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# Assessment of Redfish in Divisions 4RST

by

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## Abstract

The standardized catch rate series showed gradual increases from 1977-79 followed by substantial increases in 1980 and 1981, the 1981 level being the highest in the series. While recent catch rates indicated an improvement in the stock, attributed to the recruitment of the successful year-classes of the early 1970's to the fishery, the increases may not be proportional to increases in stock abundance. Cohort analysis was performed using M = 0.1 and a dome-shaped partial recruitment curve which was suggested by the relationship between the commercial catch at age and research vessel abundance at age. A comparison of the abundance of the 1954-60 year-classes with that predicted by a series of cohort runs suggested $F_T = 0.14$ in 1981. Assuming the 1982 TAC of 28,000 t is caught and fishing at $F_{0.1} = 0.15$ in 1983, the projected catch in 1983 was 37,000 t. Fishing at $F_{0.1} = 0.15$ in both years yielded catches of 38,000 t and 36,000 t respectively. Approximately 35% of the projected 1983 catch would be composed of the early 1970 year-classes.

## Résumé

La série des taux de capture standardisés fait voir une augmentation graduelle de 1977 à 1979. Celle-ci a été suivie d'augmentations importantes en 1980 et en 1981; les prises ont atteint leur plus haut niveau en 1981. Les derniers taux de capture dénotent une amélioration du stock qu'on attribue au recrutement des classes d'âge abondantes du début des années 1970; toutefois, il est possible que l'augmentation des prises ne soit pas proportionnelle à la croissance des stocks. On a effectué une analyse des cohortes pour laquelle M fut fixé à 0,1; une courbe de recrutement partielle hémisphéroïde fut établie par comparaison entre les prises commerciales par catégorie d'âge et l'abondance, par catégorie d'âge, des populations recensées par le navire de recherche. En comparant l'abondance des classes d'âge de 1954 à 1960 avec celle prévue par une série de cohortes, on est arrivé à une équation $F_T = 0,14$ pour 1981. En supposant que les pêcheurs atteignent les PTA de 28 000 t pour l'année 1982 et en supposant une pêche à $F_{0,1} = 0,15$ pour l'année 1983, on en est arrivé à une projection de 37 000 t pour 1983. Une pêche à $F_{0,1} = 0,15$ pour ces deux années a donné, respectivement, 38 000 t et 36 000 t de prises. Environ 35 % des prises prévues pour 1983 devraient provenir des classes d'âge du début des années 1970.

## Introduction

Nominal catches of redfish in Divisions 4RST peaked in 1973 at 130,000 t, composed primarily of the strong 1956 and 1958 year-classes. Year-classes throughout the 1960's were relatively weak, resulting in lowered catch rates through most of the 1970's. The early 1970 year-classes were determined to be the first successful ones since those of 1956 and 1958 by research vessel surveys to the Gulf in 1976 and 1978-81. These year-classes have been abundant in the commercial redfish catch since at least 1979. Catch rates have been generally increasing since 1978.

## Materials and Methods

Catch and effort data from the directed redfish fishery, defined as catches consisting of 50% or more redfish, were available for 1959-79 from ICNAF/NAFO. Preliminary information was obtained for Newfoundland and Maritime vessels for 1980-81. Effort data from vessels of tonnage class less than 4 were not used due to the doubtful value of this information. Catch and effort data were standardized using the multiplicative model developed by Gavaris (1980) to obtain estimates of the relative powers of the years 1959-81.

The redfish landings by otter trawl vessels from the three Atlantic Regions (Quebec, Maritimes and Newfoundland) for 1981 are listed by month and Division in Table 1. Length frequencies sampled from these landings are listed in Table 2 and shown in Fig. 2-4. Otoliths were selected from samples of Maritime and Newfoundland catches and totalled 396 for males and 470 for females. Data for landings and length frequencies from Quebec - based vessels were provided by J. P. Lussiaà-Berdou (Direction générale des pêche maritimes, St. Foy, Quebec).

The above commercial sampling data were used to obtain the catch at age and its variance and the mean weight at age for 1981 following the procedure outlined by Gavaris and Gavaris (unpublished)[1]. The catch at age from 1976-80 included estimates of discards of young redfish (ages 5-8) from the Port aux Choix shrimp fishery. The weight at age used from 1972-80 was based on a "standard" age/weight relationship.

The research survey of the Gulf redfish stock in 1981 was conducted by the VICKY AND BROTHERS, a vessel of the same size and power and using the same fishing gear as the BEOTHIC VENTURE which conducted previous surveys. Survey methodology was consistent with past surveys. The length frequency from the 1981 survey is presented (Fig. 5) for comparison with the commercial length frequencies.

Estimates of partial selection for 1978-81 were obtained by comparing the commercial catch at age with research numbers at age, assuming research numbers at age accurately reflect the population age structure. The relationships were smoothed by taking repeated running medians and are plotted in Fig. 6.

Cohort analysis was performed using $M = 0.1$ and a range of $F_T$ values in 1981.

[1]Paper entitled "Estimation of catch at age and its variance for groundfish stocks in the Newfoundland Region" was presented to the DFO seminar on "Sampling of commercial marine fish and invertebrate catches", Ottawa, February, 1982.

## Results and Discussion

The results of the regression of ln (catch rate), weighted by effort, versus vessel type, month, division, and year categories (Type 1, 2, 3, and 4 respectively in Table 3) were significant. The estimates of the power of years 1959-81, relative to 1959 which was set equal to 1, are shown in Table 4 and Fig. 1. Nominal catches and standardized effort are listed in Table 4.

Trends in the relative power of years indicated a generally steady decline in the stock from 1967-76. The high levels were associated with the recruitment of the strong 1956 and 1958 year-classes to the fishery while the decline was the result of subsequent poor recruitment. Increases have occurred since 1978 due to the recruitment of the successful year-classes of the early 1970's to the fishery. Very large increases occurred in both 1980 and 1981 (based on preliminary data for Maritime and Newfoundland vessels only). Increases in the commercial index may not be directly proportional to increases in the population if other factors such as the degree of concentration of the fishable biomass has changed between years.

Length frequencies of redfish from Canadian otter trawl vessels fishing in Divs. 4R and 4S showed the bulk of the catch was composed of 26-29 cm fish (Fig. 2-3). Larger fish were indicated from the catches in Div. 4T (Fig. 4). This was in agreement with research vessel surveys which have found the smaller redfish (the early 1970's year-classes) to be concentrated between Bay of Islands and Anticosti Island in Div. 4R and 4S. Approximately 87 and 89% of the nominal catch in 1980 and 1981 was taken in these divisions.

The length composition of redfish >15 cm in Div 4RST in 1982 from the research vessel survey showed an abundance of fish at 26-29 cm, similar to the commercial frequencies (Fig. 5). Larger redfish were relatively more abundant in the research length frequency however than in the commercial length frequencies which represented the bulk of the catch (Maritime and Quebec vessels fishing in Div 4R and 4S). This suggested that the commercial fishery was largely carried out in the area where the abundant year-classes of the early 1970's were concentrated. A large number of small redfish, having modal length 9 cm, were also caught. This length group may represent the first good year-class since those of the early 1970's.

The catch at age for 1981 (Table 5) was dominated by 9 and 10 year old fish, the 1971-72 year classes, as was the 1980 catch at age (Table 6). The mean weight at age, as calculated for 1981, showed fish of ages 7-16 to be heavier and ages 17-27 to be lighter than estimated using the "standard" age/weight relationship for redfish (Table 7). This difference would influence yield per recruit calculations. The $F_{0.1}$ would be higher using the 1981 weight at age rather than the standard relationship.

The partial selection patterns for 1978-81 (Fig. 6) illustrated a shift in the ages of full recruitment from older to younger fish. In 1980 and 1981, when the early 1970 year-classes began to reach an acceptable commercial size (>25 cm. approximately), younger fish became fully recruited while the selection on older fish dropped off. Catch rates increased substantially at the same time. Such a pronounced shift in the partial selection pattern is entirely likely with redfish stocks as fish of different length groups are stratified by depth. The commercial fishery may obtain higher catch rates by concentrating

fishing at depths where abundant year-classes are localized. The dome-shaped partial selection pattern derived for 1981 (Table 9) was therefore considered the best estimate for use in cohort analysis.

Several cohort runs were made with $F_T$ = .07, .14, .20, and .25. The commercial abundance index was not used to distinguish between the several runs as the large increases in the index in 1980 and 1981 were not considered to be proportional to increases in the population but rather to the concentration of the early 1970 year-classes. The criterion used to determine $F_T$ was a comparison of the abundance of the 1956 and 1958 year-classes from the research surveys in 1976 and 1978-81 with that from the various cohort runs. The abundances of the 1954-60 year-classes from the surveys and cohort runs were summed, to cover errors in ageing, and are shown in Table 8. As one year (1977) was missing from the survey data and some inconsistencies were present in the series, the data were fitted to an exponential decline ($r = -0.85$) and the predicted values used in the comparison. All series were standardized to their respective means. Closest agreement in the final years was found with an average F on the 1954-60 year-classes of 0.05 which implied $F_T = 0.14$. Thus $F_T = 0.14$ was chosen as the best estimate for $F_T$ in 1981. The resulting estimates of population numbers, mid-year biomass, and F values at age for 1972-81 are shown in Tables 10, 11, and 12 respectively.

For yield per recruit calculations and projections, a flat-topped partial selection pattern was used (Table 9) as a better reflection of long-term conditions than a dome-shaped one. The $F_{0.1}$ value was 0.16, (Table 13) considerably higher than last year's which was 0.12 (McKone et al, 1981). The 1981 partial selection pattern, showing full recruitment at an older age than in 1980, and the weight at age differences between 1981 and 1980 would both contribute to the change. For projections, $F_{0.1} = 0.15$ was used as an approximate average value for redfish. Recruitment in 1982 and 1983 was calculated as the geometric mean from cohort population numbers (Table 10), which equalled $72.6 \times 10^6$ fish.

Population numbers, catch biomass and fishing mortalities to 1983 are shown in Table 14 assuming the TAC of 28,000 t is caught in 1982 and fishing is at $F_{0.1} = 0.15$ in 1983. The suggested catch in 1983 was 37,000 t, 35% from the 1970-72 year-classes. The results for fishing at $F_{0.1} = 0.15$ in both 1982 and 1983 are shown in Table 15. The suggested catches were 38,000 t and 36,000 t (25% and 35% from the 1970-72 year-classes) in 1982 and 1983 respectively.

## References

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can J. Fish. Aquat. Sci. 37: 2272-2275.

McKone, W.D., C.A. Gavaris, and W.E. Legge. 1981. Redfish assessment for Divisions 4RST. CAFSAC Res. Doc. 81/58, 18 p.

Table 1. Monthly redfish landings by Canadian OT vessels fishing in Division 4RST in 1981.

| Month | Divisions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4R | | | 4S | | | 4T | | |
| | Can M | Can N | Can Q | Can M | Can N | Can Q | Can M | Can N | Can Q |
| January | 4 | 74 | | | | | | | |
| February | 11 | 82 | | 2 | 1 | | | | |
| March | | 31 | | 2 | 28 | | | 13 | |
| April | | | | | | 18 | 6 | 4 | |
| May | | | | | | 12 | 8 | | |
| June | 593 | 292 | 635 | 122 | 203 | 808 | 98 | | 400 |
| July | 720 | 33 | 304 | 598 | | 701 | 722 | | 400 |
| August | 1,133 | 8 | 886 | 816 | 124 | 1,467 | 179 | 196 | 100 |
| September | 869 | 236 | 968 | 415 | 49 | 1,282 | 58 | 57 | 1 |
| October | 301 | 322 | 866 | 405 | | 1,119 | 22 | | |
| November | | 6 | | 11 | 1 | 6 | 1 | | |
| December | | | | | | | | | |
| Div. Totals (all gears) | | 8,651 | | | 9,441 | | | 2,271 | |
| Area total | | | | | 21,087 | | | | |

Table 2. Redfish length frequencies collected in 1981 from Canadian OT vessels fishing in Divisions 4RST.

| Month | Divisions | | |
|---|---|---|---|
| | 4R | 4S | 4T |
| January | 2 | | |
| February | 1 | | |
| March | | | 1 |
| April | | | |
| May | | 1 | |
| June | 5 | 3 | 2 |
| July | 8 | 4 | |
| August | 17 | 3 | |
| September | 1 | 1 | |
| October | 1 | | |
| November | | | |
| December | | | |

Table 3. Results of the regression, weighted by effort, of ln(catch rate) versus vessel type, month, division, and year categories (Type 1, 2, 3, and 4 respectively) for Div. 4RST redfish.

MULTIPLE R.....0.764
MULTIPLE R SQUARED.....0.584

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DF | SUMS OF SQUARES | MEAN SQUARES | F-VALUE |
|---|---|---|---|---|
| INTERCEPT | 1 | 8.608E1 | 8.608E1 | |
| REGRESSION | 37 | 2.645E2 | 7.150E0 | 56.698 |
| TYPE 1 | 5 | 6.520E1 | 1.304E1 | 103.415 |
| TYPE 2 | 8 | 1.647E2 | 2.059E1 | 163.286 |
| TYPE 3 | 2 | 9.078E0 | 4.539E0 | 35.994 |
| TYPE 4 | 22 | 1.154E2 | 5.244E0 | 41.585 |
| RESIDUALS | 1492 | 1.881E2 | 1.261E-1 | |
| TOTAL | 1530 | 5.388E2 | | |

Table 4. The nominal catch, catch rate trends, and standardized effort for the Div. 4RST redfish stock, 1959-81. The proportion of the nominal catch used in the standardization procedure is also listed.

| YEAR | TOTAL CATCH | PROP. | RELATIVE POWER MEAN | S.E. | EFFORT |
|---|---|---|---|---|---|
| 1959 | 16978 | 0.392 | 1.000 | 0.000 | 16978 |
| 1960 | 12218 | 0.390 | 1.010 | 0.107 | 12094 |
| 1961 | 10391 | 0.394 | 1.001 | 0.107 | 10376 |
| 1962 | 6585 | 0.211 | 0.753 | 0.105 | 8750 |
| 1963 | 19794 | 0.361 | 1.450 | 0.145 | 13653 |
| 1964 | 29700 | 0.162 | 1.510 | 0.177 | 19664 |
| 1965 | 48827 | 0.243 | 1.684 | 0.157 | 28999 |
| 1966 | 65215 | 0.332 | 1.929 | 0.164 | 33815 |
| 1967 | 70036 | 0.260 | 2.235 | 0.201 | 31336 |
| 1968 | 90963 | 0.395 | 2.109 | 0.166 | 43130 |
| 1969 | 88875 | 0.494 | 1.474 | 0.109 | 60285 |
| 1970 | 87588 | 0.555 | 1.204 | 0.087 | 72773 |
| 1971 | 79406 | 0.532 | 1.158 | 0.084 | 68574 |
| 1972 | 80329 | 0.742 | 1.299 | 0.097 | 61838 |
| 1973 | 130164 | 0.834 | 1.138 | 0.083 | 114411 |
| 1974 | 63458 | 0.793 | 0.805 | 0.060 | 78875 |
| 1975 | 65401 | 0.820 | 0.770 | 0.057 | 84912 |
| 1976 | 37983 | 0.728 | 0.721 | 0.063 | 52645 |
| 1977 | 15840 | 0.498 | 0.800 | 0.075 | 19809 |
| 1978 | 13591 | 0.581 | 1.005 | 0.098 | 13525 |
| 1979 | 15034 | 0.604 | 1.112 | 0.109 | 13522 |
| 1980 | 14754 | 0.315 | 2.100 | 0.273 | 7026 |
| 1981 | 21087 | 0.329 | 2.717 | 0.344 | 7762 |

Table 5. The average weight at age (kg) and catch at age (no. X $10^{-3}$) and its variance for the Div. 4RST redfish stock 1981.

| AGE | WEIGHT | CATCH | VAR(CATCH) | STD.ERROR | COEF.VAR |
|---|---|---|---|---|---|
| 6 | 0.085 | 4 | 0.001 | 0.03 | 0.01 |
| 7 | 0.165 | 308 | 4270.851 | 65.35 | 0.21 |
| 8 | 0.219 | 2586 | 196108.149 | 442.84 | 0.17 |
| 9 | 0.263 | 10810 | 1005681.838 | 1002.84 | 0.09 |
| 10 | 0.293 | 11974 | 1254867.869 | 1120.21 | 0.09 |
| 11 | 0.320 | 7276 | 819605.205 | 905.32 | 0.12 |
| 12 | 0.346 | 5222 | 598513.531 | 773.64 | 0.15 |
| 13 | 0.388 | 3449 | 269169.247 | 518.82 | 0.15 |
| 14 | 0.406 | 2085 | 142869.303 | 377.98 | 0.18 |
| 15 | 0.454 | 1219 | 60120.295 | 245.19 | 0.20 |
| 16 | 0.465 | 940 | 41194.931 | 202.97 | 0.22 |
| 17 | 0.502 | 328 | 11608.238 | 107.74 | 0.33 |
| 18 | 0.535 | 401 | 14291.948 | 119.55 | 0.30 |
| 19 | 0.522 | 973 | 47561.301 | 218.09 | 0.22 |
| 20 | 0.569 | 858 | 29443.913 | 171.59 | 0.20 |
| 21 | 0.552 | 1133 | 42538.820 | 206.25 | 0.18 |
| 22 | 0.621 | 1192 | 42090.840 | 205.16 | 0.17 |
| 23 | 0.613 | 2120 | 69280.060 | 263.21 | 0.12 |
| 24 | 0.626 | 1235 | 48135.237 | 219.40 | 0.18 |
| 25 | 0.682 | 1555 | 45323.725 | 212.89 | 0.14 |
| 26 | 0.757 | 826 | 21885.823 | 147.94 | 0.18 |
| 27 | 0.782 | 458 | 11369.778 | 106.63 | 0.23 |
| 28 | 0.869 | 262 | 5924.725 | 76.97 | 0.29 |
| 29 | 0.879 | 136 | 2224.519 | 47.16 | 0.35 |
| 30 | 1.005 | 627 | 10875.897 | 104.29 | 0.17 |

Table 6. The catch at age (no. X $10^{-3}$) for Division 4RST redfish, 1972-81. The estimated by-catch of small redfish (ages 5-8) in the Port aux Choix shrimp fishery were added to the catch at age from 1976-80.

GULF REDFISH CATCH AT AGE

| AGE | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 142 | 273 | 170 | 355 | 7359 | 3801 | 3368 | 2266 | 125 | 1 |
| 6 | 1272 | 639 | 698 | 620 | 1482 | 2119 | 2656 | 2378 | 285 | 4 |
| 7 | 784 | 3112 | 292 | 290 | 1073 | 824 | 511 | 2233 | 2728 | 308 |
| 8 | 944 | 2380 | 444 | 401 | 372 | 669 | 280 | 2899 | 7800 | 2586 |
| 9 | 1887 | 803 | 510 | 448 | 188 | 620 | 800 | 2373 | 7928 | 10810 |
| 10 | 4297 | 3434 | 216 | 286 | 44 | 416 | 708 | 2753 | 5723 | 11974 |
| 11 | 2938 | 8043 | 403 | 161 | 146 | 409 | 491 | 1902 | 2141 | 7276 |
| 12 | 6366 | 2497 | 463 | 329 | 125 | 236 | 372 | 1838 | 1516 | 5222 |
| 13 | 2588 | 12850 | 2240 | 974 | 383 | 171 | 131 | 931 | 853 | 3449 |
| 14 | 14034 | 7060 | 5381 | 1654 | 716 | 177 | 131 | 510 | 532 | 2085 |
| 15 | 7971 | 76633 | 6364 | 2956 | 1836 | 79 | 153 | 326 | 531 | 1219 |
| 16 | 66593 | 8222 | 28739 | 4572 | 3913 | 123 | 86 | 346 | 265 | 940 |
| 17 | 5102 | 88382 | 7953 | 25149 | 4025 | 509 | 247 | 887 | 306 | 328 |
| 18 | 7659 | 5583 | 37269 | 5771 | 15842 | 379 | 1003 | 1131 | 300 | 401 |
| 19 | 4299 | 9916 | 2989 | 41020 | 3380 | 2959 | 1399 | 2392 | 500 | 973 |
| 20 | 3697 | 7166 | 3387 | 4156 | 16519 | 1273 | 3621 | 1943 | 1601 | 858 |
| 21 | 2471 | 4548 | 1371 | 3453 | 1533 | 5259 | 1294 | 3376 | 921 | 1133 |
| 22 | 2598 | 4333 | 1233 | 3489 | 2131 | 2519 | 3468 | 1542 | 2446 | 1192 |
| 23 | 2366 | 4934 | 471 | 2634 | 1431 | 2314 | 4425 | 3048 | 1348 | 2120 |
| 24 | 1168 | 1306 | 1168 | 1632 | 1317 | 1814 | 1027 | 1013 | 2219 | 1235 |
| 25 | 5840 | 2277 | 825 | 1356 | 543 | 1160 | 725 | 869 | 822 | 1555 |
| 26 | 1 | 7963 | 1815 | 1186 | 430 | 1027 | 222 | 905 | 505 | 826 |
| 27 | 1 | 1 | 5844 | 2080 | 408 | 229 | 222 | 506 | 298 | 458 |
| 28 | 1 | 1 | 1 | 7259 | 659 | 515 | 315 | 522 | 234 | 262 |
| 29 | 1 | 1 | 1 | 1 | 2370 | 196 | 103 | 102 | 78 | 136 |

Table 7. The weight at age (kg) for Div. 4RST redfish 1972-80 was derived from the "standard" redfish age/weight relationship while that for 1981 was calculated using commercial sampling data.

GULF REDFISH WEIGHT AT AGE (KG)

| AGE | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 |
| 6 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.103 | 0.085 |
| 7 | 0.135 | 0.135 | 0.135 | 0.135 | 0.135 | 0.135 | 0.135 | 0.135 | 0.135 | 0.165 |
| 8 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.219 |
| 9 | 0.205 | 0.205 | 0.205 | 0.205 | 0.205 | 0.205 | 0.205 | 0.205 | 0.205 | 0.263 |
| 10 | 0.243 | 0.243 | 0.243 | 0.243 | 0.243 | 0.243 | 0.243 | 0.243 | 0.243 | 0.293 |
| 11 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.320 |
| 12 | 0.322 | 0.322 | 0.322 | 0.322 | 0.322 | 0.322 | 0.322 | 0.322 | 0.322 | 0.346 |
| 13 | 0.362 | 0.362 | 0.362 | 0.362 | 0.362 | 0.362 | 0.362 | 0.362 | 0.362 | 0.388 |
| 14 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.406 |
| 15 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.454 |
| 16 | 0.482 | 0.482 | 0.482 | 0.482 | 0.482 | 0.482 | 0.482 | 0.482 | 0.482 | 0.465 |
| 17 | 0.521 | 0.521 | 0.521 | 0.521 | 0.521 | 0.521 | 0.521 | 0.521 | 0.521 | 0.502 |
| 18 | 0.559 | 0.559 | 0.559 | 0.559 | 0.559 | 0.559 | 0.559 | 0.559 | 0.559 | 0.535 |
| 19 | 0.596 | 0.596 | 0.596 | 0.596 | 0.596 | 0.596 | 0.596 | 0.596 | 0.596 | 0.522 |
| 20 | 0.631 | 0.631 | 0.631 | 0.631 | 0.631 | 0.631 | 0.631 | 0.631 | 0.631 | 0.569 |
| 21 | 0.665 | 0.665 | 0.665 | 0.665 | 0.665 | 0.665 | 0.665 | 0.665 | 0.665 | 0.552 |
| 22 | 0.698 | 0.698 | 0.698 | 0.698 | 0.698 | 0.698 | 0.698 | 0.698 | 0.698 | 0.621 |
| 23 | 0.730 | 0.730 | 0.730 | 0.730 | 0.730 | 0.730 | 0.730 | 0.730 | 0.730 | 0.613 |
| 24 | 0.759 | 0.759 | 0.759 | 0.759 | 0.759 | 0.759 | 0.759 | 0.759 | 0.759 | 0.626 |
| 25 | 0.788 | 0.788 | 0.788 | 0.788 | 0.788 | 0.788 | 0.788 | 0.788 | 0.788 | 0.682 |
| 26 | 0.815 | 0.815 | 0.815 | 0.815 | 0.815 | 0.815 | 0.815 | 0.815 | 0.815 | 0.757 |
| 27 | 0.841 | 0.841 | 0.841 | 0.841 | 0.841 | 0.841 | 0.841 | 0.841 | 0.841 | 0.782 |
| 28 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.869 |
| 29 | 0.889 | 0.889 | 0.889 | 0.889 | 0.889 | 0.889 | 0.889 | 0.889 | 0.889 | 0.879 |

Table 8. Abundance of 1954-60 year-class (nos. X $10^{-6}$) from research vessel surveys are compared with estimates from cohort analysis covering a range of average F values for Divs 4RST redfish. Research values were fitted to an exponential decline ($\ln Y = 5.85-0.15X$, $r = -.85$). Each series was standardized to its 1976-78 mean value.

| Year | Ages | Research | Predicted Research | Cohort $F_{AV}$=.025 | $F_{AV}$=.05 | $F_{AV}$=.073 | $F_{AV}$=.09 |
|---|---|---|---|---|---|---|---|
| 1976 | 16-22 | 264.83 | 299.33 | 712.82 | 422.03 | 334.80 | 294.11 |
| 1977 | 17-23 | | 257.44 | 599.95 | 336.83 | 257.91 | 221.09 |
| 1978 | 18-24 | 300.99 | 221.42 | 528.39 | 290.31 | 218.90 | 185.58 |
| 1979 | 19-25 | 172.06 | 190.43 | 462.66 | 247.24 | 182.62 | 152.48 |
| 1980 | 20-26 | 147.32 | 163.78 | 405.14 | 210.22 | 151.75 | 124.47 |
| 1981 | 21-27 | 144.11 | 140.86 | 357.21 | 180.83 | 127.93 | 103.25 |
| Mean (1976-1978) | | | 259.40 | 613.72 | 349.72 | 270.54 | 233.59 |

Standardized to mean

| Year | Predicted Research | Cohort $F_{AV}$=.025 | $F_{AV}$=.05 | $F_{AV}$=.073 | $F_{AV}$=.09 |
|---|---|---|---|---|---|
| 1976 | 1.15 | 1.16 | 1.21 | 1.24 | 1.26 |
| 1977 | 0.99 | 0.98 | 0.96 | 0.95 | 0.95 |
| 1978 | 0.85 | 0.86 | 0.83 | 0.81 | 0.79 |
| 1979 | 0.73 | 0.75 | 0.71 | 0.68 | 0.65 |
| 1980 | 0.63 | 0.66 | 0.60 | 0.56 | 0.53 |
| 1981 | 0.54 | 0.58 | 0.52 | 0.47 | 0.44 |

Table 9. The partial selection pattern used in cohort analysis (domed) and the partial selection pattern (flat-topped) and weight at age used for yield per recruit and catch projections for Div.4RST redfish.

| Age | Partial selection | | Weight at age (kg) |
|---|---|---|---|
| | Domed | Flat-topped | |
| 5 | .003 | .003 | .090 |
| 6 | .003 | .003 | .085 |
| 7 | .045 | .045 | .165 |
| 8 | .137 | .137 | .219 |
| 9 | .398 | .398 | .263 |
| 10 | .408 | .408 | .293 |
| 11 | .549 | .549 | .320 |
| 12 | .703 | .703 | .346 |
| 13 | 1 | 1 | .388 |
| 14 | 1 | 1 | .406 |
| 15 | .862 | 1 | .454 |
| 16 | .332 | 1 | .465 |
| 17 | .332 | 1 | .502 |
| 18 | .332 | 1 | .535 |
| 19 | .332 | 1 | .522 |
| 20 | .451 | 1 | .569 |
| 21 | .451 | 1 | .552 |
| 22 | .451 | 1 | .621 |
| 23 | .370 | 1 | .613 |
| 24 | .329 | 1 | .626 |
| 25 | .327 | 1 | .682 |
| 26 | .327 | 1 | .757 |
| 27 | .292 | 1 | .782 |
| 28 | .215 | 1 | .869 |
| 29 | .215 | 1 | .879 |

Table 10. Population numbers (X $10^{-3}$) from 1972-81 for Division 4RST redfish from cohort for $F_T$ = 0.14 and using a dome-shaped partial selection vector.

POPULATION NUMBERS

| AGE | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 50881 | 72720 | 131134 | 205313 | 401131 | 333385 | 202208 | 66196 | 10103 | 2256 |
| 6 | 38541 | 45904 | 65541 | 118493 | 185437 | 353959 | 298043 | 179761 | 57741 | 9023 |
| 7 | 61333 | 33663 | 40928 | 58640 | 106627 | 166381 | 320069 | 267154 | 160393 | 51975 |
| 8 | 23143 | 54731 | 27500 | 36755 | 52783 | 95460 | 149764 | 289124 | 239607 | 142534 |
| 9 | 32418 | 20043 | 47277 | 24460 | 32876 | 47407 | 85739 | 135246 | 258853 | 209386 |
| 10 | 75192 | 27538 | 17372 | 42293 | 21706 | 29568 | 42305 | 76819 | 120118 | 226678 |
| 11 | 54594 | 63949 | 21651 | 15513 | 37996 | 19599 | 26359 | 37606 | 66890 | 103243 |
| 12 | 98346 | 46604 | 50213 | 19207 | 13884 | 34241 | 17345 | 23384 | 32218 | 58488 |
| 13 | 91863 | 82931 | 39794 | 44994 | 17066 | 12443 | 30758 | 15340 | 19410 | 27710 |
| 14 | 334704 | 80659 | 62816 | 33876 | 39786 | 15078 | 11097 | 27707 | 12995 | 16751 |
| 15 | 123621 | 289504 | 66268 | 51720 | 29079 | 35319 | 13475 | 9916 | 24585 | 11252 |
| 16 | 421940 | 104274 | 189058 | 53908 | 43986 | 24565 | 31883 | 12047 | 8662 | 21740 |
| 17 | 88640 | 318441 | 86530 | 143729 | 44429 | 36078 | 22111 | 28767 | 10571 | 7586 |
| 18 | 70662 | 75351 | 204066 | 70731 | 106129 | 36372 | 32161 | 19772 | 25185 | 9274 |
| 19 | 51815 | 56652 | 62870 | 149195 | 58510 | 80960 | 32550 | 28146 | 16814 | 22503 |
| 20 | 27705 | 42795 | 41828 | 54044 | 95978 | 49727 | 70441 | 28122 | 23192 | 14739 |
| 21 | 18719 | 21552 | 31906 | 34626 | 44948 | 71131 | 43784 | 60294 | 23598 | 19462 |
| 22 | 17347 | 14598 | 15175 | 27566 | 28046 | 39212 | 59360 | 38387 | 51344 | 20476 |
| 23 | 11179 | 13225 | 9078 | 12558 | 21624 | 23350 | 33084 | 50412 | 33267 | 44132 |
| 24 | 13900 | 7665 | 7273 | 7766 | 8857 | 18205 | 18927 | 25727 | 42715 | 28819 |
| 25 | 85049 | 11466 | 5874 | 5470 | 5474 | 6762 | 14747 | 16149 | 22315 | 36540 |
| 26 | 12 | 71401 | 8209 | 4530 | 3659 | 4437 | 5015 | 12654 | 13786 | 19409 |
| 27 | 15 | 10 | 57031 | 5701 | 2971 | 2902 | 3038 | 4326 | 10589 | 11993 |
| 28 | 7 | 13 | 8 | 46045 | 3180 | 2300 | 2408 | 2538 | 3433 | 9298 |
| 29 | 10 | 5 | 10 | 6 | 34758 | 2251 | 1591 | 1879 | 1800 | 2884 |
| 5+ | 1791634 | 1555903 | 1289408 | 1267139 | 1440923 | 1543092 | 1566261 | 1457471 | 1290165 | 1128133 |
| 6+ | 1740753 | 1483182 | 1158273 | 1061826 | 1039792 | 1209707 | 1366054 | 1391275 | 1280082 | 1125897 |
| 7+ | 1702212 | 1437278 | 1092733 | 943332 | 854354 | 855749 | 1068010 | 1211514 | 1222341 | 1116874 |
| 8+ | 1640879 | 1403615 | 1051805 | 884693 | 747727 | 689368 | 747941 | 944360 | 1061948 | 1064899 |
| 9+ | 1617736 | 1348864 | 1024306 | 847938 | 694943 | 591908 | 598177 | 655236 | 822341 | 922365 |
| 10+ | 1585319 | 1328822 | 977029 | 823477 | 662067 | 544501 | 512438 | 519990 | 563488 | 713979 |
| 11+ | 1510126 | 1301284 | 959657 | 781185 | 640361 | 514933 | 470133 | 443171 | 443370 | 486301 |
| 12+ | 1455532 | 1237335 | 938007 | 765672 | 602365 | 495334 | 443774 | 405565 | 376480 | 383057 |
| 13+ | 1357187 | 1190731 | 887794 | 746465 | 588482 | 461093 | 426429 | 382181 | 344262 | 324569 |

Table 11. Mid-year population biomass (t) from 1972-81 for Division 4RST redfish from cohort for $F_T$ = 0.14 and using a dome-shaped partial selection vector.

POPULATION BIOMASS (MID-YEAR)

| AGE | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 4351 | 6216 | 11224 | 17569 | 34029 | 28385 | 17169 | 5569 | 860 | 193 |
| 6 | 3713 | 4467 | 6389 | 11583 | 18101 | 34783 | 29079 | 17499 | 5645 | 730 |
| 7 | 7827 | 4114 | 5239 | 7514 | 13627 | 21320 | 41085 | 34173 | 20424 | 8136 |
| 8 | 3643 | 8606 | 4386 | 5878 | 8458 | 15297 | 24062 | 46257 | 37883 | 29426 |
| 9 | 6132 | 3828 | 9171 | 4726 | 6395 | 9186 | 16646 | 26144 | 49694 | 50994 |
| 10 | 16869 | 5948 | 3991 | 9746 | 5014 | 6788 | 9698 | 17433 | 27087 | 61463 |
| 11 | 14239 | 16019 | 5754 | 4141 | 10176 | 5203 | 7005 | 9826 | 17652 | 30281 |
| 12 | 29115 | 13881 | 15313 | 5833 | 4234 | 10455 | 5256 | 6870 | 9630 | 18356 |
| 13 | 31182 | 26212 | 13306 | 15326 | 5811 | 4256 | 10572 | 5117 | 6533 | 9559 |
| 14 | 125358 | 29511 | 23007 | 12661 | 15116 | 5747 | 4230 | 10524 | 4877 | 6046 |
| 15 | 50357 | 104426 | 26525 | 21153 | 11854 | 14872 | 5647 | 4109 | 10248 | 4584 |
| 16 | 177263 | 45851 | 79703 | 23626 | 19233 | 11239 | 14604 | 5443 | 3910 | 9404 |
| 17 | 42626 | 133911 | 40828 | 64594 | 20979 | 17757 | 10899 | 14034 | 5162 | 3542 |
| 18 | 35440 | 38528 | 97937 | 36015 | 51975 | 19244 | 16831 | 10203 | 13315 | 4615 |
| 19 | 28108 | 29124 | 34774 | 71899 | 32184 | 45045 | 18048 | 15251 | 9389 | 10927 |
| 20 | 15460 | 23400 | 24050 | 31144 | 52332 | 29463 | 41164 | 16276 | 13423 | 7738 |
| 21 | 11018 | 12088 | 19739 | 20762 | 27940 | 43270 | 27282 | 37040 | 14630 | 9913 |
| 22 | 10604 | 8108 | 9650 | 17083 | 17887 | 25171 | 38225 | 24964 | 33258 | 11733 |
| 23 | 6880 | 7266 | 6135 | 7738 | 14502 | 15375 | 21354 | 33914 | 22622 | 25100 |
| 24 | 9597 | 5177 | 4803 | 4974 | 5892 | 12459 | 13284 | 18201 | 30016 | 16785 |
| 25 | 61485 | 7680 | 4076 | 3549 | 3891 | 4606 | 10775 | 11770 | 16413 | 23189 |
| 26 | 9 | 52117 | 5606 | 3012 | 2662 | 3010 | 3800 | 9446 | 10488 | 13673 |
| 27 | 12 | 7 | 43179 | 3632 | 2204 | 2226 | 2338 | 3249 | 8350 | 8748 |
| 28 | 5 | 10 | 6 | 34759 | 2328 | 1666 | 1847 | 1860 | 2729 | 7576 |
| 29 | 8 | 4 | 8 | 5 | 28357 | 1817 | 1301 | 1545 | 1488 | 2377 |
| 5+ | 691501 | 586500 | 494799 | 438921 | 415179 | 388638 | 392199 | 386716 | 375727 | 375087 |
| 6+ | 687149 | 580284 | 483576 | 421352 | 381150 | 360253 | 375030 | 381147 | 374867 | 374894 |
| 7+ | 683437 | 575817 | 477187 | 409769 | 363049 | 325471 | 345952 | 363648 | 369222 | 374165 |
| 8+ | 675609 | 571702 | 471949 | 402255 | 349422 | 304150 | 304867 | 329476 | 348798 | 366029 |
| 9+ | 671966 | 563097 | 467563 | 396377 | 340964 | 288854 | 280804 | 283219 | 310916 | 336603 |
| 10+ | 665834 | 559268 | 458392 | 391651 | 334570 | 279668 | 264159 | 257075 | 261222 | 285609 |
| 11+ | 648966 | 553320 | 454400 | 381905 | 329556 | 272880 | 254461 | 239642 | 234135 | 224148 |
| 12+ | 634726 | 537301 | 446646 | 377764 | 319379 | 267678 | 247455 | 229816 | 216483 | 193865 |
| 13+ | 605611 | 523420 | 433333 | 371931 | 315145 | 257223 | 242200 | 222946 | 206853 | 175509 |

Table 12. Fishing mortalities from 1972-81 for Division 4RST redfish from cohort for $F_T$ = 0.14 and using a dome-shaped partial selection vector.

FISHING MORTALITY

| AGE | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.003 | 0.004 | 0.001 | 0.002 | 0.019 | 0.012 | 0.018 | 0.037 | 0.013 | 0.000 |
| 6 | 0.035 | 0.015 | 0.011 | 0.006 | 0.008 | 0.006 | 0.009 | 0.014 | 0.005 | 0.000 |
| 7 | 0.014 | 0.102 | 0.008 | 0.005 | 0.011 | 0.005 | 0.002 | 0.009 | 0.018 | 0.006 |
| 8 | 0.044 | 0.047 | 0.017 | 0.012 | 0.007 | 0.007 | 0.002 | 0.011 | 0.035 | 0.019 |
| 9 | 0.063 | 0.043 | 0.011 | 0.019 | 0.006 | 0.014 | 0.010 | 0.019 | 0.033 | 0.056 |
| 10 | 0.062 | 0.141 | 0.013 | 0.007 | 0.002 | 0.015 | 0.018 | 0.038 | 0.051 | 0.057 |
| 11 | 0.058 | 0.142 | 0.020 | 0.011 | 0.004 | 0.022 | 0.020 | 0.055 | 0.034 | 0.077 |
| 12 | 0.070 | 0.058 | 0.010 | 0.018 | 0.010 | 0.007 | 0.023 | 0.086 | 0.051 | 0.098 |
| 13 | 0.030 | 0.178 | 0.061 | 0.023 | 0.024 | 0.015 | 0.004 | 0.066 | 0.047 | 0.140 |
| 14 | 0.045 | 0.097 | 0.094 | 0.053 | 0.019 | 0.012 | 0.012 | 0.020 | 0.044 | 0.140 |
| 15 | 0.070 | 0.326 | 0.106 | 0.062 | 0.069 | 0.002 | 0.012 | 0.035 | 0.023 | 0.121 |
| 16 | 0.181 | 0.087 | 0.174 | 0.093 | 0.098 | 0.005 | 0.003 | 0.031 | 0.033 | 0.046 |
| 17 | 0.062 | 0.345 | 0.102 | 0.203 | 0.100 | 0.015 | 0.012 | 0.033 | 0.031 | 0.046 |
| 18 | 0.121 | 0.081 | 0.213 | 0.090 | 0.171 | 0.011 | 0.033 | 0.062 | 0.013 | 0.046 |
| 19 | 0.091 | 0.203 | 0.051 | 0.341 | 0.063 | 0.039 | 0.046 | 0.094 | 0.032 | 0.046 |
| 20 | 0.151 | 0.194 | 0.089 | 0.084 | 0.200 | 0.027 | 0.056 | 0.075 | 0.075 | 0.063 |
| 21 | 0.149 | 0.251 | 0.046 | 0.111 | 0.037 | 0.081 | 0.032 | 0.061 | 0.042 | 0.063 |
| 22 | 0.171 | 0.374 | 0.089 | 0.143 | 0.083 | 0.070 | 0.063 | 0.043 | 0.051 | 0.063 |
| 23 | 0.252 | 0.498 | 0.056 | 0.249 | 0.072 | 0.110 | 0.152 | 0.066 | 0.044 | 0.052 |
| 24 | 0.092 | 0.192 | 0.185 | 0.250 | 0.170 | 0.111 | 0.059 | 0.042 | 0.056 | 0.046 |
| 25 | 0.075 | 0.234 | 0.160 | 0.302 | 0.110 | 0.199 | 0.053 | 0.058 | 0.039 | 0.046 |
| 26 | 0.094 | 0.125 | 0.265 | 0.322 | 0.132 | 0.279 | 0.048 | 0.078 | 0.039 | 0.046 |
| 27 | 0.073 | 0.116 | 0.114 | 0.484 | 0.156 | 0.087 | 0.080 | 0.131 | 0.030 | 0.041 |
| 28 | 0.164 | 0.087 | 0.146 | 0.181 | 0.246 | 0.268 | 0.148 | 0.244 | 0.074 | 0.030 |
| 29 | 0.111 | 0.218 | 0.106 | 0.191 | 0.074 | 0.096 | 0.070 | 0.059 | 0.047 | 0.030 |

Table 13. Yield per recruit analysis for Div. 4RST redfish as calculated using the 1981 partial selection and weight at age vectors presented in Table 9.

| | FISHING MORTALITY | CATCH (NUMBER) | YIELD (KG) | AVG. WEIGHT (KG) | YIELD PER UNIT EFFORT |
|---|---|---|---|---|---|
| | 0.1000 | 0.286 | 0.118 | 0.413 | 1.361 |
| F0.1--- | 0.1607 | 0.361 | 0.139 | 0.386 | 1.000 |
| | 0.2000 | 0.394 | 0.147 | 0.372 | 0.846 |
| | 0.3000 | 0.451 | 0.156 | 0.346 | 0.600 |
| | 0.4000 | 0.487 | 0.160 | 0.329 | 0.461 |
| | 0.5000 | 0.513 | 0.162 | 0.316 | 0.373 |
| | 0.6000 | 0.533 | 0.163 | 0.305 | 0.313 |
| | 0.7000 | 0.550 | 0.163 | 0.297 | 0.269 |
| | 0.8000 | 0.563 | 0.164 | 0.291 | 0.236 |
| FMAX--- | 0.8821 | 0.572 | 0.164 | 0.286 | 0.214 |
| | 0.9000 | 0.574 | 0.164 | 0.285 | 0.210 |
| | 1.0000 | 0.584 | 0.164 | 0.280 | 0.189 |
| | 1.1000 | 0.593 | 0.163 | 0.276 | 0.171 |
| | 1.2000 | 0.601 | 0.163 | 0.272 | 0.157 |
| | 1.3000 | 0.608 | 0.163 | 0.268 | 0.145 |
| | 1.4000 | 0.614 | 0.163 | 0.265 | 0.134 |
| | 1.5000 | 0.620 | 0.163 | 0.262 | 0.125 |

Table 14. Projected population numbers (X $10^{-3}$), catch biomass (t), and fishing mortalities to 1983 for Division 4RST redfish, given that the TAC of 28,000 t is caught in 1982 and fishing is at $F_{0.1}$ = 0.15 in 1983.

POPULATION NUMBERS

| AGE | 1981 | 1982 | 1983 |
|---|---|---|---|
| 5 | 2256 | 72600 | 72600 |
| 6 | 9023 | 2040 | 65667 |
| 7 | 51975 | 8160 | 1845 |
| 8 | 142534 | 46736 | 7348 |
| 9 | 209386 | 126512 | 41657 |
| 10 | 226678 | 179186 | 109588 |
| 11 | 103243 | 193727 | 155054 |
| 12 | 58488 | 86505 | 165059 |
| 13 | 27710 | 47961 | 72472 |
| 14 | 16751 | 21798 | 38895 |
| 15 | 11252 | 13177 | 17677 |
| 16 | 21740 | 9024 | 10686 |
| 17 | 7586 | 18778 | 7318 |
| 18 | 9274 | 6552 | 15228 |
| 19 | 22503 | 8011 | 5314 |
| 20 | 14739 | 19437 | 6496 |
| 21 | 19462 | 12521 | 15763 |
| 22 | 20476 | 16534 | 10154 |
| 23 | 44132 | 17395 | 13408 |
| 24 | 28819 | 37917 | 14107 |
| 25 | 36540 | 24903 | 30750 |
| 26 | 19409 | 31584 | 20195 |
| 27 | 11993 | 16777 | 25614 |
| 28 | 9298 | 10417 | 13606 |
| 29 | 2884 | 8164 | 8448 |
| 30 | 0 | 2480 | 6621 |
| 31 | 0 | 0 | 2012 |
| 5+ | 1128153 | 1038895 | 953582 |
| 6+ | 1125897 | 966295 | 880982 |
| 7+ | 1116874 | 964255 | 815315 |
| 8+ | 1064899 | 956095 | 813470 |
| 9+ | 922365 | 909358 | 806122 |
| 10+ | 712979 | 782846 | 764466 |
| 11+ | 486301 | 603660 | 654878 |
| 12+ | 383057 | 409933 | 499824 |
| 13+ | 324569 | 323428 | 334765 |

CATCH BIOMASS

| AGE | 1981 | 1982 | 1983 |
|---|---|---|---|
| 5 | 0 | 2 | 3 |
| 6 | 0 | 0 | 3 |
| 7 | 51 | 6 | 2 |
| 8 | 566 | 146 | 31 |
| 9 | 2843 | 1352 | 605 |
| 10 | 3508 | 2183 | 1814 |
| 11 | 2328 | 3445 | 3737 |
| 12 | 1807 | 2112 | 5445 |
| 13 | 1338 | 1839 | 3732 |
| 14 | 847 | 874 | 2096 |
| 15 | 553 | 591 | 1065 |
| 16 | 437 | 415 | 660 |
| 17 | 165 | 931 | 488 |
| 18 | 215 | 346 | 1081 |
| 19 | 508 | 413 | 368 |
| 20 | 486 | 1093 | 491 |
| 21 | 625 | 683 | 1155 |
| 22 | 740 | 1014 | 837 |
| 23 | 1300 | 1054 | 1091 |
| 24 | 773 | 2345 | 1172 |
| 25 | 1061 | 1678 | 2783 |
| 26 | 625 | 2362 | 2029 |
| 27 | 358 | 1296 | 2658 |
| 28 | 228 | 894 | 1569 |
| 29 | 120 | 709 | 986 |
| 30 | 0 | 215 | 772 |
| 31 | 0 | 0 | 235 |
| 5+ | 21484 | 28000 | 36906 |
| 6+ | 21484 | 27998 | 36903 |
| 7+ | 21484 | 27998 | 36900 |
| 8+ | 21433 | 27991 | 36898 |
| 9+ | 20867 | 27846 | 36867 |
| 10+ | 18024 | 26494 | 36262 |
| 11+ | 14513 | 24312 | 34448 |
| 12+ | 12187 | 20866 | 30712 |
| 13+ | 10380 | 18754 | 25267 |

FISHING MORTALITY

| AGE | 1981 | 1982 | 1983 |
|---|---|---|---|
| 5 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 |
| 7 | 0.006 | 0.005 | 0.007 |
| 8 | 0.019 | 0.015 | 0.021 |
| 9 | 0.056 | 0.044 | 0.060 |
| 10 | 0.057 | 0.045 | 0.061 |
| 11 | 0.077 | 0.060 | 0.082 |
| 12 | 0.098 | 0.077 | 0.105 |
| 13 | 0.140 | 0.110 | 0.150 |
| 14 | 0.140 | 0.110 | 0.150 |
| 15 | 0.121 | 0.110 | 0.150 |
| 16 | 0.046 | 0.110 | 0.150 |
| 17 | 0.046 | 0.110 | 0.150 |
| 18 | 0.046 | 0.110 | 0.150 |
| 19 | 0.046 | 0.110 | 0.150 |
| 20 | 0.063 | 0.110 | 0.150 |
| 21 | 0.063 | 0.110 | 0.150 |
| 22 | 0.063 | 0.110 | 0.150 |
| 23 | 0.052 | 0.110 | 0.150 |
| 24 | 0.046 | 0.110 | 0.150 |
| 25 | 0.046 | 0.110 | 0.150 |
| 26 | 0.046 | 0.110 | 0.150 |
| 27 | 0.041 | 0.110 | 0.150 |
| 28 | 0.030 | 0.110 | 0.150 |
| 29 | 0.051 | 0.110 | 0.150 |
| 30 | 0.000 | 0.110 | 0.150 |
| 31 | 0.000 | 0.000 | 0.150 |

Table 15. Projected population numbers (X $10^{-3}$), catch biomass (t), and fishing mortalities to 1983 for Division 4RST redfish, given that fishing is at $F_{0.1}$ = 0.15 in 1982 and 1983.

POPULATION NUMBERS

| AGE | 1981 | 1982 | 1983 |
|---|---|---|---|
| 5 | 2256 | 72600 | 72600 |
| 6 | 9023 | 2040 | 65658 |
| 7 | 51975 | 8160 | 1845 |
| 8 | 142534 | 46736 | 7334 |
| 9 | 209386 | 126512 | 41426 |
| 10 | 226678 | 179186 | 107835 |
| 11 | 103243 | 193727 | 152516 |
| 12 | 58488 | 86505 | 161429 |
| 13 | 27710 | 47961 | 70438 |
| 14 | 16751 | 21798 | 37352 |
| 15 | 11252 | 13177 | 16976 |
| 16 | 21740 | 9024 | 10262 |
| 17 | 7586 | 18778 | 7028 |
| 18 | 9274 | 6552 | 14624 |
| 19 | 22503 | 8011 | 5103 |
| 20 | 14739 | 19437 | 6239 |
| 21 | 19462 | 12521 | 15138 |
| 22 | 20476 | 16534 | 9751 |
| 23 | 44132 | 17395 | 12876 |
| 24 | 28819 | 37917 | 13547 |
| 25 | 36540 | 24903 | 29530 |
| 26 | 19409 | 31584 | 19394 |
| 27 | 11993 | 16777 | 24598 |
| 28 | 9298 | 10417 | 13066 |
| 29 | 2884 | 8164 | 8113 |
| 30 | 0 | 2480 | 6358 |
| 31 | 0 | 0 | 1932 |
| 5+ | 1128153 | 1038895 | 932968 |
| 6+ | 1125897 | 966295 | 860368 |
| 7+ | 1116874 | 964255 | 794709 |
| 8+ | 1064899 | 956095 | 792864 |
| 9+ | 922365 | 909358 | 785530 |
| 10+ | 712979 | 782846 | 744104 |
| 11+ | 486301 | 603660 | 636269 |
| 12+ | 383057 | 409933 | 483754 |
| 13+ | 324569 | 323428 | 322324 |

CATCH BIOMASS

| AGE | 1981 | 1982 | 1983 |
|---|---|---|---|
| 5 | 0 | 3 | 3 |
| 6 | 0 | 0 | 3 |
| 7 | 51 | 9 | 2 |
| 8 | 566 | 199 | 31 |
| 9 | 2843 | 1837 | 601 |
| 10 | 3508 | 2966 | 1785 |
| 11 | 2328 | 4668 | 3675 |
| 12 | 1807 | 2853 | 5325 |
| 13 | 1338 | 2470 | 3627 |
| 14 | 847 | 1175 | 2013 |
| 15 | 553 | 794 | 1023 |
| 16 | 437 | 557 | 633 |
| 17 | 165 | 1251 | 468 |
| 18 | 215 | 465 | 1038 |
| 19 | 508 | 555 | 354 |
| 20 | 488 | 1468 | 471 |
| 21 | 625 | 917 | 1109 |
| 22 | 740 | 1363 | 804 |
| 23 | 1300 | 1415 | 1048 |
| 24 | 773 | 3150 | 1126 |
| 25 | 1061 | 2254 | 2673 |
| 26 | 625 | 3173 | 1949 |
| 27 | 358 | 1741 | 2553 |
| 28 | 228 | 1201 | 1507 |
| 29 | 120 | 952 | 946 |
| 30 | 0 | 289 | 742 |
| 31 | 0 | 0 | 225 |
| 5+ | 21484 | 37726 | 35733 |
| 6+ | 21484 | 37723 | 35730 |
| 7+ | 21484 | 37723 | 35728 |
| 8+ | 21433 | 37715 | 35726 |
| 9+ | 20867 | 37516 | 35694 |
| 10+ | 18024 | 35679 | 35093 |
| 11+ | 14515 | 32713 | 33308 |
| 12+ | 12187 | 28045 | 29633 |
| 13+ | 10380 | 25191 | 24308 |

FISHING MORTALITY

| AGE | 1981 | 1982 | 1983 |
|---|---|---|---|
| 5 | 0.000 | 0.000 | 0.000 |
| 6 | 0.000 | 0.000 | 0.000 |
| 7 | 0.006 | 0.007 | 0.007 |
| 8 | 0.019 | 0.021 | 0.021 |
| 9 | 0.056 | 0.060 | 0.060 |
| 10 | 0.057 | 0.061 | 0.061 |
| 11 | 0.077 | 0.082 | 0.082 |
| 12 | 0.098 | 0.105 | 0.105 |
| 13 | 0.140 | 0.150 | 0.150 |
| 14 | 0.140 | 0.150 | 0.150 |
| 15 | 0.121 | 0.150 | 0.150 |
| 16 | 0.046 | 0.150 | 0.150 |
| 17 | 0.046 | 0.150 | 0.150 |
| 18 | 0.046 | 0.150 | 0.150 |
| 19 | 0.046 | 0.150 | 0.150 |
| 20 | 0.063 | 0.150 | 0.150 |
| 21 | 0.063 | 0.150 | 0.150 |
| 22 | 0.063 | 0.150 | 0.150 |
| 23 | 0.052 | 0.150 | 0.150 |
| 24 | 0.046 | 0.150 | 0.150 |
| 25 | 0.046 | 0.150 | 0.150 |
| 26 | 0.046 | 0.150 | 0.150 |
| 27 | 0.041 | 0.150 | 0.150 |
| 28 | 0.030 | 0.150 | 0.150 |
| 29 | 0.051 | 0.150 | 0.150 |
| 30 | 0.000 | 0.150 | 0.150 |
| 31 | 0.000 | 0.000 | 0.150 |

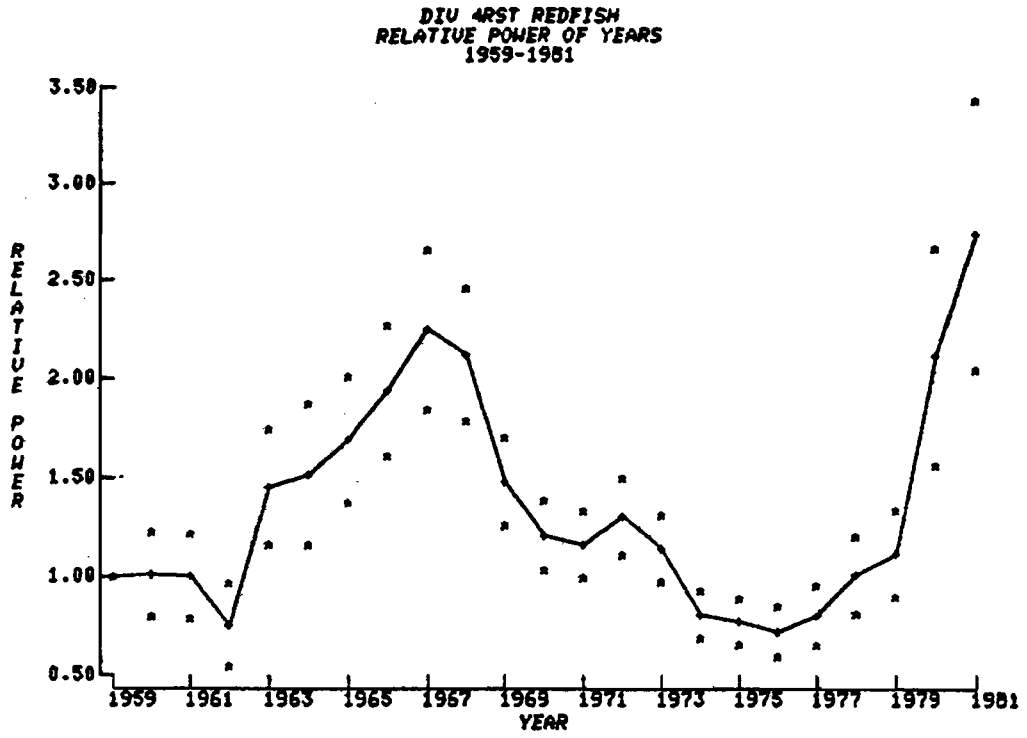


Fig. 1. The trend in relative power of years from 1959 to 1981 (with 95% C.I.) for Division 4RST redfish. Data for 1980-81 were preliminary for Maritime and Newfoundland vessels only.

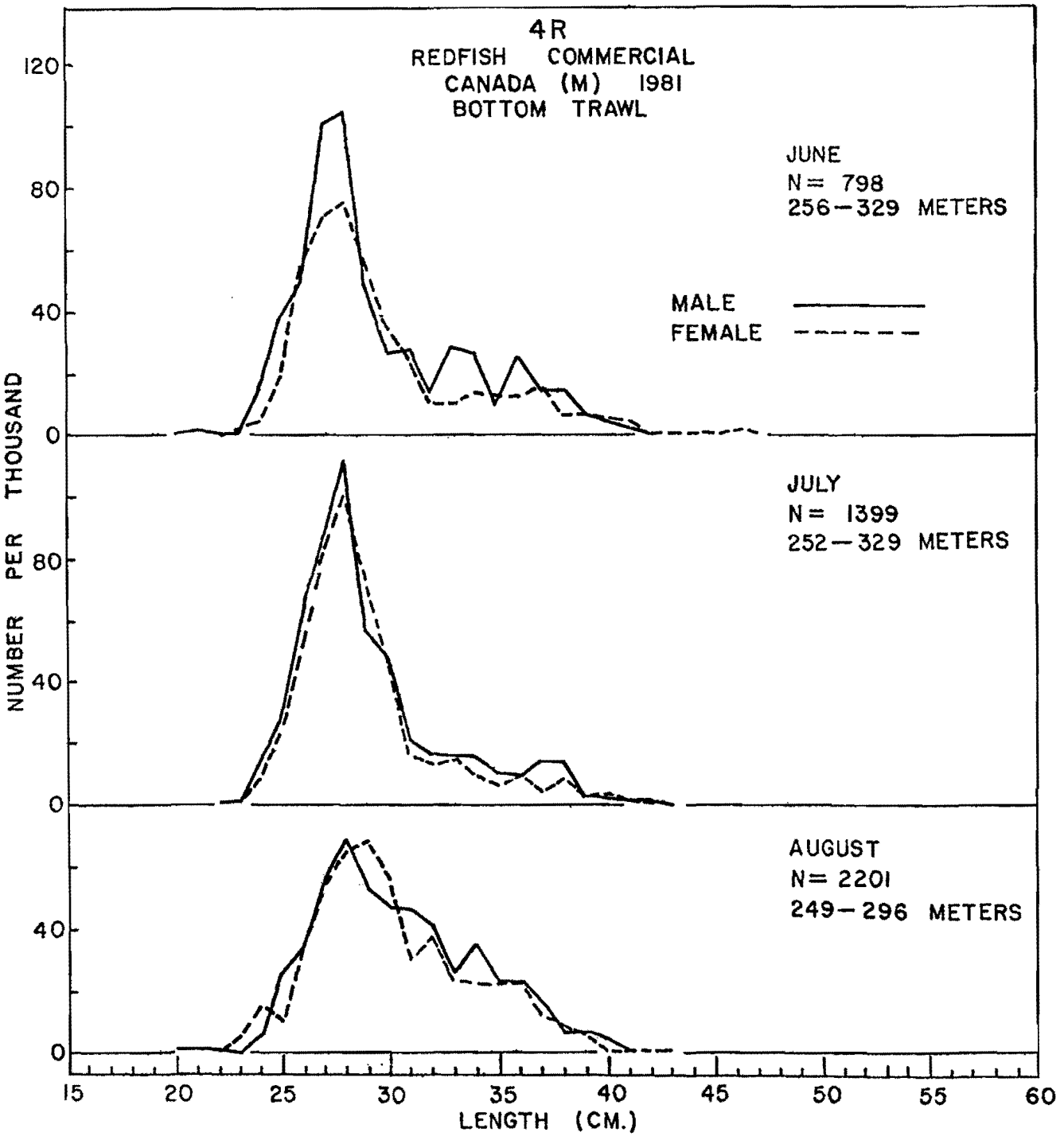


Fig. 2a. Commercial length frequencies (no. per mille) for Division 4R redfish from Canada(M) bottom trawl vessels in 1981.

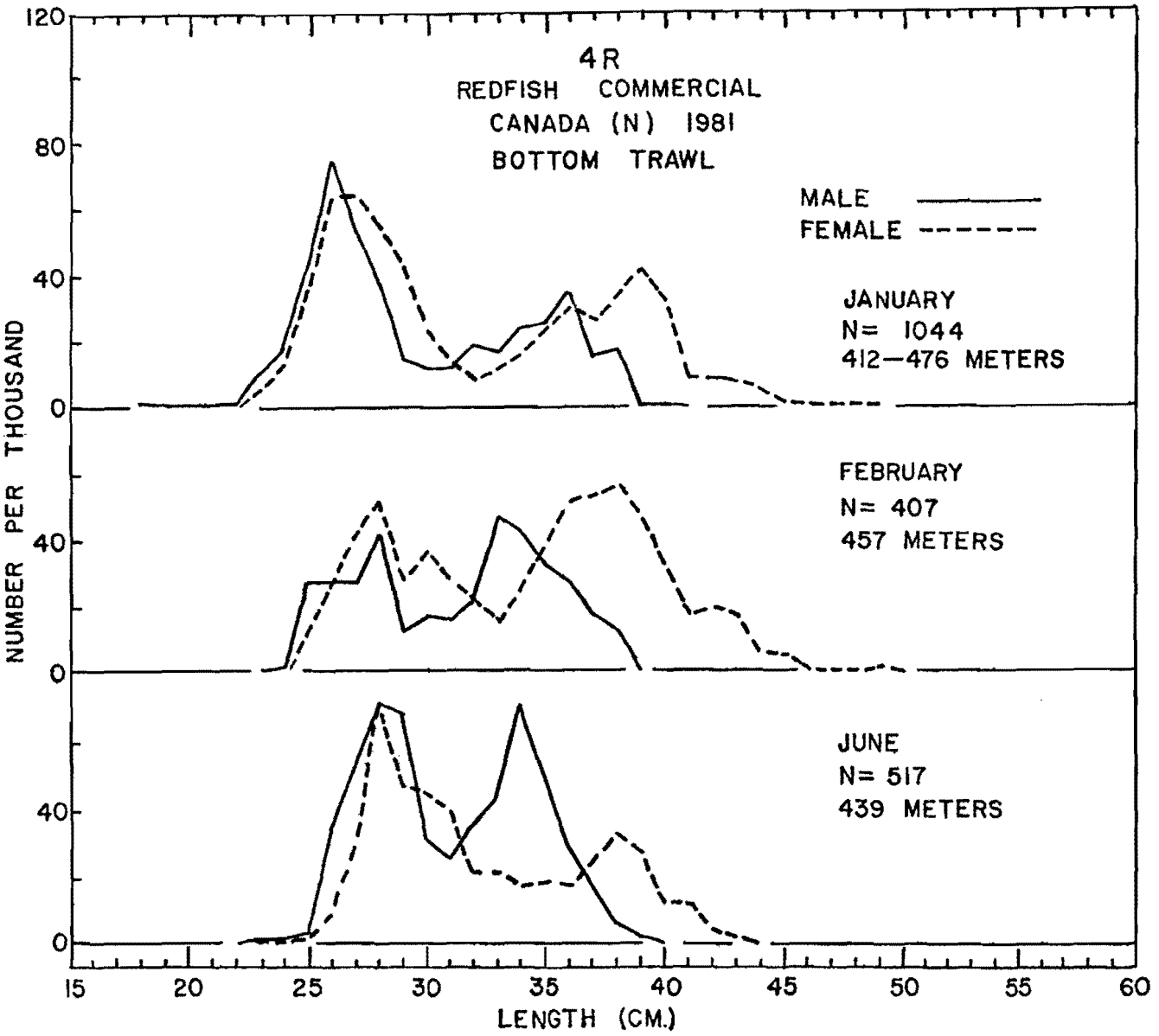


Fig. 2b. Commercial length frequencies (no. per mille) for Division 4R redfish from Canada(N) bottom trawl vessels in 1981.

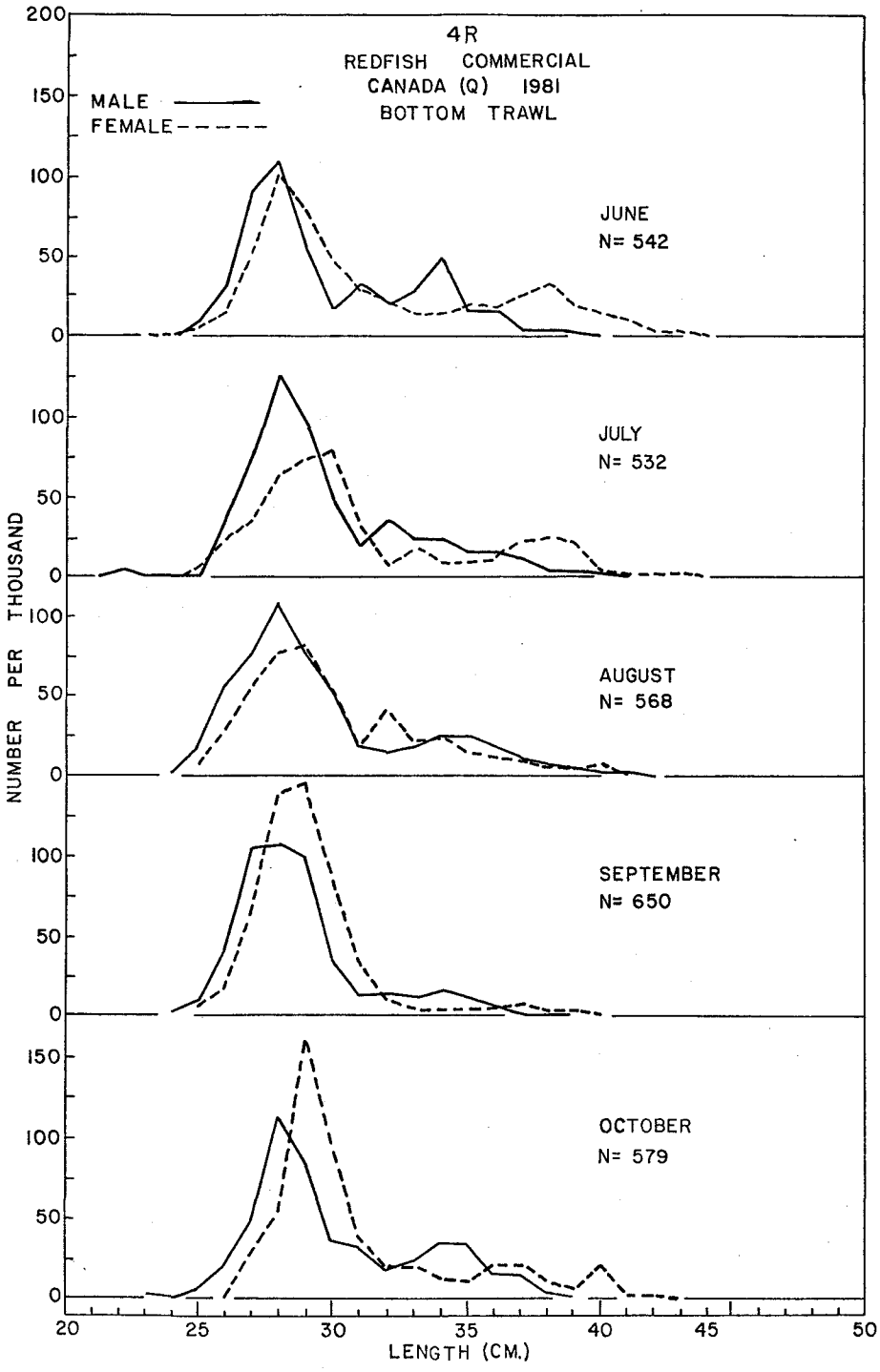


Fig 2c. Commercial length frequencies (no. per mille) for Div. 4R redfish from Canada(Q) bottom trawl vessels in 1981.

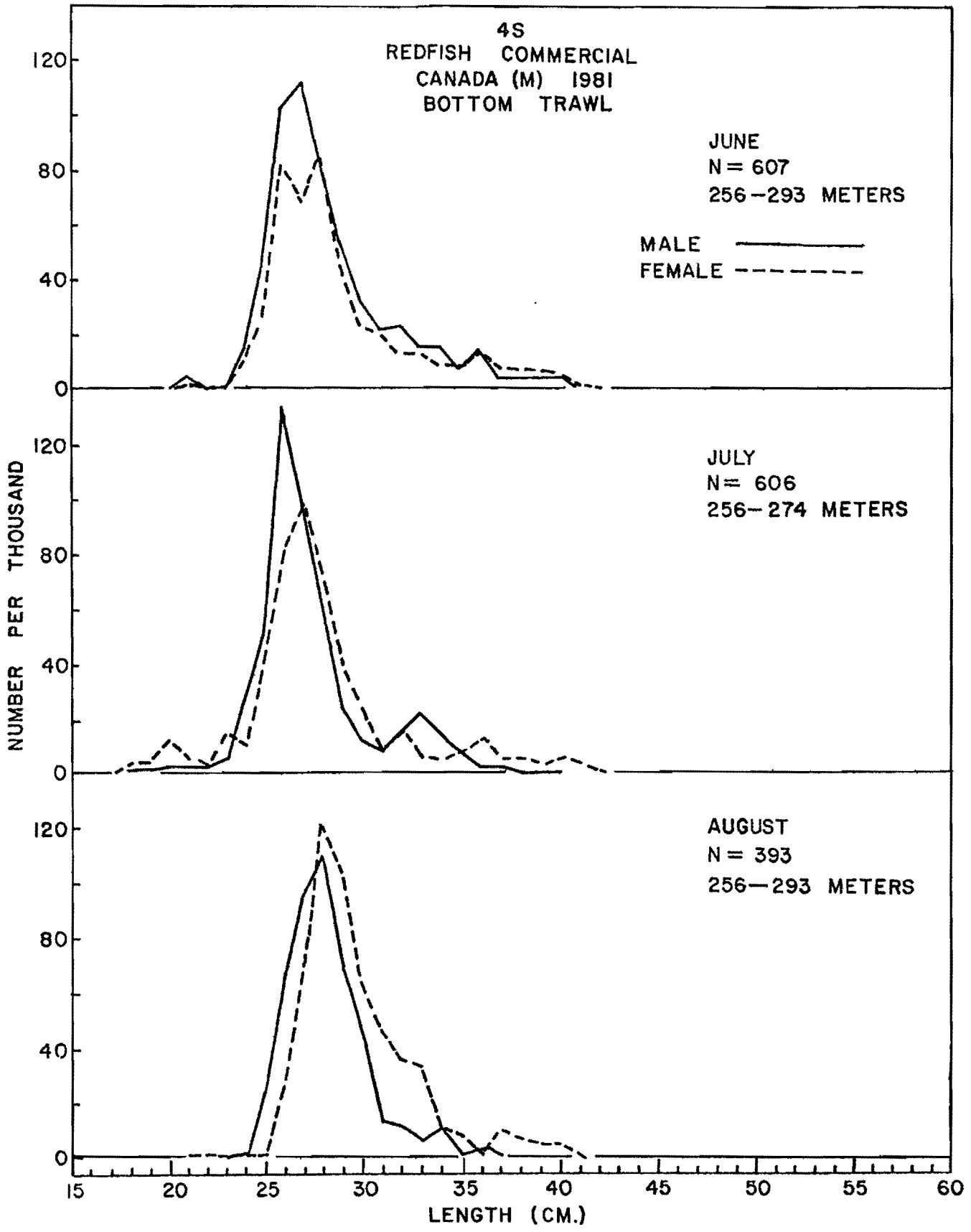


Fig. 3a. Commercial length frequencies (no. per mille) for Division 4S redfish from Canada(M) bottom trawl vessels in 1981.

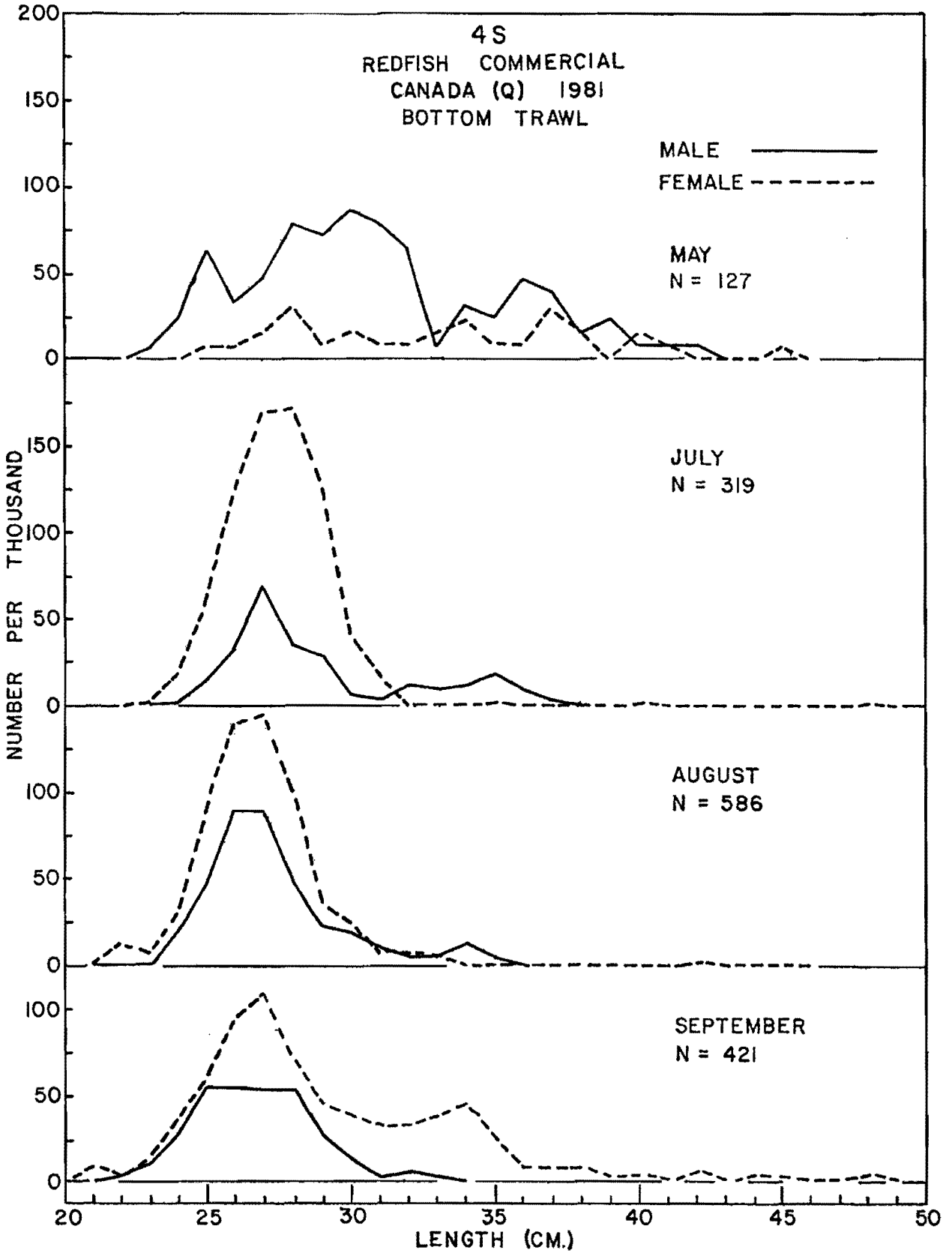


Fig. 3b. Commercial length frequencies (no. per mille) for Div. 4S redfish from Canada(Q) bottom trawl vessels in 1981.

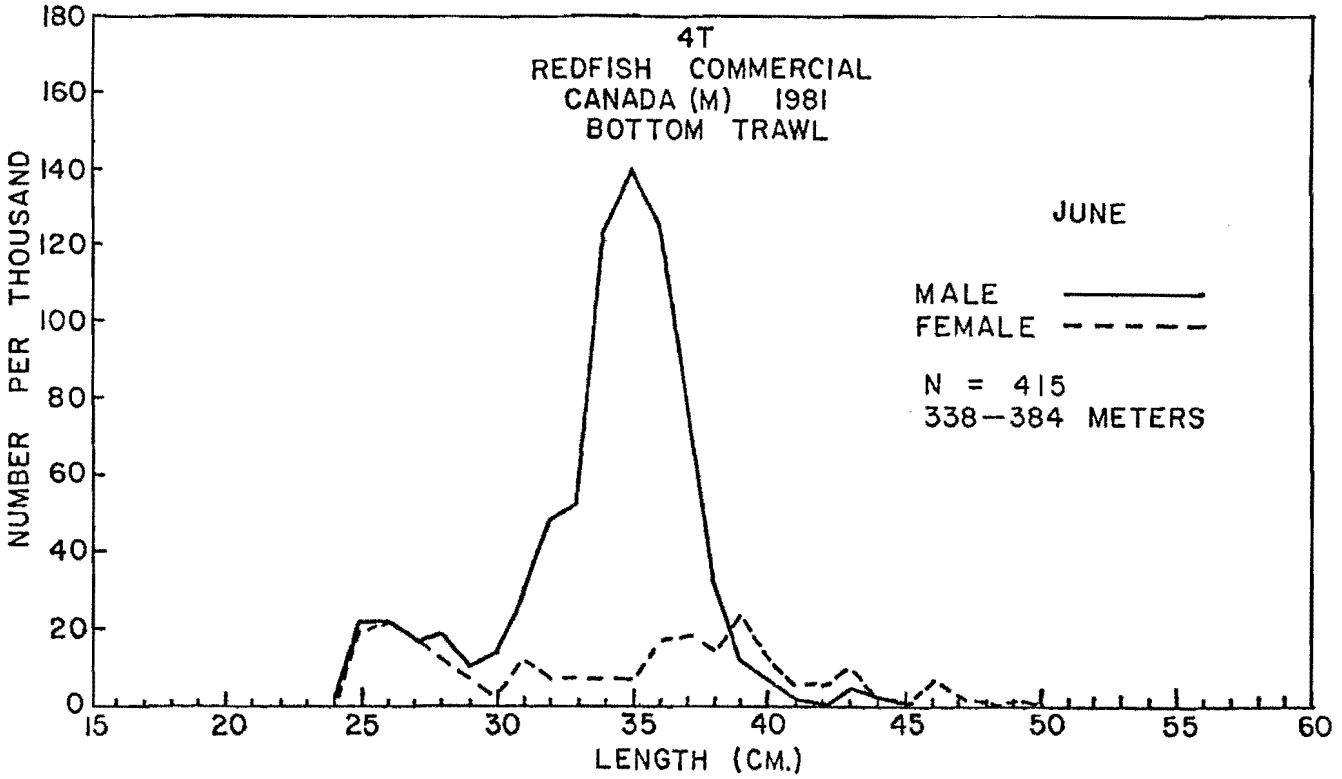


Table 4a. Commercial length frequencies (no. per mille) for Division 4T redfish from Canada(M) bottom trawl vessels in 1981.

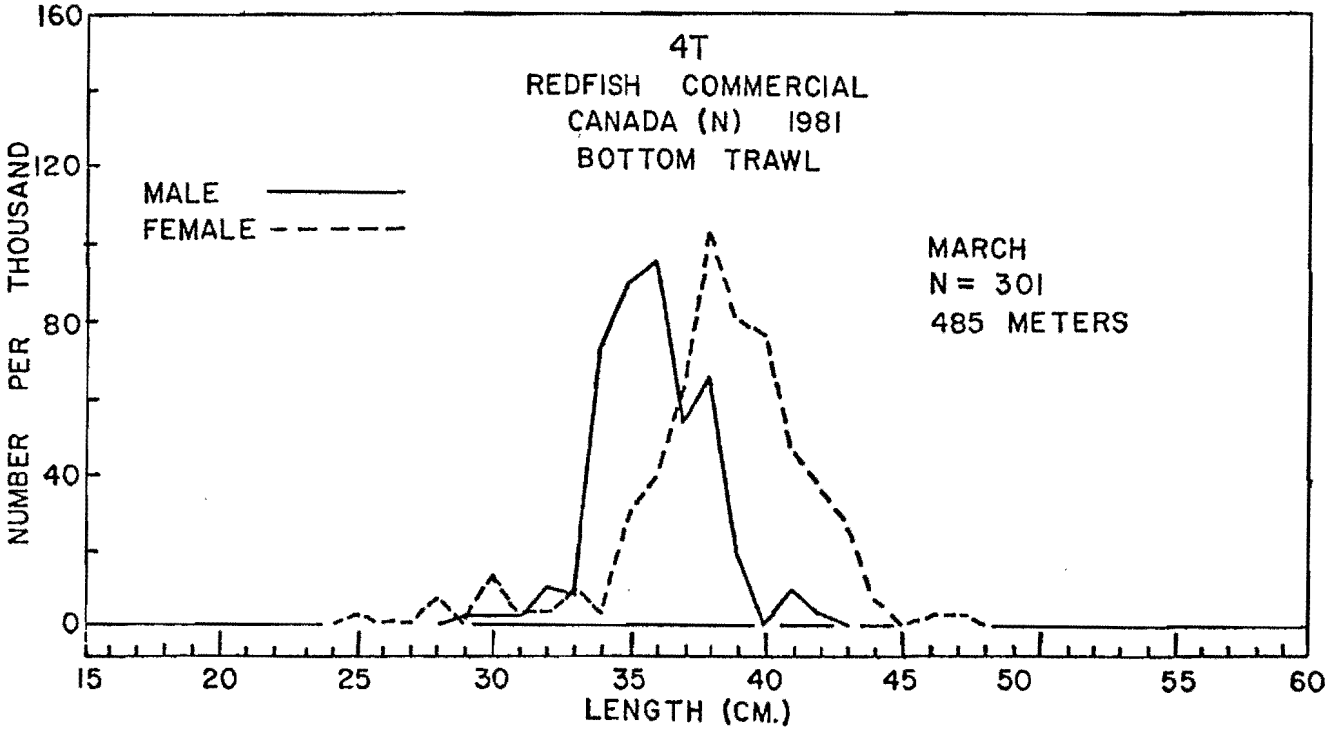


Fig. 4b. Commercial length frequencies (no. per mille) for Division 4T redfish from Canada(N) bottom trawl vessels in 1981.

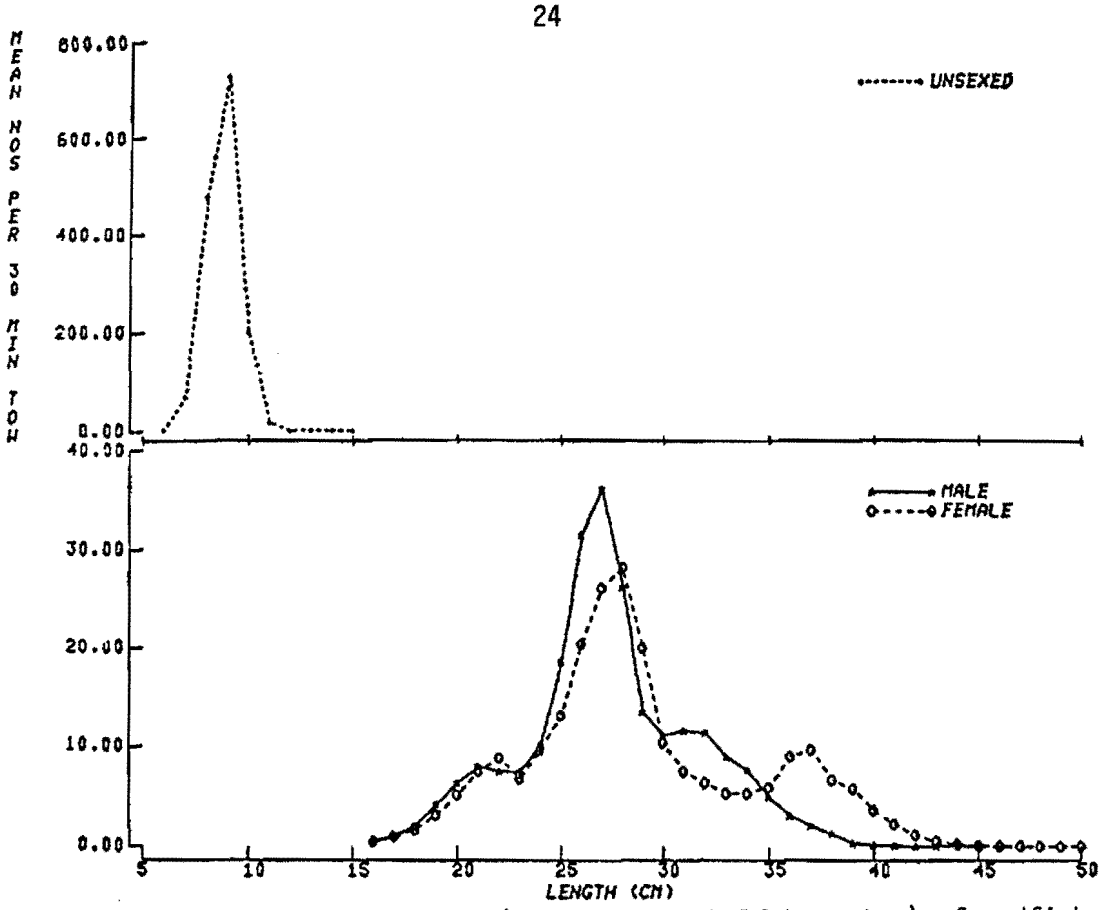


Fig. 5. Length frequency (mean nos per half-hour tow) of redfish as sampled by the 1981 research vessel survey in Div. 4RST.

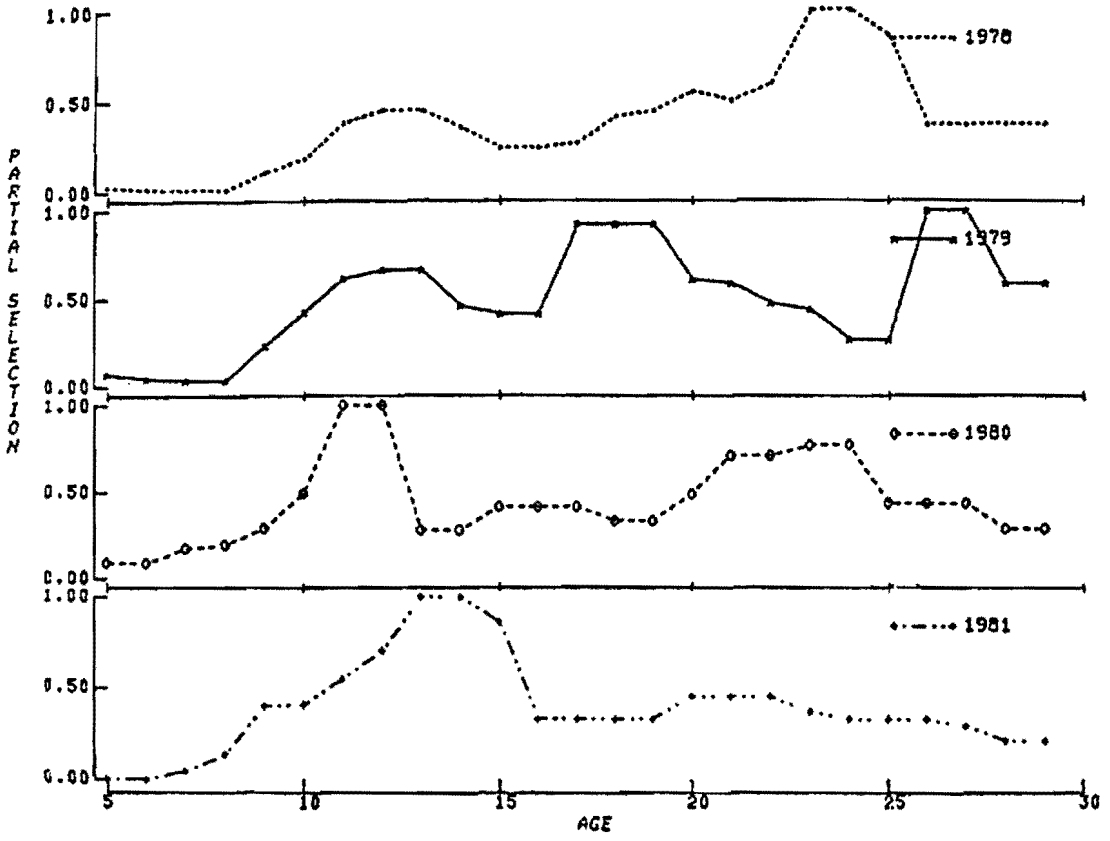


FIG. 6. THE PARTIAL SELECTION WAS CALCULATED AS THE RATIO OF THE CATCH AT AGE TO NOS. AT AGE FROM RESEARCH VESSEL SURVEYS FROM 1978-1981 FOR GULF REDFISH.