E+04	4.849E+04	0.01815	0.000E+00
34	1992	2.831E+04	3.230E+04	0.2948	4.332E+04	4.332E+04	-0.13193	0.000E+00
35	1993	1.674E+04	2.312E+04	0.2110	2.899E+04	2.899E+04	-0.32296	0.000E+00
36	1994	*	8.639E+03	0.0788	1.132E+04	1.132E+04	0.00000	0.000E+00
37	1995	*	9.358E+03	0.0854	1.350E+04	1.350E+04	0.00000	0.000E+00
38	1996	*	3.606E+03	0.0329	5.789E+03	5.789E+03	0.00000	0.000E+00
39	1997	*	2.989E+02	0.0027	5.470E+02	5.470E+02	0.00000	0.000E+00

* Asterisk indicates missing value(s).

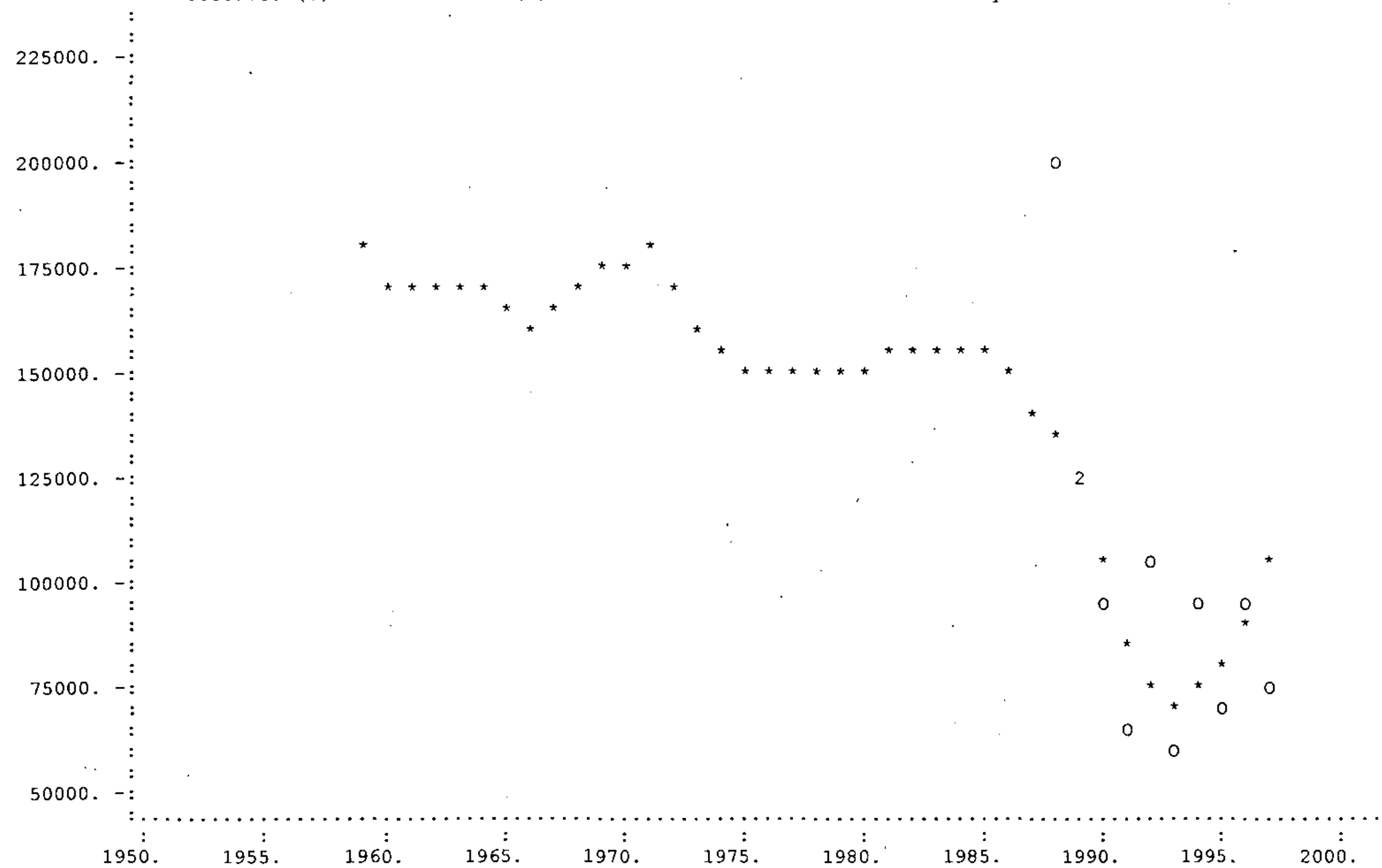
3M redfish

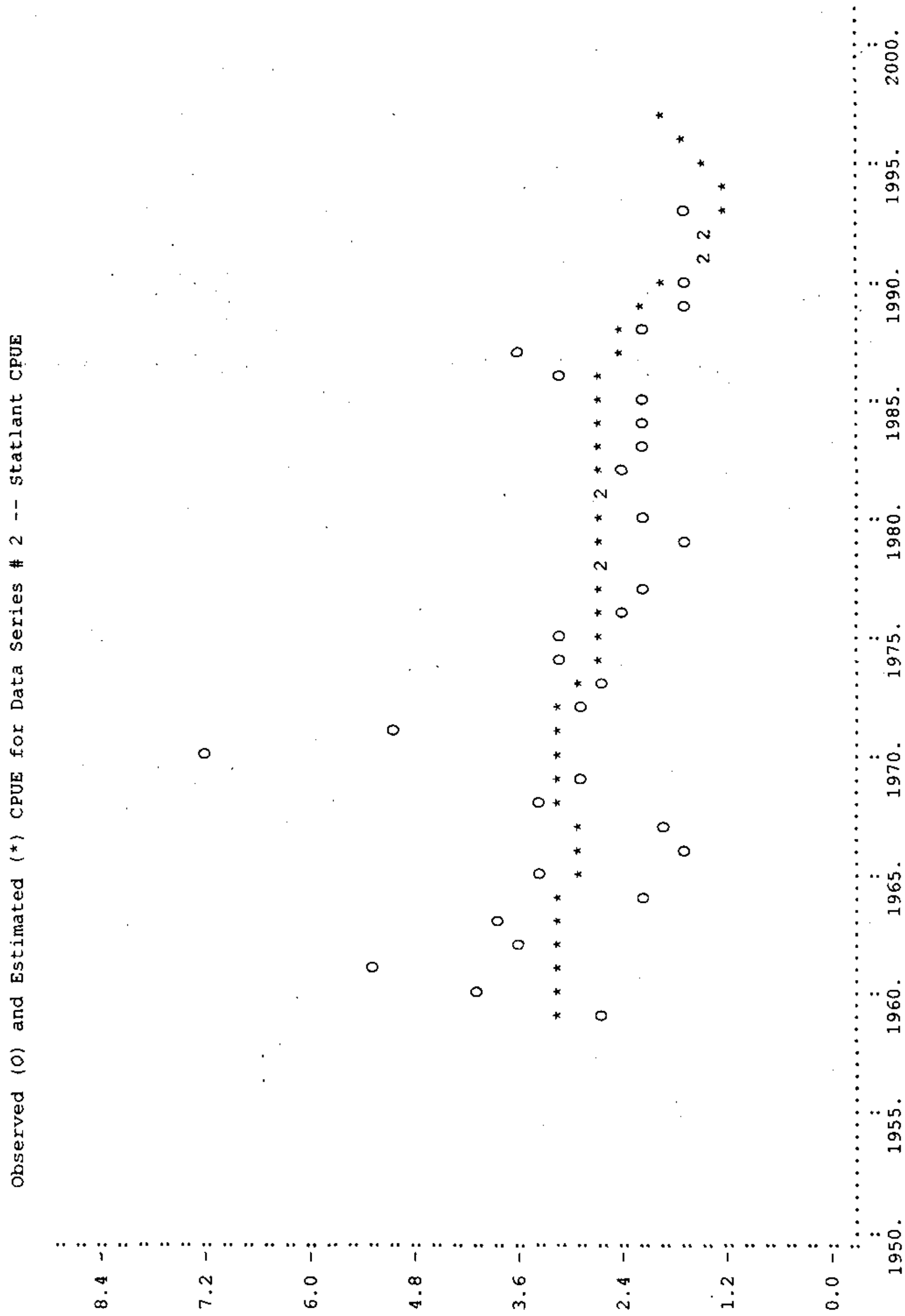
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2

Year	Residual
1959	0.1715
1960	-0.3280
1961	-0.5736
1962	-0.2049
1963	-0.2121
1964	0.2984
1965	-0.1217
1966	0.4775
1967	0.4829
1968	-0.1279
1969	0.0535
1970	-0.8413
1971	-0.4647
1972	0.0215
1973	0.1025
1974	-0.1594
1975	-0.1626
1976	0.1224
1977	0.2325
1978	0.0628
1979	0.4347
1980	0.1914
1981	0.0725
1982	0.1533
1983	0.2537
1984	0.2517
1985	0.2127
1986	-0.1889
1987	-0.3598
1988	0.1302
1989	0.3016
1990	0.1548
1991	0.0181
1992	-0.1319
1993	-0.3230
1994	0.0000
1995	0.0000
1996	0.0000
1997	0.0000



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




Observed (O) and Estimated (*) CPUE for Data Series # 2 -- Statlant CPUE
8.4
7.2
6.0
4.8
3.6
2.4
1.2
0.0
1950.
1955.
1960.
1965.
1970.
1975.
1980.
1985.
1990.
1995.
2000.

Time Plot of Estimated F-Ratio and B-Ratio