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Status of the Redfish Stocks in NAFO Div. 3M (Flemish Cap) in 1996

by

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Introduction

Flemish Cap is an isolated bank from the coastal American shelf separated from the Grand Bank of Newfoundland by the Flemish Pass, an ocean ground with depths greater than 1000m. This physical barrier contributed to the isolation of some of the Flemish Cap fish populations such as the existing three stocks of redfish: beaked redfish (*Sebates mentella*), golden redfish (*Sebastes marinus*) and American redfish (*Sebastes fasciatus*). Beaked redfish, by far the most abundant redfish species on Flemish Cap, has its maximum abundance at depths greater than 300m while either golden and American redfish prefer shallower waters of less than 400m. Each of the three species of redfish has both a pelagic and demersal distribution presenting a wide inter annual oscillation in their concentration near the bottom and in the water column. Due to the similarity of their external morphology the commercial catches of 3M redfish are reported together, and only since 1991 the beaked and American redfish catches are separated by species on the EU bottom trawl survey. Beaked redfish dominate the commercial catches due not only to its higher abundance but also to its higher value in the Asian markets, while the two other species are mainly taken as a by-catch of the Flemish Cap cod fishery.
All redfish species are long living and present a slow (and similar) growth with fish attaining a size around 20cm-22cm at 5 years old and reaching 30cm only at age 10. Spawning on Flemish Cap has a peak in March - first half of April for beaked and golden redfish while for American redfish spawning reach its maximum in July - August (Saborido-Rey, 1994).

Description of the fishery

The redfish fishery on Division 3M suffered substantial changes from the mid eighties to the present. These changes are related both with the presence (or absence) on Flemish Cap of the fleets responsible for high levels of catch in several years and with the opportunistic behaviour of the remaining fleets, for which 3M redfish has been a second choice target as regards cod and, more recently, Greenland halibut. In other words the abrupt decline observed in the 3M redfish fishery from 1990 to 1996 is not directly related with the state of the Flemish Cap redfish stocks but a consequence of an abrupt decline of fishing effort deployed in this fishery.

Recent catches ('000 tons) are as follows:

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

From 1985 to 1993 redfish catches increased from 20,000 tons in 1985 to 81,000 tons in 1990, declining since then to 29,000 tons in 1993 (Table 1, Fig. 1). During this period the fishery was conducted primarily by bottom trawlers from Portugal, Cuba and South Korea (which entered the fishery in 1989 and rapidly became a major partner, with a peak of 17,885 tons in that year) and by midwater trawlers from Russia and the Baltic states (these later fleets only showing up in 1992 and 1993). A small proportion of the catch (from 100 to 600 tons) was also taken annually by Portuguese gillneters, while for the Spanish bottom trawl fleets catches ranged between 100 tons (1993) and 1900 tons (1990), always taken as by-catch of the cod and Greenland halibut fisheries. Also throughout this period Japanese bottom trawling kept a discrete but constant presence in the 3M redfish fishery, with annual catches within 300 and 400 tons between 1985 and 1988, jumping to 2,000 tons in 1990 but declining afterwards to 1,000 tons in 1993 (NAFO, 1995a).

In 1994 and 1995 the 3M redfish fishery dropped to a level around 11,000-13,000 tons. Russia and Portugal were the main participants in the fishery, although with an important decline in the Portuguese catches from 1994 (5,630 tons) to 1995 (1,282 tons). As regards Russia, its major role in the fishery was already lost in 1992, when the respective catches fall to 2,937 tons from 24,661 tons caught in the previous year. The Baltic fleets almost vanished from Flemish Cap in 1994 and so did South Korea with no redfish catches recorded in 1994 and 1995. Following this general trend Japanese redfish catches were also depressed to a level around 500 tons. Estimated 3M redfish catches from non-Contracting Parties represented 13% and 26% of the overall catch for 1994 and 1995. Most of these catches, as well as the Portuguese catches, were taken as by-catch of the 3M cod trawl fishery and, at least in 1994, should include a high proportion of golden redfish. This assumption is justified not only by the shallower depth range of the cod fishery on Flemish Cap but also by the anomalous concentration of old fish of that species near the bottom during 1994 (Vazquez, 1995).

In 1996 the 3M redfish catch dropped again to a level around 5,800 tons, the lowest observed so far, despite the increase on both EU redfish biomass and Portuguese catch rates from trawl. The fishery was carried out basically by Korean crewed non-Contracting Party vessels (4,150 tons, from Canadian surveillance reports) indicating that, although with reflaged vessels, South Korea is again interested in the 3M redfish. Japan (678 tons) and Portugal (332 tons) were the major Contracting Parties with redfish catches recorded in 1996. The Japanese bottom trawl effort occurred in February, September and October as a direct redfish fishery (Table 2). As for Portugal trawl direct fishing occurred only in August and September between 300m and 650m, while most of the catches from the other months were taken as by-catch of the 3M Greenland halibut fishery. Based on courtesy inspections, the EU crewed non-Contracting Parties vessels in 1996 recorded a 3M redfish catch of 575 tons, most probably as a by-catch of 3M cod (NAFO, 1996a and 1997a). If confirmed, the decline of this segment of the 3M redfish catches from 3,600 tons in 1995 to 575 tons in 1996 should reflect the collapse of the cod fishery in Flemish Cap and a severe reduction on the fishing effort of EU crewed non-Contracting Party vessels during 1966.

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 brief summary is presented for the 1993-1996 period taking into account that, although most of the samples classified as beaked redfish were from depths greater than 400m, no action was taken to separate *S. fasciatus* and *S. mentella* in those samples. With the exception of 1995, information on age composition for the 3M redfish catches has been obtained using the *S.mentella* and *S. marinus* age length keys from the annual EU survey. In 1995 information on age composition for the 3M redfish catches was derived from the *S.mentella* age/length keys prepared at IPIMAR from the sampled commercial catches. All redfish otholits were read using the same criteria regardless coming from surveys or commercial catches. This criteria has been revised recently (Saborido-Rey, 1995) and all age information is presented accordingly. Mean weights at age were derived from the Power and Atkinson length-weight relationship (1990). 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.

Beaked redfish (*Sebastes mentella*)

During the period 1993-1996 sampling of trawl catches is available only for 1995 and 1996 while the gillnet catches were sampled from 1993 to1995.

Length data from trawl show that in 1995 the bulk of the catch was between 25cm - 41cm with a mode around 29cm - 30cm. In 1996 the lower and upper limit of the length spectrum moved backwards to 20 cm and 34cm, while the modal lengths also move back to 22cm -24cm (Table 3a and b). Following this shift, mean length and mean weight in the trawl catch declined from 1995 to 1996. The respective age structure of the 1995 trawl catches is mainly built up of ages 7 to 16. Although no clear mode is evident in 1995, the most abundant cohorts present in the beaked redfish bottom trawl catch were from the mid eighties (1983-1987). As for 1996 younger fish dominated the catch (ages 5 to 10) and a clear mode from both 1990 and 1991 year classes is observed.

In 1993 most of the gillnet catch fell in lengths between 30cm and 44cm corresponding to ages 8 and older. Beaked redfish 19 years and older represented 30% of the catch (Table 4a and b). During 1994 beaked redfish with a range of lengths and ages similar to 1993 dominated the gillnet catches. However a shrinkage is observed on both limits of the length spectrum, with smaller and larger lengths not present (or poorly represented) in this year catch, despite almost 50% of the catch being allocated in the age plus group. This isolated increase in the presence of old beaked redfish in the gillnet catch indicates an increase in the concentration of this redfish species near the bottom in 1994, which was detected that year by the EU survey also for golden redfish. In 1995 smaller fish, between 28cm and 32cm, increased again its presence in the lower limit of the length spectrum, but lengths greater than 45cm continued to be almost absent. Ages 19 years and older returned to the 1993 level representing 26% of the gillnet catch.

As a general comment it is noted that the 1991 and 1990 cohorts were by far the most abundant year classes presented in the trawl catches for the whole 1995-1996 period while in the gillnet catches no strong year class show up during the 1993-1995 period. Also in the gillnet catches a permanent fluctuation in the availability of the same cohorts was observed between years, inducing to an apparent negative mortality. This fact, not unusual in all 3M redfish stocks, is interpreted as a result of the fluctuation on the proportions of the pelagic and demersal component of redfish in the water column, and consequent changes in redfish availability to the bottom gears.

Golden redfish (*Sebastes marinus*)

This species has been sampled on the gillnet fishery as a target species in 1993 and as a by-catch of the cod trawl fishery in 1994.

Lengths between 28cm and 34cm were the most abundant in the 1994 golden redfish trawl catches. Age composition is spread for a large range of age groups, being ages 12 and 14 the better represented in the catch (Table 5a and b).

The majority of the 1993 golden redfish gillnet catches were within 29cm and 44cm. Age composition has two isolated peaks at ages 12 and 15, while old fish (17 plus) represented 22% of the catch (Table 6a and b).

Although from a casual and narrow sampling, these data seem indicate that for this couple of years the catches of golden redfish were supported by the cohorts from the late seventies to early eighties (1978-1882).

Information on length composition of the 1996 trawl catches came from a small sample and suggests a dominance of fish within 21cm-23cm (Table 5a). The correspondent 1996 age composition show the 1991 year-class as dominant at age 5 followed by the 1990 year-class at age 6 (Table 5b). The 1996 age composition should be taken with care due to the scarcity of the sample, but is anyway consistent with the 1994-1996 EU survey results as regards the overall strength of these year classes regardless the 3M redfish stock considered.

CPUE data

From the previous 3M redfish assessments it was concluded that a standardised cpue series based on STATLANT 21B data was useless as an indicator of the state of the 3M redfish stocks, due to high unsteadiness of the fleets aiming for redfish in Northwest Atlantic. Due to this fact it is difficult for most years to confirm if the majority of the 3M redfish catches were actually taken by direct redfish fisheries. Furthermore both the schooling behaviour and mobility of redfish species through the water column would prevent in principle the use of any cpue series as an indicator of interannual changes in these stocks. For redfish, a cpue series would be more appropriate to detect a general trend of the stocks for a time period of several years. Taking notice of those constraints a standardised cpue series of the Portuguese trawl fleet is presented, built with data taken only from monitored vessels and only from fishing days directed to 3M redfish.

Observed catch and effort data from 2-3 Portuguese trawlers, fishing for cod and redfish in Flemish Cap have been reviewed on a daily basis each year since 1988. A quantitative criteria is

used to determine the target species for each fishing day, being the species or the couple of species (if their amounts where similar) with the highest proportion in the daily catch. With the exception of one side trawler cut down in 1992, all other monitored vessels were OTB2 stern trawlers from the early seventies with quite similar fishing efficiency. For each of these trawlers direct effort to 3M redfish and associated catch, were estimated on a monthly basis. The catch rates available for each month/year/vessel were then averaged using the number of fishing days as a weighting factor. In this analysis any observation corresponding to a month and a trawler with less than 10 hours of directed effort on redfish was rejected. The observed monthly cpue's so obtained for the 1988 - 1995 period were then standardised by an additive model already fully described in a previous paper (Ávila de Melo and Alpoim, 1995) in order to built annual series of observed 3M redfish cpue's corrected for the month of each observation (Table 7a). The trend of this cpue series is then compared with the biomass trend given by the EU survey (Fig. 2a).
Redfish trawl catch rates on Division 3M gradually declined from 1989 (0.663 ton/h) to 1991 (0.562 ton/h), most probably as an immediate consequence of the unusually high catches observed in 1989 - 1990, and oscillated with no apparent trend from 1992 to 1996 (Table 7a and Fig. 2a). Those recent and wide oscillations of this index can only be attributed to large shifts in the distribution of the Flemish Cap redfish populations within the water column over the last years, with direct impact on the availability of the fish to the bottom gears, either from survey or from commercial trawlers. Variability of the standardised catch rates for the most recent years is higher than during the former period, 1988 - 1990. This is a direct consequence of the decreasing importance of this fishery for the Portuguese trawl fleet, reflected on less monthly observations each year. However, the trends in both Portuguese cpue and EU survey biomass series (for the three species as a whole) generally agree namely over this more recent period (Fig. 2a). The survey biomass is an index taken in July each year while the cpue is an index reflecting most of the times the yield in the bottom trawl redfish fishery throughout the year. The good match between them is suggesting that the fluctuation observed in the concentration of redfish near the bottom is not an "instant" phenomena changing unpredictably but something that would remain perhaps all the year round.
Although only based in two months of direct fishing (August and September), the 1996 cpue increased again, almost doubling the 1995 value. This cpue increase, together with a 1996 catch dominated by 5 and 6 years old beaked redfish (2 and 3 years old in 1993 at the beginning of the 3M shrimp fishery), indicates that the year classes of *S.mentella* from the early nineties had passed through the boom of the shrimp fishery and are recruiting now to the exploitable stock.
A multiplicative model (Vazquez, 1981) was finally applied to the observed catch rate series but this time using all records available, including those corresponding to less than 10 hours of direct fishing. Results are presented in Table 7b and compared with the cpue's given by the additive model in Fig. 2b. Both series are identical when presented as values relative to 1990 (the year with the highest number of observations available).

Research survey data

There are two survey series providing biomass indices as well as length and age structure of the Flemish Cap redfish stocks, one from Russia and the other from Spain and Portugal (EU). The Russian survey has been conducted annually in April-May as a bottom trawl survey down to the 731 m depth contour from 1983 to 1995, with an interruption in 1994. In 1996 the Russian bottom trawl survey has covered for the first time the strata within 731-914 m range. In 1992 four strata on the east-west southern limits of Flemish Cap were not swept. Also since 1992 the number of valid tows dropped from 100-130 (1987-1991) to 53-76 (1992-1996) and at least in 1996 the number of sets in most of the strata was kept constant (3 tows per strata). Survey vessels changed annually since 1991 (Igashov and Vaskov, 1997).
The Russian bottom trawl survey series has been complemented with an acoustic estimate of the pelagic component of the redfish stocks between 1988 and 1993. The biomass estimates till 1993 were for the 3 species combined whereas in 1995 and 1996 separate estimates are available for golden redfish and for American and beaked redfish together.
The EU survey has been conducted annually in June-July since 1988 as a bottom trawl survey, down to the 731 m depth contour. Swept area didn't change (Doubleday, 1981), valid tows were kept around 120 each year and the number of tows in each strata are proportional to the respective swept area. Different survey vessels were used only in 1989 and 1990. 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 15 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. Biomass indices from both survey series are presented in Table 8 and Fig. 3.
Bottom trawl biomass indices from both surveys present a large interannual variability, too

drastic to be only explained by changes in stock abundance from one year to the next. These fluctuations are caused not only by vertical migrations of redfish, basically species with a pelagic behaviour, but also by geographical migrations within the division as pointed out by the beaked redfish catches annually taken from the 3M "Sackville Spur" and "Beothuck Knoll" slopes. As cpue's, biomass indices should be interpreted with caution when comparing results between consecutive years, but are a useful tool to assess trends in stock abundance.
Discussion of survey results is restricted to the time interval common to both series, 1988-1996. Nevertheless it should be noted that each survey series presents a different picture of the recent evolution of the trawlable biomass and abundance of the 3M redfish stocks, namely 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 changes either in redfish distribution or in redfish stock abundance. 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, wich is difficult to explain taking into account the relatively short time lag between them.
A bottom trawl survey was also conducted by Canada on Flemish Cap during autumn 1996, the first one since 1985 (Brodie *et al.*, 1997) The survey used a stratification scheme down to 1462 m (Bishop, 1994) and was carried out by 2 vessels using the same fishing gear, one covering the strata till 731 m and the other covering the deeper strata, but just on the western and northern slopes of the bank. Sets were allocated proportionally to the stratum area except on the strata deeper than 731 m, were 2 sets were made on each of the covered stratum regardless their swept area.

Russian survey

The total redfish biomass from the Russian survey series declined from a level of 379,000 tons in 1988 to 107,700 tons in 1991, increasing to 147,000 tons in 1993. During the same period trawlable redfish biomass varied between 83,300 tons (1989) and 17,700 tons (1990), representing a proportion of the total biomass between 7% (1990) and 47% (1993). In 1995 and 1996 the combined redfish trawlable biomass was estimated to be 21,600 tons and 15,900 tons respectively (Vaskov, 1997). These figures are at the low level of trawlable biomass already observed in 1990 and 1992 in the Russian trawl survey series.

Beaked and American redfish

The beaked and American redfish trawlable biomass estimated by this series also oscilated from 1988 till 1993, declining to the lower limit of this former period in 1995 and 1996. Length structure of these 2 stocks combined was dominated by 19cm to 21cm redfish in 1995 (Vaskov and Karsakov, 1996) and by 20cm to 23cm redfish in 1996 (Vaskov,1997). Although a discrepancy of one year is observed between the Russian and EU age readings, the dominance of those length groups in 1995 and 1996 correspond to the same consecutive strong year classes also detected in the EU survey. In 1996 the beaked plus American redfish biomass was concentrated in strata 19 (52%, considering only the strata till 731 m depth contour), between 548 m and 731 m.

Golden redfish

As for golden redfish its biomass declined from 1988 (14,400 tons) till in 1993 (100 tons), oscillating since then between the 1993 minimum and a maximum of 5,900 tons recorded in 1996 (Igashov and Vaskov, 1997). In 1996 the bulk of the survey catch was composed of redfish with lengths within 21cm and 29cm, with 33cm-37cm length groups also well represented. Most of the 1996 golden redfish biomass given by the 1996 Russian survey came from strata 5 (92%), at depths between 183 m and 256 m.

EU survey

The trawlable redfish biomass from the EU survey series for the 3 species combined declined continuously from 158,000 tons (1988) to 64,000 tons (1991). Although no biomass by species was available at the time (except for golden redfish), most probably this decline reflects the impact on the beaked redfish biomass of the unusually high level of the 1989-1991 redfish catches taken on the 3M direct redfish fishery. Also the redfish catches taken during this period as by-catch of the cod fishery should have reached a maximum, taken into account the peak of the 3M cod catches in 1989-1990.
From 1991 to 1996 the redfish trawlable biomass oscillated with no apparent trend between

64,000 tons (1991) and 126,000 tons (1994), being in 1996 at 100,500 tons. However a further look to the abundance at age (Table 9) and biomass by species (Table 8, Fig. 4) shows that the most recent history of each of the 3M redfish stocks is not quite the same.

Beaked redfish

The most abundant redfish stock in Flemish Cap, despite the magnitude of the redfish direct fishery till 1993 and higher mean total mortality rates, estimated from the abundance at age (Table 9). The majority of the redfish from the 1990 to 1992 cohorts were beaked redfish and their growth and "recruitment" to the stock each year allowed a continuous increase of the trawlable biomass from 1993 (25,000 tons) till 1996 (78,000 tons). The 1991 cohort was the most abundant in this stock in 1996, followed by ones from 1992 and 1990.
The 1996 EU survey found beaked redfish concentrated in strata 9, 10 and 14 (73% of its biomass) at depths between 256 m and 548 m (Table 11 and Fig. 5).

American redfish

So far the most stable stock for the 1991-1995 period (at least near the bottom), with a trawlable biomass around 5,000 tons. However in 1996 the biomass increased drastically to 11,000 tons, probably due to an unusually high concentration of ages 4, 5 and 6 near the bottom, in strata 8, 9 and 10 (Table 11 and Fig. 5).

Golden redfish

The high level of redfish by-catch in the cod fishery during 1989 and 1990 should have contributed to the drop of the former biomass level of golden redfish, between 15,000 tons and 23,000 tons (1988-1990), to 4,000 tons (1991-1993). In 1994 an anomalous concentration near the bottom, in strata 6 and 7 (Cornus, 1996), of golden redfish from ages 7 to 15 pushed up the respective biomass to an isolated peak of 33,000 tons. In 1995 and 1996 the golden redfish biomass stabilised around 10,000 tons, an intermediate level between biomass levels observed in 1988-1990 and 1991-1993, with the 1990 and 1991 cohorts dominating the age structure of this stock.
Most of the 1996 golden redfish biomass (80%) was evenly spread by all the strata (7 to 11) comprised between the 258 m and 366 m depth contours (Table 11 and Fig. 5).

Juvenile redfish

Juvenile redfish biomass start growing in 1992, when juvenile biomass increased from 4,000 tons to 23,000 tons just in one year. The juvenile biomass continued to increase up to 49,000 in 1994 as a consequence of good consecutive year classes (1990, 1991 and 1992), individual growth and a progressive concentration near the bottom of those cohorts (reflected on a progressive recruitment to the trawl gear). In 1995 and 1996 EU surveys the strong cohorts from the early nineties have already grown to lengths greater than 15cm and were assigned to each redfish stock. Meanwhile the year classes after 1992 are weaker than their predecessors. The result has been a juvenile biomass at an almost residual level during 1995 and 1996.

Canadian survey

For the moment only combined trawlable biomass for beaked and American redfish is available for the 1996 Canadian survey. Consedering only the strata till 731 m depth contour there was reasonably good agreement between the biomass estimates from the Canadian survey (113,000 tons) and the EU survey (89,000 tons) (Brodie *et al.*, 1997). There was also a reasonably good match between the strata where most of the combined redfish biomass was found on each survey: strata 10, 11 and 14 accounted with 64% of the Canadian biomass estimate, while strata 9,10 and 14 accounted with 68% of the EU biomass estimate. All of these strata where within 256 m-548 m depth range.

Redfish by-catch in the shrimp fishery

Redfish has been the most important component in the by-catch of the 3M shrimp fishery, representing in terms of weight 28.4% (1993), 19.0 % (1994) and 1.1% (1995) of the total annual catch of this new fishery. In terms of catch in number the estimates were of 138 million , 89 millions and 4.8 million fish respectively (Kulka and Power, 1996). The rapid decline of the redfish by-catch in numbers from 1993 to 1995 seems to be related with two subsequent events:

the introduction of the Nordmore grate in 1994 and the reduction of the bar spacing of the grate in 1995.

In fact, applying the 1994 and 1995 beaked redfish age length keys (combined for both sexes) from the EU surveys (Vazquez, 1995 and 1996) to the length sampling of the 1994 and 1995 Canadian and Norwegian fisheries (previously adjusted to beaked redfish by-catches using the correspondent annual proportion of this species in the overall redfish abundance from the EU surveys) gives an age structure of the beaked redfish by-catch dominated by ages 4 (65%) and 5 (22%) in 1994 and ages 5 (56%) and 4 (23%) in 1995. Those ages corresponded to the 1990 and 1989 cohorts in 1994 and to the 1990 and 1991 cohorts in 1995 (Table 16). If the age structure of the 1993 beaked redfish by-catch is similar to the one observed in 1994 and 1995, then the 1989 and 1988 year classes would be the ones dominating the beaked redfish by-catch in 1993 (Table 16). Therefore the only above average year class contributing to the redfish by-catch in the 1993-1995 3M shrimp fishery was the 1990 year class in 1994 and 1995. With an increasing fishing effort on 3M shrimp over that couple of years and with the 1990 year class still well represented in both survey and commercial catches in 1996, it seems reasonable to relate the observed decline in the by-catch level with the modifications introduced in the shrimp gear. During the 1993-1995 period most probaly the 1989 year class was the one to suffer greater overall losses while the forthcoming strong year classes of 1991 and 1992 were still too young to be caught significantly by bottom trawl (Tables 15 and 16).

It remain to quantify what will be the impact of the actual level of effort of the shrimp fishery on a strong redfish year class at the time of its full recruitment to the bottom. However preliminary data from the Icelandic 3M shrimp fishery in 1996 and 1997 confirm the reduction of the proportion in weight of redfish in the shrimp catch to 1.6% and 0.5% respectively (Skúladóttir, 1997). In 1996 the 1991 and 1992 year classes were already dominant in both beaked and American redfish abundances from the EU survey (Vazquez, 1997).

Update of the loss of commercial yield of beaked redfish by the 3M shrimp fishery, 1993-1995.

A loss of commercial yield for the 3M redfish stocks due to the 1993-1995 by-catches has been previously estimated to be about 25,000 tons (NAFO, 1995b and 1997b). An attempt is now made to update this figure to 3M beaked redfish (commercially the most important redfish species and the most abundant redfish stock in Flemish Cap) using a 3M beaked redfish yield per recruit curve.

EU survey data (1993-1996) and Portuguese commercial data (1995-1996) were used to estimate a yield per recruit curve for the 3M beaked redfish stock, assuming a constant natural mortality at 0.1. In Table 12 are presented the background calculations of the partial recruitment vector and all input parameters for the yield per recruit curve are presented in Table 13.

In order to minimise variability in total mortality due to variability in vertical and geographical distribution of redfish, the mean total mortality for each age was derived from ratio between the sum of abundances at age of 4 consecutive ages (starting in the assigned age) during the 4 first years of the 1992-1996 period and the 4 next consecutive ages (starting in the assignated age plus one) during the last 4 years of the same period. Finally these mean Z's at age were smoothed to get the PR vector by averaging the total mortality of the 4 ages with the highest mean values of Z (ages 5 to 8) and by keeping the total mortality constant at 0.4 for ages 10 and older (Table 12).

The mean weights at age in the stock were a mean of the beaked redfish weights at age from the 1995 and 1996 EU surveys weighted by the respective abundance at age (Vazquez. 1996 and 1997). Mean weights at age in the catch were given by the arithmetic mean of the 1995 and 1996 mean weights at age of beaked redfish catch in Portuguese trawl (Godinho *et al*, 1996 and Alpoim *et al.*, 1997), since no precise figure for the overall beaked redfish commercial catches is available. The yield per recruit results are presented in Table 14 and Fig.6.

The catches at age of the 1994-1995 beaked redfish by-catch and also the estimated 1993 catch at age (assuming a similar structure of the catch at age in 1993 and 1994), were calculated as described above. Each of the catch in numbers at age on the annual beaked redfish by-catch was then projected each year till age 25, with F0.1 from the yield per recruit curve of 0.124, and with the mean weights at age of the catch already used in the yield per recruit curve (Table 15).

The loss of commercial yield of beaked redfish by the 3M shrimp fishery is calculated to be at 23,000 tons for a exploitation level around F0.1. 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%) (Table 17).

State of the 3M redfish stocks

During the late eighties-early nineties (1989-1991) the overall biomass of the 3M redfish stocks declined, most probably as a consequence of the unusual high level of the 3M redfish catches, both on the direct redfish fishery and on the cod fishery in Flemish Cap. Since 1992 either biomass and abundance estimates from the EU bottom trawl survey series suggests stability of the golden and American redfish stocks, together with a continuous increase of the beaked redfish stock observed since 1993. These survey results match with the catch rate series availeble for 3M redfish, which presents an interannual fluctuation sincronized with the fluctuations observed in the combined 3M redfish biomass from the EU survey. The recruitment to all stocks (but primarily to the beaked redfish stock) of at least 2 consecutive strong year classes (1991 and 1992) too young to be jeopardised by the new shrimp fishery in 1993 and 1994, along with an abrupt decline of the 3M redfish fishery since 1994 (due to the vanishing of the most important fleets in this fishery and the collapse of the 3M cod fishery), contributed to an increase in number and weight of the younger ages of all 3 redfish stocks and to an overall decline on fishing mortality. Despite the annual fluctuations on the concentration of redfish near the bottom, reflected in the observed fluctuations on the survey biomass indices, if strong year classes continue to be allowed to pass through the shrimp fishery with minimum damage and if redfish catches don't jump again to the high levels of 1989-1991, most probably the Flemish Cap redfish stocks will continue to recover in the near future.

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Table 1: 3M Redfish nominal catches, 1985-1996.

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
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
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		
E GBR							5					
E PRT	1306	10783	21823	7101	13012	11665	3787	3198	4781	5630	1282	332
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
STCAFIS Estimates of total catches from various sources												
Total	20282	28873	44411	23189	58102	81046	48489	43317	28993	11315	13495	5789

Table 2: 3M Redfish nominal catches, 1996.

	CANADA	EU	JAPAN	RUSSIA	NON CON. (E)	NON CON (K)	TOTAL
JAN					7		7
FEB		30	153		15		198
MAR		26					26
APRIL		8					8
MAY		12	13				25
JUNE	2	27					29
JULY		31					31
AUG		105					105
SEPT		25	213				238
OCT		41	210	52			303
NOV		21	89				110
DEC		6					6
Unkown					553	4150	4703
TOTAL	2	332	678	52	575	4150	5789

TABLE 3a: REDFISH (*S. mentella*), DIV. 3M, 1995-96:
length composition of the portuguese trawl catches.

LENGTH GROUP	1995	1996	LENGTH GROUP
16	0.01	1.4	16
17		1.4	17
18	4.5	1.4	18
19	9.2	4.7	19
20	14.9	25.2	20
21	15.4	67.4	21
22	8.0	153.9	22
23	3.0	114.4	23
24	3.7	91.3	24
25	23.8	51.6	25
26	41.1	31.9	26
27	52.1	50.1	27
28	66.5	51.0	28
29	86.1	58.2	29
30	87.0	56.4	30
31	69.2	59.2	31
32	72.7	49.2	32
33	69.3	37.1	33
34	58.5	35.2	34
35	60.9	12.5	35
36	59.7	9.6	36
37	53.1	13.4	37
38	44.1	5.3	38
39	28.8	8.4	39
40	27.6	2.8	40
41	20.4	1.7	41
42	9.7	2.2	42
43	4.0	0.6	43
44	2.9	0.2	44
45	2.0	0.1	45
46	0.4	0.2	46
47	1.1	0.1	47
48	0.3		48
49			49
50		1.9	50
TOTAL	1000	1000	
No. SAMPLES	46	23	
No.F.MEASURED	4713	1309	
SAMPLING WEIGHT(Kg)	2346	597	
MEAN LENGTH(cm)	32.4	27.1	
MEAN WEIGHT (g)	526	320	
DEPTH RANGE (m)	260/981	130/1120	

TABLE 3b: REDFISH (*S.mentella*), DIV. 3M, 1995-96: age composition (%), mean length (cm) and mean weight (Kg) at age of the portuguese trawl catches.

AGE	1995 AGE COMP.	1996 AGE COMP.	1995 MEAN LENGTH	1996 MEAN LENGTH	1995 MEAN WEIGHT	1996 MEAN WEIGHT	AGE
3		1.4		16.8		0.069	3
4	24.3	12.0	19.9	19.8	0.116	0.115	4
5	28.8	270.2	21.7	22.3	0.149	0.162	5
6	11.5	197.9	25.0	24.0	0.228	0.201	6
7	68.6	90.2	26.6	26.7	0.273	0.275	7
8	95.2	94.7	28.2	28.5	0.327	0.335	8
9	84.5	93.5	29.4	30.1	0.368	0.393	9
10	98.8	59.4	30.7	31.5	0.421	0.451	10
11	83.3	42.0	31.9	32.2	0.468	0.479	11
12	98.8	38.5	32.5	33.5	0.497	0.548	12
13	68.9	22.6	33.7	34.5	0.558	0.602	13
14	44.8	24.0	34.9	34.6	0.617	0.608	14
15	66.1	14.0	36.1	35.9	0.681	0.681	15
16	70.5	8.2	37.0	36.9	0.729	0.734	16
17	40.8	6.5	38.1	38.0	0.802	0.800	17
18	37.7	8.4	39.2	38.2	0.884	0.821	18
19	29.3	2.9	39.4	38.7	0.897	0.840	19
20	21.1	5.8	40.5	40.0	0.974	0.926	20
21	17.0	1.5	42.6	40.9	1.141	0.993	21
22	5.1	0.5	41.6	40.5	1.045	0.988	22
23	2.1	1.7	41.8	42.0	1.055	1.054	23
24	1.6	0.5	43.4	42.0	1.219	1.090	24
25+	1.1	3.5	47.5	47.0	1.595	1.573	25+
	1000	1000					

TABLE 4a: REDFISH (*S. mentella*), DIV. 3M, 1993-1995: length composition of the portuguese gillnet catches.

LENGTH GROUP	1993	1994	1995	LENGTH GROUP
15	0.1			15
16				16
17				17
18	0.2			18
19	0.2			19
20				20
21	0.4			21
22	0.7			22
23	6.1			23
24	7.7			24
25	6.9		1.0	25
26	6.3	1.1	2.7	26
27	13.6	2.1	3.3	27
28	26.4	6.8	16.2	28
29	31.5	13.1	17.9	29
30	58.0	6.8	45.5	30
31	45.7	34.9	52.8	31
32	33.5	31.1	61.4	32
33	42.8	59.6	61.8	33
34	43.0	44.4	57.3	34
35	54.4	65.7	79.4	35
36	65.4	57.2	83.2	36
37	74.0	87.6	98.4	37
38	62.4	95.5	92.5	38
39	76.4	105.8	74.4	39
40	91.5	85.6	71.7	40
41	52.5	73.3	61.1	41
42	54.9	57.4	49.7	42
43	40.0	54.0	29.2	43
44	39.3	45.3	23.1	44
45	22.8	28.3	12.3	45
46	26.4	17.6	3.9	46
47	10.2	16.4	1.0	47
48	1.7	9.5		48
49	1.1	0.7		49
50	0.8			50
51	0.5			51
52	0.4			52
53	0.6			53
54	1.0			54
55	0.2			55
56	0.1			56
57	0.3			57
58				58
59	0.02			59
60	0.1			60
61				61
62				62
63				63
64				64
65	0.1			65
TOTAL	1000	1000	1000	
No. SAMPLES	67	6	20	
No.F.MEASURED	5829	600	1885	
SAMPLING WEIGHT(Kg)	5221	493	1374	
MEAN LENGTH(cm)	37.3	38.8	37.0	
MEAN WEIGHT (g)	798	873	758	
DEPTH RANGE (m)	165/660	371/1040	430/900	

TABLE 4b: REDFISH (*S.mentella*), DIV. 3M, 1993 - 1995: age composition (%), mean length (cm) and mean weight (Kg) at age of the portuguese gillnet catches.

AGE	AGE COMP. 1993	1994	1995	MEAN LENGTH 1993	1994	1995	MEAN WEIGHT 1993	1994	1995	AGE
3	0.1			15.5			0.054			3
4	0.8			21.5			0.151			4
5	5.2	2.0	0.01	23.7	35.1	25.5	0.195	0.616	0.238	5
6	17.3	2.3	0.4	24.8	32.2	25.5	0.223	0.483	0.243	6
7	31.9	1.8	4.6	27.8	27.8	27.1	0.314	0.312	0.289	7
8	75.0	6.4	17.4	29.9	28.6	28.9	0.389	0.337	0.350	8
9	38.9	9.4	24.2	31.3	29.2	29.9	0.446	0.362	0.386	9
10	46.8	31.0	53.1	31.8	32.1	31.3	0.468	0.484	0.447	10
11	50.3	39.6	58.7	33.4	32.8	32.2	0.541	0.519	0.482	11
12	76.7	44.9	79.6	35.1	33.3	32.8	0.637	0.534	0.514	12
13	55.8	39.8	68.2	35.8	33.9	34.0	0.671	0.564	0.572	13
14	70.2	67.2	53.0	37.2	36.1	35.2	0.750	0.679	0.637	14
15	93.8	59.1	94.3	37.9	35.8	36.5	0.796	0.664	0.702	15
16	52.3	55.8	113.6	39.7	37.3	37.3	0.899	0.760	0.751	16
17	49.5	50.8	83.1	39.4	37.8	38.4	0.889	0.789	0.823	17
18	39.5	99.4	89.5	39.2	38.6	39.8	0.863	0.844	0.930	18
19+	295.9	490.4	260.3	43.2	42.0	41.6	1.178	1.084	1.047	19+
TOTAL	1000	1000	1000							

TABLE 5a: RED-FISH (*S.marinus*), DIV. 3M, 1994 - 1996: length composition of the portuguese trawl catches.

LENGTH GROUP	1994	1996	LENGTH GROUP
18	4.9	9.9	18
19	13.2	9.9	19
20	14.7	19.8	20
21	12.6	158.4	21
22	20.7	277.2	22
23	21.4	227.7	23
24	25.8	79.2	24
25	23.0	19.8	25
26	34.2	19.8	26
27	31.7	39.6	27
28	62.8	29.7	28
29	52.9	19.8	29
30	59.6		30
31	56.3		31
32	59.4	19.8	32
33	54.8	19.8	33
34	52.6	9.9	34
35	38.4	19.8	35
36	31.6		36
37	44.9		37
38	45.2	9.9	38
39	35.7	9.9	39
40	41.3		40
41	28.7		41
42	21.2		42
43	29.2		43
44	24.1		44
45	21.3		45
46	9.5		46
47	16.3		47
48	9.2		48
49	1.9		49
50	0.9		50
TOTAL	1000	1000	
No. SAMPLES	3	1	
No.F.MEASURED	626	101	
SAMPLING WEIGHT(Kg)	410	22	
MEAN LENGTH(cm)	33.6	24.4	
MEAN WEIGHT (g)	629	228	
DEPTH RANGE (m)	204/303	270/288	

TABLE 5b: REDFISH (*S.marinus*), DIV. 3M, 1994-1996: age composition (%), mean length (cm) and mean weight (Kg) at age of the portuguese trawl catches.

	AGE COMP.		MEAN LENGTH		MEAN WEIGHT		
AGE	1994	1996	1994	1996	1994	1996	AGE
3	3.7		30.5		0.418		3
4	6.6	22.1	19.5	19.7	0.109	0.112	4
5	39.1	535.1	20.6	22.3	0.129	0.163	5
6	73.2	251.9	24.7	24.0	0.232	0.200	6
7	81.8	65.3	26.3	27.4	0.268	0.298	7
8	81.7	33.1	28.6	28.8	0.340	0.342	8
9	84.3	4.5	30.0	31.0	0.391	0.431	9
10	59.2	13.0	31.5	33.1	0.454	0.523	10
11	81.6	16.9	33.1	33.1	0.529	0.517	11
12	96.5	18.8	35.5	34.0	0.671	0.567	12
13	72.5	17.1	35.0	35.7	0.620	0.663	13
14	100.0	7.4	38.7	37.8	0.867	0.784	14
15	41.1	10.5	40.2	38.1	0.990	0.806	15
16	5.9		39.9		0.896		16
17	50.1	4.2	40.7	38.5	0.993	0.803	17
18	50.6		42.8		1.166		18
19+	72.1		45.5		1.402		19+
TOTAL	1000	1000					

TABLE 6a: RED-FISH (*S.marinus*), DIV. 3M, 1993:
length composition of the portuguese gillnet catches.

LENGTH GROUP	1993	LENGTH GROUP
16	0.4	16
17		17
18		18
19		19
20		20
21	0.7	21
22	0.8	22
23	0.9	23
24	2.9	24
25	9.7	25
26	19.2	26
27	15.6	27
28	23.2	28
29	42.3	29
30	64.5	30
31	48.4	31
32	35.9	32
33	36.2	33
34	52.6	34
35	71.5	35
36	65.0	36
37	83.0	37
38	73.0	38
39	76.4	39
40	83.9	40
41	52.8	41
42	46.6	42
43	36.6	43
44	37.5	44
45	11.2	45
46	3.5	46
47	1.7	47
48	0.04	48
49	1.0	49
50	0.1	50
51	0.3	51
52	0.7	52
53	0.1	53
54	0.1	54
55		55
56	0.1	56
57	0.2	57
58		58
59		59
60		60
61	0.4	61
62		62
63		63
64		64
65	0.4	65
66		66
67		67
68		68
69	0.6	69
TOTAL	1000	
No. SAMPLES	59	
No.F.MEASURED	2479	
SAMPLING WEIGHT(Kg)	2055	
MEAN LENGTH(cm)	36.6	
MEAN WEIGHT (g)	750	
DEPTH RANGE (m)	165/660	

TABLE 6b: REDFISH (*S.marinus*), DIV. 3M, 1993: age composition (%), mean length (cm) and mean weight (Kg) at age of the portuguese gillnet catches.

AGE	1993 AGE COMP.	MEAN LENGTH	MEAN WEIGHT	AGE
3	0.2	16.5	0.065	3
4	0.2	17.8	0.085	4
5	2.9	24.0	0.203	5
6	18.6	25.8	0.251	6
7	52.4	27.9	0.317	7
8	87.4	30.0	0.396	8
9	61.1	32.1	0.485	9
10	69.2	33.3	0.551	10
11	67.8	35.1	0.637	11
12	127.7	37.1	0.759	12
13	46.0	35.9	0.675	13
14	81.0	37.8	0.784	14
15	120.6	39.0	0.849	15
16	49.2	39.1	0.861	16
17+	215.7	42.7	1.133	17+
TOTAL	1000			

TABLE 7a: REDFISH TRAWL CATCH RATES, 1988-96: observed mean annual cpue's corrected for the month of each observation by an additive model.

	3M CPUE	ST.ERROR	C.V.	
1988	0.564	0.040	12.2	1988
1989	0.663	0.086	39.0	1989
1990	0.645	0.049	25.1	1990
1991	0.562	0.093	43.7	1991
1992	0.828	0.177	37.0	1992
1993	0.448	0.148	66.2	1993
1994	0.792	0.199	43.5	1994
1995	0.290	0.075	58.2	1995
1996	0.523	0.164	44.5	1996

TABLE 7b: REDFISH TRAWL CATCH RATES, 1988-96: observed mean annual cpue's relative to 1990 and corrected for the month of each observation by a mutiplicative model.

name of the factor		cases	factor	s(f)	Catch	Effort	Y/f
	total	88			5302	8568	0.62
FACTOR: Year							
3M	1988	3	0.819	0.102	416	580	0.72
3M	1989	14	0.991	0.058	1374	1929	0.71
3M	1990	31	1.000	0.043	1591	2814	0.57
3M	1991	15	0.685	0.056	917	1539	0.60
3M	1992	8	1.017	0.114	707	721	0.98
3M	1993	6	0.597	0.069	150	482	0.31
3M	1994	4	0.993	0.627	54	80	0.68
3M	1995	5	0.465	0.089	77	384	0.20
3M	1996	2	1.260	3.700	16	39	0.41

Power =	2.500	
Ftest n-n =	1.863	44 - 44
Squiew =	0.319	
Curtosis =	1.422	
determination coeficient :	0.466	

TABLE 8: Trawlable biomass by species from the EU survey and combined trawlable biomass from EU, Russsian and Canadian surveys. Total redfish biomass (trawl plus acoustic estimate) from the Russian survey, 1988-1993.

		Sebastes spp.			UE	Canada	Russia	
YEAR	*S.marinus*	*S.mentella*	*S.fasciatus*	juveniles	total		bottom(1)	total(2)
1983							154.900	
1984							132.300	
1985							51.900	
1986							309.500	
1987							106.400	
1988	15.289		142.933		158.222		47.000	379.000
1989	22.958		113.675		136.633		83.300	365.900
1990	14.699	72.893		16.601	104.193		17.700	246.400
1991	4.093	50.071	5.680	4.001	63.846		45.400	107.700
1992	4.130	71.810	5.308	23.229	104.477		18.200	99.500
1993	4.173	25.056	4.425	28.935	62.589		69.800	147.100
1994	33.240	35.710	7.829	49.233	126.011			
1995	9.042	59.332	5.032	235	73.641		21.600	
1996	11.293	77.897	11.025	329	100.544	112.687	15.900	

Table 9: Abundance at age of each of the 3M redfish stocks ('0000s) from the EU surveys.

	S.marinus						*S.mentella*					*S.fasciatus*					
Age	1991	1992	1993	1994	1995	1996	1992	1993	1994	1995	1996	1992	1993	1994	1995	1996	Age
1									10	6					2		1
2				20	122	51			49	259	280			12	81	235	2
3	12	11	65	231	765	139	132		1074	3040	1620	5	82	264	400	486	3
4	225	74	125	770	1342	791	2673	173	5249	19700	11726	469	265	1284	875	1407	4
5	357	234	228	808	1529	2120	9884	550	2273	11900	30498	1131	634	1777	1108	2620	5
6	179	197	254	885	406	1168	3829	1420	1285	490	4765	417	485	885	422	1064	6
7	175	149	157	1087	281	438	3048	1013	1915	870	850	140	204	353	238	533	7
8	73	100	119	755	146	170	2181	637	1178	980	826	83	99	118	105	200	8
9	53	65	50	578	76	121	1361	228	778	570	641	54	47	40	31	127	9
10	72	56	59	431	61	87	862	317	605	550	374	16	26	23	11	23	10
11	46	56	39	448	57	63	631	335	519	610	281	19	12	15	17	27	11
12	44	35	37	324	32	72	465	410	330	280	284	13	2		8	34	12
13	39	32	11	420	48	34	446	259	253	220	168	3	5	4	7	4	13
14	9	14	14	145	26	25	321	260	161	250	188	9	3		2	13	14
15	18	14	6	222	23	28	174	297	172	260	147		1	5	1	7	15
16	9	2	4	22	14	14	172	69	85	160	106		3				16
17	18	1	4	83	17	10	107	95	59	102	69					3	17
18		3	1	24	6	3	69	44	84	87	67	2					18
19	6	3	5	50	3		72	34	38	46	32	2				2	19
20	7	1			7	3	19	26	22	38	41						20
21	3	2		23			13	31	13	25	18						21
22		1		10	1	1			13	11	5					1	22
23	1			9	1		5	10	7	5	13						23
24											5						24
25+	5	1		51	9	4	16	3	2	31	17		2				25+

Table 10: Abundance ('0000), mean length (cm) and mean weight (g) at age for each of the 3M redfish stocks, given by the 1996 EU survey.

Age	*S.marinus*			*S.mentella*			*S.fasciatus*			Age
	age comp.	mean length	mean weight	age comp.	mean length	mean weight	age comp.	mean length	mean weight	
2	51	13	38	280	13	33	235	13	38	2
3	139	15	60	1620	15	54	486	15	60	3
4	791	18	97	11726	19	95	1407	18	100	4
5	2120	21	159	30498	21	129	2620	21	150	5
6	1168	24	222	4765	23	177	1064	24	208	6
7	438	26	294	850	26	250	533	26	288	7
8	170	28	367	826	28	303	200	28	340	8
9	121	30	444	641	29	358	127	30	404	9
10	87	31	488	374	31	414	23	31	473	10
11	63	32	543	281	32	448	27	32	509	11
12	72	34	611	284	33	497	34	33	556	12
13	34	35	669	168	34	544	4	34	583	13
14	25	37	780	188	34	562	13	36	717	14
15	28	37	807	147	35	615	7	36	680	15
16	14	39	908	106	36	657			-	16
17	10	39	963	69	37	715	3	36	729	17
18	3	41	1114	67	38	735			-	18
19			-	32	38	760	2	37	760	19
20	3	41	1079	41	40	854			-	20
21			-	18	41	913			-	21
22	1	43	1244	5	40	897	1	39	885	22
23			-	13	41	963			-	23
24			-	5	42	1007			-	24
25+	4	53	2336	17	42	1046			-	25+

Table 11: Trawlable biomass by strata of the 3M redfish stocks and juveniles given by the 1996 EU survey (tons).

Strata	Depth (m)	juveniles	*S.marinus*	*S.mentella*	*S.fasciatus*	total
1	128 - 146	-	92	-	1	93
2	147 - 183	3	404	-	6	413
3	184 - 256	4	237	33	74	348
4	"	-	123	17	123	263
5	"	20	519	81	202	822
6	"	47	748	28	284	1107
7	257 - 366	93	1345	4572	891	6901
8	"	18	1194	6534	1137	8883
9	"	-	1808	20949	5142	27899
10	"	49	2621	21330	2105	26105
11	"	93	2097	4544	629	7363
12	367 - 548	-	25	2297	91	2413
13	"	-	2	2649	34	2685
14	"	-	41	10898	186	11125
15	"	-	38	3198	113	3349
16	549 - 731	-	-	296	5	301
17	"	-	-	46	1	47
18	"	-	-	173	1	174
19	"	-	-	252	1	253
total		329	11293	77897	11025	100544

Table 12 : Estimates of total mortalities and a partial recruitment vector for 3M beaked redfish.

	Beaked redfish abundance at age ('0000s)							
Age	1992	1993	1994	1995	1996	mean Z's	Z's for PR	PR
1			10	6		-1.00	0.00	0.00
2			49	259	280	-0.52	0.00	0.00
3	132		1074	3040	1620	-0.40	0.00	0.00
4	2673	173	5249	19700	11726	0.08	0.08	0.12
5	9884	550	2273	11900	30498	0.86	0.64	1.00
6	3829	1420	1285	490	4765	0.57	0.64	1.00
7	3048	1013	1915	870	850	0.59	0.64	1.00
8	2181	637	1178	980	826	0.55	0.64	1.00
9	1361	228	778	570	641	0.42	0.42	0.66
10	862	317	605	550	374	0.39	0.40	0.62
11	631	335	519	610	281	0.38	0.40	0.62
12	465	410	330	280	284	0.40	0.40	0.62
13	446	259	253	220	168	0.36	0.40	0.62
14	321	266	161	250	188	0.37	0.40	0.62
15	174	297	172	260	147	0.55	0.40	0.62
16	172	69	85	160	106	0.40	0.40	0.62
17	107	95	59	102	69	0.38	0.40	0.62
18	69	44	84	87	67	0.52	0.40	0.62
19	72	34	38	46	32	0.37	0.40	0.62
20	19	26	22	38	41	0.42	0.40	0.62
21	13	31	13	25	18	0.09	0.40	0.62
22			13	11	5	0.10	0.40	0.62
23	5	10	7	5	13	0.31	0.40	0.62
24					5	-0.02	0.40	0.62
25	16	3	2	31	17		0.40	0.62

Table 13: Yield per recruit parameters for 3M beaked redfish

	Weight at age				
Age	stock	catch	PR	Ref. M	Age
1	0.007	0.007	0.00	0.10	1
2	0.029	0.029	0.00	0.10	2
3	0.060	0.034	0.00	0.10	3
4	0.092	0.115	0.12	0.10	4
5	0.126	0.156	1.00	0.10	5
6	0.179	0.214	1.00	0.10	6
7	0.263	0.274	1.00	0.10	7
8	0.325	0.331	1.00	0.10	8
9	0.373	0.380	0.65	0.10	9
10	0.430	0.436	0.62	0.10	10
11	0.484	0.473	0.62	0.10	11
12	0.512	0.522	0.62	0.10	12
13	0.631	0.580	0.62	0.10	13
14	0.639	0.613	0.62	0.10	14
15	0.672	0.681	0.62	0.10	15
16	0.727	0.732	0.62	0.10	16
17	0.758	0.801	0.62	0.10	17
18	0.782	0.853	0.62	0.10	18
19	0.874	0.869	0.62	0.10	19
20	0.918	0.950	0.62	0.10	20
21	1.018	1.067	0.62	0.10	21
22	1.000	1.017	0.62	0.10	22
23	0.963	1.055	0.62	0.10	23
24	1.071	1.154	0.62	0.10	24
25	1.584	1.584	0.62	0.10	25

Table 14: Yield per 1000 recruit results for 3M beaked redfish

Ref. F	Yield	Slope	
0.000	0.0	1417.305	
0.025	35.4	959.944	
0.050	59.4	644.674	
0.075	75.5	427.392	
0.100	86.2	277.738	
0.125	93.2	222.689	
0.124	92.9	141.700	**F0.1**
0.175	100.1	55.810	
0.200	101.5	22.941	
0.225	102.1	0.774	
0.250	102.1	-13.982	
0.275	101.8	-23.610	
0.300	101.2	-29.692	
0.325	100.5	-33.328	
0.350	99.6	-35.283	
0.375	98.7	-36.089	
0.400	97.8		

Table 15: Long term yield losses (kg) of 3M beaked redfish by the 3M shrimp fishery, 1993-1995.

F0.1= **0.124**
M = 0.1

	1993		1994		1995	
age	by-catch	Yield	by-catch	Yield	by-catch	Yield
1	130744	14824	71122	8064	0	0
2	534186	66937	290588	36413	16330	2025
3	10748489	1488509	5846987	809722	82075	11248
4	60424552	9247979	32869883	5030736	930783	140975
5	20798871	3536362	11314216	1923718	2242908	377281
6	214370	41245	116614	22437	700279	133028
7					10076	2109
8					8818	1989
9					10810	2576
10					4443	1126
11					1173	314
12					218	61
13					51	15
14					0	0
Total	92851212	**14395856**	50509409	**7831090**	4007964	**672747**
		63%		34%		3%
				Total F0.1 1993-1995		**22899693**

Table 16: Proportion of the *most abundant year classes in* the beaked redfish by-catch in numbers, 1993-1995

Year -> Year class	1993	1994	1995
1988	**22%**	0%	0%
1989	**65%**	**22%**	17%
1990	12%	**65%**	**56%**
1991	1%	12%	**23%**
sub-Total	**87%**	**87%**	**79%**

Table 17: Long term yield losses (kg) for beaked redfish by year classes, 1993-1995

Year class	Yield	
1988	3560908	16%
1989	11304725	49%
1990	6896525	30%
1991	1017635	4%

Fig. 1: 3M redfish nominal catches, 1985-1996.

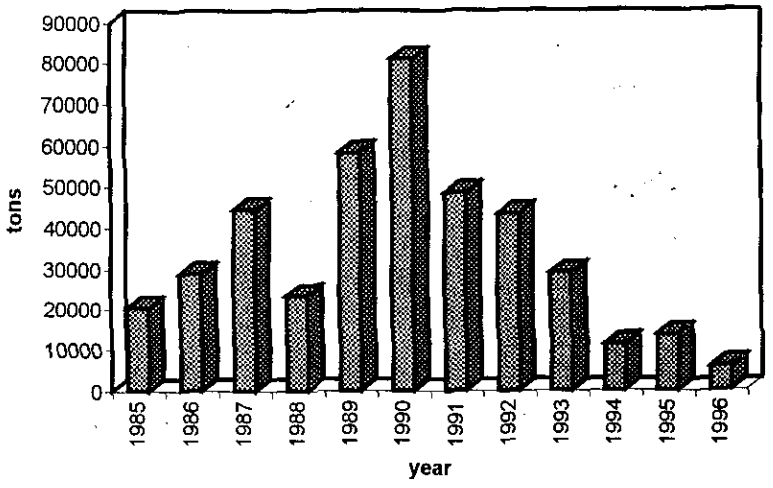

Fig. 2a: Comparison between 3M redfish commercial observed catch rates (additive model) and 3M redfish trawlable biomass from the EU surveys.

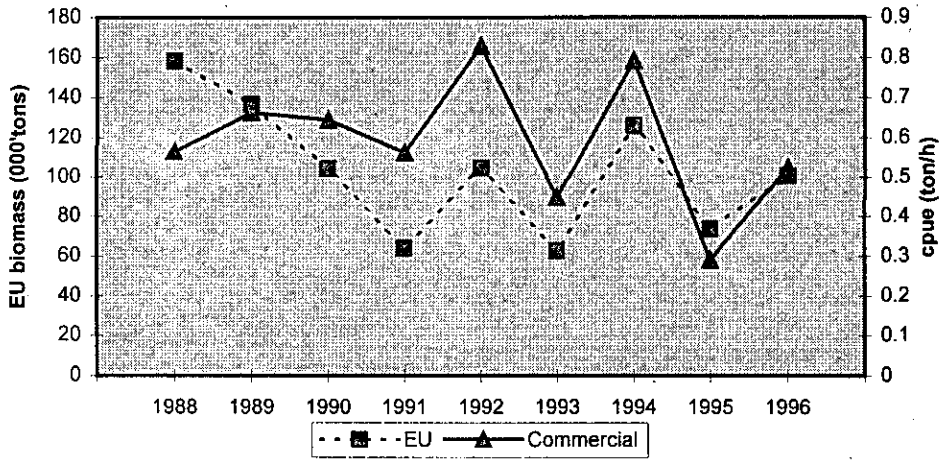

Fig. 2b: Comparison between 3M redfish commercial observed catch rates standardised by an additive and a multiplicative model (values relative to 1990).

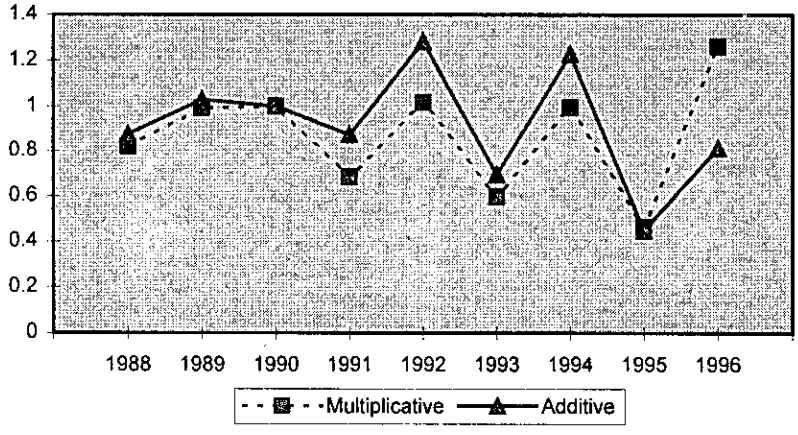

Fig. 3: Redfish combined biomass in Div. 3M.

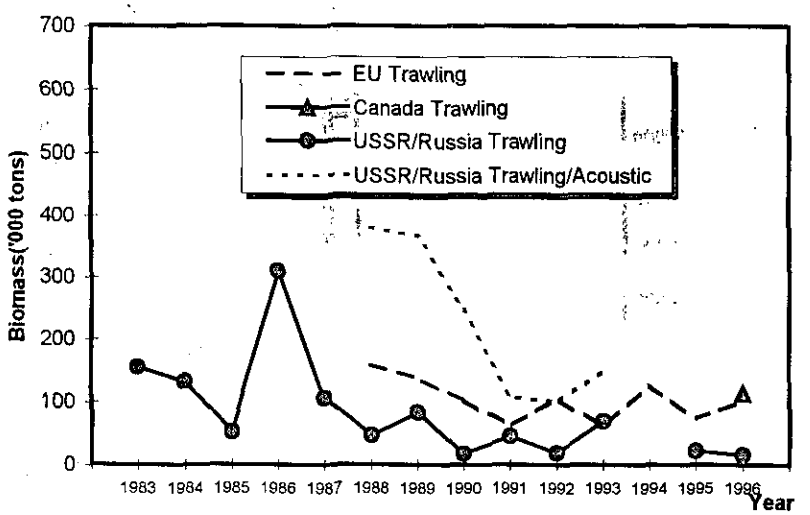

Fig. 4: Trawlable biomass by species from EU survey, 1991-1996.

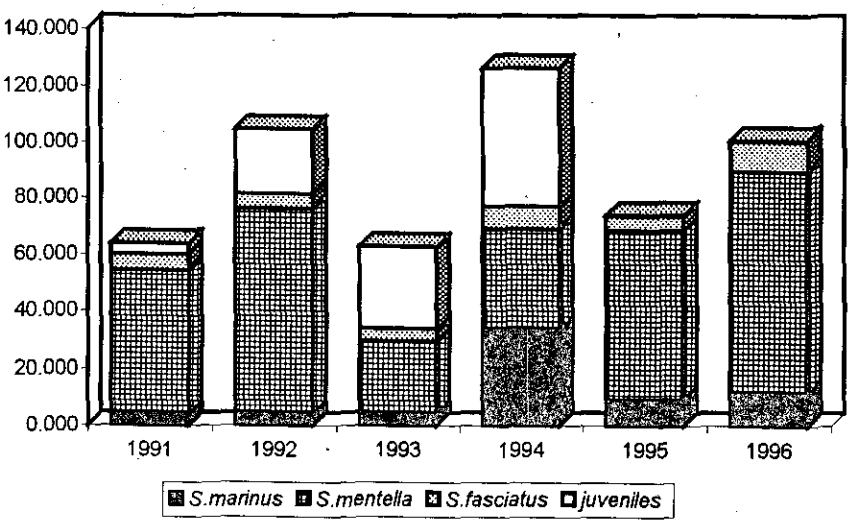

Fig. 5: Trawlable biomass by strata of the 3M redfish stocks given by the 1996 EU survey. (tons)

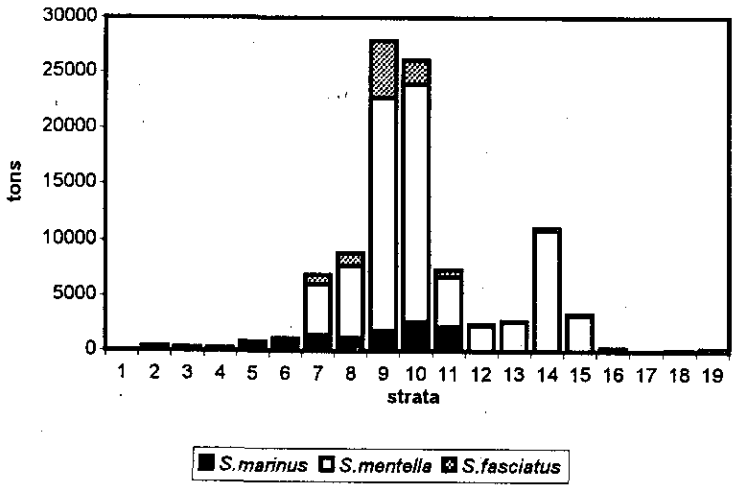

Fig. 6 : Yield per recruit curve for 3M beaked redfish