Northwest Atlantic Fisheries Organization

Serial No. N1322

NAFO SCR Doc. 87/37

SCIENTIFIC COUNCIL MEETING - JUNE 1987

# Redfish in NAFO Div. 3M

by

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## Introduction

Nominal catches over the past dozen years have ranged between 13,000 and 26,000t. The present TAC of 20,000t has been achieved in each year since 1983. Insufficient catch at age data prevents any attempts of an analytical assessment of this stock and only catch and effort data have been used in monitoring its status.

## Methods and Results

The USSR has been the predominant force in this fishery in recent years (Table 1). Provisional catch statistics from NAFO for 1986 indicate an increase in catch of about 5000t from the 1984 and 1985 totals due to the increased landings reported by the EEC. Nominal catches for the period 1959-1986 are displayed in Fig. 1. Fishing occurs throughout the year but catches are generally greater in the Jan.-Aug. period (Table 2).

Catch and effort data obtained from ICNAF/NAFO Statistical Bulletins from 1959 to 1984 were combined with provisional 1985 data from NAFO. Only data where redfish accounted for more than 50% of the total catch were selected. This database was analysed by a multiplicative model (Gavaris 1980) to obtain a standardized catch rate series for the 1959-85 period. Before employing the model catch and/or effort data less than 10 units and less than five data points of either country-gear-tonnage class or month category types were deleted.

In past assessments, when employing the multiplicative model, grouping of similar category types was done a posteriori, which has since been questioned. It was therefore decided to use the same groupings as reported in last year's assessment (Power and Atkinson MS 1986). However, in that paper the Japan OTB7 and Portugal OTB7 country-gear-tonnage class grouping and its regression coefficient had erroneously been excluded from the table. The correct groupings and their estimated regression coefficients from the multiplicative model are provided in Table 3.

In the 1986 assessment of this stock the data were weighted in the regression by $\log_{10}$ effort (Power and Atkinson MS 1986). For the present analysis an unweighted regression was chosen because of possible pro-rating of effort data prior to 1984. The regression was highly significant ($p<.01$, $r^2=.59$) the results of which are shown in Table 4. The standardized catch rate series is displayed in Table 5 and plotted in Fig. 3. Standardized effort is also plotted in Fig. 2. The standardized catch rate series shows a general decline from 1961-1967 followed by a sharp increase to the highest value on record in 1970. Since then catch rates declined until 1979 and then increased moderately to 1982 before gradually declining again to the present.

Catch per unit effort and standardized effort were used in an equilibrium general production analysis using unlagged effort data and effort lagged 6, 8, and 10 years (Gulland 1961). The regression of CPUE on unlagged effort was not significant ($p>.16$) (Fig. 4). Regressions using effort lagged 6, 8 and 10 years all showed significant relationships ($p<.03$). For the regressions using unlagged effort data the correlation coefficients for the residuals in year t versus year t-1 were not significant (6-year lag: $r=.302$ $p>.18$, 8-year lag: $r=.318$ $p>.18$, 10-year lag: $r=.069$ $p>.79$). This is different from previous analyses (Power and Atkinson MS 1986) which showed no significant serial correlation only for effort data lagged 10 years. The following results were obtained from each regression:

| Lag | MSY | $Effort_{MSY}$ (Hours) | 2/3 $Effort_{MSY}$ (Hours) | Yield at 2/3 $Effort_{MSY}$ (tons) |
|---|---|---|---|---|
| 6 | 17001 | 11602 | 7734 | 15112 |
| 8 | 17137 | 11475 | 7650 | 15233 |
| 10 | 17575 | 10384 | 6923 | 15623 |

It can be seen that the results from the three treatments are quite similar. The results for the 10-year lag are shown (for illustrative purposes) in Fig. 5 and 6.

The catch and standardized effort from the multiplicative model were used in a non-equilibrium version (Schaefer form) of a general production model (Rivard and Bledsoe 1978). Initial estimates of virgin stock biomass ($B_\infty$), MSY catchability coefficient (q) were derived from the equilibrium general production analysis in the following way: assuming 2/3 effort at MSY =
$F_{0.1}$ and that $F_{0.1}$ for redfish is generally considered to be 0.15, an estimate for q can be derived from the relation F=fq. The value for q obtained from this can be used to estimate $B_\infty$ from the relationship $a=qB_\infty$ where a is the intercept from a regression of CPUE on effort (see Ricker 1975, pg. 315-316). MSY is estimated by $a^2/4b$ from the same regression where again a in the intercept and b is the slope.

From the above procedure input values of $B_\infty \cong 156{,}000$t, MSY≅17575t and $q=2X10^{-5}$ as estimated from the regression of CPUE on effort lagged 10 years were used to start the model. With q fixed at $2X10^{-5}$ and letting the model estimate $B_\infty$ and MSY, the model did not converge to realistic values (i.e. $B_\infty$=91516t, MSY=50261t). This was considered unrealistic because biomass estimates from Canadian surveys have been in the range of 130,000 to 270,000t for the 1978 to 1985 period.

USSR trawl survey estimates of biomass for 1984 and 1985 are 132,300 and 51,000t respectively (Chumakov et al. MS 1986) however, it was pointed out in that paper that for the 1985 estimate that 200,000t was observed in pelagic waters, based on an acoustic survey, and not available to the bottom trawl. Rerunning the model with a fixed value of $q=5X10^{-6}$, $B_\infty$=500,000t and MSY=17575 resulted in convergence based on change in residual sum of squares (RSS) <.0001. Parameter estimates from this run were $B_\infty$=455007t and MSY=21063t, both considered to be realistic. The model was then rerun letting q be estimated as well. Again the model converged very quickly (RSS<.00001 and orthogonality offset <.001) with parameter estimates of $B_\infty$=454,400t, MSY=21,053t and $q=5.00767 X 10^{-6}$. The results from the two analyses are very similar. The latter run (estimating q) was considered more appropriate because of a lesser standard error around MSY as well as satisfying a second criterion for convergence. Estimated population biomass at the beginning of 1986 was 311,655t. Since there was no Canadian research survey to Div. 3M in 1986 we do not have an independent estimate to compare this with, however, past biomass estimates of this stock have been close to this value (Atkinson MS 1985, Table 6). A plot of yearly q values estimated from the final analysis is shown in Fig. 7. This is a reflection of the residuals in effort. The equilibrium curve derived from the non-equilibrium model is shown along with the trajectory of actual catches from 1959 to 1985 in Fig. 8.

The results of the non-equilibrium analysis are as follows:

| | MSY | 2/3 $Effort_{MSY}$ |
|---|---|---|
| Effort (hours) | 18,504 | 12,336 |
| CPUE (tons/hour) | 1.138 | 1.517 |
| Yield(tons) | 21,053 | 18,714 |

Projections for 1987 and 1988 were done on the basis of 2/3 effort MSY but first the 1986 non-equilibrium yield had to be adjusted iteratively to the actual 1986 catch taken. This resulted in yields for 1987 and 1988 of 18786 t and 18778 respectively.

Commercial length frequencies available from the Canadian observer program caught by USSR vessels (Fig. 9) indicate different modes at two different depth zones sampled. This reflects the hypothesis that larger redfish are found at greater depths.

There is no Canadian research survey in 1987 to Div. 3M.

## Discussion

The catch rate series from the multiplicative model show that catch rates have been on the decline since 1982 and from provisional data for 1985 this trend is continuing.

The equilibrium general production runs based on regressions of CPUE on effort lagged 6, 8 and 10 years suggest an equilibrium yield at 2/3 effort MSY int he range of 15,000t. As was pointed out in the 1986 assessment (Power and Atkinson MS 1986) the regressions were highly influenced by the 1970 and 1971 points. This same situation exists with the inclusion of the 1985 point and therefore these results are to be considered with caution.

The non-equilibrium general production analysis suggest a yield of approximately 19,000t at 2/3 effort MSY. This is about 5% less than the present TAC of 20,000t and is therefore considered an appropriate TAC for 1988.

## References


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Table 1: Nominal catches (t) of redfish in Division 3M by country and year.

| Country | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985* | 1986* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canada (M)+ | - | 4,040 | 1,402 | 486 | 443 | 218 | 12 | - | - | - | - | - |
| Canada (N) | 659 | 4,328 | 3,392 | 3,861 | 4,686 | 60 | 517 | 2 | - | - | - | - |
| France (M) | - | - | 546 | 242 | 67 | 15 | 7 | - | - | - | - | - |
| France (SP) | - | - | 25 | - | - | - | - | - | - | - | - | - |
| FRG | 4 | 44 | 10 | 300 | - | 73 | - | 41 | - | 769 | 848 | - |
| GDR | - | - | - | - | - | 1,290 | 15 | - | 40 | 98 | - | 88 |
| Japan | - | - | 138 | 321 | 636 | 976 | 386 | 392 | 390 | 389 | 313 | 399 |
| Poland | 1 | 30 | 11 | 83 | 13 | 292 | - | - | - | - | - | - |
| Portugal | 2,464 | 518 | 854 | 455 | 666 | 985 | 659 | 1,408 | 1,667 | 2,123 | 1,306 | - |
| Romania | - | - | - | 24 | 4 | - | - | - | - | - | - | - |
| Spain | - | - | 52 | 31 | 13 | 29 | 488 | 31 | 589 | 282 | 281 | - |
| UK | 552 | - | 376 | 20 | - | - | - | 3 | - | - | - | - |
| USSR | 12,393 | 8,038 | 9,507 | 9,251 | 10,441 | 10,430 | 10,434 | 10,916 | 14,517 | 15,005 | 15,703 | 13,817 |
| Ireland | - | - | 2,503 | 767 | - | - | - | - | - | - | - | - |
| Norway | 2 | - | - | - | - | - | - | - | - | - | - | - |
| Cuba | - | - | 1,451 | 863 | 1,527 | 1,549 | 1,373 | 1,853 | 2,324 | 1,562 | 1,831 | - |
| Bulgaria | - | - | - | 58 | 1,578 | 50 | - | - | - | - | - | - |
| Kor-S | - | - | - | - | - | - | - | 38 | - | - | - | - |
| EEC (Un.Sp.) | - | - | - | - | - | - | - | - | - | - | - | 11,568 |
| TOTAL | 16,075 | 16,998 | 20,267 | 16,762 | 20,074 | 15,967 | 13,891 | 14,684 | 19,527 | 20,228 | 20,282 | 25,872 |

* Provisional.
\+ Maritimes and Quebec were combined prior to 1979.

Table 2: Nominal catches (t) of redfish in Division 3M by month and year.

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 983 | 920 | 917 | 2,042 | 1,012 | 1,191 | 1,039 | 1,873 | 1,564 | 1,819 | 1,615 | 1,100 | 16,075 | |
| 1976 | 2 | 2 | 180 | 2,950 | 1,580 | 1,130 | 686 | 7,415 | 2,473 | 277 | 283 | 20 | 16,998 | |
| 1977 | 417 | 532 | 2,786 | 1,847 | 1,821 | 3,649 | 4,284 | 1,416 | 590 | 243 | 81 | 98 | 20,267 | a |
| 1978 | 394 | 354 | 963 | 1,156 | 1,026 | 4,017 | 1,004 | 1,650 | 1,301 | 2,996 | 1,067 | 834 | 16,762 | |
| 1979 | 790 | 1,560 | 896 | 4,237 | 5,147 | 2,394 | 1,393 | 56 | 111 | 1,486 | 1,369 | 635 | 20,074 | |
| 1980 | 1,212 | 1,341 | 4,751 | 2,852 | 1,377 | 735 | - | 1,083 | 1,126 | 471 | 293 | 726 | 15,967 | |
| 1981 | 198 | 849 | 2,671 | 5,120 | 1,615 | 711 | 698 | 952 | 847 | 7 | 149 | 74 | 13,891 | |
| 1982 | 987 | 295 | 2,222 | 2,825 | 2,328 | 1,484 | 1,292 | 2,209 | 543 | 241 | 125 | 133 | 14,684 | |
| 1983 | 2,393 | 1,014 | 1,128 | 2,260 | 2,395 | 3,099 | 3,384 | 1,529 | 1,500 | 691 | 51 | 83 | 19,527 | |
| 1984 | 159 | 1,725 | 2,465 | 4,283 | 3,773 | 3,679 | 1,148 | 912 | 900 | 419 | 449 | 316 | 20,228 | |
| 1985* | 267 | 422 | 445 | 656 | 2,172 | 79 | 3,135 | 7,308 | 1,046 | 614 | 2,051 | 2,087 | 20,282 | |
| 1986* | 2,728 | 3,986 | 2,011 | 1,026 | 5 | - | 1,157 | 1,392 | 513 | - | 24 | 1,462 | 25,872 | b |

* Provisional.
a includes a catch of 2,503 t from month 'unknown'.
b includes a catch of 11,568 t from month 'unknown'

Table 3: Parameter estimates from the analysis of catch/effort for redfish in Division 3M using a multiplicative model.

| Country-Gear-TC | Estimate | Month | Estimate |
|---|---|---|---|
| USSR OTB 4 | -1.596 | Mar. | -0.248 |
| CAN(N) OTB 5 | -0.793 | Jan. | -0.099 |
| | | Dec. | |
| JPN OTB 6 | -0.632 | | |
| POL OTB 7 | | Feb. | |
| | | Apr. | |
| JPN OTB 7 | -0.357 | May | |
| POR OTB 7 | | Jun. | |
| | | Jul. | 0.000 |
| CAN(N) OTM 4 | | Aug. | |
| CAN(MQ) OTB 5 | 0.000 | Sep. | |
| USSR OTB 7 | | Oct. | |
| CUBA OTB 7 | | Nov. | |
| CAN(M) OTB 5 | | | |
| CAN(MQ) OTM 5 | 0.350 | | |
| CUBA OTM 7 | | | |
| CAN(N) OTM 5 | | | |
| POR OTB 6 | 0.481 | | |
| USSR OTM 7 | | | |

Table 4: Regression of multiplicative model for redfish in Division 3M.

multiple r............. 0.768
multiple r squared..... 0.590

analysis of variance

| source of variation | df | sums of squares | mean squares | f-value |
|---|---|---|---|---|
| intercept | 1 | 3.650e1 | 3.650e1 | |
| regression | 34 | 1.274e2 | 3.748e0 | 15.094 |
| type 1 | 6 | 6.929e1 | 1.155e1 | 46.505 |
| type 2 | 2 | 1.955e0 | 9.773e¯1 | 3.936 |
| type 3 | 26 | 1.567e1 | 6.028e¯1 | 2.428 |
| residuals | 356 | 8.840e1 | 2.483e¯1 | |
| total | 391 | 2.523e2 | | |

Table 5: The predicted catch rate for redfish in Division 3M.

| | ln transform | | retransformed | | | |
|---|---|---|---|---|---|---|
| year | mean | s.e. | mean | s.e. | catch | effort |
| 1959 | 0.4063 | 0.0204 | 1.683 | 0.239 | 51977 | 30882 |
| 1960 | 0.7281 | 0.1449 | 2.181 | 0.802 | 8388 | 3845 |
| 1961 | 0.9792 | 0.0834 | 2.892 | 0.819 | 15517 | 5366 |
| 1962 | 0.5770 | 0.0766 | 1.941 | 0.528 | 6958 | 3585 |
| 1963 | 0.4142 | 0.0621 | 1.661 | 0.408 | 7035 | 4235 |
| 1964 | 0.2046 | 0.2691 | 1.214 | 0.591 | 17647 | 14533 |
| 1965 | 0.4057 | 0.0630 | 1.646 | 0.407 | 33427 | 20303 |
| 1966 | ¯0.0685 | 0.2622 | 0.927 | 0.446 | 7241 | 7808 |
| 1967 | ¯0.2839 | 0.2622 | 0.748 | 0.359 | 729 | 975 |
| 1968 | 0.3938 | 0.0587 | 1.630 | 0.390 | 4963 | 3044 |
| 1969 | 0.3521 | 0.0920 | 1.538 | 0.457 | 2801 | 1821 |
| 1970 | 1.2105 | 0.0458 | 3.714 | 0.787 | 3168 | 853 |
| 1971 | 0.9293 | 0.0228 | 2.836 | 0.426 | 8033 | 2833 |
| 1972 | 0.5282 | 0.0159 | 1.906 | 0.240 | 41946 | 22013 |
| 1973 | 0.5334 | 0.0359 | 1.896 | 0.356 | 22352 | 11787 |
| 1974 | 0.5406 | 0.0135 | 1.931 | 0.224 | 34671 | 17950 |
| 1975 | 0.5940 | 0.0117 | 2.039 | 0.220 | 16075 | 7882 |
| 1976 | 0.3056 | 0.0125 | 1.528 | 0.170 | 16998 | 11126 |
| 1977 | 0.2825 | 0.0121 | 1.493 | 0.164 | 20267 | 13572 |
| 1978 | 0.3352 | 0.0096 | 1.576 | 0.154 | 16762 | 10636 |
| 1979 | 0.1066 | 0.0086 | 1.255 | 0.116 | 20074 | 16000 |
| 1980 | 0.3300 | 0.0108 | 1.567 | 0.162 | 15957 | 10183 |
| 1981 | 0.4276 | 0.0119 | 1.727 | 0.188 | 13891 | 8045 |
| 1982 | 0.5605 | 0.0134 | 1.971 | 0.227 | 14684 | 7452 |
| 1983 | 0.3143 | 0.0121 | 1.542 | 0.169 | 19527 | 12667 |
| 1984 | 0.2662 | 0.0167 | 1.466 | 0.189 | 20228 | 13801 |
| 1985 | 0.2008 | 0.0207 | 1.370 | 0.196 | 20282 | 14802 |

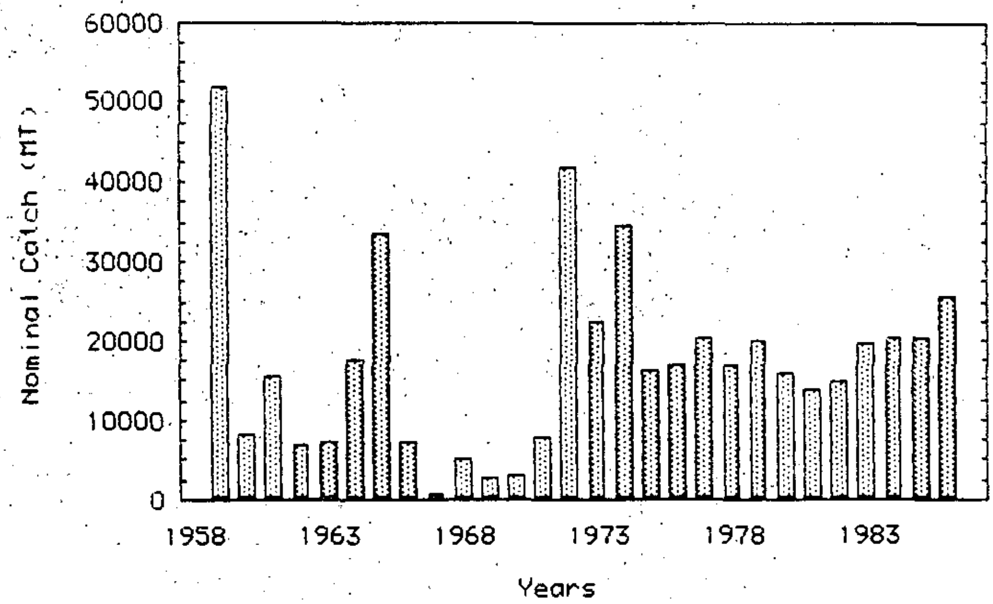


Fig. 1: Nominal catches of redfish from Division 3M, 1959-1986.
(1985 and 1986 are provisional)

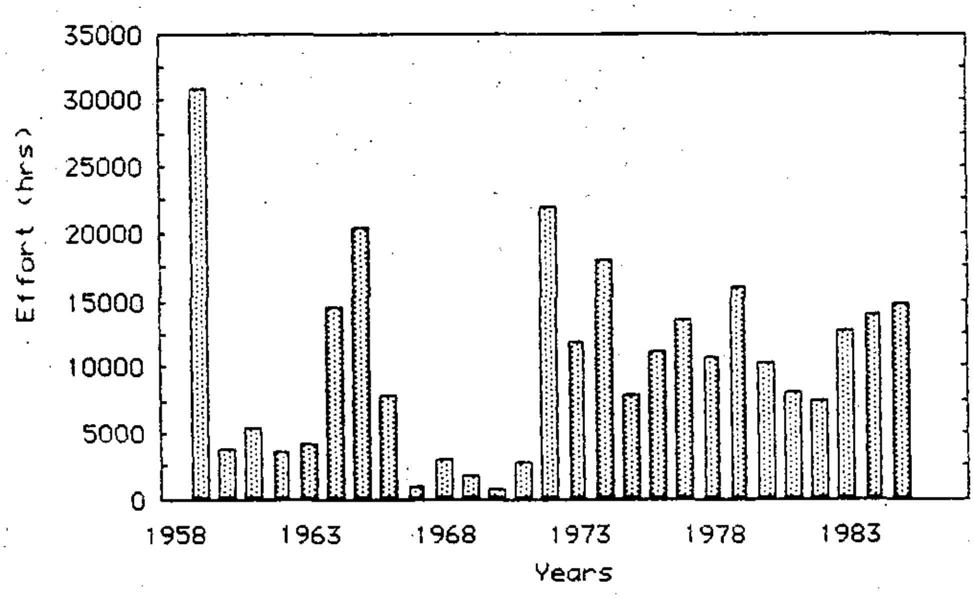


Fig. 2: Standardized effort for redfish in Division 3M, 1959-1985.
(1985 is provisional)

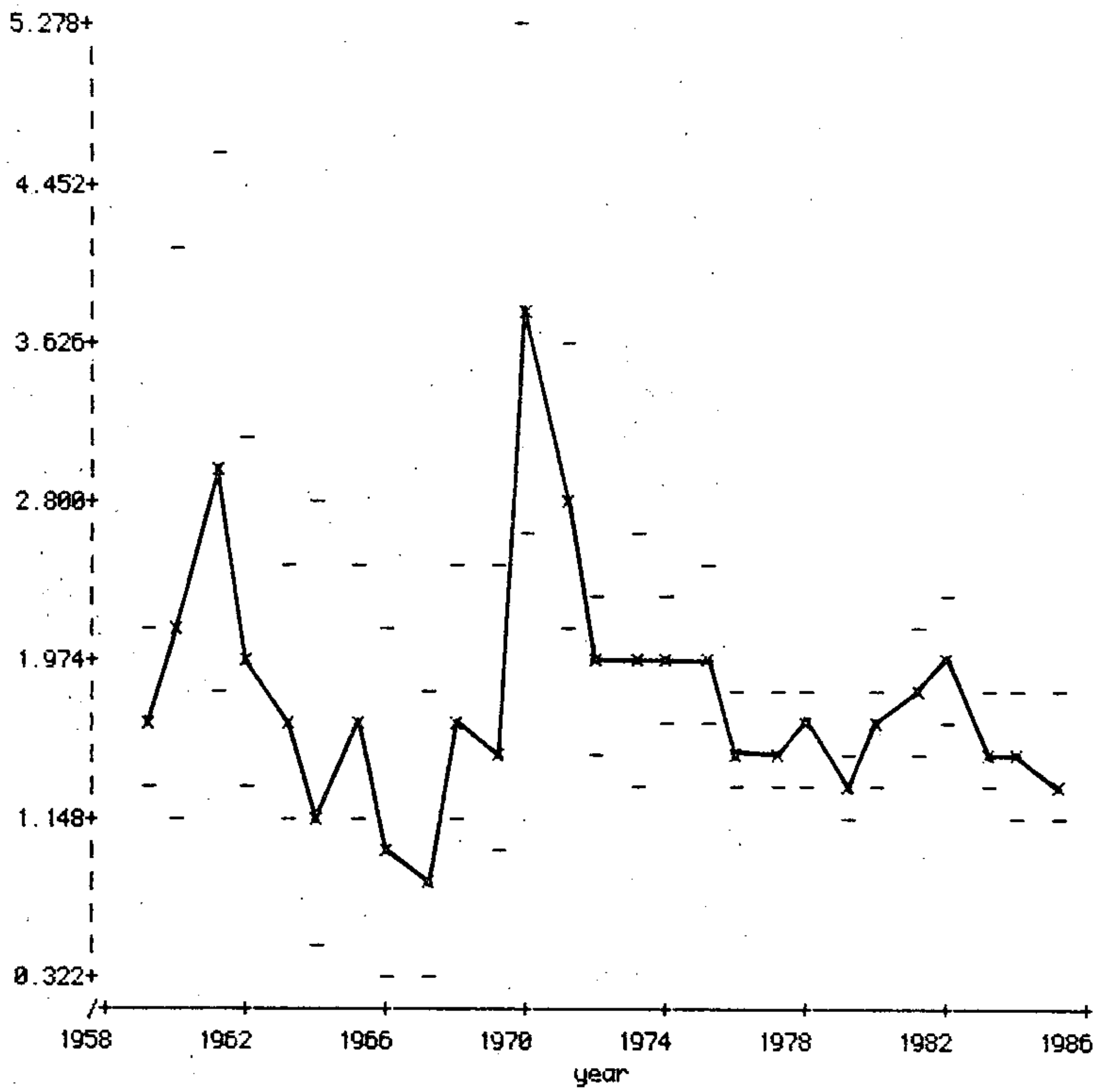


Figure 3: Plot of catch rates for redfish in NAFO Division 3M in the period 1959-1985 as derived using a multiplicative model (1985 is preliminary).

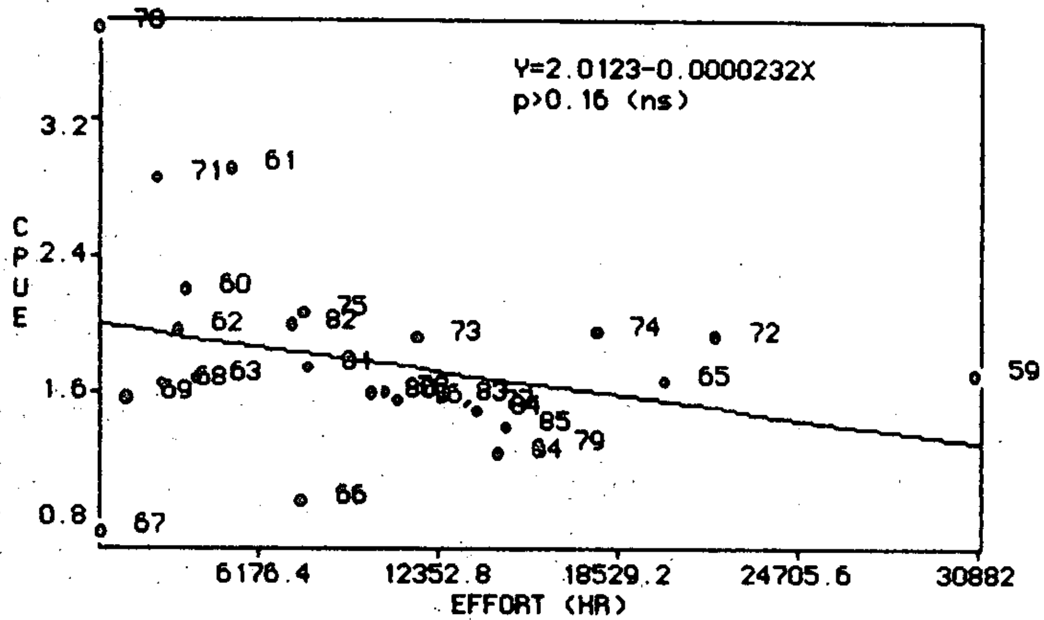


Figure 4: Regression of standardized CPUE on unlagged standardized effort for redfish in NAFO Division 3M for the period 1959-1985 (1985 is provisional).

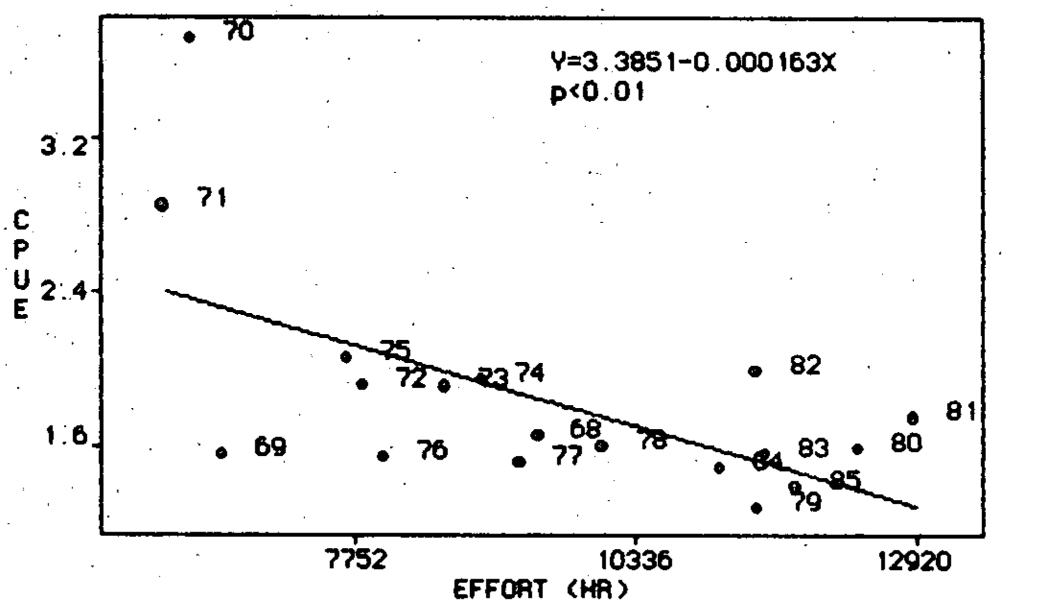


Figure 5: Regression of standardized CPUE on standardized effort lagged 10 years for redfish in NAFO Division 3M for the period 1959-1985 (1985 is provisional).

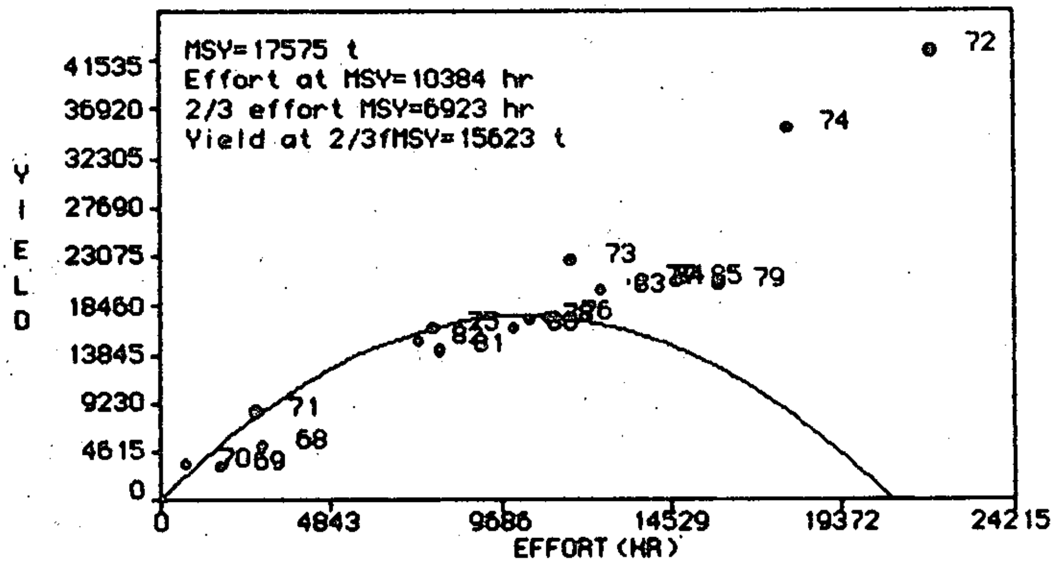


Figure 6: Equilibrium curve for redfish in NAFO Division 3M derived from effort lagged 10 years and showing actual yield and effort (unlagged) for 1968 to 1985 (1985 is provisional).

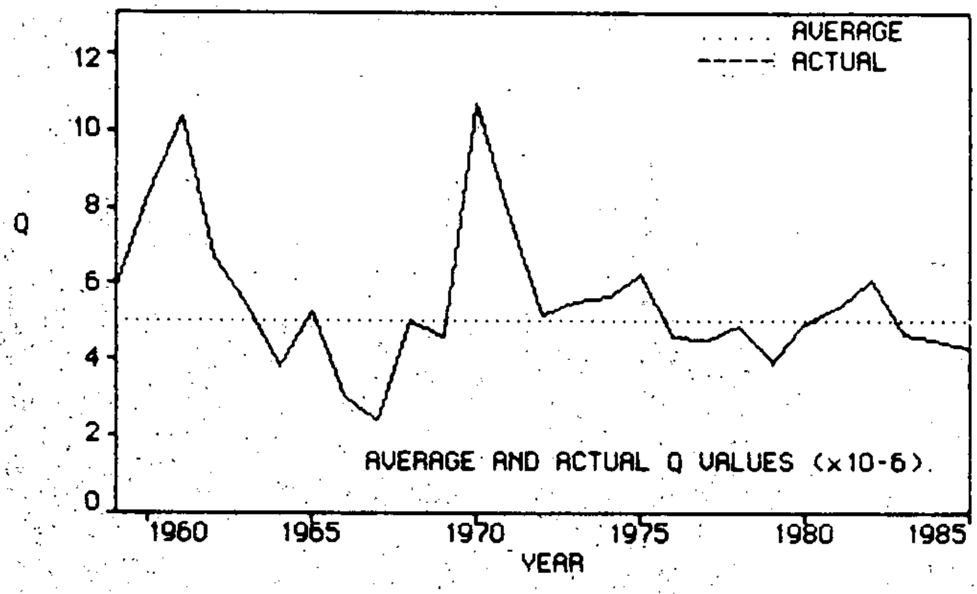


Figure 7. Comparison of average q as fixed in the non-equilibrium model and the actual annual q estimated by the model for redfish in NAFO Division 3M.

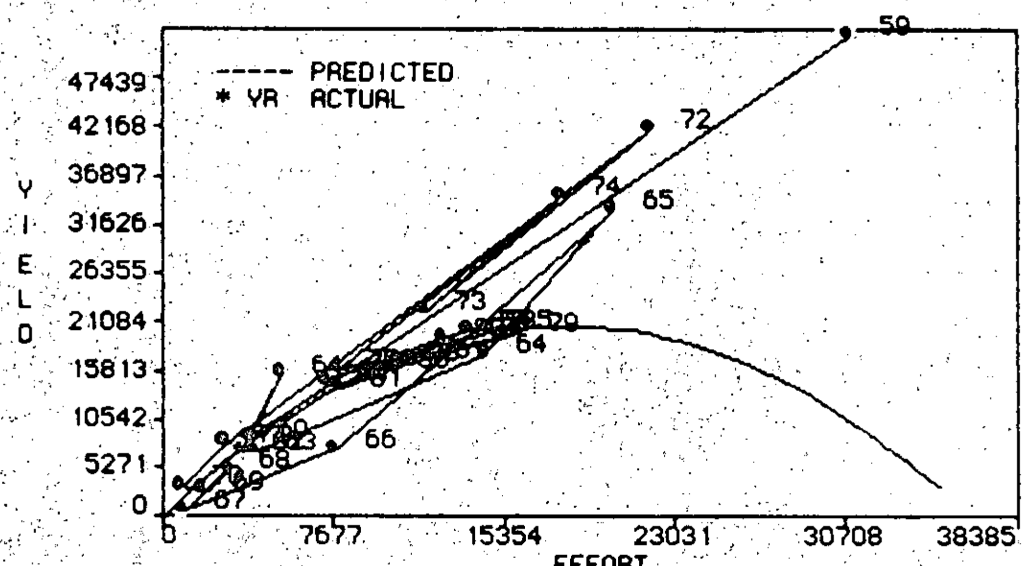


Figure 8. Equilibrium curve derived from the non-equilibrium model for redfish in NAFO Division 3M. Also shown are the actual annual values of catch and effort with their trajectory.

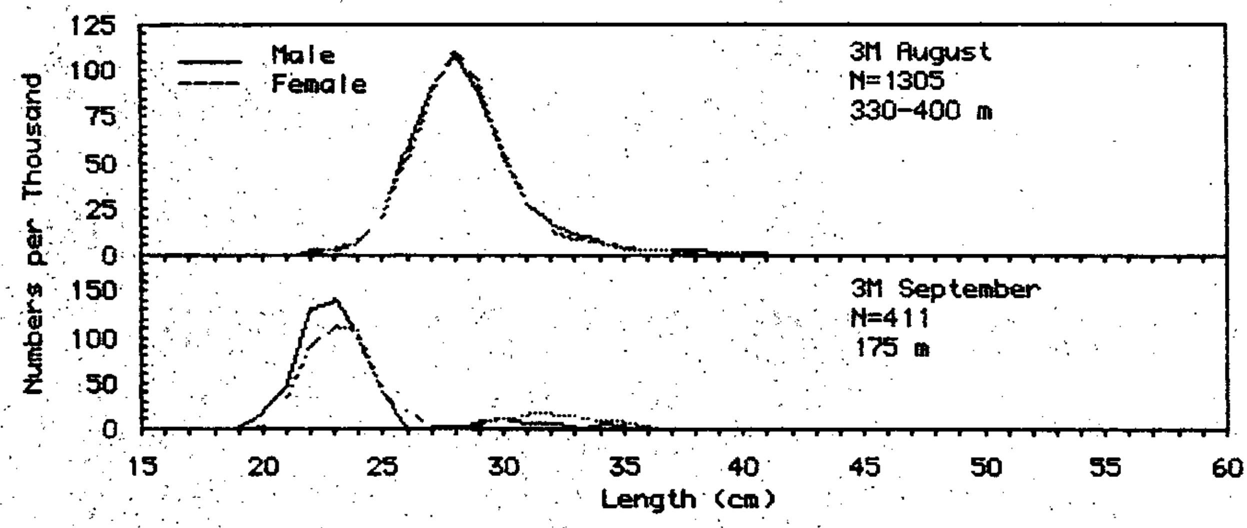


Fig. 9: Commercial length frequencies of redfish caught by the USSR in NAFO Division 3M in 1986 (sea sampling).